INFORMACIJSKA DRUŽBA

Zbornik 21. mednarodne multikonference - IS 2018

INFORMATION SOCIETY

Proceedings of the 21st International Multiconference - IS 2018

Slovenska konferenca o umetni inteligenci
Slovenian Conference on Artificial Intelligence

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Cognitive Science

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Collaboration, Software and Services in Information Society

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Workshop Electronic and Mobile Health and Smart Cities

Uredili / Edited by

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8.–12. oktober 2018 / 8–12 October 2018
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Dostop do e-publikacije:
http://library.ijs.si/Stacks/Proceedings/InformationSociety

Ljubljana, oktober 2018

Informacijska družba
ISSN 2630-371X

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID=297704192
ISBN 978-961-264-134-4 (pdf)

PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2018

Multikonferenca Informacijska družba (http://is.ijs.si) je z enaindvajseto zaporedno prireditvijo osrednji srednjeevropski dogodek na področju informacijske družbe, računalništva in informatike. Letošnja prireditev se ponovno odvija na več lokacijah, osrednji dogodki pa so na Institutu »Jožef Stefan«.

Informacijska družba, znanje in umetna inteligenca so še naprej nosilni koncepti človeške civilizacije. Se bo neverjetna rast nadaljevala in nas ponesla v novo civilizacijsko obdobje ali pa se bo rast upočasnila in začela stagnirati? Bosta IKT in zlasti umetna inteligenca omogočila nadaljnji razcvet civilizacije ali pa bodo demografske, družbene, medčloveške in okoljske težave povzročile zadušitev rasti? Čedalje več pokazateljev kaže v oba ekstrema – da prehajamo v naslednje civilizacijsko obdobje, hkrati pa so notranji in zunanji konflikti sodobne družbe čedalje težje obvladljivi.

Letos smo v multikonferenco povezali 11 odličnih neodvisnih konferenc. Predstavljenih bo 215 predstavitev, povzetkov in referatov v okviru samostojnih konferenc in delavnic. Prireditev bodo spremljale okrogle mize in razprave ter posebni dogodki, kot je svečana podelitev nagrad. Izbrani prispevki bodo izšli tudi v posebni številki revije Informatica, ki se ponaša z 42-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2018 sestavljajo naslednje samostojne konference:

- Slovenska konferenca o umetni inteligenci
- Kognitivna znanost
- Odkrivanje znanja in podatkovna skladišča – SiKDD
- Mednarodna konferenca o visokozmogljivi optimizaciji v industriji, HPOI
- Delavnica AS-IT-IC
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- Delavnica za elektronsko in mobilno zdravje ter pametna mesta
- Vzgoja in izobraževanje v informacijski družbi
- 5. študentska računalniška konferenca
- Mednarodna konferenca o prenosu tehnologij (ITTC)

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija, Slovensko društvo za umetno inteligenco (SLAIS), Slovensko društvo za kognitivne znanosti (DKZ) in druga slovenska nacionalna akademija, Inženirska akademija Slovenije (IAS). V imenu organizatorjev konference se zahvaljujemo združenjem in institucijam, še posebej pa udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

V letu 2018 bomo šestič podelili nagrado za življenjske dosežke v čast Donalda Michieja in Alana Turinga. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe bo prejel prof. dr. Saša Divjak. Priznanje za dosežek leta bo pripadlo doc. dr. Marinki Žitnik. Že sedmič podeljujemo nagradi »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono letos prejme padanje državnih sredstev za raziskovalno dejavnost, jagodo pa Yaskawina tovarna robotov v Kočevju. Čestitke nagrajencem!

Mojca Ciglarič, predsednik programskega odbora

Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2018

In its 21st year, the Information Society Multiconference (http://is.ijs.si) remains one of the leading conferences in Central Europe devoted to information society, computer science and informatics. In 2018, it is organized at various locations, with the main events taking place at the Jožef Stefan Institute.

Information society, knowledge and artificial intelligence continue to represent the central pillars of human civilization. Will the pace of progress of information society, knowledge and artificial intelligence continue, thus enabling unseen progress of human civilization, or will the progress stall and even stagnate? Will ICT and AI continue to foster human progress, or will the growth of human, demographic, social and environmental problems stall global progress? Both extremes seem to be playing out to a certain degree – we seem to be transitioning into the next civilization period, while the internal and external conflicts of the contemporary society seem to be on the rise.

The Multiconference runs in parallel sessions with 215 presentations of scientific papers at eleven conferences, many round tables, workshops and award ceremonies. Selected papers will be published in the Informatica journal, which boasts of its 42-year tradition of excellent research publishing.

The Information Society 2018 Multiconference consists of the following conferences:

- Slovenian Conference on Artificial Intelligence
- Cognitive Science
- Data Mining and Data Warehouses - SiKDD
- International Conference on High-Performance Optimization in Industry, HPOI
- AS-IT-IC Workshop
- Facing demographic challenges
- Collaboration, Software and Services in Information Society
- Workshop Electronic and Mobile Health and Smart Cities
- Education in Information Society
- 5th Student Computer Science Research Conference
- International Technology Transfer Conference (ITTC)

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, Slovenian Artificial Intelligence Society (SLAIS), Slovenian Society for Cognitive Sciences (DKZ) and the second national engineering academy, the Slovenian Engineering Academy (IAS). On behalf of the conference organizers, we thank all the societies and institutions, and particularly all the participants for their valuable contribution and their interest in this event, and the reviewers for their thorough reviews.

For the sixth year, the award for life-long outstanding contributions will be presented in memory of Donald Michie and Alan Turing. The Michie-Turing award will be given to Prof. Saša Divjak for his life-long outstanding contribution to the development and promotion of information society in our country. In addition, an award for current achievements will be given to Assist. Prof. Marinka Žitnik. The information lemon goes to decreased national funding of research. The information strawberry is awarded to the Yaskawa robot factory in Kočevje. Congratulations!

Mojca Ciglarič, Programme Committee Chair

Matjaž Gams, Organizing Committee Chair

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Volume A

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http://is.ijs.si

11.–12. oktober 2018 / 11–12 October 2018
Ljubljana, Slovenia

PREDGOVOR

V letu 2018 smo ponovno priča neverjetnim dosežkom umetne inteligence. Tako je bila letos poleti v Stockholmu največja svetovna konferenca na področju umetne inteligence IJCAI združena z evropsko ECAI, s čimer je imela 37 % več prispevkov kot prejšnje leto. Združeni konferenci sta skupno pritegnili preko 6.000 udeležencev. Približno polovica vseh prispevkov je bila kitajskih, pol manj je bilo evropejskih in ameriških. Velesile se zavedajo, da je področje umetne inteligence eno izmed ključnih, zato tako Putin kot Trump in Ši Džinping intenzivno povečujejo sredstva za njen razvoj, Evropa pa jih bo v prihodnjih letih nekajkrat povečala.

Dnevno umetna inteligenca sprejme neverjetnih 10 bilijonov odločitev. Samo v lanskem letu je bilo dosežkov umetne inteligence toliko, da jih lahko omenimo le majhen delež. Na področju varnosti po svetu uporabljajo sistem, ki vsak dan izdela nov urnik obhodov varnostnikov po letališčih, pristaniščih in podobnih okoljih. Kjer so ti sistemi uporabljeni, je izmerjena bistveno večjo učinkovitost. V skrbi za okolje so raziskovalci pod vodstvom prof. Tambeja (med njimi je bil tudi naš doktorand dr. Kaluža) tovrstne sisteme podarili 60 rezervatom po svetu, da se bodo uspešneje upirali krivolovcem. Leta 2015 so sistemi na osnovi globokih nevronskih mrež začeli dohitevati ljudi pri prepoznavanju vidnih nalog in danes jih že prekašajo, npr. pri prepoznavanju malignih tkiv. Pri nekaterih nalogah, recimo pri ostrenju slike (zaradi dežja, megle, snega itd.), so sistemi osemkrat boljši od ljudi. Ob tem se seveda pojavlja tudi strah, vendar če na diagnozo, ali imate raka ali ne, čakate nekaj tednov, v ZDA pa to diagnozo postavi umetna inteligenca v nekaj minutah in to bolje kot katerikoli zdravnik – kaj pravite, ali bi jo uvedli tudi pri nas? V Sloveniji potrebno znanje že imamo, zatika se le pri vpeljavi. Pri nekaterih posegih, kot je recimo presaditev organov, so sistemi umetne inteligence že desetletja v uporabi in so rešila na tisoče življenj. Nekateri sistemi so tudi novejši – letos so tako vpeljali prvi inteligentni sistem, ki ugotavlja diabetes na podlagi pregleda oči, prav tako tudi prvi program za ugotavljanje abnormalnosti prsnega koša pri slikanju. Hiter razvoj je najbolj znan pri avtonomni vožnji – danes imajo povprečni avtomobili kar nekaj avtonomnih inteligentnih funkcij, modernejši (npr. Tesla) pa vozijo praktično sami in jih nadziramo samo še v nenavadnih situacijah. Nesreč avtonomnih vozil je približno stokrat manj kot tistih človeških voznikov, medijski odziv nanje pa je pogosto veliko bolj poročan in zato napihnjen.

Mnoge zanimive dosežke umetne inteligence predstavljamo tudi na Slovenski konferenci o umetni inteligenci (SKUI), ki je naslednica konference Inteligentni sistemi in je sestavni del multikonference Informacijska družba že od njenega začetka leta 1997. Slovensko društvo za umetno inteligenco, ki letos praznuje že 26. obletnico, SKUI šteje za svojo konferenco. Letos je bilo sprejetih 17 prispevkov. Kot pretekla leta jih je največ z Instituta »Jožef Stefan«, nekaj pa jih je prispevala Fakulteta za računalništvo in informatiko, ki ima skupaj z Institutom vodilno vlogo pri raziskavah umetne inteligence v Sloveniji. Upamo, da bo prispevkov iz industrije in nasploh izven Instituta prihodnja leta še več, saj je ključen cilj SKUI povezovanje vseh slovenskih raziskovalcev umetne inteligence, čeprav na konferenci niso nič manj dobrodošli tudi prispevki iz tujine.

Mitja Luštrek, Rok Piltaver, Matjaž Gams

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Monitoring Bumblebee Daily Activities Using Microphones

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ABSTRACT

We present initial results of the study where we used microphones, placed in front of nest boxes, to monitor daily foraging activity of bumblebees. Sound recordings were analyzed using a custom-made computer algorithm which detects flight buzzing sounds coming from arrivals or departures of individual bees. In addition, the algorithm distinguishes between arrivals and departures. We show examples of daily activities for three species (*B. pascuorum*, *B. humilis* and *B. hypnorum*), each was monitored over the course of one day. This paper presents initial results of a longer study where we plan to systematically investigate the activities of bumblebees in various circumstances.

Keywords
Bumblebees, foraging activity, sound analysis

1. INTRODUCTION

Bumblebees (genus *Bombus* from the bee family Apidae) are an important group of wild pollinators. Due to different morphology and lifestyle, when pollinating plants, they are often more effective than honeybees – they are able to go foraging in rainy and cold weather, and in addition, they use a special technique, called buzz-pollination, to extract pollen from plants such as tomatoes. In addition to pollination in the wild, this makes bumblebees important players in greenhouse agriculture.

Pollinator monitoring, as well as monitoring of wild pollinators, is of high interest to agronomists, ecologists, and experts in the field of conservation. In studies of bumblebee activity, currently the most typical approaches are observations and capturing. Capturing is problematic as it includes removal of individuals from the environment. Sometimes, bumblebees are also studied in laboratory conditions, by raising an entire colony in a lab, which typically involves commercially available bumblebee species. One can expect that the behavior in a laboratory is not identical to that in a natural environment. A better approach to controlled studies is introducing the bumblebees into special nest boxes outside. This allows us to monitor them in a near-natural environment.

In this paper, we present the first results of a study where we used microphones to monitor bumblebee daily foraging activities. These activities are important to monitor as they provide a direct insight into pollination service. Using a microphone (recording sounds) is clearly advantageous from personal monitoring (such as in Grad et al. [1]) since it is continuous and allows us to monitor several sites simultaneously (using several microphones). Bumblebee buzzing sounds have been studied before, though with a different focus. Gradišek et al. [2] developed a machine-learning-based algorithm to recognize individual species and types (queen or worker) of bumblebees based on flight buzzing sound. Heise et al. [3] developed an algorithm to detect bee buzzes from field recordings. In our case, the task was to detect arrivals and departures of bumblebees from the nest boxes (both of which result in buzzes recorded by the microphone), therefore the algorithm was optimized for this task. We discuss the algorithm and show some initial results.

2. MATERIALS AND METHODS

2.1 Data Collection

USB stick microphones dB9PRO VR1.0 [4] were used for sound recordings. Each microphone has 8 GB of flash memory, which gives it nominal storage capacity above 90 h. Sound is recorded at 48 kHz with a 192 Kbps bit rate. After each charging, a microphone can record for around 10 h. Microphones were placed in front of nest box entrances in order to record arrivals and departures. In the following, we demonstrate the results for three different bumblebee families, each of them monitored over the course of one day. The details of the investigated families are listed in Table 1. In all cases, the microphones were set around 8 am. For *B. pascuorum*, the microphone kept recording until the battery lasted while for the other two families, on the following day, the microphones were collected around 6 pm as the weather deteriorated.

Table 1. Bumblebee families studied

Species	Date	No. of workers	Weather
B. pascuorum	28 May 2018	10	14 – 28 °C, morning fog, sunny during the day, storms in the evening
B. humilis	29 May 2018	20	16 – 26 °C, morning partially cloudy, light rain after 4 pm, heavy rain after 6 pm
B. hypnorum		30	

2.2 Sound Recording Analysis

The flowchart of the algorithm is shown in Figure 1. The algorithm was inspired by that of Heise et al. [3], but simplified in order to work faster as recordings of arrivals and departures in front of a single nest box are typically cleaner than those from a microphone located in the field. Our preliminary analysis was carried out using the Audacity software while a more detailed analysis was done in Matlab, using in-built packages and own code. In each recording, we manually labelled around 10 buzzes at the beginning in order to optimize the thresholds for the algorithm (described in the following). In addition, we manually labelled the entire recording of *B. pascuorum* in order to evaluate the performance of the algorithm.

Preliminary inspection showed that the microphones recorded bumblebee buzzes well, while also recording a series of noises from the environment, such as passing traffic or human speech. Sometimes, these sounds can be louder than the buzzes themselves. The task of our algorithm is therefore to detect loud events and to check whether they are buzzes or noise. For positively identified buzzes, we next determine whether they correspond to arrival or departure of the bumblebee.

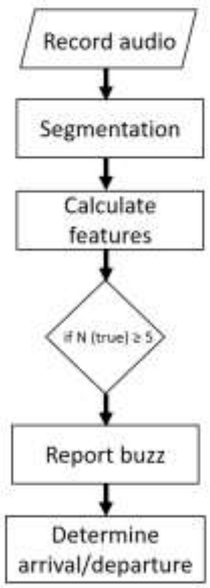

Figure 1. Flowchart of the buzz detecting algorithm

The algorithm is the following:

1. The recording, typically several hours long, is cut to segments of 5 seconds. This length was determined to be sufficiently long to contain the entire event while short enough to contain only a single event.

As the recording is cut into segments, there is a possibility that the cutting occurs in the middle of a buzz. To identify such cases, a special function first checks whether the peak amplitude occurs in the first second of the segment. If it does, it checks the last second of the previous sample, if the peak amplitude occurs in the last second there (indicating that the buzz was cut to two segments). In such cases, both segments are merged into a single segment and the analysis proceeds as described in the following (with only one buzz counted).

2. For each segment, we calculate the Fourier transform of the time-domain signal to obtain the spectra (frequency domain, spectrum amplitude as a function of frequency)

3. For each segment, we calculate seven independent Boolean features that we use to decide whether the segment contains an event or not. In the following, the natural frequencies (the frequency that a bumblebee flaps its wings during flight) are optimized for *B. pascuorum*. For species with significantly different natural frequencies (see [2]), we modify the boundaries. The feature thresholds are set for each family as well, based on some manually inspected events (about 10 – 15 events at the beginning of each recording).

a) We calculate the average amplitude of the segment (which can generally be done either in time or in frequency domain). If the amplitude is larger than a manually determined threshold value, this is a possible event (e.g. true).

b) The natural frequency is f = 180 Hz. We count the number of peaks between 160 and 200 Hz (using the *findpeaks* function). If the number of peaks is smaller than the threshold, this is considered a buzz, otherwise we are dealing with noise.

c) We calculate the ratio of average amplitudes around the proposed peak (average amplitude value on the interval 160 – 200 Hz) and below it (60 – 120 Hz). If the ratio is larger than the threshold, this can be a true buzz, otherwise it is likely to be noise.

d) Similar to feature c), we check the ratio of the average amplitude around the proposed peak and above it (220 – 280 Hz).

e) Similar to feature b), we look for a peak at double natural frequency (first harmonic), looking at the interval (2 * f – 20 Hz, 2 * f + 20 Hz).

f, g) We follow the same procedure as for features c) and d), just at the frequency of first harmonic and correspondingly higher interval boundaries.

If five or more features return “true”, we consider the segment to contain a buzz. This criterion was determined on a series of manually labelled events in order to maximize the accuracy.

Once we know that a segment contains a buzz, we can determine whether it corresponds to arrival or departure. This part is carried out using signal in time domain. Figure 2 shows examples of both events. They are roughly symmetric in shape, which is reasonable given the dynamics of the process. When a bumblebee arrives to the nest box, it is initially far from the microphone and then gets closer – resulting in an increasing signal amplitude. When it lands, it stops buzzing, thus a sharp drop in signal. For departure, the bumblebee starts flying (sharp jump) and then flies away from the microphone (gradual drop in amplitude).

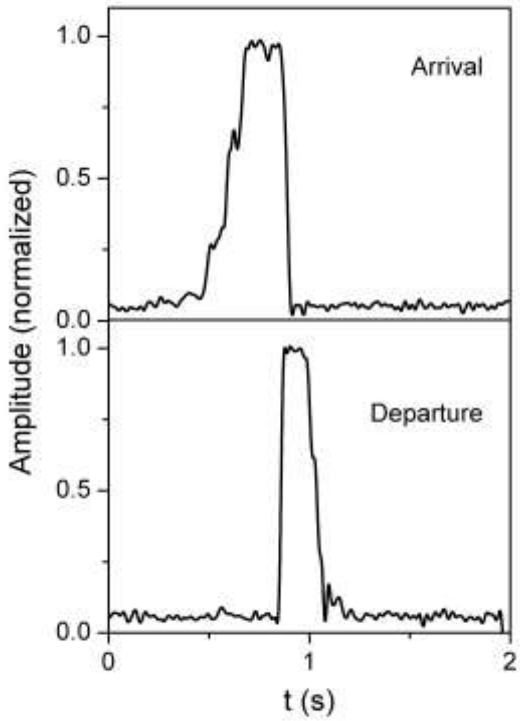

Figure 2. Signal envelope in time domain for arrivals (top) and departures (bottom)

To classify the event as an arrival or a departure, we do the following. First, we calculate the signal envelope and smooth it to reduce the noise. Such envelopes can be seen in Figure 2. Next, we use the *findpeaks* function to identify peaks and we calculate the maximum absolute difference between two consecutive peaks. We call this a “drop”. Looking at Figure 2, we see that the drop appears at the end of arrival and at the beginning of departure. By integrating the area before and after the drop over a chosen interval, we can determine the arrival or departure.

As each segment has a timestamp, we are able to plot histograms of either arrivals or departures of bumblebees throughout several hours.

3. RESULTS AND DISCUSSION

Figure 3 shows three histograms for bumblebee departures on a chosen day, on hourly basis.

Figure 3 only shows the number of departures. The numbers for arrivals are very similar, as is to be expected. These three histograms provide a good insight into the daily dynamics of each family. Different species have different foraging habits, for example, *B. pascuorum* were mostly active around noon and in the afternoon while less active in the morning. On the other hand, *B. hypnorum* were more active after 3 pm. Light rain at 4 pm made the *B. humilis* workers stay inside but it did not affect *B. hypnorum*. Of course, as these are initial results on limited datasets, a longer data collection will be required to investigate the dynamics as the family develops over the course of several months.

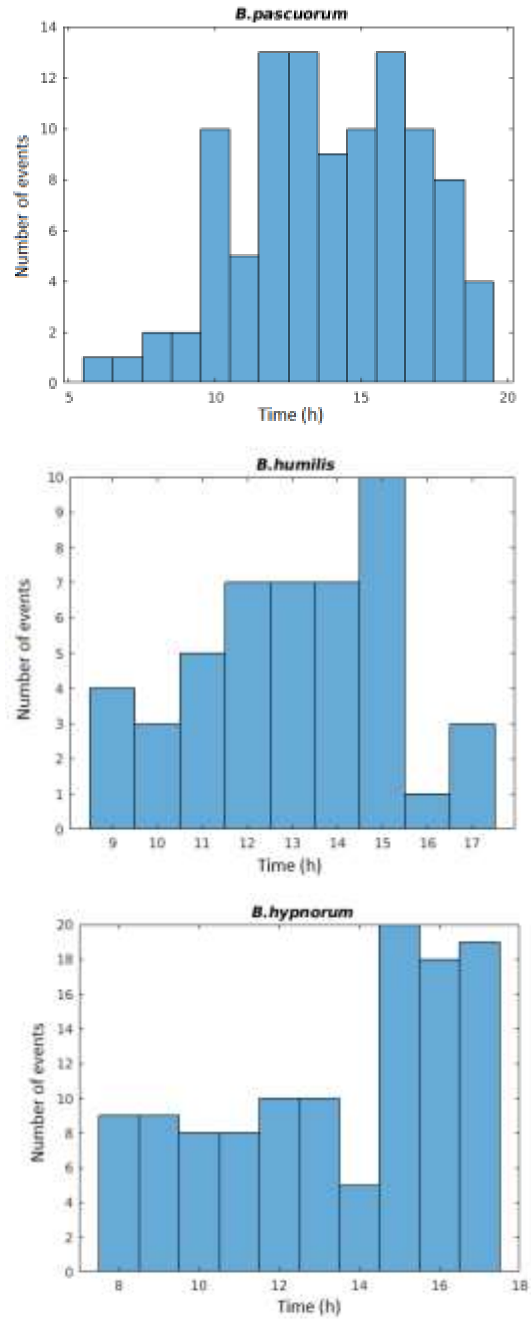

Figure 3. Histograms for number of departures (reflecting daily activity) for three bumblebee families, as described in Table 1.

To check the accuracy of the algorithm, we tested it on the manually-labelled recording (*B. pascuorum*). Out of 180 actual events (counting arrivals and departures together, P), our algorithm correctly detected 171 events (TP), 9 detected events were not buzzes (FP), and 9 events were missed (FN). Based on this, we can determine the algorithm sensitivity, TP / P = TP / (TP + FN) = 0,95 and precision TP / (TP + FP) = 0,95. Clearly, this estimate is based on a single long recording and may vary for other conditions (different species or different structure of noise).

4. CONCLUSION

We demonstrate that microphones can be used as a simple tool to study bumblebee foraging activity, as opposed to personal monitoring. The algorithm we developed detects potential buzzes and classifies them as either arrivals or departures. Compared to the performance of a human manually labelling the buzzes in the recording, the algorithm works with 95 % sensitivity and 95 % precision, which we consider sufficient for meaningful results. In future, we plan to study several bumblebee families throughout the year to investigate the effects of the weather, temperatures, family size, and other parameters on foraging activity.

5. ACKNOWLEDGMENTS

The research is partially funded by National Geographic Grant NGS-282-18 (to C. Galen).

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Reconstructing PPG Signal from Video Recordings

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ABSTRACT

Physiological signals give important insight regarding someone's health. It would be in the interest of people to monitor such signals without any wearable devices. We used RGB camera recordings of faces to reconstruct the PPG signal, which can be used to monitor many physiological signals such as heart rate, breathing rate, blood pressure, etc. A deep learning method was developed to enhance existing state-of-the-art methods. This method uses the output of an existing method as an input into a LSTM neural network, which substantially improves the reconstruction of PPG.

Keywords

remote PPG, signal processing, deep learning

1. INTRODUCTION

Physiological signals, such as photoplethymogram (PPG), are traditionally measured using wearable devices like cuffs and wristbands. While such devices are rather unobtrusive, it would be preferable to omit them completely. This can be achieved with the use of contact-free devices such as RGB cameras, which can blend into the environment, allowing for remote physiological signal reconstruction. An example group for whom such a system would be useful are people with profound cognitive impairment, who are the subjects participating in the INSENSION project[1], for which our system is being developed.

This paper aims to compare and enhance existing approaches for reconstructing PPG from video data, i.e., remote PPG (rPPG). The PPG signal describes the changes of blood volume in the skin tissue, which corresponds to the heart periodically pushing the blood towards the periphery of the body with each beat. When skin tissue gets filled with blood, it becomes slightly darker and absorbs more light. The light source in contact sensors (e.g., wristbands) is concentrated and constant (a light emitting diode – LED) and enables high-quality PPG reconstruction. Reconstructing rPPG from a camera recording is more difficult as the source of light is most commonly the sun or the lighting of a room. This makes such an approach more sensitive to environmental conditions and less accurate compared to contact sensors. rPPG reconstruction would allow for estimation of several physiological parameters, such as heart rate (HR), breathing rate, heart-rate variability and blood pressure, without a wearable device.

The rest of the paper is organized as follows. Section 2 reviews the related work. The methods for reconstructing the PPG signal are described in Section 3, while the experiments and results are discussed in Section 4. Finally, Section 5 concludes the paper with ideas for future work.

2. RELATED WORK

There are two main approaches for reconstructing rPPG, which are based on different underlying physiological phenomena.

The first approach focuses on variations in blood volume, which is reflected in the changes of the skin color. To detect the variations of blood volume using non-contact sensors (camera), tiny changes in RGB intensity of the skin pixels between two sequential video frames are analyzed. For example, Poh et al. [9, 10] applied independent component analysis (ICA) on the RGB color signals, which were computed as the average of the red, green and blue intensity of all the skin pixels over time. They then chose the most PPG-like resulting signal. Lewandowska et al. [5] used principal component analysis (PCA) instead of ICA to reconstruct the PPG signal. Haan et al. [2] reconstructed the PPG signal simply by calculating a specific linear combination of the obtained RGB traces. Other approaches do not calculate the average of all skin pixels, but treat each skin pixel independently. For example, Wang et al. [11] tracked the variation of color in each skin pixel independently and chose the most PPG-like signal afterwards. The changes of the skin pixel values were also tracked to reconstruct the PPG signal [12]. Petil et al. [7] used the basic RGB signals as inputs to a

[1] `http://www.insension.eu`

neural network to reconstruct various physiological signals. Another example by Wu et al. [13] amplified all the color changes of the facial pixels to follow the blood flow in these pixels. Although the presented methods seem promising, an independent evaluation conducted by Heusch et al. [3] on a publicly available dataset showed that they are not accurate enough to be used in real-world scenarios. More precisely, this evaluation re-implemented three state-of-the-art methods for reconstructing PPG from RGB cameras, and the results showed that there is a very low correlation between the reconstructed and ground-truth PPG.

The second approach for PPG reconstruction from video analyzes the small head movements that are induced by the blood being pumped into the head. Such a study was conducted by Balakrishnan et al. [1], however, it should be noted that such movements are very subtle and might not be detectable with a low quality camera, imposing an additional hardware requirement on this approach.

3. RECONSTRUCTING PPG WITH VISION-BASED METHODS

This section presents the developed deep-learning-based method for reconstructing the PPG signal from video data. This method enhances the signal reconstruction of an existing state-of-the-art method, as none of them were satisfactory. We first present the state-of-the-art methods used in the evaluation. All of these methods have a similar preprocessing step, which is presented in Section 3.1. The steps specific for each ofcoh these methods are presented in Section 3.2. Finally, in Section 3.3 we present the developed method that takes as input the PPG reconstructed with an existing method and returns an enhanced reconstruction of PPG.

3.1 Preprocessing of Video Data

The first preprocessing step consists of the detection of the subject's face as the "region of interest" (ROI). For detecting the face, we used the Haar cascades, implemented in the OpenCV library[2]. More precisely, the video was segmented into individual frames and only the selected face ROI was cropped from each frame.

The second step of video preprocessing aims at discriminating between skin and non-skin pixels. For this purpose, we implemented two classification methods. The first method transforms the RGB color space into the YCbCr color space, which contains less redundant information. Pixel values are then classified as either skin or non-skin using thresholds. This method is fast, simple and works well on the test dataset, however it probably does not generalize well to datasets where the degree of variation of skin colors and shades is higher. The second method applies one-class support vector machines (SVM) to classify the skin pixels. It learns a decision function for novelty detection from positive examples (corresponding to skin pixels), which are obtained from the forehead region of the first three frames of each video. New data is then classified as similar (skin) or different (not skin) to the training set. The forehead region is detected as the facial area of fixed dimensions above the eyes, which can be easily detected using OpenCV. The SVM method produces worse results than the threshold-based method, but generalizes well for various skin colors and shades. Both skin classification methods incorrectly classify some of the non-skin pixels as skin. To avoid false positives, we selected only the pixels that are most likely to actually be skin. We did this by calculating the mean value of all the skin pixels returned by the classifier and then removing the outlier pixels with respect to the mean in the YCbCr color space.

3.2 State-of-the-Art Methods

We have evaluated a set of state-of-the-art methods. These methods can be classified as color-based or movement-based as described in Section 2.

Poh-et-al method: This is a color-based method that sequences the mean value of the red, green and blue intensity of all the skin pixels to create three different color traces. Since all the traces contain some information about the blood flow, it first normalizes them and then transforms them with ICA using the FastICA algorithm [4, 9, 10]. This method returns three signals, so we choose the one with most frequencies in the range [0.6 Hz, 4 Hz], i.e., the frequency range of PPG. This is done by analyzing the power spectrum of each output signal.

Haan-et-al method: This is also a color-based method which, similarly to the previous method, uses the mean of the red, green and blue intensity of all the skin pixels [2]. It then creates a linear combination from the red, green and blue traces, resulting in two new traces X and Y, calculated as: $X = 3R - 2G$; $Y = 1.5R + G - 1.5B$. The X and Y traces are then filtered and combined to reconstruct the PPG signal. In our experiments, we used the method implementation from the BOB library[3].

Wang-et-al method: This color-based method uses all the skin pixels from an individual frame to define the color space of frames [12]. By tracking the changes in this space, we reconstruct the PPG signal. To accomplish this, a covariance matrix is computed. This covariance matrix changes for each frame due to the blood flowing into the skin. By calculating the eigenvectors of the original frame and the eigenvalues of the covariance matrix, we get a representation of the color space for the skin pixels. The rotation between two eigenvectors of sequential frames represents the changes of the color space. This rotation is also related to different relative PPG contributors. Therefore, by concatenating the rotation between the first opposing to the second and the third eigenvector, PPG-like traces are retrieved. The eigenvalues are also influenced by the pulsatile blood and are thus used to normalize the PPG-like signals. As for the previous method, we also used the method implementation from the BOB library[3].

Balakrishnan-et-al method: In contrast to the previously presented methods, this is a motion-based method, since it focuses on the oscillations of the head [1]. This method does not need to detect skin pixels, therefore, the second step of data preprocessing is skipped. To reconstruct the oscillations, the Lucas-Kanade flow-tracking al-

[2] `https://opencv.org`

[3] `https://pypi.org/project/bob.rppg.base`

gorithm [6] is applied, which tracks the flow of the head movements in the vertical direction. The oscillation signals are then filtered using a band-pass filter with the frequency interval [0.6 Hz, 4 Hz], i.e., the frequency range of PPG. Afterwards, PCA is applied to select the most PPG-like signal.

3.3 Deep-Learning-Based Method

We developed a new method for reconstructing the PPG signal, which takes the PPG reconstructed by an existing method as the input, and outputs an improved reconstruction of the PPG signal. To achieve this, it applies deep learning, which has recently shown superior performance in machine learning on many domains compared to traditional approaches.

To build the deep learning model, we used a Long-Short Term Memory (LSTM) network [8]. Its architecture comprised two LSTM layers and one fully-connected layer. The window length was set to 100 samples, i.e., five seconds. Each layer had 50 LSTM units, each taking input of length 100 and returning output of the same length, as shown in Figure 1. The output of the Wang-et-al method [12] has been selected as the input to the LSTM network.

4. EXPERIMENTS AND RESULTS

In order to evaluate the quality of methods described in Section 3.2 and our method, the reconstructed PPG was compared with the ground truth obtained with a fingertip PPG sensor.

4.1 Materials and Experimental Setup

The existing methods and the developed method have been evaluated on the COHFACE dataset[4]. This dataset consists of 160 videos from 40 different subjects with corresponding synchronized PPG collected with a fingertip device. The mean value of heart rate over the whole dataset is 70.25 beats per minute (BPM) with the corresponding standard deviation of 11.56.

A preliminary test has been done to select the best skin classification method. The evaluated skin classification methods were threshold-based method and SVM-based method as described in Section 3.1. Examples of the masks returned by both methods are shown in Figure 2. The results show that the threshold-based method is better than SVM-based. However, it should be noted that the selected thresholds were fitted to the selected dataset, therefore, the method might not generalize well to other data.

To evaluate the developed method, a leave-one-subject-out experiment was conducted with the aim of testing its predictive performance and generalization capability. To this end, mean absolute error (MAE) and mean squared error (MSE) were used as metrics. Additionally, to evaluate the quality of HR predictions, we computed the number of peaks in the reconstructed signals and compared it to the number of peaks in the ground truth PPG.

4.2 Experimental Results

Results of all the evaluated methods, as well as the developed method, are given in Table 1. All three previously mentioned metrics are reported, i.e., MAE, MSE and HR MAE. Note that the heart rate MAE of the baseline is 9.67 BPM, while our method achieves 8.75 BPM. In addition, the first 10 seconds of the reconstructed PPG using each of the methods on a subset of videos are shown in Figures 3–5.

[4]`https://www.idiap.ch/dataset/cohface`

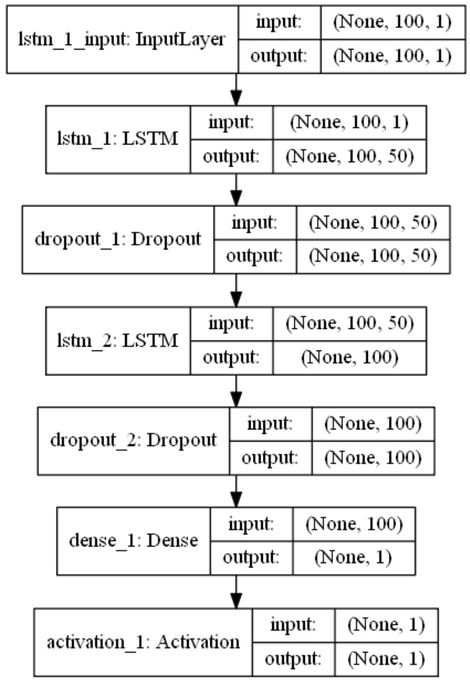

Figure 1: The architecture of the network used in the Deep-Learning-Based method.

(a) (b)

Figure 2: Classified skin using the (a) threshold method, and (b) machine learning method.

The results show that the Deep-Learning-Based method produces better reconstruction of the PPG signal, as the error between the estimated and actual HR is the lowest. Table 1 also shows that the developed method outperforms state-of-the-art methods on the COHFACE dataset by a notable margin.

5. CONCLUSIONS

We presented a new approach for the reconstruction of the PPG signal from video data. This approach enhances state-of-the-art methods with a deep learning model. It has been evaluated on the COHFACE dataset and the results show that it improves the PPG reconstruction with respect to the state-of-the-art methods.

However, the reconstructed PPG signal is still noisy and it

Table 1: Comparison between state-of-the-art methods and the developed method

Method	MAE (signals)	MSE (signals)	MAE [BPM] (heart rates)
Poh-et-al	0.04	0.15	42.00
Haan-et-al	0.16	0.04	20.75
Wang-et-al	0.16	0.40	11.73
Balakrishnan-et-al	0.16	0.04	39.00
Deep-Learning	**0.04**	**0.01**	**8.75**

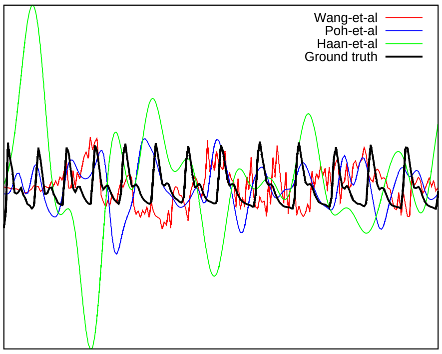

Figure 3: First 10 seconds of the color-based methods.

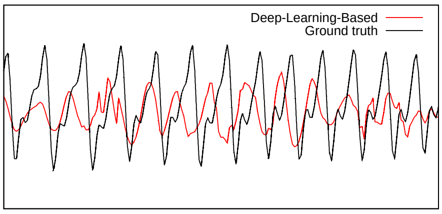

Figure 5: First 10 seconds of the Deep-Learning-Based method.

would thus be difficult to estimate any physiological parameters from it, which will need to be improved in future work. Additionally, higher quality of the recordings, especially regarding the lighting conditions, will be evaluated with the aim of obtaining better results.

6. ACKNOWLEDGMENTS

This work is part of a project that has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No. 780819.

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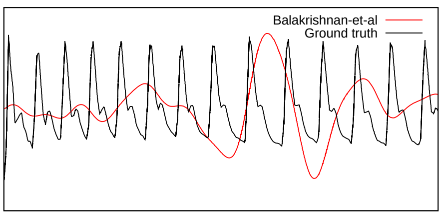

Figure 4: First 10 seconds of the motion-based method.

The Influence of Communication Structure on Performance of an Agent-based Distributed Control System

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ABSTRACT
Industrial Internet of Things (IIoT) is a new concept denoting extensive use of ubiquitous connected devices on the manufacturing shop floor. While most recent research in this area focuses on the monitoring capabilities of IIoT and on the resulting data analysis, IIoT also presents an opportunity from the perspective of distributed control. The paper suggests that agent-based control of an industrial process can be realized by a multi-agent system in which each agent is able to learn the influence of its actions on the behaviour of the system and to communicate with other agents in its proximity. Influence of the communication structure on performance, robustness, and resilience are analysed for a case of an industrial compressed air system. The simulation results suggest that in such systems, communication between the supply and the demand side improves resilience, while the robustness is improved through learning.

KEYWORDS
Industrial Internet of Things, multi-agent system, distributed control, machine learning, robustness

1. INTRODUCTION
Cyber-physical systems (CPS) represent an emerging paradigm integrating computational, networking and physical processes to address requirements of future industrial systems [1]. Often the interfaces between the physical and the virtual worlds are realized using connected intelligent sensing and actuating devices. Their use in manufacturing environment is the basis of the concept of Industrial Internet of Things (IIoT). Numerous connected IIoT devices enable acquisition and sharing of large amounts of data, promising time and cost savings, scalability and efficiency. However, as IIoT systems grow in size and complexity, their response times and computational complexity outgrow traditional centralized control systems. Researchers work on enhancing flexibility, robustness, adaptability and reconfigurability of CPS by employing concepts of distributed and autonomous control in dynamic environments of flexible manufacturing systems.

A common way to implement distributed control in manufacturing systems is by using autonomous computational entities called agents. Agents acquire information about their environment and take actions to influence the environment. They can exhibit various levels of intelligence depending on the method used to select an action based on the state of environment. Reflex agents passively react to signals from environment, while pro-active agents select their actions continuously to achieve a goal or utility. An agent that has the capacity to adapt its operation based on feedback from the environment is called learning agent [2].

In some applications, multiple software agents are used to collectively solve problems by interacting with each other and reaching mutual agreements through negotiations, bidding and other communication mechanisms, enabling reconfigurability and scalability [3]. Agents acting in parallel results in the system's global behaviour that may include emergent phenomena and is often difficult to predict in advance. Design of interactions between elements is therefore mostly performed using simulations to obtain the desired behaviour of the system in a trial and error manner. Although the ideas of agent-based systems originated more than two decades ago and much research has been done on intelligence of software agents and coordination mechanisms, not many examples of real-life implementations can be found in the manufacturing industry [4].

Despite the challenges of implementation in industrial applications, emerging computing paradigms, developing communication protocols, and decreasing cost of computing power and network communications are suggesting that the research field should be revisited in context of industrial applications.

In [5] a control method using rationally bounded learning agents was proposed. This paper extends this work by analysing the influence of different connection schemes on performance in normal and adverse conditions. The response of the system in adverse conditions can be evaluated from the point of view of robustness and resilience. Robustness measures the extent to which a disturbance affects the system's performance while resilience represents the system's ability of restoring normal operation. Using a simulation of an industrial compressed air system it is shown that (1) the communication between the agents representing the supply (compressors) and the agents representing the demand (consumers) improves the response of the system to repeated disturbance, (2) full connectedness is not necessary as additional connections beyond a certain point do not contribute to improved system performance, and that (3) the communication structure influences resilience, but not robustness.

2. DISTRIBUTED CONTROL WITH RATIONALLY BOUNDED AGENTS
A perfectly rational agent makes decisions under the assumptions that (1) it has complete knowledge of the problem space and is aware of all its available actions, (2) the preferences of actions are known and (3) it has the ability to discover the optimal policy regardless of the necessary computational demand [6]. Absence of any of the three assumptions makes an agent rationally bounded [7]. In the engineering field, the use of the term bounded rationality refers to limited calculation time and computational

capacity. Design of artificial agents strives for optimization under time and capacity constraints.

The presented agent model assumes that in a truly distributed system none of the agents has an overview of the state of the whole system and that each agent can communicate only with elements of the system (i.e. sensors, actuators, and other agents) in their proximity. Based on these limitations, the agent model defines what agents observe, how they learn from the observations, and how they communicate with other agents.

3. AGENT MODEL

A multi-agent system is described as a network $N = (A, CA, S, CS, T, CT)$ where A represents a set of agents and CA a set of communication channels between pairs of the agents. S is a set of sensors, and CS a set of measurement channels between the agents and the sensors, where one agent is connected and reads measurement values from at least one sensor and each sensor is connected to one or more agents. Sensors and communication with other agents enable the agents to gain information about the system but each agent can only have a partial view and no agent has an overview of the whole state of the system. Each agent is connected to exactly one actuator from the set of actuators T, the connections are represented in set CT.

All agents in the system have the same structure, regardless of their function in the system. The components of the model are shown in Figure 1. Agent $a_i \in A$ has some belief b_i about its environment based on measurements of the sensors it has access to S_i and predictions received from other agents P_{ji} as shown in Eq. (1).

$$b_i = f(S_i, P_{ji}) \quad (1)$$

The agent model also includes an environment model M_E that is used to make a set of predictions P_i about future sensor values based on current belief b_i and actions available U_i as shown in Eq. (2).

$$P_i = M_E(b_i, U_i) \quad (2)$$

Based on predictions P_i and the sensor goal values G_i the agent selects its next action u_i, as shown in Eq. (3), that minimizes the selection criterion (e.g. an error estimate) in the form of a function f_A.

$$u_i = \underset{U_i}{\operatorname{argmin}}\big(f_A(M_E(b_i, U_i), G_i)\big) \quad (3)$$

The environment model M_E is learned by observing the control actions u_i taken to influence the environment and the environment's response to the actions, captured by the agent's belief b_i. In absence of communication with other agents the environmental model represents the physical model of the system implicitly including other agents' influence on the state of system. When connected to other agents, an agent receives predictions of future states of environment. These predictions include the knowledge of other agents about their influence on the environment implicitly captured by their environmental models.

The agent acquires the environmental model using random forest algorithm [8]. The algorithm is a highly accurate ensemble learning method, resistant to overfitting and easy to use, since no scaling and normalization of the data is required.

4. EXPERIMENTAL CASE

Compressed air is widely used in industrial systems as a medium for energy transfer to various systems, for example power equipment, spraying tools, conveyers, and power controls. It is safe, easy to use and maintain. However, more than 75 % of the life-cycle costs of compressed air system are accounted for by energy consumption [9] and reports estimate that only about 10–20% of the total input energy is utilized for useful work [10]. In the European Union compressed air systems are reported to consume 80 TWh of electricity [9] or 10% of industrial electricity consumption [10] but at the same time potential economic savings of more than 30 % are estimated [9]. Inefficiencies can be attributed to many reasons, the most important being leakages and inefficient control [10].

Few compressed air systems operate at full-load all of the time. Part-load performance is therefore critical and is primarily influenced by compressor type and control strategy. The choice of the type of control depends largely on the type of compressor being used and the demand profile of the system. For a system with a single processor and mostly steady demand, a simple control system may be appropriate. Simple control approach most often uses two pressure thresholds; when pressure drops below the lower threshold the compressor is turned on and if pressure exceeds the upper threshold the compressor is turned off. However, a complex system with multiple compressors, varying demand, and many types of end-uses requires a more sophisticated control strategy.

This developed distributed control model aims to present a robust and scalable alternative approach for a compressed air system with multiple compressors and compressed air storage tanks using autonomous switches for turning the compressors on or off and autonomous valves for controlling the transport paths.

5. SIMULATION

The simulated compressed air system, shown in Figure 3, consists of 2 compressors, 2 compressed-air tanks, 4 consumers, 3 smart valves, and piping. Each compressor supplies air to one tank and each tank has a safety valve to prevent the tank from becoming over-pressurized. Pressure sensors are installed on both compressed-air tanks and consumers.

The position of the valves in the system enables flow control of the air in the system. Smart valves and compressors' on/off switches are controlled by software agents, that are also connected to corresponding sensors as depicted in the figure. The parameters of the model, e.g. the pressures, time constants and leakage rates, are chosen to correspond to values that are commonly found in real systems. Agents have set target values for their corresponding sensors and the goal is to keep the air pressure values as close to the target values as possible all the time, regardless of consumption.

The agent has one random forest regressor for learning the environmental model for each of its connected sensors. The number of estimators is set to 100.

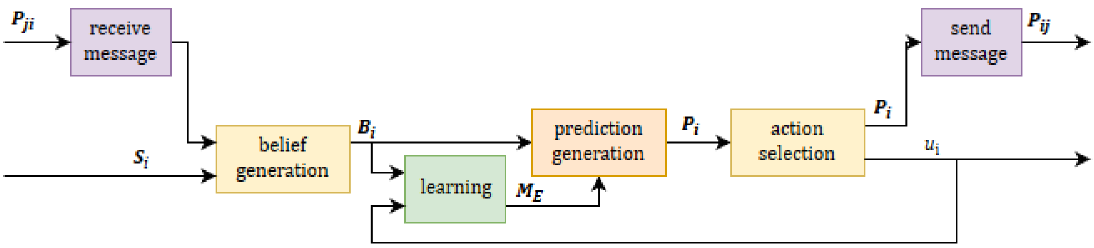

Figure 2. Communication schemes for different scenarios

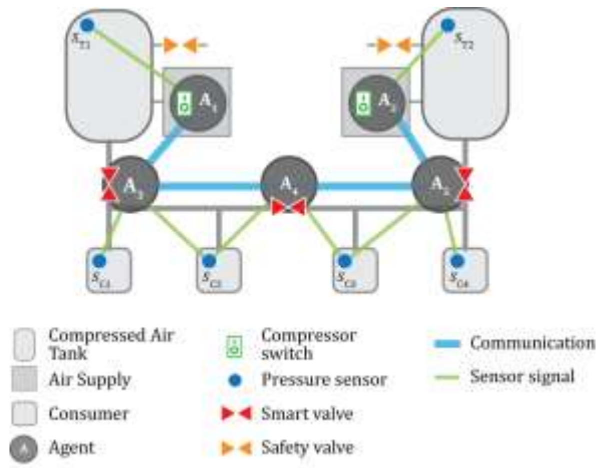

Figure 3. Simulated compressed air system

The input features for the regressor for the $k-th$ sensor consist of the last action u_i taken by the agent, the observed sensor values $s_{ik} \in S_i$, the differences ΔS of each sensor value s_{ik} compared to every other sensor value $s_{im}; m \neq k$, the other agents' predictions P_{ji}, the differences in the other agents' predictions denoted as ΔP_{ji} and the existence of the other agents' predictions denoted as P^* as shown in Eq. (4).

$$x = \{u_i, S_i, \Delta S, P_{ji}, \Delta P_{ji}, P^* \} \tag{4}$$

The associated outputs y are the differences of the sensor values at times t and $t + \Delta t$, as shown in Eq. (5).

$$y = \{S(t + \Delta t) - S(t)\} \tag{5}$$

When calculating predictions for more than one step in advance, predictions of all agent's sensors for each following timestep (within the observed agent) are calculated prior to calculating predictions for the next timestep.

The next action is selected using the mean-square-error function for evaluating the predictions against the goal values for all sensors. The function is shown in Eq. (6), where S_i is a set of agent's sensors, H is the number of future times for which the effects of the action $u \in U_i$ are assessed, called the prediction horizon, and p_{ik} and g_{ik}, $k \in S_i$, are predictions and goal values for the k-th sensor, respectively.

$$f_A(u) = \frac{1}{|S_i|} \sum_{k=1}^{|S_i|} \left(\frac{1}{H} \sum_{h=t+\Delta t}^{H} (p_{ik}(h) - g_{ik})^2 \right) \tag{6}$$

In 5 scenarios, the influence of different communication connection schemes, presented in Figure 3, was tested. In scenario A the agents don't communicate among themselves, in scenario B the compressor agents communicate with each other and the smart valves agents communicate with neighbouring smart valves agents. Communication connections in scenario C follow the flow of the air in the system. In scenario D each compressor agent communicates with the nearest two smart valves and the smart valves are also connected to their neighbours. The last scenario E represents full communication scheme in which all agents communicate with all other agents in the system.

The total time of one simulation is set to 4000 s. Each scenario was simulated 150 times. The consumers' activity is random, each consumer is alternately set to on for 1 – 4 s and off for 30 – 40 s. The goal values of the compressor and the smart valves agents are set to 6.3 and 5.0 bar respectively and the safety valve has a set pressure of 10 bar for all scenarios.

The time step Δt is set to 1 s. The predictions are calculated for the next 1-3 s. The duration of current prediction horizon determines the duration of the corresponding reasoning cycle. The environmental model is updated every 500s.

In all scenarios a disturbance was simulated. The disturbance is represented by compressor 1 failure and opening of the corresponding tank's release valve, it is repeated 5 times and lasts for 200 s. Time of start of disturbance in simulation is noted $t_d{}^1$ = 1700 s, $t_d{}^2$ = 2200 s, $t_d{}^3$ = 2700 s, $t_d{}^4$ = 3200 s and $t_d{}^5$ = 3700 s.

The results of the simulations were used to evaluate the ability of the system to withstand adverse conditions, called robustness, and its ability to recover from disturbance, called resilience. In the context of this paper, robustness c_{rob}, shown in Eq. (7), is defined as the ratio between the pressure drop in the system during disturbance Δp_d and the pressure p_s subtracted from the whole.

$$c_{rob} = 1 - \frac{\Delta p_d}{p_s} \tag{7}$$

The moment t_{bb} when the rise of the pressure in the system after the end of the disturbance reaches 1-1/e = 63,2% of the pressure drop is observed. The difference between this moment and the time of the end of the disturbance is defined as bounce-back time Δt_{bb}. Resilience c_{res}, for the context of this paper, is defined as the inverse of the bounce-back time as shown in Eq. (8).

$$c_{res} = \frac{1}{\Delta t_{bb}} \tag{8}$$

6. RESULTS

Simulation results for average sensor values measured by sensor S_{C1} for all five scenarios are shown in Figure 4. Due to learning, the pressure drop in the time of disturbance is lower after every repetition of the disturbance in the first four occurrences of the event.

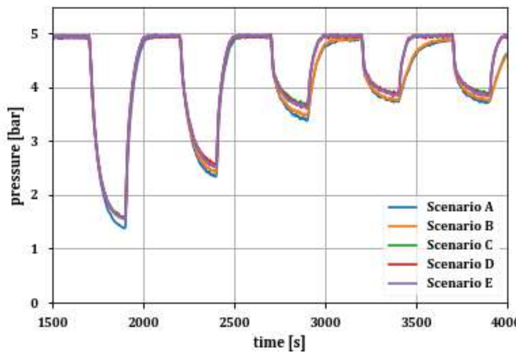

Figure 4. Comparison of average pressure on sensor S_{C1} for 5 scenarios

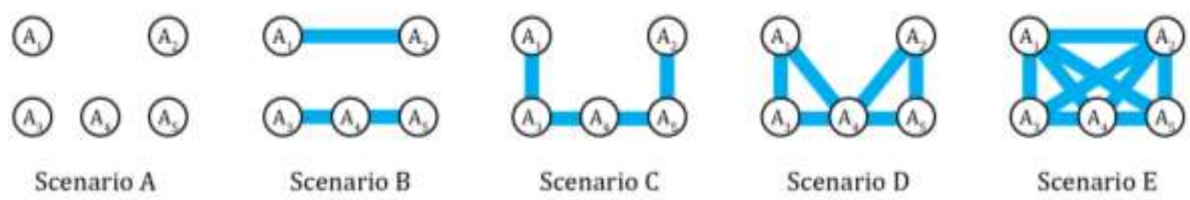

Figure 5 shows the pressure values 50 seconds after the end of the first and the fourth disturbance, effectively demonstrating the effect of learning in the considered scenarios. The first disturbance (Figure 5a) has approximately the same effect in all scenarios because the agents have not yet learned how to mitigate its effects. However, the bounce back from the fourth disturbance (Figure 5b) differs significantly depending on the scenario. In scenarios A and B in which the supply (compressors) and the demand (consumers) are not connected, the bounce back is slower and more scattered than in scenarios C, D, and E.

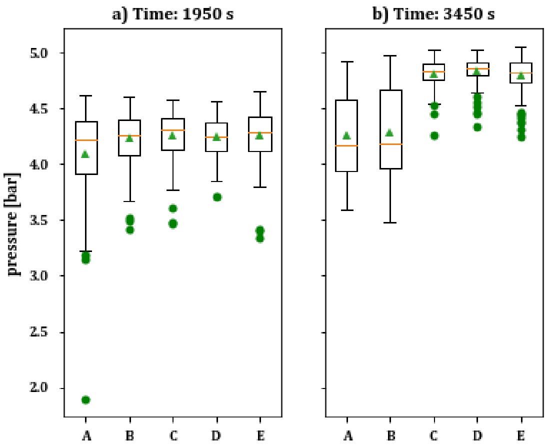

Figure 5. Pressure values measured by sensor S_{C1} after disturbances, green triangles show the average value and green dots represent the outliers

The results for evaluation of robustness and resilience from data measured by sensor S_{C1} are shown in Figure 6.

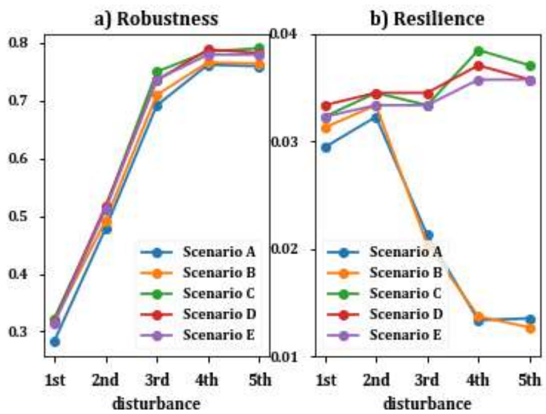

Figure 6. Robustness c_{rob} and resilience c_{res} during disturbances

As seen in Figure 6a, robustness improves over time in all scenarios. As agents learn to create better predictions of the effects of their actions, their responses improve. This is similar in all simulated scenarios, suggesting that it is not influenced by the communication structure.

Figure 6b shows that resilience improves over time in scenarios C, D, and E, in which the supply and the demand are connected. The resilience decreases in scenarios A and B where there is no communication between compressors and smart valves. In scenarios A and B, the agents on the demand side cannot directly detect the pressure drop which happens due to the disturbance. Their response is based solely on the observation of the pressures on the demand side. In time, they learn to prefer to keep the valves closed in order to maintain the pressure on the consumers during the disturbance. However, since they cannot detect the end of the disturbance directly, they have a delayed response when conditions normalize which lowers the overall resilience.

7. CONCLUSION

The paper argues that the current understanding of the role of IIoT, which is mostly related to monitoring and data analytics, should be extended to the domain of distributed control. A distributed, agent-based control model is presented. The model assumes that no agent has an overview of the whole system state, but rather only has a partial view of its neighbouring sensors, actuators, and other agents.

The paper builds on a previously conceived agent model [5] and explores the effects of the intra-agent communication structure for a simulated case of an industrial compressed air system. The results show that the communication structure influences resilience but not robustness. Robustness is improved through the learning mechanism in which the agents learn to predict the effects of their actions on the behaviour of the nearby system constituents. The presented agent model enables a smart controller to operate in a system without prior knowledge of the effects of its actions on the controlled variable. However, this paper shows that to achieve both robustness and resilience of the multi-agent control system, appropriate communication structure of the network must be implemented.

Future work will focus on the development of a real demonstrator and transfer of the learned policies from simulation to the demonstrator.

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Complex Decision Rules in DEX Methodology: jRule Algorithm and Performance Analysis

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ABSTRACT
DEX (Decision EXpert) is a qualitative multi-criteria decision-modeling methodology. DEX models are used to evaluate and analyze decision alternatives. An essential component of DEX models are decision rules, represented in terms of decision tables. Decision tables may contain many elementary decision rules and may be difficult to be understood by the decision maker. A more compact and comprehensible representation is obtained by converting elementary decision rules to complex rules. The DEX-Rule algorithm, which is currently implemented in software DEXi, has been found inefficient with large decision tables. This research is aimed at improving the efficiency of the DEX-Rule algorithm. We propose a novel algorithm, called jRule, which generates complex rules by specialization. According to performance analysis, jRule is indeed more efficient than DEX-Rule. The compactness of complex rules produced by both algorithms varies and there is no clear winner.

Categories and Subject Descriptors
H.4.2 [**Types of Systems**]: Decision Support

F.2.0 [**General**]

General Terms
Algorithms, Performance, Experimentation

Keywords
DEX methodology, decision rules, complex decision rules, algorithm analysis

1. INTRODUCTION
Decision-making is a difficult and complex process. During this process, a decision maker (DM) faces several decision alternatives. To choose a particular alternative from the set of possible alternatives, a decision-analysis approach [3, 4] can help to satisfy the aims or goals of a decision maker. Decision analysis [3, 4] is the discipline used to help a decision maker to deal with uncertainty, complexity, risk, and trade-offs of the decision. The idea of decision analysis is to develop a decision model, which can help decision makers to evaluate alternatives and to choose the best action.

The decision maker in a decision problem have to deal with multiple and possibly conflicting criteria. Multiple Criteria Decision Analysis (MCDA) or Multiple Criteria Decision Making (MCDM) [3] provides methods for structuring, planning and solving such decision problems. DEX methodology is one of the MCDM methods. DEX is a qualitative multi-criteria decision-making methodology [1, 2, 5] aimed at the assessment and analysis of decision alternatives. DEX is supported by software DEXi (http://kt.ijs.si/MarkoBohanec/dexi.html).

DEX models have a hierarchical structure, which represents a decomposition of some decision problem into smaller, less complex sub-problems. DEX models are developed by defining (i) attributes, (ii) scales, (iii) hierarchically structured attributes (the tree of attributes), and (iv) decision rules. In DEX models, attributes are variables that represent properties of decision alternatives. Attributes can be either basic or aggregated. Aggregated attributes have subordinate attributes, while basic attributes do not. Basic attributes represent inputs and aggregate attributes represent outputs (results). A scale represents a set of values that can be assigned to an attribute. Scales are qualitative and can take discrete values like 'excellent', 'acceptable', 'inappropriate', etc. Decision rules represent the mapping of subordinate attributes to an aggregated attribute (see section 2 on more details about decision rules in DEX).

In a DEX model, an aggregated attribute may involve many subordinate attributes (e.g., more than five) in which case the decision table will contain many elementary decision rules and may be difficult to be understood. In order to obtain a more comprehensible representation, the DEXi software implements DEX-Rule, an algorithm that converts elementary decision rules to more compact complex rules. DEX-Rule has been found inefficient in decision tables with many subordinate attributes and many elementary decision rules that map to a single decision value.

This research is aimed at improving the efficiency of the DEX-Rule algorithm. We propose a novel algorithm, called jRule, which finds complex rules by specialization, i.e., by narrowing down too general rules that are constructed initially. The jRule algorithm performed better regarding the running time. The results generated by both algorithms are guaranteed to cover the whole decision table.

This paper is structured as follows: Section 2 formulates the Decision Rules in DEX, Section 3 presents the DEX-Rule algorithm, Section 4 presents the jRule algorithm, Section 5 presents the comparison of the two algorithms regarding the algorithm complexity and the number and form of complex decision rules that they generate. Section 6 summarizes and concludes the paper.

2. DECISION RULES IN DEX
In DEX models, attributes can be either basic or aggregated. Aggregated attributes are attributes which depend on their descendants, known as subordinate attributes. Decision rules in DEX define the bottom-up mapping of the scale values of

subordinate attributes to the values of the aggregated attribute. An example of such mapping, represented in terms of a decision table, is shown in Table 1. The example is taken from a well-known model for evaluating cars based on attributes such as buying price, maintaining price, safety, and comfort [1]. The example occurs at the top level (root) of the model and maps the subordinate attributes *PRICE* and *TECH.CHAR* (technical characteristics) to the overall evaluation of a *CAR*. The value scale of the involved attributes are ordered values as follows:

- *PRICE = {high, medium, low},*
- *TECH.CHAR = {bad, acc, good, exc},* and
- *CAR = {unacc, acc, good, exc}.*

Each row in Table 1 defines the value of the aggregated attribute *CAR* for each combination of subordinate attributes' values. Therefore, the decision table maps all the combination of *PRICE* and *TECH.CHAR* scale values into the value of *CAR*.

Table 1. Decision table with elementary decision rules of DEX model known as CAR Evaluation Model [1].

	PRICE	*TECH.CHAR*	*CAR*
1	high	bad	**unacc**
2	high	acc	**unacc**
3	high	good	**unacc**
4	high	exc	**unacc**
5	medium	bad	**unacc**
6	medium	acc	**acc**
7	medium	good	**good**
8	medium	exc	**exc**
9	low	bad	**unacc**
10	low	acc	**good**
11	low	good	**exc**
12	low	exc	**exc**

A decision rule consists of the condition and decision part:

if $subAttr_1 = value_1$
and $subAttr_2 = value_2$
…
and $subAttr_n = value_n$
then $aggAttr = value$ (or interval of values)

The condition part is the Cartesian product of the scale values of the subordinate attributes of an aggregated attribute ($subAttr_1$, $subAttr_2$, …, $subAttr_n$). The decision-maker defines the *value* of each decision rule, which might be a single value or an interval of values of the aggregated attribute. Such decision rules are also called *elementary decision rules*, since each rule defines the value for exactly one combination of subordinate attributes' values.

In this way, the first row in Table 1 represents the following elementary rule:

if *PRICE = high* **and** *TECH.CHAR = bad* **then** *CAR = unacc*

An alternative representation of the decision rules can be by an *n*-dimensional matrix, depending on the number of subordinate attributes. Figure 1 shows such a representation of Table 1. Here, each cell of the matrix represents one elementary decision rule from the decision table.

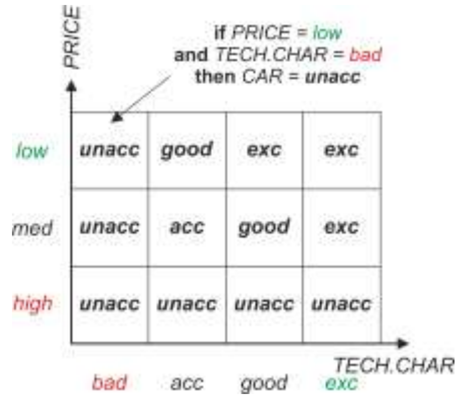

Figure 1. Elementary decision rules represented in a matrix.

In order to represent the decision table in a more compact and possibly comprehensible way, DEX uses *complex decision rules*. A complex decision rule consists of the condition and decision value part. In contrast with elementary rules, each clause in the condition part can represent an interval. The decision value is always a single value. Thus, a complex rule generally takes the form:

if $subAttr_1 \in [low\_value_1 , high\_value_1]$
and $subAttr_2 \in [low\_value_2 , high\_value_2]$
…
and $subAttr_n \in [low\_value_n , high\_value_n]$
then $aggAttr = value$

For comprehensibility, DEXi software traditionally represents intervals as follows:

- '*': the asterisk include all possible scale values of a specific subordinate attribute;
- '>=*w*': stands for *better than or equal to value*;
- '<=*w*': stands *for worse than or equal to value*;
- 'w_1:w_2': interval between value w_1 and value w_2, including the two values.

Figure 2 shows several complex decision rules on the matrix from Figure 1. It is important to notice that each complex decision rule covers an area that corresponds to one or more elementary decision rules. In this way, the number of complex rules that completely cover the matrix is generally lower than the number of elementary rules, and the resulting representation is more compact.

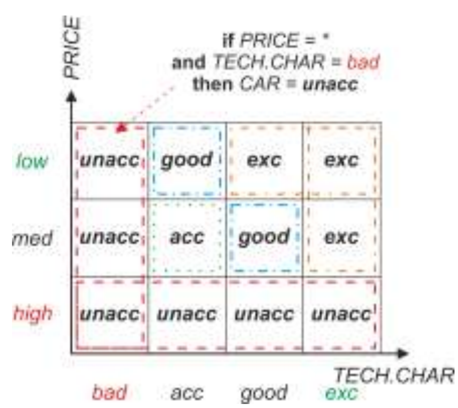

Figure 2. Complex decision rules represented in a matrix through different dotted rectangles for each decision value.

3. DEX-RULE ALGORITHM

DEX-Rule is an algorithm currently implemented in DEXi [1] that converts elementary decision rules into more compact complex decision rules. The DEX-Rule generates complex decision rules by finding areas limited by bounds, which may cover more than one elementary decision rule. An area is represented by two bounds: a low and a high bound. Both are vectors of scale values of the subordinate attributes.

The input to the DEX-Rule algorithm is a decision table, represented in a form of a decision matrix, such as in Figure 1. All the rules are marked as uncovered. The low and high bound (*l* and *h*) are vectors (coordinates) that define an area of decision rules with the target value *t*. Initially, $l = h$, which means that they define a single elementary decision rule. Later, with recursive invocation of the algorithm, these boundaries are gradually extended to cover larger areas with the target value *t*. On the output, DEX-Rule generates a set of decision rules, such as in the example shown in Table 4. DEX-Rule proceeds by considering all target decision values, *t*, in succession. For each *t*, DEX-Rule proceeds by generalization, as shown in Algorithm 1.

Algorithm 1. Pseudo-code of the DEX-Rule Algorithm.

```
Inputs:
  l := low bound.
  h := high bound.
  t := target decision value.
  m := last elementary decision rule from decision table
       (representing the highest current bound).
Outputs:
  p := complex decision rules
begin
  cover := ValidateBounds(l, h, t)
  if cover then
    for i = 0 to |h| do
      if h[i] < m[i] then
        DEXRule(l, Increase(h), t, m)
      end if
    end for
    for i = 0 to |l| do
      if l[i] > 0 then
        DEXRule(Decrease(l), h, t, m)
      end if
    end for
    p.add(l + h)
  end if
end
```

For each decision value *t* and each elementary decision rule that has not been covered so far (represented by *l* and *h*, $l = h$), DEX-Rule tries to extend the boundaries *l* and *h* in different directions. When the area cannot be extended any more, a complex decision rule is created. More precisely, a complex decision rule is generated in two cases:

- when the algorithm reaches the highest or lowest scale value for the specific subordinate attribute, see Figure 3.a, or
- when an extension would cover an elementary decision rules with a different target value, see Figure 3.b.

The process continues until the matrix has been completely covered by complex rules.

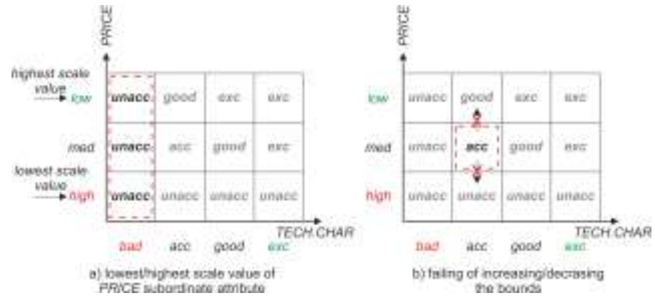

Figure 3. Two cases of generating complex decision rules with DEX-Rule algorithm.

4. JRULE ALGORITHM

The aim of this research was to improve the efficiency of the DEX-Rule algorithm. We propose a novel algorithm, called jRule. While the main idea behind DEX-Rule is to find areas by generalization (extending the area bounds), the main idea of the jRule is to reverse this method and use specialization. jRule proceeds by finding largest areas covering yet uncovered rules for *t* and gradually reducing them.

Algorithm 2. Pseudo-code of the jRule Algorithm.

```
Inputs:
  t := target decision value.
  ger := elementary decision rules for target value t,
         lexicographically sorted by subordinate attribute values.
Outputs:
  p := complex decision rules
begin
  l := lowest subordinate attributes' values from ger
  for i = |ger| to 0
    if !ger[i].isCoveredBy(p) then
      lb = l
      hb = ger[i]
      while !ValidateBounds(lb, hb, t) do
        lb = Increase(lb) // reduce the area by increasing the lb
      end while
      p.add(lb + hb)
    end if
  end for
end
```

The pseudo-code of the jRule algorithm is shown in Algorithm 2. First, the algorithm finds *l*, the lowest bounds for each subordinate attribute of elementary rules for the target value *t*. Then, it locates the last (i.e., highest) currently uncovered elementary rule. This gives the high bound of the area. If the area with bounds *lb* and *hb* is valid, meaning that covers only rules for *t*, a new complex rule is generated. Otherwise, this area is reduced by increasing the low bound *lb*. This process is repeated until all elementary rules for *t* have been covered by complex rules. Notice that, unlike DEX-Rule, areas in jRule are gradually reduced by increasing only the low bound *lb*. Figure 4 illustrates this process for elementary rules shown in Table 1 and the target value *t* = *unacc*. In this case, *ger* is composed of rules 1, 2, 3, 4, 5 and 9 (in this order) from Table 1. The low bound is *lb* = <high, bad>. jRule makes two iterations, first finding the high bound from rule 9 (*hb* = <low, bad>) and then from rule 4 (*hb* = <high, exc>). In both cases, the areas cover *t* and no reduction is necessary.

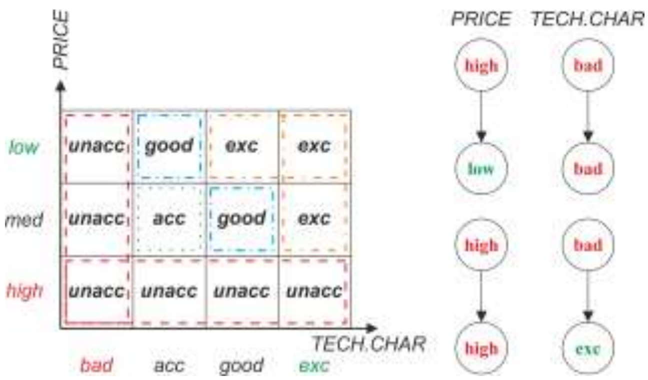

Figure 4. jRule Algorithm identifying the lowest and highest bound for elementary decision rules with decision value *t* = *unacc*.

5. PERFORMANCE ANALYSIS

The comparison between the DEX-Rule and jRule algorithms is made with respect to (i) time complexity, (ii) the running time and (iii) the number of complex rules that these two algorithms generate.

Regarding the time complexity, the DEX-Rule algorithm is $O(m^n)$ because of its recursive nature, where m is the number of subordinate attributes and n is the number of the elementary decision rules. On the other hand, the time complexity of the jRule algorithm is $O(n^2m)$.

The experimental comparison of the algorithms is based in different DEX models for different aggregated attributes. Both algorithms are implemented in JDEXi (http://kt.ijs.si/MarkoBohanec/jdexi.html) and DEX.NET2 (http://kt.ijs.si/MarkoBohanec/dexinet.html). The algorithms were compiled with the same compiler and run on the same computing environment. Table 4 shows running times of the algorithms on three selected DEX models. Generally, jRule is more efficient, and a major difference occurs with Model 2, which is a large decision table having five subordinate attributes and 1728 elementary decision rules.

Table 4. Difference between two algorithms based on running time and number of generated complex rules.

#	Running time [s]		# of complex decision rules	
Models	DEX-Rule	jRule	DEX-Rule	jRule
1	0.75	0.200	30	18
2	1280.00	0.395	121	64
3	1.94	0.980	11	26

Table 5. Complex decision rules generated by DEX-Rule for *CAR* aggregated attribute of CAR Evaluation model.

#	*PRICE*	*TECH.CHAR*	*CAR*
1	**high**	*	**unacc**
2	*	**bad**	**unacc**
3	medium	acc	acc
4	medium	good	good
5	*low*	acc	good
6	>=medium	*exc*	*exc*
7	*low*	>=good	*exc*

The two algorithms, in general, produce different complex decision rules. For example, Tables 5 and 6 show the respective complex rules for the *CAR* evaluation model. The rules are very similar, there is only a small difference in rule 7. In some other cases (Table 4), the differences between the algorithms are more pronounced: jRule produces more compact representations for Models 1 and 2, but less compact for Model 3. More research is needed to establish which algorithm is better and under which circumstances.

Table 6. Complex decision rules generated by jRule for *CAR* aggregated attribute of CAR Evaluation model.

#	*PRICE*	*TECH.CHAR*	*CAR*
1	**high**	*	**unacc**
2	*	**bad**	**unacc**
3	medium	acc	acc
4	medium	good	good
5	*low*	acc	good
6	>=medium	*exc*	*exc*
7	*low*	good	*exc*

6. CONCLUSIONS

In this work, we proposed a novel algorithm jRule for converting elementary decision rules to complex decision rules in the DEX methodology. In contrast with the current DEX-Rule algorithm, which employs generalization, jRule uses the principle of specialization.

Regarding the time complexity and running time, jRule algorithm perform better than DEX-Rule in all experiments performed for different DEX models. On the other hand, none of the algorithm was clearly better with respect to the number of generated complex decision rules. As part of this work, both algorithms were implemented in two open source libraries, JDEXi V4 and DEXi.NET2.

7. ACKNOWLEDGMENTS

The Public Scholarship, Development, Disability and Maintenance Fund of the Republic of Slovenia (Contract no. 11011-44/2017-14) financially supported this research.

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Sensitivity Analysis of Computational Models that Dissolve the Fermi Paradox

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ABSTRACT

Given the estimated number of stars and planets in our galaxy, the probability of existence of intelligent civilizations seems high. The first to indicate this was the Drake equation with the assumed default parameters. Yet, the actual observations have yet to reflect those expectations. This discrepancy corresponds to the so-called Fermi Paradox. Although many key factors about the likelihood of alien civilizations still remain largely unknown, new methods of estimating the probability are being proposed. Some of them use probability distributions and the Monte Carlo methods. In this paper we recalculate one of those – the Sandberg interpretation of the Drake equation, analyze the difference between the methods, their strengths and weaknesses. In the conclusion, we find that the probability distribution better reflects our ignorance about the properties of alien environments than the dot-product method.
In our opinion, there are several ways to further improve the computational model based on the Drake equation using the AI methods, thus eliminating the problem with too small probabilities and introducing 3D views.
What makes these analysis relevant, is not only the number of estimated civilizations in our galaxy and a probability that we encounter them in the near future. More important, these models enable estimation of the life-span of the human civilization. Unfortunately, there is a considerably high probability that it will be quite short.

Keywords: Drake equation, Fermi paradox, Monte Carlo, Probability distribution, Extraterrestrial intelligence

1. INTRODUCTION

There are billions of stars in the observable universe. Hundreds of millions are broadly estimated to be in our galaxy alone. If there is at least a modest chance of intelligent life emerging on a given planet, surely there should be at least some number of alien life in the relative vicinity, yet we see none. We are apparently the only one in our part of the universe even though we were able to expand our search quite successfully in recent decades [5].

Why is there no evidence of other civilizations in our galaxy despite the sheer number of planets we now know of? This is the question physicist Enrico Fermi first asked in 1950 and is known as the Fermi paradox. Fermi was particularly effective when dealing with estimates of ill-defined physical phenomena. However, he did not coin the first universally accepted equation for an estimate of the number of civilizations.

1.1 Drake equation

Probably the best known equation for an estimate of the number of detectable civilizations in the Milky Way was composed by Frank Drake [3], phrased as a product of seven factors:

$$N = R_* f_p n_e f_l f_i f_c L$$

The parameters are: R_* which is the rate of star formation per year, f_p is the fraction of stars with planets, n_e is the number of Earth-like (or otherwise habitable) planets per a star that has planets, f_l is the fraction of habitable planets with actual life, f_i is the fraction of life-bearing planets that develop intelligence, f_c is the fraction of intelligent civilizations that are detectable and L is the average longevity of such civilizations. finally N is the number of detectable civilizations.
The Drake equation is used to directly estimate the number of civilizations or as an analysis tool for various components in our galaxy. Most importantly, it can also be used to estimate the lifespan of our civilization (L). The Drake equation can provide exact numbers given proper parameters (i.e. factors), but the problem is that several factors in the equation are not well determined either by observations or with laboratory models. By assuming different values for them, say f_l – probability of life on a habitable planet, results vary a lot [1].

1.2 Point estimates

When trying to estimate the number of civilizations in the galaxy, a point estimate is often used for each of the seven parameters of the Drake equation. This provides an exact

numerical value. If we take estimates based on the distributions in Sandberg's paper [6], we get: $R_* = 10$, $f_p = 0.3$, $n_e = 0.3$, $f_l = 0.5$, $f_i = 0.03$, $f_c = 0.1$, $L = 10^6$ which gives us N around 270. Drake with colleagues originally estimated that $L = N$ and probably between 1000 and 100.000.000. Current best estimates[4] differ from several hundreds to several millions for the civilization's lifespan, and from being alone to several millions civilizations in our galaxy.
Based on actual observations, it seems quite likely that the optimists overestimate their factors: If an advanced civilization appeared somewhere in the galaxy before, moving with the speed of one percent of light speed, it would reach all parts of our galaxy in less than 2o million years. This is a tiny fraction of the lifespan of our galaxy, which is as old as our universe, i.e. around 13.5 billion years, with the perimeter around 100 - 200.000 light years.

2. SETTING THE PARAMETERS AND COMPUTATIONAL MODELS

Sandberg and colleagues [6] suggested that using point estimates to solve the Drake equation is too wild a guess, providing only one number. In their paper they suggest an approach that models each parameter by it's distribution, thus the computation results in a probability distribution. They used a Monte Carlo method for calculating the distribution of the final result. During each iteration, they sampled from distributions to obtain point estimates to use in Drake equation, which results can be used to generate final distribution of N.

2.1 A toy model

To show how using distributions for calculations leads to results that differ from those obtained by simply multiplying point estimates, Sandberg and colleagues introduced a simplified toy model. In their toy model to demonstrate the differences, there are 9 parameters (f_1,f_2,...), which if multiplied together determine probability of ETI (extraterrestrial intelligence) on a single star. Each of those parameters can obtain values from an interval [0, 0.2], with an average of 0.1. In their case-example, the point estimate of each factor is set to 0.1, the same as the average from the interval. For 100 billion stars (as in our galaxy) the computation gives 100 intelligent civilizations. But if instead of using a point estimate we sample from a uniform distribution with an average of 0.1, we get the results indicating that there is 21.45% chance that we are alone in the galaxy.

2.2 Recomputing the Sandberg interpretation of Drake equation

Sandberg et al. applied probability distribution as a way of recalculating the Drake equation, but instead of a uniform distribution presented in Subsection 2.1, they used the probability distribution for each factor obtained from scientific literature – a range and the type of the distribution. They defined a parameter "log-uncertainty" of a parameter X (LU[X]= $\log(\frac{\max(X)}{\min(X)})$) as an estimate of the number of orders of magnitude of the current uncertainty of parameter X. Consequently, the factors were defined in the following way:
– Star formation rate R_* is fairly well constrained by astronomical data and ranges over a maximum of 5 orders of magnitude given other galaxies. Our uncertainty about this parameter is from 2 to 16 solar masses, LU[R_*] = 0.9.
– Fraction of stars with planets f_p is also pretty well known and is about 1 with LU[f_p] = 1.
– The estimates for n_e, which is number of habitable plants, range from $<10^{-12}$ in rare earth arguments to >1 when taking non terrestrials like icy moons into account. Sandberg proposed LU[n_e]=12. Post-2000 literature estimates cover smaller orders of magnitude so they postulated earth-like planet as rocky planet within habitable zone and assumed LU[n_e]≈2.
– The parameters with the most uncertainty are f_l and f_i. f_l (probability of life) is modeled as a physical transition that occurs at some rate per unit time per unit volume of a suitable prebiotic substrate. The probability on a habitable planet with volume V, time period t and abiogenesis rate λ is $f_l = 1 - e^{-\lambda V t}$. They take log-uniform distributions of t with LU[t]=3 and range from 10^7 to 10^{10}, V with LU[V] $\geq$ 20 range from 10^{-35} to 10^{15}. They use log-normal distribution for λ with a mean of 1 and σ of several orders of magnitude. In the paper they do not specify the exact number used for σ, just that its very big. When we recreated their experiment we tested several values for sigma and 200 gave the most similar results.
– Based on the literature, the parameter f_c, which is the fraction of planets which develop civilization, is between 0.001 and 1.
– The final factor L, is longevity of a space-communicating civilization in years and is in the range from 100 to 10^{10}, which is the current estimate of the age of the universe.

All parameter(factor) distributions are listed in Table 1.

With this set of parameters we managed to obtain a distribution for N, displayed in Figure 1, quite similar to the one by Sandberg and colleagues. The two axes in Figure 1 represent N and its corresponding frequency with blue color. A vertical black line marks N equal to 1. The blue graph is therefore PDF (probability density function). It is scaled so that the highest value is 1 to fit on the same graph as the red line which is CDF (cumulative density function). From Figure 1 it can be observed that the probability of us being alone in our galaxy is about one half, e.g. since the red graph reaches 0.5 around N equal to 1.

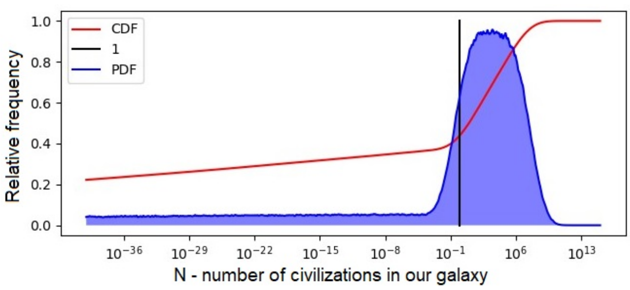

Figure 1: Recomputation of the Sandberg approach: probability density function and cumulative density function of N computed with Monte Carlo method.

Parameter	Distribution
R_*	log-uniform from 1 to 100
f_p	log-uniform from 0.1 to 1
n_e	log-uniform from 0.1 to 1
f_l	log-normal rate, described above
f_i	log-uniform from 0.001 to 1
f_c	log-uniform from 0.01 to 1
L	log-uniform from 100 to 10,000,000,000

Table 1: Summary of the current knowledge about the parameters of the Drake equation.

3. ANALYSIS OF THE SANDBERG'S COMPUTATIONAL MODEL

In this section, we present our initial analysis of the Sandberg et al. computational approach. We tested various issues only on the toy model as it is simpler and better reflects the issues with the computational model. We hypothesized that if one parameter is assigned a number close to zero, the whole product will be a very low number no matter what the other parameters are. For example, the blue graph in Figure 1 might give a misleading impression that the majority of the possibilities is on the right side of the black line indicating 1. However, due to the logarithmic x scale, it is about the same possible that there is only 1 civilization in our galaxy compared to 2 or more, as the red graph shows. The probabilities on the left of the black line indicating 1 are therefore significantly higher. The closer to 0, the higher, meaning lots of Ns are strangely close to 0. From the AI field we are familiar with this problem from the analysis of the naive Bayer theorem: if one of the factors is 0 or close to 0, it should better be modified. We tried to analyze this hypothesis by calculating the same results by using a different number of parameters and by using ranges with small offset ϵ to move away from zero. Namely, if any of the parameters is zero, then there is no intelligent civilization in that galaxy.

3.1 Effect of small values with multiple parameters

Tu study the effect of small values of parameters/factors in the product, we varied the number of parameters. To normalize the result, we adjusted the number of stars so that the average value of N according to the distribution obtained by the Monte Carlo analysis is still 100 as it is in the original case of 9 parameters and 10^{11} stars. So the number of stars is 10^{2+Np} where Np is the number of parameters. All the parameters are in the range [0, 0.2]. The graph showing 3 parameters and 9 parameters can be seen in Figure 2. The solid lines are PDFs and the dotted lines are CDFs. The PDF is scaled like before so that the maximum value is 1. In both cases the average value is still 100. With green dot we mark the probability that there is no civilizations in the toy galaxy. Note that the size of our toy galaxy also varies with the number of parameters to enable comparison. The dot is on the CDF at value of one civilization in the galaxy. It can be seen that the value at 9 parameters is higher than the value at 3 parameters. Therefore, the more parameters, the more probability of being alone. Or in other words: the more uniformly distributed parameters one introduces in a product, the more likely small values of N if parameter values are in [0,1].

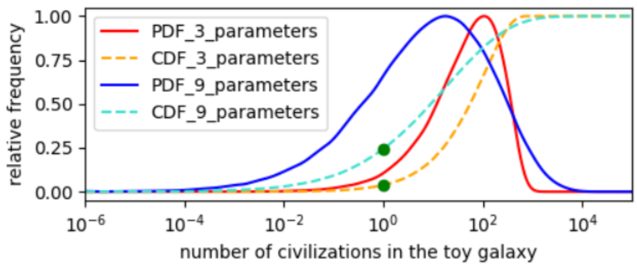

Figure 2: Graphs for Toy model with 3 parameters and 9 parameters.

We tested this phenomenon on multiple number of parameters ranging from 1 to 9 and the result can be seen in Figure 3. We can see that by increasing the number of parameters the PDF widens, thus increasing the possibility of us being alone.

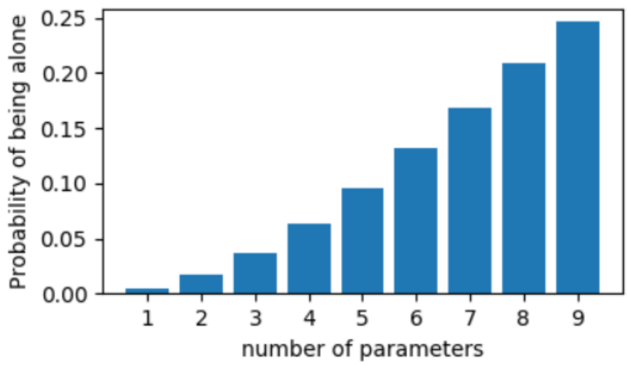

Figure 3: Probability of there being no civilizations depending on the number of parameters (1-9)

3.2 Modifying small values with epsilon

We tried to minimize the effect of parameter/factor values being too close to zero, which seemingly spoils the calculation, by introducing an offset ϵ. Instead of the range [0, 0.2] we now try the same experiments with range $[0+\epsilon, 0.2-\epsilon]$. The offset on the left side ensures that the minimum value is increased and the offset on the right side is there to keep the same average. As we can see in Figure 4 for [0.02, 0.18], the computed N changes significantly. In Figure 5, the same effect is demonstrated for values from 0.00 to 0.040 by a blue line. By increasing the ϵ, the curve becomes narrower thus chances of us being alone decrease.

3.3 Effects of log-uniform distributions

The toy model had all its parameters distributed uniformly. We recreated the same experiments, but with log uniform distribution of parameters, which is the same type of distribution as in the Sandberg paper. In Figure 5 one can see that the effect of adding epsilon in the log distribution modifies the graph even more. Figure 6 represent another analysis with the toy problem and various epsilons, using the log uniform distribution. This is another indication that the small values of parameters introduced by probability distribution by Sandberg strongly influence the final result.

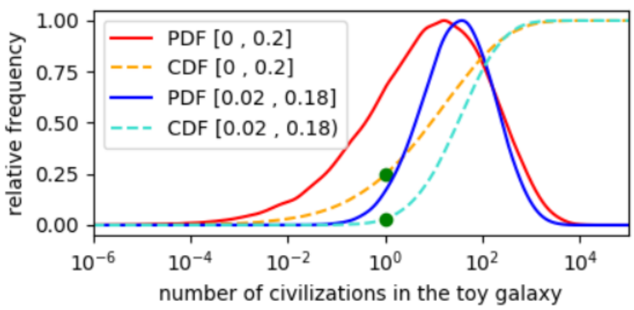

Figure 4: The effect of ϵ on the probability distribution

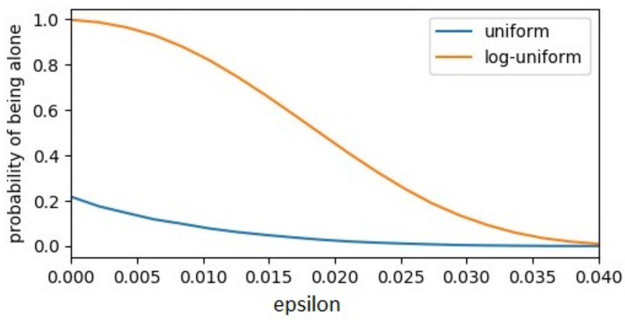

Figure 5: Effect of ϵ is enhanced with log-uniform distributions.

4. DISCUSSION: AI-BASED MODIFICATIONS

The proposed and to a certain extend already tested AI-based modifications are to be fully described in the submission of an SCI paper. Some of the ideas will be presented live at the paper presentation. Here, a couple of hints are presented here.

The first observation when reanalyzing the Sandberg approach is that the it is significantly more informative than point estimates. Unlike providing just one number based on assumptions, it shows the whole probability distribution, i.e. all possible combinations of values of parameters. On the second thought, the computational model has a weakness - when multiplying with zero or very small values. In the Drake equation, several factors are multiplied together, but originally, none of them was very close to 0. However, when dealing with probability distributions, numbers close to 0 can appear and as a result N becomes very small. We presented this effect in the Toy problem with uniform distributions, and later with log uniform distributions where the effect intensified.

In AI, there have been similar problems when multiplying with small values and solutions. For example, several analyses of the Naive Bayes were performed for the case when one of the factors was zero. One of the first analysis was by Cestnik [2].

By modifying the Cestnik or Laplace approach for the Sandberg method, we managed to introduce important modifications.

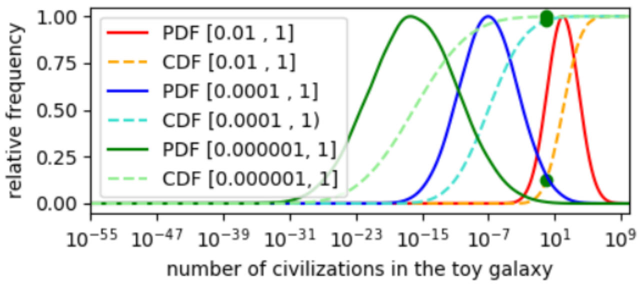

Figure 6: How ϵ affects distributions in log-space.

5. CONCLUSION AND DISCUSSION

We first showed how the number of ETIs was estimated using the original Drake equation, and then with the advanced approach by Sandberg and colleagues. Our re-computation of the Sandberg method yielded nearly the same results.

When reanalyzing the Sandberg approach, one issue emerged - multiplying with small values. We analyzed this phenomena and found out that with increasing number of parameters the probability gets closer to zero. We also introduced some corrections to the ranges of parameters.

While it is unlikely that the computing mechanisms will solve the Fermi problem on its own, they can provide better understanding of the current and future observations.

The computational models and universe observations progress, increasing our knowledge and narrowing the unknowns in the estimation of the number of civilizations and the lifespan of our civilization. However, until we meet another civilization or none for a long time or, as the third and most tragic option - our civilization decays, there is still a long way to go.

6. ACKNOWLEDGMENTS

We would like to thank Filip Talimdzioski for his advice and cooperation.

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Context-Aware Stress Detection in the AWARE Framework*

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ABSTRACT

Physiological signals are good predictors of stress, which can be thought of as part of a user's context. In this work, an option to combine the user's stress level with other contextual factors is presented. This is done in the form of two AWARE plugins – Android applications that can be incorporated into a smartphone monitoring setup. In the first part, the stress detection method is described, which consists of a lab stress detector, an activity classifier, and a context-aware stress model. In the second part, two plugins are described. One streams the data from the Empatica E4 wristband and the other one uses this physiological data to predict stress. Finally, some possibilities to improve this work are presented.

Keywords

AWARE, plugin, stress detection, Empatica E4, physiology

1. INTRODUCTION

Mental stress is most often researched because of its negative health consequences when it is chronic. The ability to detect stress from physiological signals collected with a wearable device is thus valuable for research in situations when stress occurs, as well as to trigger stress-relief interventions. In addition, stress affects one's short-term psychological state and behaviour, which makes it a part of the user's context as understood in ambient intelligence. Detecting stress is therefore also valuable for adapting intelligent services to the user (e.g., a mobile application may postpone non-essential notifications when the user is stressed). In this paper we present a stress-detection plugin (and its prerequisite – the plugin for the Empatica sensing wristband) for the AWARE framework [3]. This makes stress detection easily accessible to researchers and other interested parties.

AWARE is an Android framework, used to capture the phone sensors' data to infer context. Its modular nature enables it to be extended by plugins. There are already several plugins available such as a Google activity recognition plugin, which captures the users' mode of transportation, and a Fitbit plugin, which enables collecting data such as heart rate and sleep duration from a Fitbit device.

In this work, a state-of-the-art stress detection method is implemented as an AWARE plugin. To make this possible, the method was adapted to real-time operation, being previously only used offline. The plugin classifies the user's physiological data as representing a stressful or a non-stressful condition, after receiving the data from the Empatica wristband via another plugin. Both plugins are planned to be released publicly, so that other researchers will be presented with a ready-made solution for the first time.

In Section 2, we first present the stress-detection method and what data is needed for it. In Section 3 our implementation in the AWARE framework is presented: a plugin for the stress detection model itself (Section 3.2) and a plugin for data collection (Section 3.1). Finally, some possible improvements are outlined in Section 4.

2. CONTEXT-AWARE STRESS DETECTION METHOD

The stress-detection AWARE plugin is based on a real-life stress detection method as described by Gjoreski et al. [7], and the more general context-based reasoning framework introduced by Gjoreski et al. [5]. It consists of three separate machine learning components: a laboratory stress detector, an activity recognition classifier, and a context-based (real-life) stress detector. Each is presented in its own subsection.

2.1 Lab Stress Detection

The lab stress-detection model was trained using data obtained in a laboratory experimental setup during a standardized stress-inducing experiment [7]. The main stressor in this experiment was solving a mental arithmetic task under time and evaluation pressure. The laboratory data was then labelled taking into account both the difficulty of an

*The work presented in this paper was carried out as a part of a project funded by the Slovenian Research Agency (ARRS, project ref. N2-0081).

equation-solving session (easy, medium or hard) and short STAI-Y anxiety questionnaires [8] filled out by the participants. According to this information, the data was classified into three degrees of stress: no stress, low and high. Additionally, baseline no-stress data was recorded on a separate day when the participants were relaxed.

For the creation of the laboratory stress-detection classifier, the machine-learning pipeline involves segmentation, signal filtering, feature extraction, model learning, and evaluation of the models.

Segmentation refers to the partitioning of the data into windows for the purposes of feature extraction. According to the windowing experiments, which provide a performance comparison between models for varying data window sizes, the optimal data window size was 5 min with 2.5 min overlap.

The signals obtained from the Empatica sensors are: blood volume pulse (BVP), interbeat intervals (IBI), heart rate (HR), electrodermal activity (EDA) and skin temperature (TEMP). After filtering the signals to reduce noise, numerical features are extracted from each data window using statistical functions, regression analysis, and frequency and time analysis, depending on the type of signal. A total of 70 features are extracted from these signals.

The best performing classifier on this dataset proved to be the WEKA implementation of the support vector machine algorithm. Its final output is a stress level prediction of 0 (no stress), 1 (low stress) or 2 (high stress), which is then used as input to the context-based stress detector.

2.2 Activity Recognition

It is important for a stress-detection system to be aware of the user's physical activity, since physical activity elicits physiological arousal similar to psychological stress. For this reason, we used the 3-axis accelerometer provided by the Empatica wristband, which has proven to be successful in recognising activities, according to Gjoreski et al. [6]. The activity recognition model was trained on 60 minutes of real-life Empatica data from one person, with nearly 10 minutes of labelled data per class.

The machine-learning pipeline for the acceleration data is similar to the one used in the lab stress detector. Here, data segmentation involves an overlapping sliding-window technique, which divides the continuous stream into 4 s windows with a 2 s overlap.

Feature extraction produces 52 features: seven represent body posture, while the remaining represent body motion. The extracted feature vectors are fed into a machine-learning algorithm to build an activity-recognition classifier.

The best performing algorithm on multiple acceleration datasets was Random Forest [6], so this is the final algorithm used to build the activity-recognition model. The final output of the activity recognition model is a numeric activity level on a scale from 1 to 5, where each number corresponds to an everyday activity as follows: 1 = lying, 2 = sitting, 4 = walking or standing, 5 = cycling or running. Finally, the activity recognition classifier's output is input into the context-based stress detection model.

2.3 Context-Based Stress Detection

The context-based stress detection classifier was trained using the data obtained as part of the real-life experimental setup described in Gjoreski at al. [7] The data duration totalled to 1327 h and involved 5 participants who wore Empatica E4. The labelling process involved a combination of a stress log and Ecological Momentary Assessment (EMA) prompts implemented on a smartphone. For the stress log, the participants logged the start, duration, and intensity (on a scale from 1 to 5) of everyday stressful situations. The EMA prompts were additionally displayed randomly 4 to 6 times throughout the day, with at least 2 hours between consecutive prompts.

The labelled data was then windowed using non-overlapping windows lasting 10 min, since aggregation experiments showed that most algorithms perform better for smaller aggregation windows (10 min to 17.5 min) as compared to larger ones.

The context-based stress detector's input is four-fold:

- context features,
- features extracted from the output of the activity-recognition model,
- features extracted from the output of the lab stress-detection model, and
- a subset of the lab stress detector features.

The whole stress-detection method, including lab stress detection and activity recognition, is illustrated in Figure 1.

The context features refer to the hour of the day (1 to 24) and the type of day (a weekday or weekend).

The output from the activity recognition model gives an estimate of the reliability of the lab model's prediction. Aside from features extracted from the activity level predictions themselves, the activity level is also taken into account as a modifier to the lab stress predictions prior to performing feature extraction on them. The lab model's prediction is discarded if it is made in an unsteady environment, which is defined as the occurrence of an average activity level above 4 (high) in one of the (5-minute long) instances within the last 30 min. Additionally, the stress prediction is decreased (its class is changed to a lower one, or left unmodified if its already zero) if the subject exhibited an average activity level between 2 and 4 (moderate) within the last 20 min.

There are a total of 15 features extracted from the modified lab stress prediction. A subset of lab stress detector features is also used as input to the context-based stress detector.

The best performing algorithm for making a binary ("stress" or "no stress") prediction using the outlined windowing parameters on the labelled real-life data was a Decision Tree [7], so this algorithm was used to build the final context-based real-life model. Using event-based windowing, this algorithm achieved an F-score of 0.9 using leave-one-subject-out cross-validation.

3. AWARE IMPLEMENTATION

AWARE is a mobile instrumentation toolkit which had the initial purpose of inferring users' context [4]. Extensibility, however, was a primary requirement when developing the framework. Specifically, extending the context by using external sensors was explicitly envisioned, as was using the gathered data and machine-learning techniques for "creat[ing] new higher-level context"[4, p. 4].

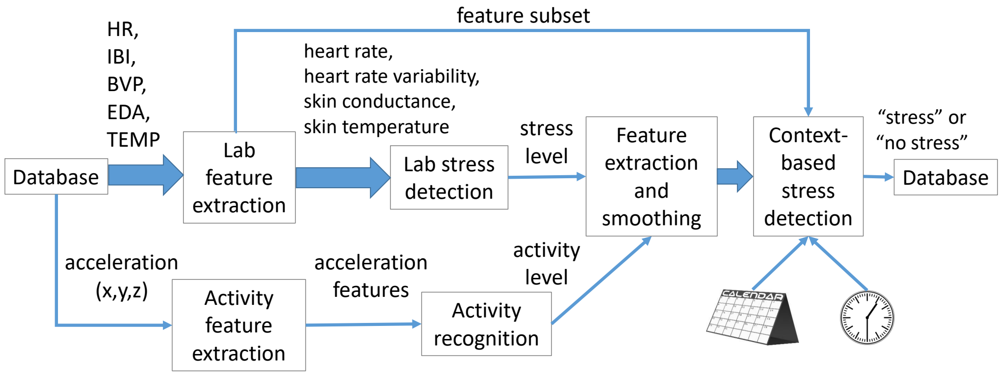

Figure 1: An overview of the context-based stress detection model. Features are extracted from physiological signals from Empatica and input to a lab stress detector. Its predictions are used in the context-based stress detector, which in addition takes activity features from acceleration data into account and considers the time and the type of day.

In the next two sections, two such extensions are presented. The first one gathers physiological data from Empatica, saving it in the standard AWARE format. The second implements the stress detection method presented in Section 2 as an AWARE plugin.

3.1 Empatica Data Streaming Plugin

The AWARE framework already offers plugins for acquiring data from Fitbit and Android Wear wristbands, but it does not have one for the more research-oriented Empatica E4. Our goal was to create an AWARE plugin that enables users to easily connect the Empatica E4 wristband to an Android smartphone.

Figure 2 shows the overview of the processes implemented in this plugin. The physiological data is first transmitted over a Bluetooth connection. It is then available to other plugins via broadcasts and written to a database for later use.

The data from Empatica is transmitted over a low-energy Bluetooth connection, so that the impact on the smartphone's battery is minimal. This enables Empatica E4 to stream up to 24 hours on a single charge [1]. When a sensor reading is successfully transmitted from the wristband to the smartphone, specific functions (`didReceiveAcceleration`, `didReceiveBVP` etc.) are called automatically.

In our case, these functions were expanded to include code to send broadcasts and to save the reading to the database. In this we follow the logic of other AWARE sensors or plugins, in which received data is accessed via broadcasts to display and handle in real time, via content providers (through database) for more complex analysis (the middle part of Figure 2).

Broadcasts are inter-app messages that are sent when a specific event happens, in our case triggered by the data transmission. These messages can be read with observers (broadcast receivers) from any app or plugin that is installed on the phone. Since broadcasting happens in real time, other plugins can use the data from Empatica without including code for communication with the wristband (an example of such a plugin is described in the following section). The data can also be displayed in real time in the native AWARE application.

The collected physiological data is also written to a database (the lower part of Figure 2) by using content providers. Because of different sampling rates, each Empatica sensor has its own content provider. A separate SQL table for each sensor contains columns for `id`, `timestamp`, `device id` and a `value` from the sensor. Columns are defined in this way, so that the database tables maintain the standard AWARE format. Again, each content provider has its own "content URI", a unique address used by other plugins to identify providers for specific sensors.

When broadcasts are sent and the data is written to a database, it is up to other plugins to use it. Even though the main purpose of this plugin is to provide the data that will be handled by other plugins, it also offers a basic user interface. It has its own activity (a user interface that most Android apps have) from which users can export and clear the data in the database.

Contrary to most other Empatica data acquisition applications, our plugin is meant to run in the background. Therefore, it was anticipated that the connection is lost without users noticing. In an effort to solve this problem, our plugin uses a notification to inform the user about the current state of connection.

3.2 Stress Detection Plugin

The goal of the stress detection plugin is to provide real-time stress predictions based on the context-based stress detection method described in Section 2.

In the original stress-detection study [7], the sensor data was recorded in the Empatica E4 wristband's internal memory and later transferred to a computer for further processing. The novelty in our AWARE plugin is that the data is streamed to an Android device via Bluetooth in real time and stored in the phone's database. This allows for real-time processing and classification.

The machine-learning pipeline for the stress detection plugin mirrors the original pipeline used to train and test the context-based stress detector. The three models (lab stress

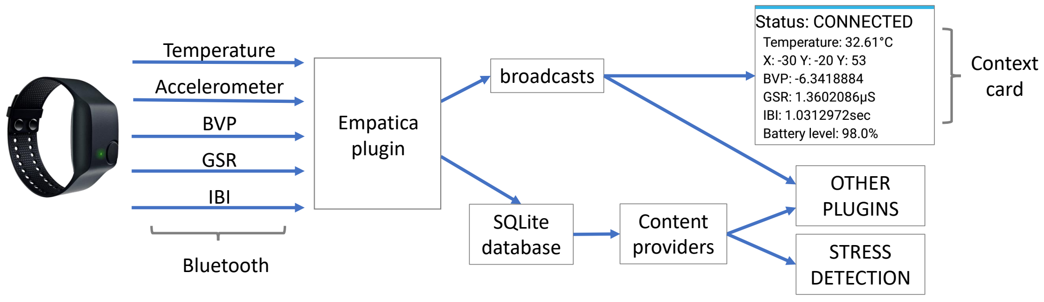

Figure 2: An overview of the Empatica data streaming plugin. The data is first received via a Bluetooth connection and can then be broadcast to other plugins or written to a database.

detector, activity recognition classifier and context-based stress detector) are independent and saved locally in the plugin's assets. The models are triggered periodically using the optimal time intervals discussed in Section 2.

As discussed in Section 3.1, the Empatica data streaming plugin writes the raw data from the E4 in SQL tables in real time. The stress detection plugin then has access to this data through the former's content providers. The plugin reads the last 5 min of raw Empatica data every 2.5 min and provides this data to the models for processing. The context-based model gets its context features using the phone's current date and time.

The features from the lab stress detector, the activity recognition classifier and the context-based stress detector are, both broadcasted and saved in the phone's database. The same is true for each lab stress prediction, activity level prediction and context-based prediction. The stored data is further accessible through content providers for any other application to use, as is the case with other AWARE plugins. In this way, both the Empatica data and the stress prediction method are easily available for other researchers to use.

4. FURTHER WORK AND CONCLUSIONS

The plugins described in the previous section offer a ready-made solution which researchers could use to add a stress level to the user's context. There are some limitations in their current implementation which we aim to amend.

Currently, the standardization (normalization) of some of the features is arbitrary. It is done by subtracting a "typical" value of a given signal and divided by a "typical" standard deviation. To account for inter-individual physiological differences, means and variability could be calculated on a person-specific basis. This would, at the very least, require keeping track of a user ID and then calculating signal mean and variability over a longer time-period when a new user would start using the application. If baseline values would be needed, this would also require the user to indicate when they are not under stress and calculate their specific physiological values in that time-window. This type of user interaction has not been accounted for in the current implementation.

An evaluation of this method is also planned. The models described in Section 2 have been evaluated as outlined in related work, but they have been used in different experimental scenarios. Online real-life use of the method would merit its own evaluation.

To understand causes of stress and the situation where a physiological stress response arises, it is helpful to know as much as possible about a user's context. The plugins described in this work will simplify combining physiological data with other contextual data the AWARE framework already provides. Additionally, stress predictions can be used as context themselves and inform other interactions with users, such as offering them prompts at certain stress levels by using the AWARE Scheduler [2] and using stress predictions as broadcast triggers.

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BRISCOLA: Being Resourceful In Stacking Cards - Opponent, Lament Away!

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ABSTRACT

This paper describes a robot system that can play the popular Mediterranean card game called Briscola. It elaborates on the three main components needed for an operational platform. First, it describes several artificial intelligence agents that can play the game using a combination of probabilities, heuristics and the min-max algorithm. Second, it describes the computer vision component for card detection using both classical and deep learning approaches and finally, it proposes a scheme for a robotic arm that can move the cards on the table.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*

Keywords

Intelligent Society, Computer Vision, Game Theory, Robot Arm

1. INTRODUCTION

Briscula is one of Italy's most popular card games, played all around the Mediterranean (Italy, Spain, France, Greece, Slovenia, Croatia). Despite that, the possibility of making an artificial intelligence player for the game is poorly researched, with no papers on the topic found. We propose a system that can not only play the game on a computer, but can actually play against human players in the real world using a robotic arm. To do so, we developed three separate modules. First, we used a combination of heuristics, card probabilities and min-max algorithm to plan agent's moves. Second, we used computer vision (CV) algorithms to determine which cards the AI agent has and which cards are being played by the (human) opponent. Finally, we proposed a robotic arm that is capable of picking up a card from a predetermined spot using suction at the arm's end.

1.1 Briscula - Rules Overview

The game is played with a special deck, containing 40 cards divided equally into 4 colors - Spade, Coppe, Bastoni, Denari [Figure 1]. One card is selected at random at the beginning of the game and is placed face up under the deck. Its color is called "Briscola", giving the game its name. In this paper we consider the 2-player variant of the game. Both players start with three cards. Every turn both players play a card and at the end of the turn draw a card from the deck. After both players play their cards, the second player wins if his card shares the color with the Briscola card or shares the color with the first card and has greater strength, which is based on the card number. The winning player gets points corresponding to the played cards value. After 20 rounds, whoever gets more than 60 points wins (a 60-60 score results in a draw).

Figure 1: The 4 aces of Briscola.

2. PLAYING THE GAME

First task was to develop an artificial agent that would be able to play the game in a virtual environment. Due to the lack of external opponents, we developed several progressively stronger AI agents and matched them against each other to determine their strengths. Final version was also matched against five human opponents to further evaluate its performance.

Mr. Random

The first agent plays cards completely at random. While this strategy seems inadequate, it both provides a basic baseline, and demonstrates an interesting property of the game: the game's variance is so high, that even this agent wins more than 5% of the games against the best agent (and significantly more against others), simply by having superior cards. High degree of chance, explains why progressively better agents have diminishing returns in their win rate.

Mr. Greedy

This agent tries to maximizes the score after the current round. It opens the round with the lowest card, while taking with the strongest card, if possible, when second. While this provides the biggest boost in performance, its liberal spending of strongest cards does not lead to optimal play.

Mr. Heuristics

Agent implements author's expert knowledge using if-else rules. The wide set of rules includes holding strong cards until a valuable card is played, trying to start each round second if possible (as seeing your opponent play lets you know how to best respond) and being careful in which situations to open the round with a valuable card.

Mr. Probable

The use of heuristics can be amplified by predicting the likelihood of cards the opponent might be holding. Predicting that the opponent has a strong card of one color, might lead the agent to open the round with another. This was done by weighting the influence of each conflicting if-else rule, by the probability that it applies. The play was then determined by the "strongest" rule.

The prediction of card probabilities however, is not trivial. By counting the cards already played, we can determine cards left in the deck and calculate the base probability that any of them is in the opponent's hand, given his hand size. This probability can be further modified by two factors. First, we can exclude some types of cards from their hand, given their past plays. This step assumes that the opponent has an elementary knowledge of the game, and will play the obviously good play, given opportunity. For each card in opponent's hand, we track when was it drawn, and what plays were made since then. This allows us to predict more precisely what kind of card it is. Second, cards of high strength or Briscula color tend to get "stuck" in player's hand, as players wait for a good opportunity to play them. This means that their likelihood of being in a hand is greater than the base probability would suggest, especially in the later game. Their probability was weighted with an empirically determined weight, that moved from 1 to 1.5 as the game progressed.

Mr. Calculator

To avoid the if-else behavior, an agent can try to calculate different game branches and then decide for one that most likely leads to the desired outcome. There are two popular frameworks for this task: variants of the min-max algorithm and the Monte-Carlo tree search. We decided to try the former and leave the latter for future work.

The base version of the min-max algorithm [8] works with perfect information and thus had to be adapted for this probabilistic case. Instead of using the probabilistic variant of min-max, that would have a huge branching factor, we tried to transform the problem into a perfect information one. Three cases were considered. 1.) In the last three rounds, all cards are drawn and thus we have the case with perfect information. 2.) When only a few cards remain in the deck, we can do an exhaustive search of all possible orders of cards in the deck and all subsets of cards that can be in the opponent's hand, and do a simple min-max search for each possibility, averaging the results. 3.) In remainder of the game we sampled 100 different hands the opponent could have each round, with regards to the probability described in the previous subsection. For each of the possibilities the min-max search is performed and the results were averaged. In all cases, the search depth was set to three rounds, as reliability of our information on the opponent decreases with time. The heuristic used at the end nodes was simply the number of points accumulated in those rounds.

This variant performed best of all described and matches expert human play. The contribution of each min-max use case was individually assessed by replacing it with heuristics for that part of the game, and it was determined that all three parts contribute to the game-play improvement.

3. RECOGNIZING CARDS

In order to be able to play the game in real-life, it is essential to detect cards on the table and cards that are picked up from the deck. In this image recognition problem we assume that the card's images are constant and that they are placed on a mostly uniform background - table. The problem gets complicated due to the fact, that the card's images can be very similar, they frequently overlap in practical play and they can be sometimes covered by the opposing player's hands. Here we present several attempted approaches, ranging from the simplest to the beyond state-of-the art deep learning.

Removing background

Since the cards are on the table and thus the surface color does not change much, we first tried to remove the background color from the image and detect cards left on the table. A predetermined threshold, based on the RGB values of pixels was used. This approach proved unreliable, as the subtle changes in lightning (lights in the room, clouds over the sun) could change the color scheme enough for the threshold to fail to remove enough of the background.

Comparing differences

Similarly, since most of the image is static (table, deck of cards) and the only changes are the two cards being placed on the table, we looked at the history of images and tracked changes between them. Ideally, when a new card is placed on the table it should be the only changed part of the image and could easily be detected. Once exact card position is known, any template matching technique could be used to identify the card. The same approach could solve the overlapping cards problem, as they could be identified one by one, as they are played. In reality however, this approach did not work either. Due to the camera noise, most of the image was constantly changing. Second and bigger problem was that when a card was placed on the table, hands and their shadows went over half of the table, changing pixel values in the image, complicating the use of this approach.

Edge detection

Another attempt was to detect the edges of the objects on the table using Canny Edge detector [2]. To detect a card from the edges we used Hough Line Transform [3] in order to detect straight lines that could later be combined into square shapes to form cards. This improved the results significantly, however due to the camera noise and wood pattern of the table, the edges were often miss-detected.

SIFT

SIFT [5] is a scale-and-rotation-invariant image-recognition algorithm, which means that the object in the image can be rotated or scaled and the method should still be able to

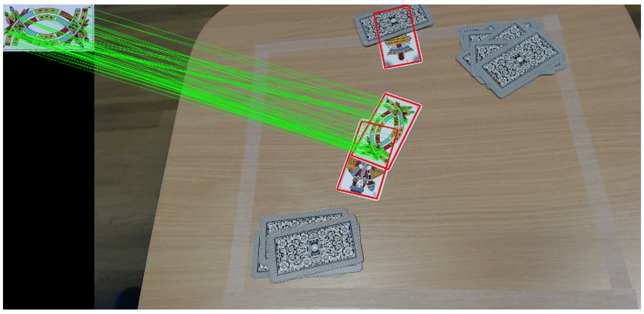

Figure 2: Detecting Spade 4 card. Matching features from template image to camera view.

detect it. SIFT finds so called interesting points (features) in the image, these are usually shapes of edges, stores all features from the sample images and then compares them with the features found in the new images, as seen on Figure 2. By comparing features position, the algorithm can also determine the image position, rotation and scale.

This algorithm proved to work much better than previously described methods. It's detection rate was high, detecting even partially obscured (overlapped) cards.However, it has two drawbacks. For each frame in the video (image) it has to compare image (table) with 40 template cards. Depending on the resolution this can be very slow, ranging from 1 to 15 seconds. Sadly the accuracy is correlated with the size of the image, which means that for good predictions high resolution images need to be used, which slows detection significantly. Second problem was distinguishing between lower "Denari" cards.

Deep learning

In the last decade deep learning has become the dominant ML approach for multiple domains, with different deep learning architectures achieving almost human level precision for problems regarding computer vision.

The standard approach is using several layers of convolution, which is similar to what SIFT does, and then combining several fully connected layers in order to classify the features. This works fine for image classification, but is unable to detect objects on the image. A naive approach would be to have a small sliding window that goes through the whole image and classifies every part of it. This would be accurate, but extremely slow. Several approaches have been developed in order to tackle such problems: YOLO [6], Faster R-CNN [7], SDD [4]. Mentioned papers all go through the image only once (working with 30-60 fps), but still achieve comparable results to slower window CNN approach.

To test how well deep-learning approach works on our problem we implemented the YOLO architecture. Architecture consists of roughly 120 layers of convolution, pooling, regularization and fully connected layers. The training started with pre-trained weights, obtained from VOC 2017 object detection. We manually labeled around 1000 card images, using the VOC format, and then trained the network for 3 days on NVIDIA's GeForce GTX 1080 graphic card. The trained network performed relatively fast, achieving around 15 fps, which is more than enough for real time detection. Detection accuracy was high when there were only 1 or 2 non-overlapping cards on the table [Figure 3], however it had problems with overlapped card. After investigating, we found out that since the network is trained with bounding boxes that are always aligned with the x and y axis, if the card is tilted at an angle, only half of it will be in the bounding box. Therefore the network is unable to learn to tightly detect a card and when they overlap the overall error is smaller if it just combines the two cards into one bounding box.

Figure 3: Detecting cards with YOLO is fast and reliable if objects do not overlap.

To solve this problem we started working on a modified architecture that in addition to bounding box also predicts the angle at which the bounding box is rotated. The initial results on generated data (photos of cards stitched on top of different backgrounds) show promising results, where for most of the single cards in the image the network correctly predicts the rotation of the bounding box. The network works a bit worse where there are two overlapping cards but still manages to recognize a large percentage of images. We believe that with some more time, larger set of training images, tweaks and optimization of the architecture we could achieve close to 100% accuracy for the detection using this new architecture.

3.1 Robotic Arm and Cameras

The last step in bringing the agent to the real world is the presence of sensors and actuators. This component is composed of two cameras and a simple robotic arm. The robotic arm has 4 Degrees of Freedom created by 4 servo motors, that are controlled by Wemos D1 mini board. The board acts as a web client, receiving the commands from the main server and executing movement (controlling servo motors) actions. At the end of the arm there is a suction pump for lifting and dropping the cards. All movements are predetermined and described with sets of motor's rotation degrees. Two movement patterns exist: drawing a card and placing it on one of the three predetermined spots and picking the card from one of the three spots and dropping it at the center of the table.

The system also has two cameras, first one to overlook the table – tasked with detecting the cards played by the opponent. The second one is behind the arm, turned from the floor up. Before dropping a card on the table, arm is rotated

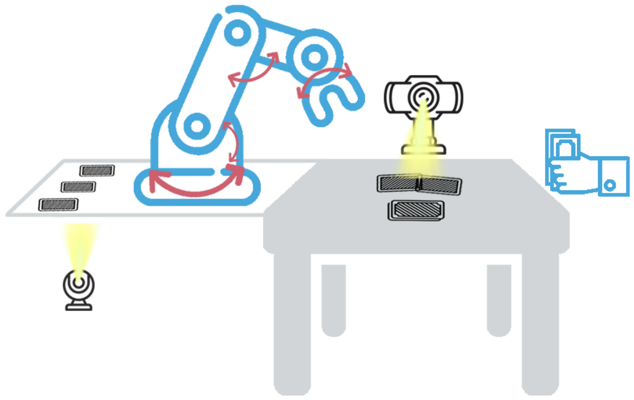

Figure 4: Server controls the robot arm. There are two cameras to oversee the table and picked up cards from the deck.

	R	G	H	P	C
R	-	26	13	14	6
G	74	-	21	18	15
H	87	79	-	42	34
P	86	82	58	-	40
C	94	85	66	60	-

Table 1: Win percentage (%) of row agent against the column agent. Agents: Mr. Random (R), Mr. Greedy (G), Mr. Heuristic (H), Mr. Probable (P), Mr. Calculator(C)

so the card is over the second camera and can be identified. The system is schematically presented in Figure 4 and its first prototype is recorded and can be seen on the web [1].

The main logic for controlling the arm and taking actions is on the server, coupled with CV model and AI in order to take appropriate actions.

4. RESULTS

We started by assessing the comparative strength of the different AI variants. Each played 1000 games against each other. Results are shown in Table 1 and show that the agent's skill increases with their increasing complexity. It also shows high degree of variance in the games, as even random agent got surprisingly many wins and the best agent - Mr. Calculator is achieving only 66% win rate against simple ones. In repeated experiments we noted, that win rate fluctuates ±2% between runs.

Next we compared the play strength against 10 human opponents of different skill levels. Each played 10 games against Mr. Calculator. Results are listed in Table 2 and show an average 69% win rate of the AI against the human opponents. Volunteers that played, commented that the skill level of the agent is quite high, with some room for improvement in regards to increasing the agent's risk aversion. While the sample size is too small for definitive conclusions, we can assume that the agent is at least on par with average human players of the game.

1	2	3	4	5	6	7	8	9	10	avg.
80	90	80	90	85	70	60	60	25	50	69

Table 2: Win percentage (%) of Mr. Calculator against 10 human opponents of roughly increasing strength.

To test the CV component we recorded several human games from the same angle as the final system uses. We then manually compared the cards predicted by the CV with the actual ones. The best two approaches were SIFT and YOLO algorithms. The first worked flawlessly in all cases, except differentiating some of the Denari cards. The second could flawlessly recognize all cards, when they were not overlapped. Overlapped cards had roughly 50% accuracy. In the end we decided to use the SIFT algorithm for our first system prototype, since second player usually overlaps the first card.

5. CONCLUSION

In this work we described three different components (from different computer science fields) of a system that is able to play the Briscola card game against the human opponent in a real-life setting. For each component we individually tried different approaches, creating a strong AI agent and a serviceable CV and robotic component. While the current version should be able to reliably play the game, all components still have room for improvement - we plan to test the Monte-Carlo search tree and improve the deep learning architecture. We hope that we will be able to successfully present a live demonstration at the paper's presentation.

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Emotion Recognition Using Audio Speech Signal

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ABSTRACT
Emotion recognition is an important part of affective-aware applications. Specifically, using audio speech signal has the advantage of being compatible with applications using a natural language interface. There are multiple valid representations of emotions. We propose a new representation aimed at using differently labeled databases jointly. We include a short overview of some of the available databases and methods for feature extraction and selection. Both classification of emotions and regression in 2D emotional space are discussed. We concentrate on using neural networks for both tasks. Regression provides good results but is hard to interpret while classification is more robust.

Categories and Subject Descriptors
I.5 [**Pattern recognition**]: Neural nets; I.5.2 [**Design methodology**]: Classifier design and evaluation

Keywords
Emotion recognition, Neural networks, Affective computing

1. INTRODUCTION
Nowadays applications such as personal digital assistants are becoming more popular. Some also utilize natural language interfaces. Next step in this direction seems to be affective computing - applications that can detect human emotions. Such applications can enrich the user experience by responding according to the user's current mood and perhaps even detect when the user is not happy with the application's functioning. However, in order to implement such applications we need to first be able to understand the user's emotions. This, in conjunction with other knowledge (such as user's daily routines and other contextual information) makes it possible to detect certain mental health problems, such as depression or bipolar disorder, shown by Osmani et al. [8].

Models we are developing will be used in an emotionally-aware virtual assistant application. Our priority is to deliver information that can be acted upon in order to better the user experience. Application's target population are people from Italy, Spain and Denmark.

1.1 Representations of Emotions
When talking about emotions in the context of affective computing, we first need to consider how to represent human emotions. In psychology, there exist many different theories about human emotions. We can choose a discreet representation of emotions or a contiuous representation in some space of emotions. In first case, we define different categories that represent different emotional states. The most widely known categorization is Paul Ekman's basic emotions. Ekman studied facial expressions of emotions across different cultures and came to the conclusion that there are six basic emotions that are expressed equally across cultures. Those are sadness, happiness, anger, fear, disgust and surprise.

On the basis of Ekman's work others proposed different models. Some of them have a different set of categories. Others use a continuous representation in two, three or four dimensional spaces. There is Plutchik's wheel of emotions that represents emotions as four pairs of exclusive categories, that are treated as four axes along which emotions are spread. Emotions are represented as points in this space. J. Russel proposed a different model, a two dimensional space. Dimensions are arousal, which represents how active one feels, and valence, representing pleasurableness of the emotion.

For our purpose, we prefer classification robustness over precision. We don't need very fine-grained information to better the user experience of the application. Therefore in order to use as much training data as possible, we propose a four-class representation of emotions. The main idea of this representation is to be able to easily transform labels in other representations into a common one. Classes correspond to quadrants in space of arousal and valence, and to groups of Ekman's basic emotions: **Happy**: positive arousal and positive valence, includes basic emotion happiness. **Calm**: negative arousal and positive valence, there are no basic emotions in this quadrant. Instead we include neutral. **Sad**: negative arousal and negative valence, includes basic emotions sad and bored. **Upset**: positive arousal and negative valence, includes basic emotions disgust, anger and fear.

Therefore, we can jointly use databases that are labeled in space of arousal and valence (Recola, Semaine), as well as those labeled discretely (EmoDB, Ravdess).

1.2 Learning from Features or Raw Audio
Traditionally in machine learning we first extract features from audio. This can be done using specialized software, such as OpenSMILE [3], or libraries, such as LibROSA [6].

With deep learning, it is possible to learn from raw audio signal. This recent approach is interesting, as in the raw audio signal there is encoded certain information that is missing in extracted features. Deep learning has two problems: (1) larger databases are needed for training, and (2) training is very computationally expensive, both regarding computational power and large amounts of memory needed.

2. DATABASES

There are many public audio databases available for use in affective computing. Most of them are targeted towards speech recognition or a subset of emotions, specific for a given problem (such as detecting frustration in call centers). We describe the few of them that we have used. [1]

We chose those based on the way they were labeled, language and audio format used. Regarding labels we preferred labels in space of arousal and valence or basic emotions in order to be able to do both regression in some emotional space or classification of emotions. We decided to only use European languages, since it has been shown that model trained on language from similar cultural background to target population gives slightly better results [2]. Audio simply needs to be of high enough quality. Human speech ranges up to 5kHz so we need at least 10kHz sampling rate. To be on the safe side and not lose any non verbal information we decided to only use audio recorded at 16kHz or higher.

2.1 EmoDB

EmoDB [1] (Berlin Database of Emotional Speech) is an older database. It contains 535 utterances spoken by 10 different actors. Each actor expressed each of the Ekman's 6 basic emotions (and a neutral version) at least once for each of the ten different texts. Each file is labeled. Texts themselves are emotionally neutral. Utterances are quite short, recordings are between a couple of seconds long up to half a minute.

Problematic aspects of this database are:

- Utterances are very short. Often when classifying audio, recordings are cut into segments from 1 second up. If we do that with EmoDB, there are simply not enough instances to use deep learning techniques, in same cases there are even not enough for traditional ML.

- Expressed emotions are extreme to the point of overacting. This means that classifiers trained on this set may produce weak generalization, as most speech is closer to neutral as considered in this database.

2.2 Semaine

The SEMAINE [7] database is a multi-modal database that includes audio, video and transcripts of English texts. The database is labeled on a continuous scale along many dimensions. Not all sessions (couple of minutes long recordings) are labeled in all dimensions. Most are labeled along the arousal and valence dimensions, as well as intensity and power. Fewer are labeled along basic emotions (e.g. only 2 session labeled for fear). Each available dimension is labeled by at least 2 annotators. Differences among different annotators are quite noticeable which is to be expected in such a setting.

Problematic aspects of this database are:

- Very unbalanced due to the chosen labeling methodology. Counting each label sample, there are almost 4x as many examples of low arousal and high valence than examples of high arousal and low valence.

- For some dimensions label values span a very small interval, which may cause problems with regression along those dimensions.

- Differences between annotators are often quite big. Some files have inter annotator correlations below 0.2. While this is not unexpected - emotion expression and perception are inexact - it is problematic for training and testing.

- Expressed emotions are very mild and often noticeably acted. There are examples in which we can hear the actor, supposedly gloomy and depressive, express amusement by laughing. While extreme emotions are problematic so are very mild emotions - ML algorithms often overfit to find other characteristics in the data.

2.3 Recola

Recola Database is a French multimodal datset of emotional speech. It includes audio, video, biosignals, labels (annotations) and metadata. It is similar to Semaine in that it is also labeled continuously. It is only labeled along arousal and valence dimensions, but labels are of higher quality. Each recording is labeled by 6 different annotators, 3 male and 3 female.

Problematic aspects of this database are:

- Each file is exactly 5 minutes long, but some of the labels are missing a few samples. We have cut the audio files to match the label lengths.

- There are only 23 recordings. Since each is 5 minutes long it is still quite large.

- It is quite unbalanced. Counted by each label sample, there are more than 8x as many examples of high arousal and high valence than examples of low arousal and low valence.

2.4 Ravdess

The Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS) contains video and audio of 24 actors. Emotions expressed include the 6 Ekman's basic emotions, neutral and calm. Each utterance corresponds to one emotion. There are 1440 files in the speech section and 1012 in the song section.

Problematic aspects of the speech section of this database are:

- All utterances contain one of the two texts: (1) "Kids are talking by the door" or (2) "Dogs are sitting by the door". This may represent a problem as all files are in a way very similar. On the other hand, this is good as it helps prevent overfit as the algorithm can't learn to differentiate utterances based on text contained.

[1] Some of reportedly high quality databases such as the Humaine database and Vera am Mittag (eng. *Vera at noon*, a database of German emotional speech taken from reality TV and talkshows) are not available anymore.

- Utterances are very short, similar to EmoDB.

3. FEATURES

Among features used for classification of audio of human speech are (1) simple features such as loudness, signal energy and pitch, (2) Mel spectrum: similar to frequency spectrum, transformed to Mel scale which corresponds roughly to human perception of pitch, (3) Mel frequency cepstrum coefficients: inverse Fourier transform of log-scaled Mel spectrum, (4) Jitter, shimmer: frequency noise instability and amplitude instability, (5) Formants: most present harmonic frequencies, (6) Spectral features: describe the shape of the frequency spectrum and (7) Chroma features: describe tonal properties, such as melody.

3.1 Tools

Some of the commonly used tools for audio feature extraction are OpenSMILE and LibROSA.

OpenSMILE is a standalone program with a very step learning curve. Writing custom configuration files which is needed for extracting custom features as opposed to using one of the predefined features sets is quite complicated. Most users use predefined configurations, which can also be found online.

LibROSA library is an easy to use alternative that works with Python and offers similar functionality. It also offers some utility functions for reading and storing audio files, filters etc.

3.2 Feature Selections and Analysis

Feature selection is an important step in the ML pipeline as having fewer features is beneficial for reducing training time as well as reducing the possibility of overfitting.

We have performed feature selection using each of described databases, using features calculated by OpenSMILE (using a slightly modified ComParE13_LLD configuration) and separately using features calculated using the LibROSA library.

1. Remove features with variance below 0.2, as they hold little information.

2. Sort by correlation with labels and remove those with absolute correlation below 0.1 as they mostly contribute noise or bias towards groups with certain vocal qualities.

3. Greedy feature selection: take the feature with the highest correlation, add it to the feature set and test on a surrogate model (logistic regression or random forest classification). We use surrogates to reduce the computation time. Keep feature if it improves performance of the surrogate.

Using this method the number of features was reduced from 132 to 60 (feature set ComParE_lld extracted using OpenSMILE), and from 167 to 110 (custom feature set extracted using LibROSA). We achieved the same performance on the models while reducing the training time compared to no feature selection.

4. EXPERIMENTS

We have tested regression in the space of arousal and valence and classification of basic emotions in order to compare two very different approaches and decide which is preferable for our use-case.

4.1 Regression in Arousal and Valence Space

While deep learning on raw audio signal is slower and more computationally expensive, it may produce better results as raw signal contains more information. We have replicated the experiment done by Trigeorgis et al. [9]. Due to hardware constraints we had to introduce certain modifications: (1) we had to use 3 second segments instead of 6 second segments and (2) we used a mono-directional LSTM layers instead of bi-directional as in the paper. Network topology is otherwise same.

Training and testing was done on the RECOLA database. Data was split into train and test sets by actors - 80% of actors in the train set and 20% in the test set. Our results were very similar to those reported in the paper. Measurements shown in Table 1 are Concordance correlation coefficients (CCC)[2] between predictions and ground truth, obtained as averaged labels. Predictions are scaled to have the same standard deviation as the ground truth and time-shifted in order to remove any delays that a human annotator may produce. Thus we can confirm that deep learning from raw audio data is feasible.

	Arousal CCC	Valence CCC
Raw audio	0.641	0.250
Features	0.574	0.187
Trigeorgis et al. [9]	0.684	0.249

Table 1: Valence and arousal regression results

The network is made of two distinct functional units. First are the convolutional layers that learn to perform feature extraction. It has been shown [9] that certain neurons are highly correlated to some of the known good features. The second part is made of two LSTM layers. These learn to regress arousal and valence from extracted features.

The same experiment was repeated using only the second part of the neural network, trained using extracted features (feature set ComParE_lld). Results were somewhat worse, which indicates that the convolutional part of the full neural network learns to extract a better set of features than we get using simple feature selection (as described above). Unfortunately predictions in the space of arousal and valence are hard to interpret and there is no direct way to convert them to basic emotions.

4.2 Classification of Emotions from Features

We have used EmoDB for initial experiments. All reported results are averaged over leave-one-person-out cross validation. Simple fully connected feedforward neural networks tend to overfit. This can be reduced with hyperparameter adjustment (learning rate and algorithm, mini-batch size, early stopping etc).

[2]Concordance correlation coefficient is a measure of agreement, often used to measure inter-rater reliability.

This was tested on the database split into 3 sets, train, test and evaluation. Using 3 sets show that overfit is still there, but the difference in performance was small between train set and test set probably due early stopping based on test set loss. Performance on evaluation set is still much lower.

We used all features from the ComParE_lld feature set. Input layer therefore has 130 units, fist hidden layer 70, second hidden layer 30 and output layer 7 (6 Ekman's basic emotions + neutral). For the experiment, MSE was used as loss function, and Adam as optimizer. Without using regularization, we achieve very poor performance. As the model starts to overfit we stop training it, which is before it achieves good performance. Without regularization accuracy is therefore very low on all sets. Even with strong regularization, using both added Gaussian noise ($std = 1/2std(features)$) to input layer and dropout ($p = 0.5$), large differences on train set and evaluation set can be seen.

We compare out results to state of the art as achieved by Yenigalla et al. [10] in 2018 and Gjoreski et al. [4] from 2014. Yenigalla et al. achieved high performance using convolutional neural networks, trained using extracted features and phonemes. IEMOCAP dataset was used. Gjoreski used Auto-WEKA, a machine learning tool that automatically chooses best classical-ML algorithm. They trained and tested using EmoDB.

	Accuracy (test)	Accuracy (eval)
No regularization	0.54	0.48
Noise, dropout	0.82	0.65
Gjoreski et al.	/	0.77
Yenigalla et al.	/	0.73

Table 2: Classification results for test set and evaluation set, compared to state of the art [10].

We have also performed some preliminary experiments using Optimal Brain Damage (OBD) algorithm[5] to prune the network. Results are not yet conclusive but seem promising. We did not achieve better performance, but did achieve same performance while pruning up to 60% of all units.

5. CONCLUSION

We have experimented with regression in space of arousal and valence. Results confirm that a combined convolutional and recursive neural network can effectively learn on raw audio signal. Since the authors who propose this approach state that the convolutional part of the network learns to perform feature extraction we tested only the recursive part of the neural network, trained on pre-extracted features. Results were somewhat worse, which can be interpreted as the convolutional part of the network learns to extract better features. Aditional experiments, such as classification using a similar neural network are needed in the future.

We have also tried using a fully connected artificial neural network (FNN) to classify emotional speech. FNN is extremely prone to overfit. Even using very aggressive regularization techniques show some overfit. It seems that either (1) FNNs need a larger amount of labeled training data or (2) are not well suited for this problem. Related future work is performing experiments using OBD to prevent overfit.

A new categorization of emotions was proposed with the aim of using multiple databases jointly. Preliminary experiments show that we can use it for machine learning on multiple databases. Whether models trained in such way will perform better is yet to be seen.

In conclusion, emotion recognition using audio signal is a complex and difficult task. Some of our experiments come close to state of the art, but still not very good. We believe we can improve our work further in the future.

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Improvement of AI through Deep Understanding

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ABSTRACT
Humans have concerned with semantics behind words, objects and facts for thousands of years. Yet, when a computer uses a model and learns to recognize it from a video, does it really understand what it is or does it only map a number of specially colored pixels and shapes to a term "object"? In addition, humans use semantics to improve performance; therefore, it seems reasonable to assume that computers would as well. This paper overviews latest state of the art papers that learn and use semantics in order to improve the results of established methods in different areas. Two branches of AI: natural language processing and computer vision seem to be especially active in this area.

Categories and Subject Descriptors
I.2.m [Artificial Intelligence]: Semantic analysis

General Terms
Algorithms, Theory.

Keywords
Review paper, semantics, ML

1. INTRODUCTION
Machine learning and artificial intelligence are as old as modern computer science. However, there is an essential difference. Even though we have thought the computer for example to recognize the images of a cat, be able to predict the future of a stock or play a game of chess, in reality we just thought computers a good enough mathematical model that approximates the real world application. The computer methods seem to be qualitatively much different than the way humans use intelligence and learn.

In early 2010, deep learning started gaining popularity. Google was the first one to successfully use deep neural networks (DNN) when trying to classify cats in photos on the internet. They used Convolutional Neural Networks (CNN) architecture and were incredibly successful. No method before achieved such classification accuracy for image recognition, not yet similar to humans, but splitting the difference in two. A couple of years later, the DNNs achieved the human level accuracy and from that threshold on, each year further improvement in their performance is made.

Because deep networks work like a black box, we do not know exactly why something is classified as is. People started to wonder, has Google made a first step to superintelligence? Has their method actually learned what a cat is, learned the meaning, semantics and everything that goes with it? With further experiments the question deepened. For example, the network "knew" that a cat has four legs, a tail and so on. It knew how to distinguish it from a dog, who also has a tail and four legs. In the end however, it tuned out the method was practically as "shallow" as everything that came before. The legs of the animals were collection of pixels statistically grouped around the body, the color was a number and classification was a calculation pointing towards one possible class. The class itself was a number and was linked to a term "cat" by humans.

In the past and nowadays alike, semantics are often treated just as another feature, another numerical input to the computer system. The computer uses it to improve performance, but in a similar way as any other numerical feature, without additional semantics, meaning or procedures attached to it. It can and usually does increase classification accuracy, but the model does not understand what it means. For computers to "understand" does not necessarily mean to be very similar to the way humans use semantics, in particular regarding the way the understanding is coded in the computer model, which is likely to be different in humans. Rather, understanding in computers should be functionally somehow similar, i.e., enabling solving tasks in somehow similar way.

In this paper we provide a brief overview of the latest state-of-the-art papers that learn or use semantics to further improve their models.

2. SEMANTICS IN NATURAL LANGUAGE PROCESSING

2.1 Approximating Word Ranking and Negative Sampling for Word Embedding [8]
Word embedding is a technique to present each word by a dense vector, aiming to capture the word semantics in a low rank latent space, e.g. each word is translated into a vector of 0 and 1s in such a way, that words that are semantically closer differ in less bits than semantically different words. It is widely adopted in Natural Language Processing (NLP) tasks. Variants can also be used in almost any domain where semantics play a role, such as computer vision. One of the latest approaches in implementing word embedding is Continuous Bag-of-Words (CBOW) [9]. CBOW predicts a target word given a set of contextual words, where the target word is labeled as positive and the others are classified as negative, e.g. if we have a sentence and want to predict word w_i (positive) we take a look at the neighboring words w_{i-2}, w_{i-1}, w_{i+1}, w_{i+2} (negative). However, the method treats all words equally based on frequency in text instead of favoring the positive ones.

Authors of this paper [9] develop a new approach to word embedding, based on CBOW that favors positively ranked words. They do so by selecting negative words that tend to decrease overall performance. The method works in two steps: it first increases the score of the positive words, and in the next step decreases the score of the negative words. With this approach they improve the overall performance compared to other BOW approaches.

This approach works relatively well for larger texts but still struggles with short texts. Authors in [7] propose additional steps that can be taken in order for the approach to also work with short texts. The words are usually represented as vectors, and based on the Hamming distance of the embedded vectors, one can notice that semantically closer words are also grouped closer (have shorter Hamming distance) as seen in Figure 1.

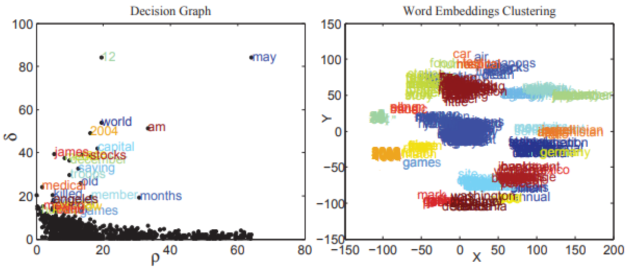

Figure 1. Word clustering based on their semantical meaning. In the left image the words are randomly located around 0,0, while on the right side image we can see that clusters form.

2.2 Task-Guided and Semantic-Aware Ranking for Academic Author-Paper Correlation Inference [6]

In this paper [6], the authors consider author-paper correlation inference in big scholar data, such as Google Scholar, Microsoft Academic or aMiner. In other words, they would like to provide an author relevant and related publications based on the author's previous papers and citations.

To solve the problem, the authors propose a model by joint content semantic encoding and heterogeneous relations augmented ranking, and design the corresponding learning algorithm. In the first step they use Gated Recurrent Neural Networks (GRU) in order to obtain latent features for authors and semantic embedding for each paper. To further improve the results, authors also include citations and transitive citations (multiple papers deep) of author and his/hers papers using a heterogeneous network (HetNet). The architecture is presented in Figure 2.

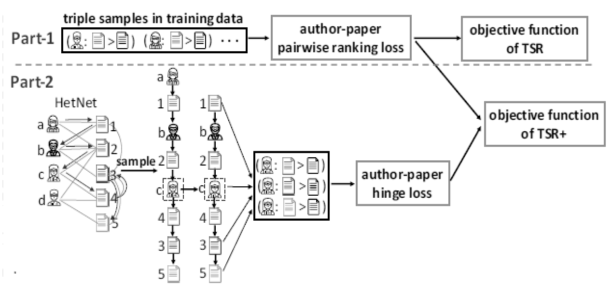

Figure 2. Framework is composed of GRU for direct author paper relation and HetNet for indirect author paper correlations.

The paper learns semantic representation of each paper and then compares it with related papers allowing authors to better find related work based on their paper history.

3. SEMANTICS IN COMPUTER VISION

3.1 Semantic Locality – Aware Deformable Network for Clothing Segmentation [1]

This paper [1] tries to solve the problem of clothing segmentation and identification from photos of people wearing them. While the network doesn't predict or use semantics as an output or input for predictions, semantics proves to be essential in training phase.

In order to learn to recognize different pieces of clothing, the authors proposed a twofold deep learning architecture [Figure 3]. The first part is standard CNN architecture while the second is only the feature extraction part. Both networks are then forced to produce features for different (pairs) of images. If the images are semantically similar, the output features should be as close as possible.

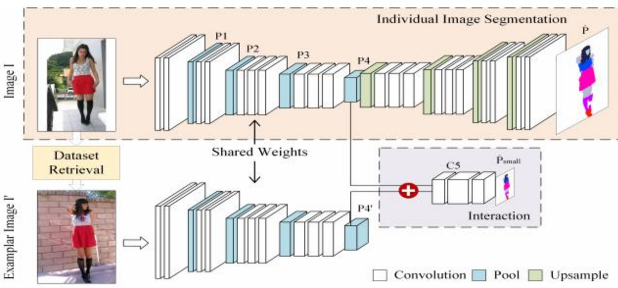

Figure 3. Semantically similar images should have similar weights.

In this paper the contextual knowledge of clothing images is manually defined as finding neighboring images with similar appearances or poses. This is because such images also have similar high-level features. The authors decipher the pose and appearance from the image using OpenPose [2] tool by extracting it from the convolutional layers. To then find the two closest images they use Euclidian distance between the extracted features.

The semantics in this paper are manually defined as a pose and appearance of the model in the image. The method in the end is still incapable of understand semantical meaning of the clothing, but can use it as an additional feature in order to help with training and in the end increases overall accuracy of the model.

3.2 Deep Joint Semantic-Embedding Hashing (DSHE) [3]

The days when searching for similar images meant comparing histograms, colors or metadata attached to the image are long gone. Nowadays the labels for the images are automatically created, for example if the image contains a cat it will be labeled as a cat and so on for every object it contains. This works well for reasonable numbers of pictures, but because of the sheer number of images on the internet it would take too long to compare labels for each image that exists. To solve this problem, a special hash is used that transforms the text label into a vector of 1s and 0s. Ideally the visually (contextually) similar images should have this vector very close to each other when using the Hamming distance. This means that a vector of a dog should be closer to the vector of a cat compared to a vector of a dinosaur, which should still be closer to the pair then to a vector of a truck. The approach is similar to the vectors gained from word embedding described in the previous sections.

Authors in this paper [3] present a new approach to hashing. They use twofold deep architecture [Figure 4], one part of which is tasked with feature extraction (CNN), while the other embeds labels to vectors. The features extracted are then joined in common semantic space, where dependencies between image and labels are learned. By doing so the features extracted from the image are forced to be similar for images with similar semantics.

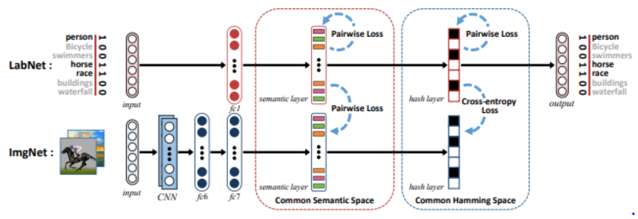

Figure 4. Features extracted from labels and images are joined in second half of the architecture where semantic dependencies are learned.

The semantics used in this paper are hidden and calculated inside the network. The network actually learns deeper connections between labels and the images. The network now not only knows how a cat looks like but also knows that a cat is closer to a dog than it is to a car.

3.3 Semantic Structure-based Unsupervised Deep Hashing [4]

Hashing is becoming increasingly popular for approximate nearest neighbor searching in massive databases due to its storage and search efficiency. Related work shows promising results when learning from labels, however it is significantly more difficult to do the same in an unsupervised setting.

The paper [5] shows that a lot of semantic information can be extracted from features obtain from CNN. Authors first analyze statistical properties from the obtained features. With this information they are able to construct a semantic structure that explicitly captures the semantic relationship across different data points. In the following step they calculate semantical distance between two points using cosine distance. The experiments show that semantically closer features have lower distance - as expected. In the last step they use special loss function that calculates inner product between significantly similar or dissimilar points and use it to train hash codes using deep learning. Network schematics can be seen in Figure 5.

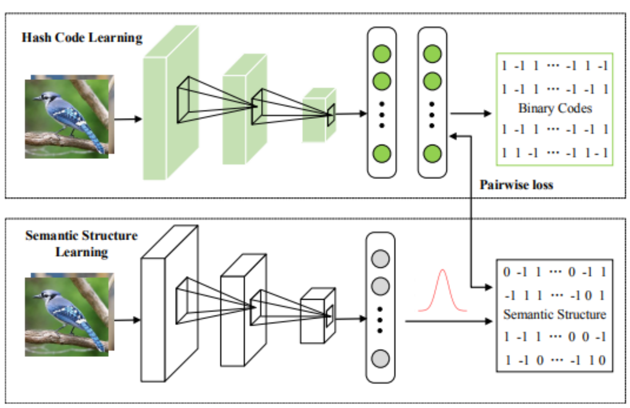

Figure 5. Network architecture. Network first discovers statistical properties from CNN features. Then it learns their hash functions using special loss.

This paper [4] takes the next step and removes the need of semantically labeling the images. It forces the architecture to learn semantic relations without telling it what the main context / feature of detected object is.

3.4 Adversarial Attribute-Image Person Re-identification [6]

In previous sections we described a different approaches in extracting and storing semantical meaning from different types of images. In this section, one possible use case is presented where semantics are used to find or identify a person in an image.

In the previous section [3.2] it was presented how the computer method finds similar images using semantical labels and hash codes. Those approaches work fine; however, they have one major drawback - they require an input image from which they can calculate those features and then search for similar image. However, when humans want to look up for someone or describe it to someone, they usually describe that person's features [Figure 6], for example: Caucasian, male, 1.8m tall, blue eyes, wearing a hat and a blue backpack. If a human were given these instructions it would be easily for them to find a person in a set of images, but for computer methods, on the other hand, this present a major problem.

Figure 6. Person identification using high level descriptors.

The framework described in the paper learns semantically discriminative structure of low-level person images, and generates a correspondingly aligned image-analogous concept for high-level attribute toward image concept. This averts direct estimation of the attributes in a person image and solves the problem of imperfect prediction and low semantic discriminability.

The framework [Figure 7] is trained using adversarial learning approach. This means that part of the network is trying to generate concepts while the other part is trying to distinguish if they are good or not. Both parts of the network are trained simultaneously, learning to be better at their task and thus competing against each other while at the same time improving.

The network again consists of two parts. The first part is tasked with concept extraction from the images, while the other branch is tasked with concept generation from the labels. Both branches are then joined in semantic classification.

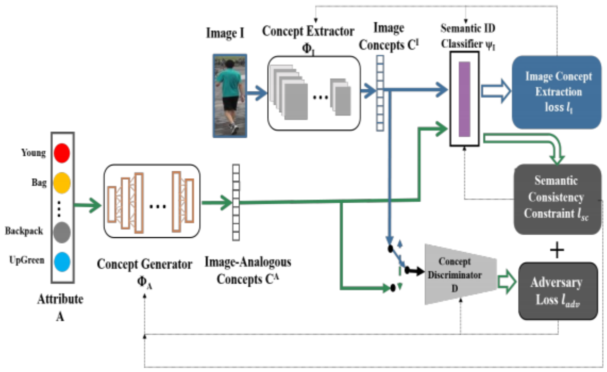

Figure 7. Network architecture has two parts, concept extraction from image and concept generation based from the description.

4. CONCLUSION

In this paper we presented a short overview of latest state of the art methods and approaches that use semantics in several different ways. We first looked at semantic extraction in NLP tasks, more precisely with word embedding, where semantically closer words also have smaller Hamming distance. In later sections we looked at semantics being used primarily as an additional attribute for object recognition in images.

The architectures used are similar across all papers. They consist of two part deep networks, one part is usually tasked with extracting features from the image, while the other part is tasked with extracting semantical meaning, either from labels or learning it on its own. In the next steps both parts are merged, which forces the network to incorporate semantical knowledge into the features extracted from the images.

One can see that semantics are more often than not used as an additional parameter, i.e. feature, which helps the established model achieve better accuracy. The question here is if true understanding of semantics behind could further increase the model's performance and bring us one step closer to true intelligence or even superintelligence. With enough training examples, can an architecture learn the deeper meaning behind the images, words and sentences and use it to better model the real world?

In summary, one of the central questions can be presented as follows: *Can deeper understanding through automated semantic extraction increase the AI performance independently of domain or task?*

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Assessment and Prediction of Auxiliary Carabid Species in Agricultural Fields

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ABSTRACT
Biological pest control depends on the abundance and richness of beneficial species. Development of efficient pest management plans requires new knowledge about complex interactions between the elements of agricultural ecosystems and their natural and management environment. Empirical ecological data represent a big obstacle in the acquisition of this specific knowledge as they are most often, incomplete, inconsistent and imbalanced. In addition, they require a lot of pre-processing for their use in analyses and modelling. In this study, we are dealing with carabid beneficial species that could provide biological pest control in agricultural fields. In particular, our goal is to describe taxonomical and functional diversity of carabid species to assess the potential performance of biological pest control in the studied area and to develop predictive models for the most abundant carabid species and their predator functional group. The results show high potential of carabids to provide biological pest control in the studied area, but the predictive models achieved relatively low predictive performance. They could be improved by an additional set of attributes describing specific habitat requirements of carabid species.

Keywords
Carabidae, beneficial species, data pre-processing, taxonomic and functional diversity, data mining, predictive models

1. INTRODUCTION
Sustainable agriculture enhances biological pest control in order to reduce the use of pesticides and to foster natural biodiversity and improve the quality of the environment.

In this context, the control of pests provided by the natural enemy populations reduces the dependency on plant protection products. Predatory (beneficial) species such as *Syrphidae* (hoverflies), which control aphids, and *Carabidae* (ground beetles), which feed on slugs, are the main natural enemies of these crop pests [1]. To improve the regulation of pests by predatory species, we need knowledge about the effects of landscape, soil and crop management on these beneficial species. This is a demanding research challenge because of two main reasons. The first reason is the complexity of interdependencies among elements of agricultural ecosystems and their interactions with the environment (e.g., climate, soil humidity). The second reason are the empirical ecological data that are many times incomplete, inconsistent, containing out-of-range values, are collected at different temporal and spatial scales, dispersed in different databases, noisy and imbalanced [2]. To obtain new information and knowledge about biological pest control from empirical data, an extensive data pre-processing is needed [3].

The goals of this study was to assess and predict the abundance of predatory species that could perform biological pest control in agricultural fields. In particular, we are exploring the taxonomic and functional biodiversity of ground beetles of the family *Carabidae,* which prey on slugs, that are the most damaging pests to cereal crops.

In this paper, we first present the comprehensive data pre-processing that was carried out in order to obtain high quality datasets. These were later used for assessment of the abundance and taxonomic and functional diversity of carabid species. In the part that follows, we present the predictive models developed by data mining. The paper ends with conclusions and directions for further work.

2. MATERIALS AND METHODS
2.1 Data
Abundance and biodiversity assessment is based on data from field surveys. For the development of the predictive models, we included also data describing the environmental conditions and the applied agricultural practices. Therefore, we used data from several different datasets and data providers.

Specimen data from field surveys were provided by ARVALIS, Institut du vegetal, France. Field surveys of carabid species were conducted in Boigneville (central France) in years 2009 to 2011 and 2013 to 2015. Carabid species were collected in pitfall traps (Figure 1) using a standardized sampling scheme. There were 21 pitfall traps in the period from 2009 to 2011 and 15 for the period 2013-2015. They were placed in four fields and their locations were permanent throughout the study period. Specimens were taken from pitfall traps on a weekly basis between April and July and September and November. The caught specimens were determined to the species level and the number of caught specimens per species was counted. The total number of pitfall samples included in our research was 2873.

To describe the ecological functional traits of carabid species, we used an additional and extensive database "Functional traits of *Carabidae* species" [4], compiled, maintained and provided by ARVALIS. It includes information on species' size, diet (larvae and adults), humidity preferences, wintering habitat, reproduction period and ability to fly. The database contains traits information for 171 carabid species.

Figure 1: Pitfall trap.

Data about the landscape structure and crop properties were obtained for an area within a 500 m radius around each pitfall trap (Figure 2). In the delineated area, the absolute and relative surface of different crops and natural vegetation types were measured, as well as the length of linear corridors (tree lines, grass strips, grass pathways, hedges, roads). Landscape data were obtained from digital maps using GIS software tools. In addition, crop development stages were estimated for each crop in the studied area and crops were grouped into several categories according to the habitat preferences of carabid species.

Soil data were obtained from the ARVALIS soil database, which contains information on chemical, physical and biological soil properties (e.g., soil texture, available water holding capacity, bulk density, etc.).

Climate data were obtained from the French national meteorological station located in Boigneville. Data about maximum, minimum and average temperature, and cumulative rainfall have been collected at daily bases for the period from 1.1.2009 to 31.12.2019.

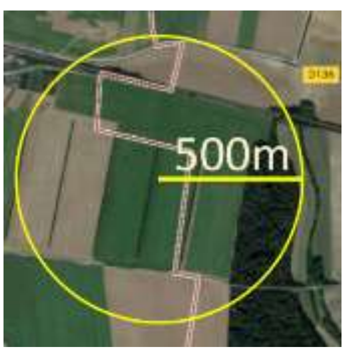

Figure 2: An area within a radius of 500 m around a sampling point for which data about landscape, soil and crop properties was obtained.

2.2 Data pre-processing

The collected data were very heterogeneous and as such their harmonization, normalization and aggregation for the purpose of the analysis and modelling was required. To overcome these problems, we used a lot of modelling and ecological knowledge background. In addition, we followed the standard data pre-processing procedure to ensure high quality of the input data, such as data cleaning, outlier detection, missing value treatment, etc. The data describing the abundance of carabid species were highly imbalanced. Therefore, we used the Inverse Hyperbolic Sine transformation of the abundance data that were later used for development of the data mining predictive models.

In addition, several other attributes describing the taxonomic and functional diversity of carabid species were calculated from the available data. The richness of carabid species was described by the Shannon's and Simpson's diversity indices [2]. To measure the distribution of abundances between species, evenness was calculated [3]. Since the interpretability of individual diversity is hard we combined indices of species richness into Hill numbers (N0, N1, N2), which are very suitable for ecological interpretation [3]. In particular Hill numbers (H0-number of all species, H1-numer of abundant species and H2-number of very abundant species) are calculated from the three most important and known measures of diversity: S-number of species, H'-Shannon's index and λ-Simpson's index [2]. A more detailed explanation of diversity indices is given in the conference paper explaining the diversity of syrphid species that provide biological control of aphid pest species [5].

To describe the habitat diversity in a radius of 500 m around the sampling point, we applied Shannon's and Simpson's indices and evenness indices for landscape diversity as well. The former two describe the habitat richness and diversity and the latter emphasizes the evenness of the landscape categories [2]. Despite the fact that the used indices were initially developed for description of species diversity, they can be used for description of landscape diversity as well. In our case, we used the types of landscape instead of species and instead of abundance, we used the land cover area (m^2) of a particular landscape type.

The presence and activities of carabid species depend on their development stage (e.g., larva, pupa, adult) that is primarily driven by daily temperatures that are expressed in degree-days. Degree-days are the most common phenological indicator in entomological research. Degree-days provide information about the cumulative value of average daily temperature for a time period when the average daily temperature is above the selected minimum threshold. We used the most recommended simple logistic equation for calculation of the degree-days with the minimum temperature threshold of 5^0C. Using degree-days, we can compare the abundance and diversity dynamics of carabid species between years and locations. This could not be done by using calendar dates because the climatic and environmental conditions of the selected dates are different in different years.

The pre-processing of environmental, agricultural, taxonomic and functional data resulted in a dataset containing groups of attributes describing the taxonomic and functional structure of carabid species, soil properties, climatic conditions, landscape and crop properties. The total number of obtained/calculated attributes used was 95 (Table 1).

Table 1: Groups and number of attributes in the final dataset.

Group of attributes	*Number of attributes*
Field description	13
Species description	7
Soil description	7
Landscape description	48
Climatic conditions	7
Temporal component	4
Functional aspect of species	9

2.3 Data mining

To discover the interactions between the attributes describing geographical, environmental and management parameters and abundance of the most abundant carabids, we choose data mining methods for induction of decision trees. They are ideally suited for discovery of relations between attributes in complex ecological data, because they are interpretable and can provide meaningful explanations of the relationships and causalities among attributes. In our case, the dependent variables are the abundance of the selected carabid species and the abundance of the predator functional category, which comprises of all predatory carabid species that have been caught in the fields by pitfall traps.

To develop the predictive models, we applied the M5 algorithm to induce regression trees using the WEKA data mining software. To evaluate the induced data mining models, we used 10-fold cross-validation as the most common and standard way of estimating the performance of a model on unseen cases [6].

3. RESULTS

For the purpose of biological pest control, the abundance of predatory and parasitic individuals is as important as diversity. Analysis of the abundance of all caught carabid species in the studied area shows that at yearly basis three species significantly prevail over the others (Table 2) with *Poecilus cupreus* being the most abundant one (Figure 3). Three species appear as the most abundant in all sampled years and in total as well (Table 2).

Table 2: Relative abundance of carabid species for all years (2009-2011 and 2013-2015).

Carabid species	2009-2011 and 2013-2015 (%)
Poecilus cupreus	53
Pterostichus melanarius	13
Anchomenus dorsalis	7
All other carabid species (98 carabid species)	27

Figure 3: *Poecilus cupreus*, the most abundant carabid species in all sampling years (2009-2011, 2013-2015).

The richness metrics of carabid species are presented in Table 3. The values of the Hill number N2 (N2 – number of very abundant species), which varies from 2.8 to 3.5, and the evenness (values from 0.439 to 0.556) are consistent with the results about the rank abundance of carabid species presented in Table 1. A highly uneven distribution of the abundance is indicated when the evenness index has values far from 0 (i.e., equal distribution of the abundances of all species gives values of evenness index close to 0).

Table 3: Richness indices, evenness and Hill numbers for the carabid species caught at the experimental sites in different years.

Year	Richness metrics			Hill numbers		
	Shannon	**Simpson**	**Evenness**	**N0**	**N1**	**N2**
2009	1.521	0.335	0.556	58	4.6	3.0
2010	1.542	0.354	0.497	68	4.7	2.8
2011	1.905	0.285	0.439	42	6.7	3.5
2013	1.550	0.327	0.555	54	4.7	3.1
2014	1.729	0.316	0.467	60	5.6	3.2
2015	1.733	0.322	0.452	57	5.7	3.1
All	1.680	0.326	0.473	101	5.4	3.1

The functional characteristics of the three most abundant species (*Poecilus cupreus, Pterostichus melanarius, Anchomenus dorsalis*) show that they are all predators throughout all of their life stages (larvae and adults). They avoid dry habitat conditions, they are wintering as adults and they reproduce in spring time.

According to the selection of the independent attributes, we constructed two types of models to predict the abundance of carabid species. The first group of models included the attributes describing the current structure of the carabid species in the sampled fields, such as Hill numbers, evenness, Shannon's and Simpson's indexes. This type of prediction models gave us insight into the interspecies interactions and because of that, we named them "ecological models". However, to use these models for predictions in reality is very demanding because they require very specific data describing the carabid community, which are very hard to obtain. To overcome this practical problem with data, we created a second type of predictive models, where the attributes describing the community structure were not included as independent attributes. The data required to populate this type of models can be easily obtained. This makes the application of the models in reality easier and therefore we named them "management models".

Table 4: Validation performances of the regression trees for predicting the abundances of the most dominant carabid species and the two relevant carabid functional groups for biological pest control.

Predictive models	***Correlation coefficient***		***Mean absolute error***	
	Ecolog. model	***Manage. model***	***Ecolog. model***	***Manage. model***
Poecilus cupreus	0.694	0.628	1.42	1.55
Pterostichus melanarius	0.614	0.542	1.20	1.21
Anchomenus dorsalis	0.318	0.287	1.10	1.15
Predator species – larvae	0.253	0.211	1.48	1.64
Predator species – adults	0.374	0.328	1.24	1.42

We obtained predictive models (regression trees) for the three most abundant carabid species (Table 1) and for two functional groups of predator carabid species, where we made a distinction between larval and adult life cycle development stages. The predictive performances obtained using 10-fold cross validation for all induced predictive models are given in Table 4. The total number of instances was 2873. The abundance is predicted in a weekly time step.

Figure 4: Ecological predictive model for abundance of *Poecilus cupreus.*

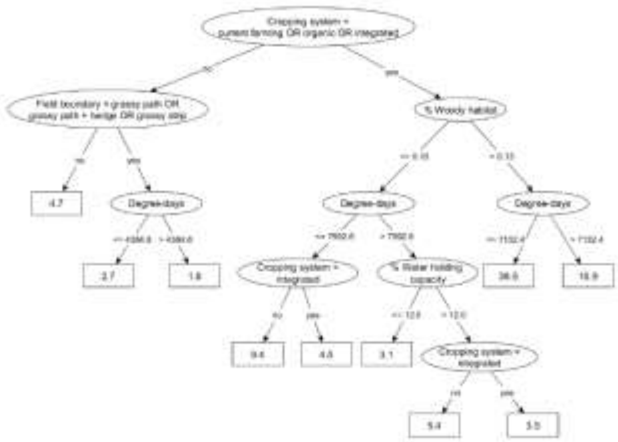

Figure 5: Management predictive model for abundance of *Poecilus cupreus.*

The structure of the ecological model for *Poecilus cupreus* (Figure 4) shows the sensitivity of this carabid species on the presence and abundance of other carabid species and on the habitat type. Its highest weekly abundance appears in conditions of low number of other carabid species and presence of forest habitat. Under such conditions, this species gets very abundant, surpasses other species and it becomes the most abundant one. In the case of absence of attributes describing the carabid community (management model), the abundance of *Poecilus cupreus* depends mostly on the quality of the habitat they are occupying (Figure 5). In particular, the presence of a woody habitat nearby stimulates its abundance. Both models gave consistent and complementary interpretations, which show that *Poecilus cupreus* can be potentially efficient predator of slugs in well preserved agricultural environments and in conditions of low diversity of the carabid community. This is consistent with observations where high abundance of *Poecilus cupreus* in fields is detected in early spring time, particularly if semi-natural habitats, like woodland, are in the vicinity of the fields.

4. CONCLUSIONS

This study has confirmed the complexity of using empirical ecological data. The data pre-processing was the most demanding and time consuming step in the analysis of the taxonomic and functional diversity of carabid species for the construction of predictive models using data mining methodologies.

The results about the taxonomic and functional diversity of carabid species show a great potential for biological pest control in the studied area, as the identified most abundant species of ground beetles are predators of slugs. In addition, the high abundance of the predatory carabids provides an additional quantitative support to the biological control of slugs.

However, the predictive performances of the model are not that promising. Despite the large amount of data and the long list of attributes, we were not able to produce trustable predictive models. The main reason could be having a non-optimal selection of the attributes that ARVALIS used for describing the sampling locations and habitats. The structures of the predictive models indicate that both carabid community and habitat properties influence the abundance of the predicted species. In addition, the attributes describing the temporal variation of environmental conditions appear in the models as well (e.g., degree days, soil humidity). So the models contain all major ecological components that direct the abundance of carabid species.

We can conclude that both the abundance and the diversity (taxonomic and functional) of carabid species in the studied area has high potential to provide efficient pest regulation. Based on the structure of the predictive models, simple guidelines for crop management for enhancement of the biological control of slugs can be proposed (e.g., enlarge woody area, introduce organic or integrated crop production). In addition, we suggest to include additional attributes in the monitoring schema describing habitat conditions that are specific for ground dwelling carabid species. Such additional data would enable us to employ several other data mining methodologies in order to provide significant contribution to the development of efficient biological pest control strategies.

5. ACKNOWLEDGMENTS

This research is supported by the applied project "Structured output prediction with application in sustainable agricultural production" financed by ARRS and co-financed by ARVALIS.

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Taxonomies for Knowledge Representation of Sustainable Food Systems in Europe

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ABSTRACT
Sustainability is becoming a core concept in every area (scientific, social, environmental and economic) of human life. Sustainability acknowledges that human civilization takes resources to sustain our modern way of life and strives towards balancing between our competing needs – our need to continue developing technologically and economically, and the need to protect the environment in which we live. However, sustainability is a very complex concept that incorporates social, environmental and economic aspects and interactions between them and can be described by a number of different sustainability indicators. Therefore, assessing the sustainability of a system is a demanding task and requires gathering and structuring of knowledge from experts, literature surveys and other sources. In this paper, we present the use of taxonomies to represent the complex concept of sustainability of European food systems. Structuring the knowledge on sustainable food systems in Europe is a first step in assessing their level of sustainability. The goal of this study is to use the developed taxonomies as basis for the development of a complex DSS system for assessment of the sustainability of legume food systems across the whole quality chain.

Keywords
Taxonomies, knowledge representation, sustainability, food systems.

1. INTRODUCTION
The world's population is increasing at a speeding rate and with that the production and consumption of food as well. All this comes at an enormous environmental cost. Each year, more than 10 million hectares of arable land are lost to degradation, plant-protection products pollute the rivers and aquifers and one third of all greenhouse gas emissions are due to agriculture [4]. Therefore, a shift to more sustainable agri-food systems is needed in order to address these problems. A formal definition of sustainable food systems given by the Food and Agriculture Organization (FAO) states the following: "A sustainable food system is a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised." [2].

Assessment of the sustainability of a food system is not an easy task, as there is not a simple and measurable indicator to assess it. Instead there exists a set of interrelated concepts and indicators that describe the sustainability from different aspects. The sustainability is defined through three main pillars/aspects: economic, social and environmental pillar/aspect (Figure 1) [7].

The ***economic pillar*** of sustainability represents the economic functions of the food systems, which should provide prosperity (wealth) to the (farming) community and thus refers to the economic viability of the food system. The ***social pillar*** represents several social functions, both at the level of the community, as well as at the level of society (e.g., awareness and legislation protection of the health of people from pollution, or access to basic resources without compromising the quality of life). The ***environmental pillar*** represents environmental functions that are connected to the management and conservation of natural resources (water, air, soil, energy and biodiversity) and fluxes within and between these resources [13].

Figure 1. The three pillars of sustainability and their intersections describing partial (bearability, viability, equitability) and overall sustainability.

In order to assess the sustainability of a food system, one needs to understand and take into account all these different aspects of sustainability, which is a demanding task. This paper describes the first step towards modelling the transition towards sustainable food systems, which is done within the H2020 project TRUE

(TRansition paths towards sUstainable legume based systems in Europe) [12]. In order to set the foundations for the development of a Decision Support System (DSS) for sustainability assessment of legume systems, we carried out an extensive literature survey in order to capture as extensive knowledge as possible on sustainable food systems and all the concepts and indicators connected to that. The knowledge and concepts were organized in a hierarchical structure using taxonomies. This kind on knowledge has not been represented in an organized, systematic and formal way so far. Using these taxonomies, we wrote a glossary of terms, which will serve as a knowledge library when constructing the DSS system.

2. MATERIALS AND METHODS

In order to produce a working protocol for harmonization of data and knowledge to develop the future DSS within the TRUE project, we had to derive definitions of sustainability terms and concepts, and review as much sustainability indicators as possible, which are non-deterministic and ambiguous. For that purpose, we reviewed more than 24 papers and 7 books dealing with different aspects of sustainability of (legume) food systems.

The obtained knowledge from the extensive literature survey was structured using taxonomies. Taxonomies, like ontologies, provide ordered/structured representation of concepts and terms in a form of a hierarchy. They are semantic classification schemes and represent a knowledge map [6]. They are *classification schemes*, because they group related things together, so that if you search one thing within a category, it is easy to find other related things in that category. They are *semantic* because they provide a vocabulary to describe the knowledge in them. Finally, if the taxonomy is complete, it should provide an immediate grasp of the overall structure of the knowledge domain it covers.

Many of the taxonomies have hierarchical tree structures. The tree structure is the most intuitive representation, because it provides a visual representation of the relationships between categories and sub-categories, enabling navigation between categories. However, they can be represented in other forms, such as:

- Lists
- Trees
- Hierarchies
- Polyhierarchies
- Matrices
- Facets
- System maps.

The taxonomies presented in this paper are represented in a tree structure and discussed in the Results section.

3. TAXONOMIES FOR SUSTAINABLE FOOD SYSTEMS: RESULTS AND DISCUSSION

The taxonomy describing the knowledge on sustainability of food systems in Europe starts by the general sustainability aspect of European food systems (Figure 2). It incorporates sustainability in its general form, sustainability level, sustainability indicators and sustainability assessment.

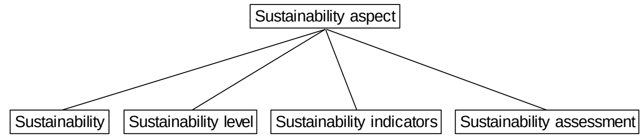

Figure 2. Top level of the taxonomy, decomposing the sustainability aspect into four sublevels: sustainability, sustainability level, sustainability indicators and sustainability assessment.

3.1 Sustainability

The general sustainability as described in the Introduction section, consists of three sustainability pillars: *environmental, social* and *economic* [5, 11]. True sustainability requires a balance between the environmental, social and economic aspects describing it. Besides these, the intersections between them (*bearability, viability* and *eqitability*) are also an important partial aspect of the sustainability as a whole (Figure 3) [5].

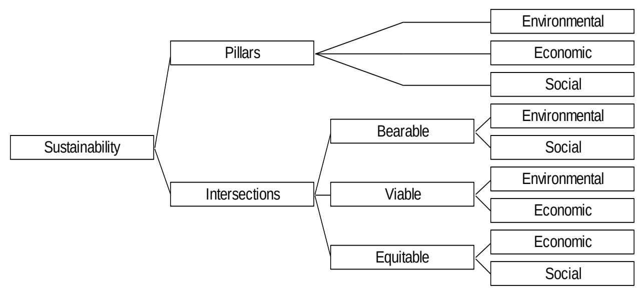

Figure 3. Decomposition of the "Sustainability" part of the taxonomy.

Bearability is the intersection between the environmental and social sustainability pillars. It represents a system that is both environmentally and socially sustainable, but lacks an economic sustainability [11]. *Viability* is the intersection between the environmental and economic sustainability pillars, and e*quitability* is the intersection between the economic and social sustainability pillars.

3.2 Sustainability Level

The next part of the taxonomy represents the concepts connected to the sustainability levels, with respect to the different spatial and temporal scales of sustainability. The sustainability levels can be observed and defined through different aspects (Figure 4):

- Normative
- Spatial
- Temporal
- Systems

Normative level refers to the building blocks (aspects) of sustainability (environment, economic, social), which we described earlier, as well as their interactions (equitability, viability, bearability) [3].

The *spatial level* of sustainability refers to the spatial specifics of sustainability. Sustainability of a food system can be considered/assessed on a local, regional, national or international level [3].

The *temporal* aspects of sustainability refers to the time horizon of the sustainability assessment.

Finally, the boundary of the (food) system under consideration should be defined, the hierarchy of aggregation levels and their interactions for descriptive, assessment and management purposes in relation to sustainable development, which gives us the *system level* of sustainability [3].

3.3 Sustainability Indicators

Indicators are quantified information, which explain how things are changing over time. The sustainability indicators measure the sustainable development and its progress. They have to reflect the definition of sustainability and be able to connect partial conditions to policies for sustainable development and monitoring its progress [9]. Indicators are used to compare the actual state of the system with reference values for sustainability (sustainability assessment), or with the state of the system in the past and in the future (sustainability monitoring) [13]. The part of the taxonomy addressing the Sustainability indicators is given in Figure 5.

Sustainability indicators should satisfy certain *criteria*, which represent specific objectives relating to a state of the system. The criteria should consider the environmental, economic and social characteristics of the system. They must provide specific conditions for the development of sustainability indicators that will have analytical soundness and will be measurable and suitable for application at different scales (e.g., farm, district, country, etc.).

The actual *indicators* are variables of any type that can be induced from the sustainability criteria and can provide information about the potential or realized effects of human activities on the sustainability of the food system. These are variables that can be used to assess both the socio-economic and environmental conditions of the food system, to monitor trends and conditions over time, to provide early warning signal of change and a solid basis for decision making processes, consistent with sustainable development principles at all levels [1, 10]. The indicators can be also used to reduce the complexity of the system description and integrate information about processes, trends or states into a more readily understandable form at local, regional and global levels.

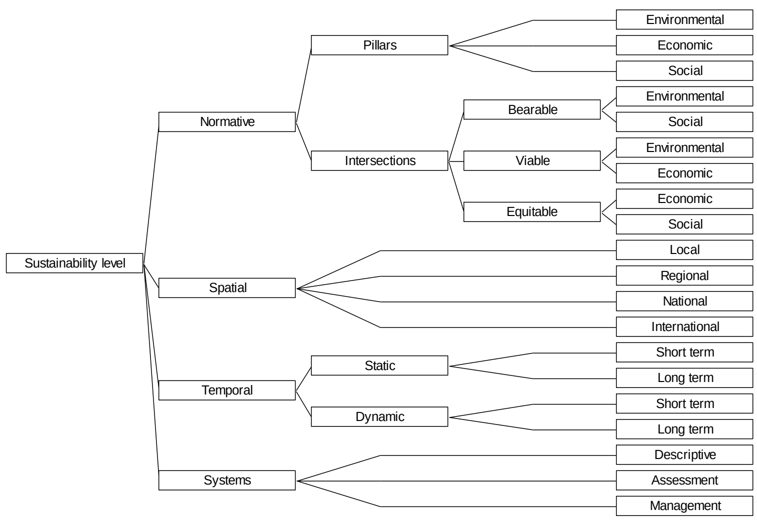

Figure 4. Decomposition of the "Sustainability level" part of the taxonomy.

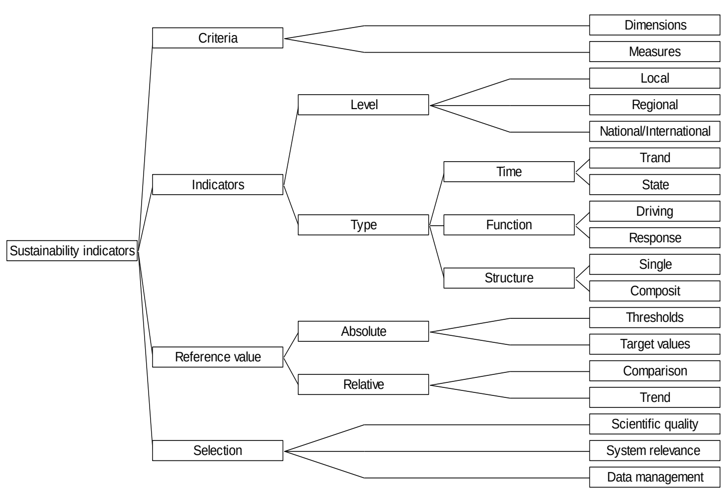

Figure 5. Decomposition of the "Sustainability indicators" part of the taxonomy.

The indicators can have different *levels* [3, 8, 10]:

- *Local* – measure the state of the system regarding sustainability
- *Regional* – compare the system's performance from an economic, social and environmental aspect
- *National/international level* – inform policy makers about the current state and trends in sector performance and facilitate public participation in sustainability discussions.

The *type* of indicators refers to their functional category according to their purpose of use. According to the type, the indicators can describe [1]:

- *Time-related issues*:
  - Trend indicators – describing temporal dynamic aspects of sustainability over time
  - State indicators – describing the condition of the assessed system at a certain time point
- *Function-related issues*:
  - Driving indicators – measure the changes of the assessed food system due to management practices and other farming inputs
  - Response indicators – measure the response of a system to the induced management changes or inputs
- *Structure-related issues*:
  - Single indicators – characterizing single parts of the food system
  - Composite indicators – aggregate environmental, social and economic indicators into a unique measure describing complex functions and processes of the system.

The *reference values* of the sustainability indicators refer to the desired level of sustainability for each indicator. They are established on scientific or empirical basis and can be presented as absolute (fixed) values, as threshold values, or as relative reference values according to a selected baseline [13].

Finally, the *selection* of indicators should be made according to their scientific quality, system relevance and data management principles.

4. CONCLUSIONS

Structuring and organizing domain knowledge in a structured and formalized way, using taxonomies, is a crucial first step towards understanding complex problems and concepts. It also represents a crucial pre-processing step, which sets the basis for data mining analyses or development of Decision Support Systems.

Within the TRUE project, the taxonomies for knowledge representation of sustainable food systems in Europe were "translated" into a glossary of terms, which will be evaluated by a group of domain experts. In that way, they will validate and confirm the structure of the taxonomy.

The obtained knowledge on sustainability of European food systems, represented using taxonomies will represent the basis for the development of a complex Decision Support System for finding transition pathways towards sustainable legume-based food systems.

5. ACKNOWLEDGMENTS

This research is supported by the TRUE project, funded by the EU Horizon2020 Research and Innovation Programme, Grant Agreement number 727973.

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Uporaba povezave kalkulacijskega simulacijskega modela z analizo tveganja pri podpori odločanja v kmetijstvu

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POVZETEK

Kmetijska gospodarstva se pri načrtovanju pridelave neprestano odločajo o načinu proizvodnje, izbiri poljščin in količini pridelave. Pri tem se soočajo z vprašanjem kako ob čim manjšem ekonomskem vložku ter obvladovanju pridelovalnih in okoljskih tveganj zagotoviti optimalen ekonomski rezultat. Raziskava obravnava sistem za podporo odločanja, ki temelji na integraciji simulacijskega modela ekonomske kalkulacije in sistema analize ekonomskega tveganja na primeru pridelave ječmena, fižola in koruze v premenah hmelja. Rezultati simulacijskih modelov in analiz tveganja so pokazali, da je v premenah hmelja najboljše ekonomske kriterije dosegla pridelava fižola. Zaključki naše raziskave govorijo v prid povečanju pridelave stročnic, ki predstavljajo trajnostno možnost za povečanje samooskrbe z rastlinskimi beljakovinami in zmanjšanju obremenitve okolja z negativnimi vplivi kmetijske pridelave.

Ključne besede

Sistem za podporo odločanja, kmetijska pridelava, ekonomske kalkulacije, ekonomsko tveganje, hmeljarstvo, trajnostno kmetijstvo

1. UVOD

V kmetijstvu ekonomsko upravičenost skupnih stroškov pridelave ugotavljamo s pomočjo ekonomskih kalkulacij, ki so eno od osnovnih orodji za planiranje in podporo odločanja v kmetijskem menedžmentu. Na podlagi kalkulacij so ocenjeni skupni stroški pridelave in izračunani indikatorji ekonomske uspešnosti, kar predstavlja osnovo za nadaljnje načrtovanje kmetijske pridelave [7].

Tveganje je pomemben poslovni vidik v kmetijstvu. Visoka proizvodnja in cenovna tveganja so postala stalnica kmetijske proizvodnje in so v večji meri odraz nepredvidljivega obnašanja naravnih dejavnikov (vreme, škodljivci, bolezni, itd.). Uspešnost obvladovanja teh tveganj vpliva na ekonomsko uspešnost kmetijskih gospodarstev, saj napačne odločitve hitro vodijo v zmanjšanje dohodka. Kmetijski pridelovalci so pri tem soočeni s kompleksnostjo odločevalskega problema saj so primorani sprejemati številne odločitve tako na vsakdanjem nivoju, kot tudi na nivoju dolgoročnejših investicij [6].

Doseganje boljšega in predvsem stabilnejšega rezultata kmetijske pridelave je zato zelo odvisno od obvladovanja tveganja v procesu odločanja. V načrtovanju kmetijske proizvodnje zato spremljanje in ocenjevanje tveganja predstavlja zelo pomemben segment v procesu spremljanja in načrtovanje kmetijske pridelave [4].

Zaradi velike odvisnosti od uvoza hrane in krme se v Sloveniji premalo zavedamo kako pomembno je varovanje in ohranjanje kmetijskih pridelovalnih zemljišč za samooskrbo pridelave hrane [2]. Učinkoviti sistemi ekonomskega upravljanja in obvladovanja tveganja bodo omogočili učinkovitejše upravljanje s tem naravnim virom ob hkratnem zagotavljanju kvalitetnega življenjskega standarda prebivalstva, ki mu kmetijstvo predstavlja osnovno ekonomsko dejavnost. Od tega je odvisna tudi sposobnost ohranjanja kmetij in agrarne krajine.

Kmetijska gospodarstva se morajo neprestano prilagajati spremembam lokalnih in globalnih družbeno ekonomskih dejavnikov. Okoljska in gospodarska razvojna politika od pridelovalcev zahteva povečevaje pridelave in izboljševanje njene kakovosti ob hkratnem upoštevanju vse bolj zahtevnih kriterijev trajnostnega kmetijstva.

Pridelava hmelja predstavlja eno od zelo potencialnih kmetijskih dejavnosti glede možnosti izpolnjevanja kriterijev in zahtev sodobne družbe glede trajnostne pridelave hrane [5]. Hmelj je trajnica in kot večletna monokultura negativno vpliva na kvaliteto tal. Povečuje zbitost tal in zmanjšuje količine aktivnega humusa v tleh [9]. Da bi odpravili tovrstne negative vplive na tla in da bi nasade zavarovali pred povzročitelji bolezni in škodljivci, se na površinah za pridelavo hmelja, hmelj za krajše obdobje nadomesti z drugimi poljščinami, kar imenujemo premena [3].

Osrednji cilj raziskave je izgradnja sistema za podporo odločanja, ki temelji na integraciji simulacijskega modela ekonomske kalkulacije in sistema analize ekonomskega tveganja na primeru pridelave ječmena, fižola in koruze v premenah hmelja. S pomočjo izbranih kriterijev tveganja ocenimo posamezne alternative, ter izberemo tisto, ki je glede na specifiko konkretnega primera premene hmelja najustreznejša. Izračuni, ocenjeni na osnovi uporabljene metodologije tveganja in predpostavljenih ekonomskih parametrov pridelave na modelni kmetiji, predstavljajo pomembno podporno orodje za nosilčeve nadaljnje odločitve.

Preostali del prispevka je strukturiran kot sledi. Opis podatkov in zasnova so predstavljeni v poglavju 2. Sledi opis obravnavanih metod v poglavju 3. Rezultate razprave predstavimo v poglavju 4 in zaključimo v poglavju 5.

2. PODATKI

Raziskava analizira podatke pridobljene iz referenčne kmetije izbrane v Žalcu v spodnji Savinjski dolini. Kmetija je poljedelsko-živinorejska, integrirano usmerjena, s 25 ha pridelovalne površine hmelja. V premenah hmelja trenutno pridelujejo izmenično koruzo, fižol in ječmen (Slika 1). V prihodnosti želijo kmetijo preusmeriti zgolj v poljedelsko dejavnost. Podatke, ki opisujejo trenutno stanje na kmetiji smo pridobili z osebnim intervjujem lastnika kmetije in sodijo v obračunsko leto 2017.

Slika 1: Premena hmelja z visokim fižolom

3. METODE

Za reševanje problemov ekonomske upravičenosti pridelave in tveganja smo uporabili izviren pristop integracije dveh sicer pogosto posamično uporabljenih metod, ki jih uporabljamo v načrtovanju pridelave na nivoju kmetije. Z njuno uporabo lahko z različnih zornih kotov ovrednotimo razvoj kmetijskih gospodarstev in pokažemo možnost povečanja dodane vrednosti v kmetijstvu.

3.1 Kalkulacijski modeli

Ekonomske kalkulacije v kmetijstvu zahtevajo uporabo kvalitetnih vhodnih podatkov [10], ki smo jih v našem konkretnem primeru zagotovili.

Kalkulacije so samostojni simulacijski modeli, ki na podlagi opredeljenih (izbranih) vhodnih atributov omogočajo oceno porabe vnosov v kmetijsko proizvodnjo (npr. semena, gnojila, krmila, škropiva, gorivo, najem strojev…) in s tem oceno skupnih stroškov pridelave kmetijskih pridelkov oz. proizvodov [7]. Poraba vnosov je odvisna od intenzivnosti pridelave, pridelovalne površine, oddaljenosti od kmetije, nagiba terena itd. Za razliko od t.i. kalkulacij pokritja, modelne kalkulacije pri posameznem pridelku neposredno vključujejo vse skupne stroške pridelave, ki so povezani s proizvodnjo in ne samo spremenljive stroške, kar omogoča tudi neposredno primerjavo skupnih stroškov pridelave s skupnim prihodkom ter izračunom različnih ekonomskih kazalcev. Za potrebo naše raziskave smo uporabili v nadaljevanju na kratko opisane kazalce:

$$SS = FS + VS$$

Skupni stroški pridelave (SS) predstavljajo seštevek fiksnih stroškov (FS) (zavarovanja, obresti kreditov, plače delavcev) in variabilnih stroškov (VS) (stroški ki so odvisni od obsega proizvodnje, npr. stroški amortizacije…) [11].

$$FR = VP - SS$$

Finančni rezultat (FR) predstavlja razliko med skupnim pridelkom proizvodnje (VP) in skupnimi stroški pridelave (SS) [11].

$$VP = Y \times C_y \times PR + Y_1 \times C_{y1}$$

Vrednost pridelave (VP) predstavlja zmnožek količine pridelka (Y) in njegove cene (C_y), pomnoženega s površino pridelka (PR), k temu pa prištejemo še količino stranskega pridelka (Y1), (npr: pri koruzi je stranski pridelek slama), pomnoženega s ceno stranskega pridelka (C_{y1}) [11].

$$LC = SS/Y$$

Lastna cena (LC) predstavlja višino skupnih stroškov pridelave za proizvodnjo enote izbranega pridelka (proizvodnja enota pridelka je definirana kot vrednost pridelave za 1 kg pridelka). Izračunan je kot koeficient med skupnimi stroški pridelave (SS) in količino pridelka (Y) in je ekvivalent prelomni ceni proizvoda [11].

$$KE = SP/SS$$

Koeficient ekonomičnosti (KE) predstavlja razmerje med skupnimi prihodki (SP) in skupnimi stroški pridelave (SS). Z njim ugotavljamo gospodarnost poslovanja. Če je koeficient ekonomičnosti večji od ena pomeni, da je poslovanje ekonomično in obratno [11].

Glavni namen kalkulacij je spremljanje skupnih stroškov pridelave. S tem pridobljene informacije predstavljajo kmetu osnovno informacijsko podporo za odločanje v načrtovanju proizvodnje, načrtovanju nadaljnjih investicij in ostalih aktivnosti na kmetiji.

3.2 Analiza tveganja v kmetijstvu

Deregulacija trgov, spremembe glede potreb po hrani in druge družbene zahteve (npr. trajnost), ter vplivi podnebnih klimatskih sprememb vodijo v vedno večja cenovna, pridelovalna in dohodkovna nihanja in posledično s tem tudi v povečevanje tveganja v kmetijstvu [1]. Tveganje na kmetijskih gospodarstvih ne smemo zanemariti, saj poskušajo nosilci odločanja v kmetijstvu tveganja obvladati in predvsem tudi zmanjševati [6].

Med kmetijskimi gospodarstvi obstajajo pomembe razlike v izpostavljenosti, zaznavanju in upravljanju tveganja. Učinkovito obvladovanje tveganja je eden izmed ključnih dejavnikov uspešnega poslovanja. Nosilci kmetijskih gospodarstev lahko pri upravljanju s tveganjem izbirajo med različnimi ukrepi in orodji. Kaj bo posameznik izbral, pa je odvisno od njegove naklonjenosti tveganju in okoliščinam v katerih kmetuje [12] .

Za analizo tveganja je potrebno zapisati tako imenovano tabelo odločanja (Tabela 1), ki se uporablja pri vseh kriterijih tveganja. V tabeli prikažemo vse alternative (A) kot vrstice (kjer i= 1, 2,…m) in stanje (S) kot stolpce (kjer j=1, 2,…n). R_{ij} nam ponazarja ekonomski donos za izbrano alternativo A_i, če pride do stanja S_j in p nam ponazarja porazdelitev verjetnosti, ki velja za S (niz verjetnosti p_j, ki opisuje verjetnost, da se bo stanje S_j zgodilo).

Tabela 1: Tabela odločanja

A	S			
	S_1	S_2	…	S_n
	p_1	p_2	…	p_n
A_1	R_{11}	R_{12}	…	R_{1n}
A_2	R_{21}	R_{22}	…	R_{2n}
…	…	…		…
A_m	R_{m1}	R_{m2}	…	R_{mn}

V naši raziskavi smo kot modelno poljščino obravnavali pridelavo hmelja, kjer se v premenah na isti pridelovalni površini pridelujejo tudi druge poljščine. Pridelavo poljščin smo analizirali s pomočjo petih kriterijev tveganja, ki so v naslednjih podpoglavjih na kratko opisani. Pri tem je potrebno poudariti da uporaba različnih kriterijev, lahko pripelje do izbere različnih alternativ.

3.2.1 *Waldov kriterij (MaxMin)*

Waldov kriterij ali *MaxMin* kriterij je kriterij pesimizma, kjer odločevalec upošteva le najmanjše vrednosti alternativ in izbere alternativo ki ima izmed najnižjih najvišje rezultate. *MaxMin* kriterij vpliva na odločevalčevo zavest, kateri si prizadeva zagotoviti, da v primeru negativnega izida, obstaja vsaj minimalno izplačilo[8].

3.2.2 *MaxMax kriterij*

Kriterij imenujemo tudi optimističen kriterij in je ravno nasprotje MaxMin metode. Je optimističen in agresiven pristop k odločitvi pod pogojem negotovosti. Z MaxMax kriterijem bo odločevalec vedno računal na najboljši izid pri vsaki alternativi. MaxMax pravilo je primerno za ekstremne optimiste, kateri pričakujejo najbolj udoben položaj [8].

3.2.3 *Hurwizcev kriterij (H)*

Hurwizc pristop poskuša vzpostaviti ravnovesje (sredino) med *MaxMax* in *MaxMin* kriteriji. Namesto ob predpostavki popolnega optimizma ali pesimizma, Hurwicz uporabi parameter (α), ki je na intervalu med 0 in 1 in jo odločevalec izbere subjektivno [8].

Če je vrednost α bližje 1, pomeni absolutni optimizem in velja *MaxMax kriterij* (maksimalna vrednost maksimalne vrednosti prihodka na letni ravni)

Če je vrednost α bližje 0, pomeni daje absolutni pesimizem in velja *Waldov MaxMin kriterij* (maksimalna vrednost minimalne vrednosti prihodka na letni ravni)

Vrednost α nam hkrati poda koeficient pesimizma 1-α, ki odraža odločitev odločevalca na tveganje. Hurwiczovo tehtno povprečje se sedaj lahko izračuna za vsako alternativo A_i [8].

$H(A_i) = \alpha$ (vrstica alternative z maximum vrednostjo) + (1-α)(vrstica alternative z minimum vrednostjo) je pozitiva (dobiček, prihodek)

$H(A_i) = \alpha$ (vrstica alternative z minimum vrednostjo) + (1-α)(vrstica alternative z maximum vrednostjo) je negativna (stroški, prihodek)

3.2.4 *Savageov kriterij (MinMax)*

Z drugim imenom poznan tudi kot *MinMax* kriterij obžalovanja. Je pesimistični pristop, ki proučuje obžalovanje, izgubo [8]. Ta kriterij se povsem osredotoča na izogibanje najhujših možnih posledic, ki lahko nastanejo pri odločanju [8].

Izguba priložnosti (OL) se definira kot razlika izplačil med najboljšim možnim izidom pod pogojem S_j in dejanskim rezultatom iz izbire A_i, če se pojavi S_j. To pomeni, da če izbrana alternativa poda najvišjo možno vrednost, potem izguba ni prisotna in je definirana kot vrednost nič.

Savageov kriterij je definiran kot:

OL_{ij} = (stolpec stanja j maximum izplačil) - R_{ij}, je pozitivna (upoštevamo dobiček, prihodek)

$OL_{ij} = R_{ij}$ - (stolpec stanja j minimum izplačil) je negativna (upoštevamo vrednost stroškov)

Rij ponazarja vsoto vrstic i in stolpcev j v tabeli odločanja (poglavje 3.2). Najboljši možen rezultat je 0 – kar pomeni, da ni obžalovanja. Višja kot je vrednost rezultata, večje je obžalovanje za odločitev.

3.2.5 *Laplaceov kriterij*

Ta kriterij je realističen, ter izhaja iz principa maksimalnega neznanja. Po Laplaceovem kriteriju predpostavljamo, da so vsi rezultati enako verjetni, kjer vrednosti med seboj seštejemo ter določimo alternative z najvišjo dano vrednostjo. Odločevalec lahko izračuna iz vsake vrstice tabele odločanja (Tabela 1) povprečno vsoto, kot rezultat pa izberemo najvišjo povprečno vrednost vrstice [8]. Pravilo Laplaceove odločitve:

1. Dodajte $p_j = P(S_j) = 1 / n$ vsaki S_j v S, za j = 1, 2, ..., n.
2. Za vsako A_i (vrstica matrike izplačil) izračuna pričakovano vrednost (E): $E(A_i) = \Sigma_j\, p_j\, (R_{ij}) = p_j\, \Sigma_j\, R_{ij}$.
3. Kot optimalno odločitev izberemo najboljšo vrednost alternative $E(A_i)$, ki najboljše predstavlja dobiček in minimalno predstavlja stroške.

4. REZULTATI IN RAZPRAVA

Raziskava je zasnovana v dveh sklopih. V prvem sklopu smo razvili modelno matematično orodje za analizo ekonomske upravičenosti posamezne pridelave. Pridobljene rezultate smo nato v drugem sklopu prenesli in uporabili pri analizi tveganja v kmetijstvu. Z integracijo kalkulacije in tveganja smo odločevalcu omogočili dodatno natančnejšo vrednotenje alternativ ter s tem zanesljivejše odločanje.

4.1 Rezultati kalkulacij

S simulacijskim kalkulacijskim modelom smo za vsako od treh obravnavanih poljščin (fižol, ječmen in koruzo) ocenili njihove glavne ekonomske kazalce, predstavljene v poglavju 3.1 (Skupne stroške pridelave (SS), skupne prihodke (VP), lastno ceno (LC), koeficient ekonomičnosti (KE) in končni finančni rezultat (FR)), ki temeljijo na podatkih iz obravnavane kmetije. Izračuni so pokazali, da so največji skupni stroški pridelave nastali pri pridelavi fižola, medtem ko so najnižji skupni stroški pridelave bili pri ječmenu (Tabela 2). Analiza ekonomičnosti pridelave je pokazala, da je najvišjo vrednost pri glavnih ekonomskih kazalnikih dosegala pridelava fižola, najslabše rezultate pa je kljub boljši lastni ceni od koruze prejela pridelava ječmena (Tabela 2).

Tabela 2: Rezultati analize ekonomičnosti

	Skupni stroški pridelave (eur/ha)	**Finančni rezultat (eur/ha)**	**Lastna cena (eur/kg)**	**Vrednost proizvodnje (eur/ha)**	**KE**
Fižol	**4378**	**3032**	**0,89**	**7411**	**1,7**
Koruza	**2026**	**1303**	**0,10**	**3330**	**1,6**
Ječmen	**1505**	**457**	**0,28**	**1962**	**1,3**

Koeficient ekonomičnosti (KE) je vseh treh primerih večji od ena (Tabela 2), kar pomeni da je prodajna vrednost večja od skupnih stroškov pridelave (poglavje 3.1). Pridelava fižola je tako kljub najvišjim skupnim stroškom pridelave, iz ekonomskega vidika najustreznejša poljščina za pridelavo v premeni hmelja (Slika 2).

Slika 2: Finančni rezultat kalkulacij

4.2 Rezultati tveganja

V okviru ekonomske analize smo kot vhodne podatke za nadaljnjo analizo kriterijev tveganja uporabili finančne rezultate pridobljenih v prvem delu raziskave (poglavje 4.1).

Tabela 3 prikazuje tabelo odločanja (poglavje 3.2), ki prikazuje vrednosti prihodka na letni ravni in sicer glede na različne scenarije potencialne prodaje pridelka (p), (100%, 80% in 50% možnostjo prodaje).

Tabela 3: Tabela odločanja vrednosti prihodka različnih poljščin (alternativ) na letni ravni glede na različne scenarije prodaje

	Možni scenariji		
Možni scenariji	**Scenarij 1 (p_1 = 1.00): 100% prodaja (eur/ha)**	**Scenarij 2 (p_2 = 0.80): 80% prodaja (eur/ha)**	**Scenarij 3 (p_3 = 0.50): 50 % prodaja (eur/ha)**
A1 - fižol	3032	2426	1516
A2 - koruza	1304	1043	652
A3 - ječmen	457	366	228

Če primerjamo rezultate analize tveganja pridelave obravnavanih poljščin (Tabele 4) vidimo, da Waldov kriterij predlaga alternativo A1 - fižol z dobičkom 1516 EUR/ha. Najvišji donos za pridelovalca kažejo izračunane vrednosti za MaxMax kriterija, ki predlaga alternativo A1 - fižol, v vrednosti 3032 EUR/ha. Prav tako prikaže najboljši donos alternative A1 - fižol Hurwicz in Laplacov kriterij. Poudariti je potrebno da smo pri Hurwicz kriteriju uporabili koeficientom optimizma, ki je v našem primeru znašal (k=0,7), ter koeficientom pesimizma, ki smo ga izračunali kot: 1- koeficient optimizma (k=0,3). Po Savage kriteriju pa se odločimo za alternativo A2 - pridelava koruze, s čim bi dosegli 1728 EUR/ha.

Tabela 4: Skupni rezultati analiz tveganj

Kriterij tveganja	**Odločitev**
Waldov kriterij pesimizma - MAXMIN	A1 – fižol
Kriterij optimizma - MAXMAX	A1 – fižol
Hurwiczov kriterij za koef.optimizma = 0,7	A1 – fižol
Savageov kriterij - MINMAX	A2 - koruza
Laplaceov kriterij	A1 - fižol

Rezultati so pokazali, da je z ekonomskega vidika kot najbolj primerna odločitev izbira alternative A1 - fižol. Slednje pomeni, da je ekonomsko najučinkovitejše, da obravnavana kmetija v premeni hmelja prideluje fižol.

5. ZAKLJUČEK

Cilj raziskave je bil izgradnja sistema za podporo odločanja, ki temelji na kalkulacijskem modelu za oceno kmetijske pridelave ječmena, fižola in koruze v premenah hmelja, ter s pomočjo pomembnejših kriterijev tveganja opredeli katera izmed izbranih alternativ je za izbrano kmetijo ekonomsko najugodnejša. Predstavljeno metodo lahko zlahka prenesemo v proces izbire tudi drugih poljščin in v druge pridelovalne procese. Želeli smo oblikovati trajnostne smernice za razvoj kmetije in z izračuni ocenjenimi na osnovi uporabljene metodologije razviti podporno orodje za pridelovalčeve nadalje odločitve, ki bodo poleg ekonomskih kazalnikov upošteval tudi tveganje, ki je v kmetijstvu močno prisotno. Zavedati se moramo da je znižanje tveganja možno le do določene mere in da se bo tveganje v prihodnje, verjetno samo še povečalo. Ključno merilo tveganja je variabilnost obsega proizvodnje, ki je tesno povezana z tipom proizvodnje. Tako je npr., variabilnost rastlinske pridelave bolj povezana z vremenskimi vplivi kot živinorejska. Ob tem velja izpostaviti, da tveganje samo po sebi še ne pomeni škode. Ta nastane takrat, ko se predvideno tveganje tudi zgodi, kar povzroči negativne ekonomske posledice.

6. ZAHVALA

Raziskavo podpira TRUE projekt, ki ga financira program EU za raziskovanje in inovacije Horizon2020, sporazum o dodelitvi sredstev št. 727973.

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Hierarchical Multi-label Classification for Activity Recognition

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ABSTRACT

Activity recognition using wearable sensors is very important in many domains of health monitoring and is therefore well researched. Most commonly classification considers all activities to be 'equal' (we will use term flat classification). However, intuition suggest better results could be achieved using a hierarchical approach for classification. In this paper we compare three different approaches to classify activities: (i) *Flat classification* - classes are equal and we build one model to classify all of them; (ii) *Multi-model hierarchical classification* - classes are arranged in trees, we build different models to classify activities on different levels. We apply two different approaches; (iii) *Hierarchical classification using CLUS* software[1].

Keywords

Activity recognition, hierarchical multi-label classification, wearable sensors

1. INTRODUCTION

Activity recognition (AR) using wearable sensors has been addressed many times, some of the most important application being personalized health systems. Many of developed methods for recognizing different activities used triaxial accelerometers worn on different body parts. With development of wrist-worn devices in past several years and with their growing popularity in everyday life, methods for recognizing sports activities [2], daily activities [3] and hand-specific activities [4] using just wrist-worn sensors were proposed. Although the performance gets better with adding additional body sensors, as Attal and al. [1] proved in 2015 by reviewing the research done by then, we decided to focus our research on wrist-worn sensors due to before mentioned accessibility and popularity.

Vens and al. [6] defined hierarchical multi-label classification (HMC) as a variant of classification, that differs from normal classification in two ways: (1) a single example may belong to multiple classes simultaneously; and (2) the classes are organized in a hierarchy: an example that belongs to some class automatically belongs to all its superclasses, the so-called *hierarchy constraint.*

Although hierarchical approach might seem quite intuitive for AR, as certain activities are pretty obvious grouped together, the usage of hierarchical classification for AR has only been addressed a few times. None of the cases was specifically directed towards usage of wrist-worn device for recognizing different hierarchical activities (physical, daily, hand-movement activities). Khan and al. [8] proposed a hierarchical recognizer for recognition of limited amount of physical activities (static, transitions, dynamic) using a chest-worn sensor device. Zheng [9] explored human activity based on the hierarchical feature selection and classification framework. He explored 2D and 3D motion (jumping, running, walking forward/left/right, upstairs/downstairs, static activities).

2. DATASET

The dataset we are working with consists of data from seven people involved in different activities (sport, rest, handwork, eating chores...). We organize the activities in hierarchy as presented in Table 1. First we tried to create structure tree by using Orange[2] software for hierarchical clustering. We calculated features as will be explained later in paper and put them into Orange software. We were looking for some indications of the hierarchy for different groups of activity. However, there was no clear or extremely obvious structure visible. The final structure was designed using knowledge achieved from previous research on the same dataset where flat classification (for instance in research made by Cvetkovic et al. [4]) has been used for recognition of activities.

Table 1: Activity grouping

Group	Activity
Daily activities	chores eating handwork washing
Exercise	nordic running walking
Static	lying sitting standing

3. METHODS

In this paper we are comparing three different approaches for activity recognition. First we addressed flat classifica-

[1]https://dtai.cs.kuleuven.be/clus/index.html

[2]https://orange.biolab.si/

tion, which is commonly used in previous research. Next, we implemented two multi-model hierarchical algorithms, based on approach proposed by Paes et al.[11]. We use the term multi-model as different models were used for different levels of hierarchy. Finally we used Clus software, which has algorithms for hierarchical multi-classification (HMC) already implemented and is mostly used in the field of functional genomics and text classification as shown by Vens et al.[6].

The users were wearing a wearable device (wristband or smartwatch) on their non-dominant hand. For the purpose of this paper we only considered triaxial accelerometer data, however for further research other measurements are available as well (heart rate, galvanic skin response..)

From raw measurements we crated instances using 2 second sliding window and computed set of various features from accelerometer data that were shown to perform well in similar setting (mean, average, skewness, kurtosis, peak counts) [4]. Additionally we computed the Euler angles pitch and roll and calculated some extra features from them as well - for instance, pitch and roll manipulation, amount of roll motion, regularity of roll motion... Altogether we computed 105 features. Afterwards feature selection was applied and the best of them were used to build models.

3.1 Feature Selection

Feature selection was used only in the cases of flat classification and MM-HMC.For feature selection, we first ranked the features by gain ratio. After that, we used a wrapper approach. We started with an empty feature set and added features in the order of their rank. After each feature was added, we evaluated its contribution by building random-forest classifiers and internally cross-validating them on the training set. The feature was kept only and only if it increased the overall average accuracy. The ranking by gain ratio and the random forest algorithm were implemented in the Weka machine-learning suite and run with default parameter values.

3.2 Flat Classification

The most common approach for AR is the so-called flat classification. All classes are considered equal, hierarchy is not taken into account. Algorithms were implemented in java, using Weka[3] library.

3.3 Multi-Model Hierarchical Classification

We implemented two different approaches for hierarchical classification. The first one, traditional hierarchical strategy *Per Parent Top Down* (PPTD - Figure 1), based on "local per parent node" model, and the second one, named *Sum of weighted Votes* (SWV - Figure 2), "local per level" model, proposed by Paes et al. in [10]. On the upper level we built a model to distinguish between three groups - daily activities, exercise and static. This was done the same for both approaches. From here on, the approaches differ.

1. **PPTD** For this approach, we split instances into three different subsets regarding to the classified group. We then run feature selection for each of the subsets separately and built three different models - on for each group of activities. Features were different for each group.
2. **SVW** After the first level, the classified group has been added to instances as an additional feature. Feature selection has been done again - this time for the whole level, and one model has been built to distinguish between activities.

[3]https://www.cs.waikato.ac.nz/ml/weka/

Same authors have explored feature selection for both approaches in [11], where they have shown that the best results are obtained when using the *lazy* approach - this approach executes feature selection at the classification time of each instance. We have decided to use the *eager* approach, where feature selection is done prior to classification.

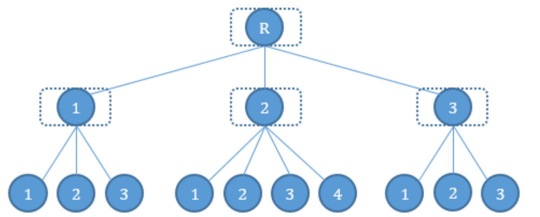

Figure 1: PPTD - local per parent node approach

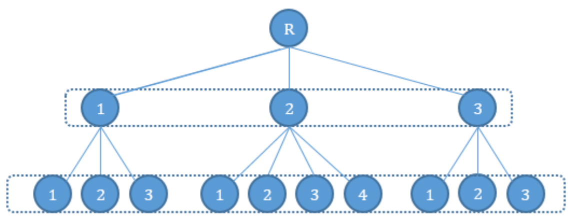

Figure 2: SVW - local per level approach

Figure 3: Hierarchical classifiers

3.4 CLUS-Classification

CLUS is a decision tree and rule learning system that works in the predictive clustering framework. One of its important functionalists is the CLUS-HMC algorithm for hierarchical multi-label classification. The software has been shown to work very well in the field of functional genomics [6], so the idea to use it in hierarchical classification for activity recognition seems reasonable. Clus-HMC algorithm is a variant of standard greedy top-down algorithm for decision tree induction. To achieve the task of predicting a set of classes instead of a single class, additional changes to the learning procedure are needed, as shown in [12].

```
[Hierarchical]
Type = Tree
HSeparator = /
WType = ExpMinParentWeight
WParam = 0.5
OptimizeErrorMeasure = AverageAUPRC
ClassificationThreshold = [0.5, 0.7, 0.9, 0.95]
MEstimate = Yes
SingleLabel = Yes

[Tree]
PruningMethod = M5
M5PruningMult = 2.0
FTest = 0.1

[Constraints]
MaxDepth = 20

[Ensemble]
EnsembleMethod = RForest
FeatureRanking = Genie3
PrintAllModelInfo = Yes
```

Figure 4: CLUS settings file example.

In our experiment we worked with random forest (to make it comparable with other two approaches), and we allowed the decision tree to go up to depth 20. We have shown experimentally that performance increases sharply up to decided depth, while afterwards the contribution has become negligible. The error we used for optimization was the average AUPRC (area under the precision-recall curve). We have tested the performance by changing the threshold determining when the probability output by the model is considered to predict a class. All of the above mentioned parameters are set in the settings file as seen in Figure 4.

4. EXPERIMENTAL SETUP AND RESULTS

In our case the hierarchy is very simple, reduced to two levels. For HMC problems Clus returns several error values. To get fair results for each person included in the dataset, leave-one-person-out approach has been used, as mentioned before. For evaluation of the results we decided to choose standard measurements - precision, recall and F-score. However, when it comes to the evaluation of highly skewed class distributions, similar as with our dataset where for instance daily activities have a much higher frequency than rest, precision-recall curves are the most suitable evaluation tool [7], so this was also added. Vens el al. [6] have addressed the problem of most eligible evaluation tools for hierarchical classification. From the proposed evaluation tools we used the area under the precision-recall curve.

To evaluate predictive models independently from the threshold, two types of evaluation are suitable: ROC analysis and analysis of precision-recall curves (PRC). ROC analysis is better known in machine learning, however for hierarchical multi-label classification PR is more suitable. [?] PR curve plots the precision of a model as a function of its recall, and although it helps understanding the predictions, single value is more appropriate for comparing quality of different models. A score often used to represent this is the so-called "area under the PR curve" (AUPRC). The closer the AUPRC is to 1.0, the better the model.

$$\overline{AUPRC}_{\mathrm{w}} = \sum_i \mathrm{w}_i \cdot AUPRC_i$$

If all the weights are set to $\mathrm{w}_i = 1/|C|$, where C is the set of classes, score is called average AUPRC, and is denoted as $\overline{AUPRC}$. If the weigths are set to $\mathrm{w}_i = v_i/\sum_j v_j$ where v_i is the frequency of class c_i in data, we call this weighted AUPRC and denote it as $\overline{AUPRC}_{\mathrm{w}}$. We have compared the performance of the proposed methods by comparing the precision, recall, F-score and $\overline{AUPRC}$ score by activity. Validation has been done using "leave-one-person-out" approach. We computed all of the mentioned measures for each person and averaged them to get the performance accuracy by method. Methods that we compared are flat classification, multi-model classification using SVW (local per level) approach and CLUS-classification using same approach. We decided to leave out the comparison of PPTD algorithm due to lack of data. Classes for *static* gorup were poorly represented from the beginning and after classification on the first level some were left with only few examples. To avoid loosing data we propose additional approach, which is roughly explained in the conclusion.

Using the same dataset Cvetkovic and al. [4] have reported on 70% accuracy for five different classes (sports, eating, chores, handwork, washing). We expected high confusion in group of daily activities (handwork, chores, eating, washing) and some confusion between other groups and within them as hand movements can be very similar in this group. Table 2 and Table 3 show the results of the experiments. We could not compare the $\overline{AUPRC}$ of flat classification when classifying groups, as we only get the values for classified activities on lower level. However, we could compare flat classification to other two approaches using other measures. As shown in Table 2 MM-HMC performs the best for AR on the upper level, but not much better than flat. On the lower level the results from flat classification and from MM-HMC were quite similar, with one approach performing better in some cases and worse in others. From the fact that direct classification on the upper level (MM-HMC) is not much better from the indirect, it is safe to conclude that this is the reason, that for similar results between the mentioned two approaches on the lower level. The achieved average accuracy for flat classification has been 70.5% and very similar for MM-HMC. Each works better in some cases. Results using CLUS are not the most promising. However, there are many possible combinations of settings available and the performance could be improved by choosing different set of parameters and their values. We tried many possible combinations and the presented results are the best so far.

Table 2: Results upper level (group)

	Flat	MM-HMC	CLUS
Fscore	82.05%	83.71%	74.36%
Precision	82.03%	83.73%	76.22%
Recall	82.12%	84.05%	73.10%
$\overline{AUPRC}$		89.61%	81.09%

Table 3: Results lower level (activity)

	Flat	MM-HMC	CLUS
Fscore	65.14%	66.79%	52.23%
Precision	68.29%	65.92%	58.31%
Recall	65.48%	67.69%	51.08%
$\overline{AUPRC}$	68.63%	66.67%	54.76%

5. CONCLUSION

In this work we compared three approaches to activity recognition. Our results show that for the purpose of activity recognition with 2 levels of activity (group and activity), flat classification performs as well as both types of hierarchical classification - or even better. In some other uses of HMC, for instance functional genomics, fast performance and correct classification of higher levels is of greater importance than correct classification of lower levels. Unfortunately in the case of activity recognition fast performance was the only upside.

There are some possible improvements for future work. The dataset we were working on, was not really extensive. There were many activities involved and not many instances of each. This could be solved with joining more similar datasets.

Some of the HMC-related papers mentioned different classifiers for classification. We used random forest, as it has performed the best in our previous research where we were only using flat classification, however some other classifiers may perform better on the hierarchical problem. Better accuracy could as well be achieved by adding measurements from some other sensors (heart rate sensor), as maybe there are some more distinctive differences between subsets of the proposed hierarchy.

A possibility to improve the performance of MM-HMC is to add additional activities to each of the groups. For instance, we add *exercise* and *static* as two new activities in group of *daily activities*. Similar would be done for other two groups of activities. After building models for the lower level, we would then build additional models for all "new activities" classified to wrong group. We will try this approach in our future work.

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Aiding the Task of Process-Based Modeling with ProBMoTViz

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ABSTRACT

Process-based modeling (PBM) is an equation discovery approach for automated modeling of dynamical systems, which takes at input substantial expert knowledge and measured data of the observed system. The resulting process-based models offer both high-level representation (in terms of building blocks / model components, i.e., entities and processes) and low-level representation (a set of ordinary differential equations). ProBMoT, a software platform for modeling, parameter estimation, and simulation of process-based models, is the latest implementation of the process-based modeling approach. While ProBMoT has been successfully applied to the task of modeling dynamical systems, compared to other modeling and simulation software, it is substantially behind in terms of user-friendliness. The goal of the present work is to overcome this limitation of ProBMoT. We design and implement an extension of ProBMoT, named ProBMoTViz, which is a platform consisting of a GUI (Graphical User Interface) for ProBMoT and a PBM Visualizer for process-based models. We evaluate the versatility of ProBMoTViz on example case studies.

1. INTRODUCTION

ProBMoT [4, 10] is the latest implementation of the process-based modeling approach [3, 6] for automated modeling of dynamic systems. Given a background knowledge, modeling constraints and measured data at input, ProBMoT constructs completely defined process-based models, represented with entities and processes.

ProBMoT has been successfully applied to a variety of modeling tasks in a number of real-world domains, such as aquatic ecosystems [4]; population dynamics [5]; biological systems [11]; oscillatory systems [8]; as well as predicting future behavior of the system at hand [9]. Unlike other modeling and simulation tools [7], ProBMoT is a domain-free tool and can be applied to any modeling task that involves model structure identification and/or parameter estimation. However, it still straggles behind these tools in terms of graphical/visual representation of the constructed models, comprehensibility of the output for a broader user-base as well as user-friendliness when it comes to preparing and running a PBM task. User feedback indicates that a GUI and a visual representation of process-based models can overcome these obstacles.

In this work, we set out to overcome the usability limitations of ProBMoT, i.e., to expand its user scope by developing and implementing an extension for it. In particular, we propose ProBMoTViz, a software platform which includes a Graphical User Interface (GUI) for ProBMoT and a PBM Visualizer for process-based models. On one hand, the GUI supports the basic operations of (automated) modeling dynamical systems in terms of providing appropriate input for the modeling and examining the outputs thereof. On the other hand, the PBM Visualizer illiterates the (currently textual) output models with a higher-level visual representation, that better communicates with the domain experts.

2. PROBLEM DEFINITION

ProBMoT addresses the task of automated modeling in terms of automated search of the appropriate model structure and estimating its parameter values. The input to the tool includes several input files: (1) a library of background knowledge (*.pbl* file specifying the domain); (2) a conceptual model (*.pbm* file specifying the problem); (3) a data file; and (4) a task specification *.xml* file, specifying the particular task.[1]

To this end, running ProBMoT require cumbersome and time-demanding procedures of preparing an appropriate input. For instance, the *.xml* task specification file defines all the hyper-parameters needed for ProBMoT to run properly, such as the paths of the input files, definition and mapping of variables and outputs to data sets, settings of the parameter fitter and the simulator, etc. All these components are represented with different XML tags. In response, the main contribution of ProBMoTViz is facilitating the task of process-based modeling with ProBMoT. In particular, the ProBMoT workflow will be encapsulated in a shell, where the *.xml* file is not written manually, but its representative settings are tuned interactively.

On the other hand, the constructed process-based models can be complex and difficult to understand[2]. The textual representation of process-based models can be improved, thus further enhancing their interpretability and communicability with domain experts. ProBMoTViz implements state-of-the-art visualization techniques able to overcome

[1] Tables 3-5 in the Appendix, present these inputs for a particular modeling task.
[2] Table 6 in the Appendix

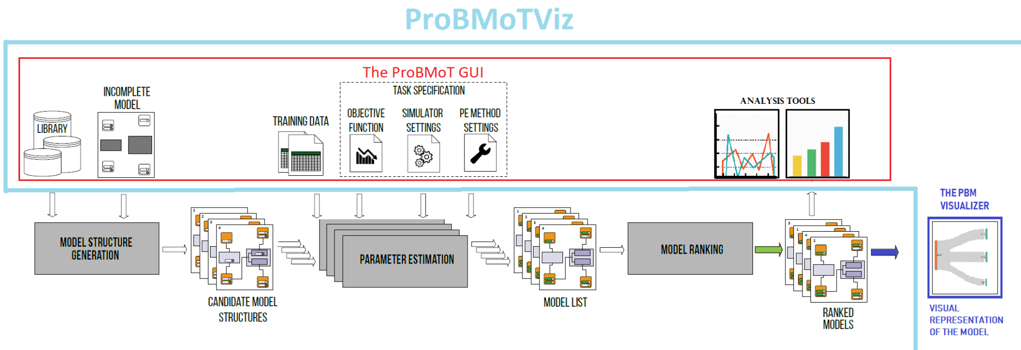

Figure 1. **ProBMoTViz, the proposed extension of ProBMoT, consists of a GUI for ProBMoT and a PBM Visualizer.**

the potential comprehensibility obstacles and usability limitations of the current textual representations.

3. PROBMOTVIZ

ProBMoTViz consists of two main components: the ProBMoT GUI and the PBM Visualizer (Figure 1). The former guides the user through the process of creating and defining a new PBM task step-by-step. It is a desktop-based application, developed in JavaFX [12], that facilitates the task of PBM, allowing for the settings, mappings, and all of the other customizable properties which must be specified in the *.xml* task settings file, to be now adjusted interactively in a workflow. The platform is divided into nine main scenes through which the user must progress in order to define the modeling task, monitor its progress, as well as to analyze the process-based models obtained at output. In particular, the scene sequence is as follows: (1) Library - the scene where the library file must be chosen and all the library components (template entities and processes) are shown; (2) Model - the scene where the (in)complete model file must be chosen and all the model components (instance entities and processes) are shown; (3) Data - the scene where the data files must be chosen, with the opportunity to inspect/ visualize the data; (4) Inputs - the scene where the input mappings must be specified, i.e., the mapping of the time dimension and the exogenous variables to a column in the data set; (5) Outputs - the scene where the outputs and their mappings to a specific column in the data set must be specified; (6) Overview scene; (7) Settings - the scene where all the task settings are specified, i.e., the evaluation, simulator, fitter, and other settings; (8) Run scene - where the particular task can be exported in an .xml format for later (re)use and (9) Results - the scene where the resulting process-based models can be inspected and analyzed.

The latter component, the PBM Visualizer, is a web application produced using the D^3.js (Data Driven Documents JavaScript library) [2]. It offers an interactive visual representation of the complex hierarchies of process-based models depicting both the high-level structure of the models as well as the interactions between its components. In particular, process-based models are depicted as a Sankey diagram [1], where the nodes denote the components of the process-based models. We define two main types of components that correspond to: *entities* and *processes*. Moreover, entities have one sub-type: *hierarchical entities* (representing the hierarchy that the entity comes from), while the processes have two sub-types: *hierarchical processes* (representing the hierarchy that the process comes from), and *children processes* (representing the nested processes in a process), as shown in Figure 2.

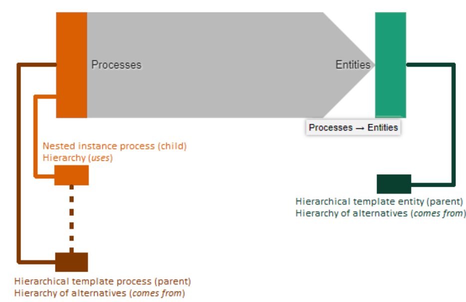

Figure 2. **Schematics of the visual representation of model components.**

To better illustrate how ProBMoTViz works, we present the important details of preparing a task for modeling a two cascaded water tanks system (Equation 1). The system consists of two cascaded water tanks with free outlets, placed one above the other, fed by a pump. In the governing equations for this system, the water levels of the tanks are denoted with *h1* and *h2*. *A1*, *A2*, *a1* and *a2* denote the areas of the tanks and their effluent areas, while the applied voltage-to-flow conversion constant is denoted with k. The task is to model the water level in the lower tank. The data is obtained by laboratory measurements [13] and it consists of 2500 samples (1500 train and 1000 test set) of the input voltage applied to the pump and the water levels in both tanks.

$$\begin{cases} \frac{dh_1}{dt} = -\frac{a_1\sqrt{2g}}{A_1}\sqrt{h_1} + \frac{k}{A_1}u(t) \\ \frac{dh_2}{dt} = -\frac{a_2\sqrt{2g}}{A_2}\sqrt{h_2} + \frac{a_1\sqrt{2g}}{A_2}\sqrt{h_1} \end{cases} \quad (1)$$

First, after loading the PBM library into ProBMoTViz (Figure 3), one can explore the encoded domain knowledge (for this example, for modeling fluid dynamics) in the traditional PBM formalism. In particular, the entity *Tank* encodes a variable that represents its water height level, and constants denoting the inflow and outflow areas. Analogously, the

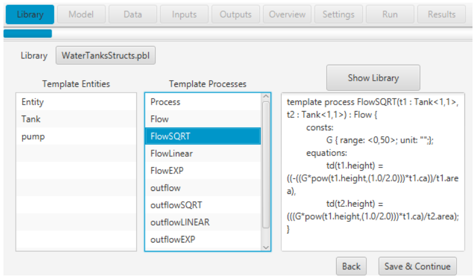

Figure 3. **The water tanks library of background knowledge.**

other entity *Pump* incorporates a variable denoting the input voltage in the system. Moreover, the library also encodes the different (plausible) interactions between the entities in terms of water transmissions between: two tanks, a tank and the environment as well as a tank and a pump. Note that, these interactions can also have different behaviour, therefore the library encodes different modeling alternatives for each of them in terms of a squared-root, linear or exponential dynamics.

In the next step, after loading the incomplete model (Figure 4), one can explore the specific components of the particular problem, i.e. two tanks and one pump. The task is defined as follows: in a two-tank system with an electric pump, identify the underlying dynamics of the three different interactions that describes the behaviour of the lower thank.

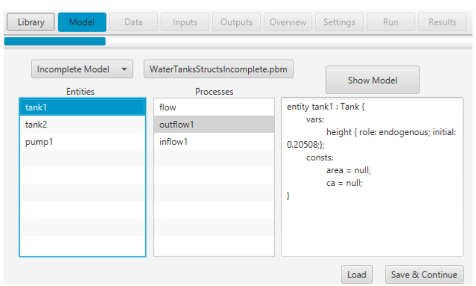

Figure 4. **The water tanks conceptual model.**

With loading the data, followed by specifying the mappings, defining the outputs and specifying the settings, our particular task is completely defined and ready for execution, as shown in Figure 5.

Finnaly, ProBMoTViz, lists the constructed models (Figure 6), and offers additional tools (error-plots and visual representation of the constructed process-based models) for further analyses.

4. CASE STUDIES

As a case study, we tackle the tasks of modeling two benchmark nonlinear dynamical systems: (1) Two cascaded water tanks system and (2) The SilverBox – an oscillatory system using ProBMoTViz. For evaluating the performance of our models, we measure the relative root mean squared error (RRMSE) of each model's output, shown in Equation 2. The number of samples in the test set is denoted with n; y_t is the measured and $\hat{y}_t$ is the predicted value (obtained

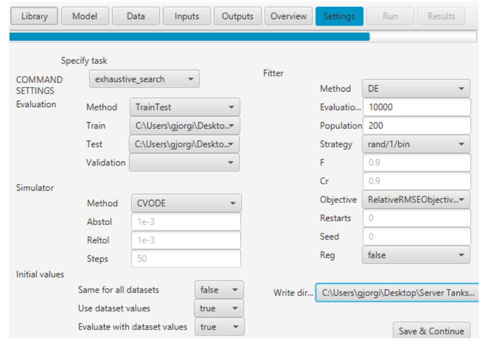

Figure 5. **The settings parameters for modeling the two water tanks system shown.**

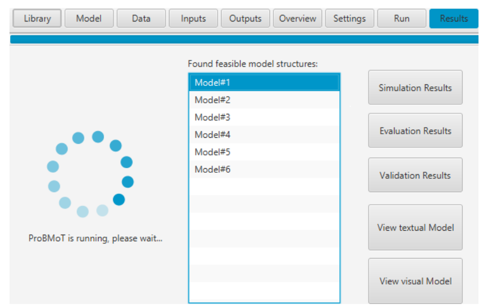

Figure 6. **The resulting models from modeling the two water tanks system.**

by simulating the model m on the test set) of the system variable y at time point t. The mean value of y in the test set is denoted with $\overline{y}$. This metric is relative to the standard deviation of the system variable in the test data, thus allowing us to compare the errors of models for different system variables with measured values on different scales.

$$RRMSE(m) = \sqrt{\frac{\sum_{t=0}^{n}(y_t - \hat{y_t})^2}{\sum_{t=0}^{n}(y_t - \overline{y})^2}} \qquad (2)$$

4.1 Two cascaded water tanks system

For the previously defined water tanks system, given an input voltage, the output of interest in our model is the water height level of the lower tank. The particular process-based modeling task yields 9 feasible models, as shown in Table 1. The best obtained model (Figure 7) is contained of the processes *Inflow*, *FlowSQRT* and *OutflowSQRT*, which corresponds to the original system.

Table 1. **The results of modeling the two cascaded water tanks system.**

Model	Train RRMSE	Test RRMSE
ModelSqrtSqrt	**0.2208**	**0.2673**
ModelLinSqrt	0.2285	1.1837
ModelExpSqrt	0.2448	0.3101
ModelSqrtLin	0.2916	0.3200
ModelLinLin	0.3138	0.3323
ModelExpLin	0.3576	0.4249
ModelSqrtExp	0.7233	0.8507
ModelLinExp	0.7312	0.8585
ModelExpExp	0.7457	0.8835

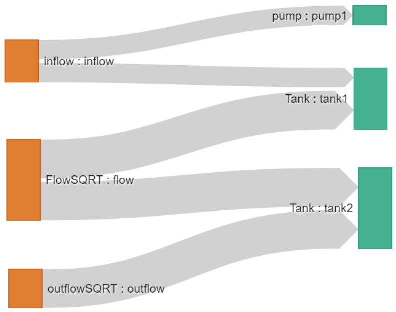

Figure 7. **The water tanks visual process-based model.**

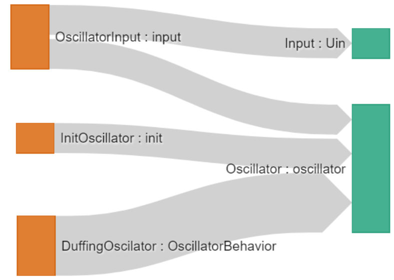

Figure 8. **The SilverBox visual process-based model.**

4.2 SilverBox Oscillator System

The second case study, addresses the task of reconstructing a nonlinear mechanical oscillating system, referred as the SilverBox system - an electronic implementation of the Duffing oscillator. The system's dynamics (Equation 3) relates to the displacement *y(t)* (the output) to the input voltage *u(t)*. The parameter m is a moving mass, d is viscous damping, and *k(y)* is a nonlinear progressive spring described by a static but position-dependent stiffness. The data is generated by an almost idealized representation of the oscillator [13]. It consists of 130000 samples (90000 train 40000 test set) of the input voltage and the output displacement of the oscillator.

$$\begin{cases} m\frac{d^2y(t)}{dt^2} + d\frac{dy(t)}{dt} + k(y(t))y(t) = u(t) \\ k(y(t)) = a + by^2(t) \end{cases} \tag{3}$$

The PBM library incorporates the domain knowledge where the entity *Oscillator* encodes the input voltage, output displacement and its mass. Moreover, behaviors of different oscillators: (1) Duffing, (2) Simple, (3) Harmonic and (4) Universal oscillator, all of which differently affect the output displacement of the oscillator are also encoded in the library. The incomplete model specifies the particular problem of one oscillator with unknown oscillatory behavior.

The process-based modeling task yields 4 feasible process-based models, as shown in Table 2. The best obtained model (Figure 8) contains the processes *InitOscillator*, *OscillatorInput* and *DuffingOscillator*, which corresponds to the original system.

Table 2. **The results of modeling the SilverBox system.**

Model	Train RRMSE	Test RRMSE
ModelDuffing	**0.2353**	**0.2741**
ModelSimple	∞	∞
ModelUniversal	0.8803	0.8796
ModelHarmonic	0.9330	0.9327

5. CONCLUSIONS

In this work, we present a novel software tool, ProBMoTViz. It consists of two components: a GUI for ProBMoT and a PBM Visualizer for process-based models. The GUI supports the basic operations necessary for (automated) modeling of dynamical systems. Moreover, it allows for comprehensible and user-friendly preparation and analyses of modeling tasks. This enables the user to have better overview and control over the input parameters necessary when running ProBMoT, therefore saving time and computational resources when performing large amount of- and/or delicate experiments. The PBM Visualiser, on the other hand, aids in visualizing the complex (hierarchical) structure of process-based models, in turn allowing for better understanding and comprehensibility.

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Appendix: ProBMoT inputs

Tables 3-5 present the necessary inputs for ProBMoT for the tasks of automated modeling of a water tank dynamic system. Table 6 presents a resulting process-based model in the standard PBM formalism.

Table 3. Library of domain knowledge

```
library WaterTanksLibrary;
//ENTITIES
template entity Tank {
vars:
        height {aggregation:sum, range:<0,500>};
consts:
        area {range: <1.0E-3,30>},
        ca {range: <1.0E-3,30>}; }
template entity Pump {
vars:
        v{aggregation:sum, range:<-15,15>};
consts:
        k {range:<0.2,1E6>}; }

//PROCESSES
template process Flow (t1 : Tank, t2 : Tank) {
consts:
        G {range: <0,50>},
template process FlowSQRT : Flow {
equations:
        td(t1.height) = - (G * pow(t1.height,1/2) * t1.ca)/t1.area,
        td(t2.height) = (G * pow(t1.height,1/2) * t1.ca)/t2.area; }
template process FlowLINEAR: Flow {
equations:
        td(t1.height) = - (G * t1.height * t1.ca)/t1.area,
        td(t2.height) = (G * t1.height * t1.ca)/t2.area; }
template process FlowEXP : Flow {
equations:
        td(t1.height) = - (G * exp(t1.height) * t1.ca)/t1.area,
        td(t2.height) = (G * exp(t1.height) * t1.ca)/t2.area; }
template process Outflow (t:Tank) {
consts:
        G {range: <0,50>}; }
template process OutflowSQRT: Outflow {
equations:
        td(t.height) = - G * pow(t.height,1/2) * t.ca/t.area; }
template process OutflowLINEAR :Outflow {
equations:
        td(t.height) = - G * t.height * t.ca/t.area; }
template process OutflowEXP :Outflow {
equations:
        td(t.height) = - G * exp(t.height) * t.ca/t.area; }
template process Inflow (p: pump, t: Tank) {
equations:
        td(t.height) = p.k * p.v/t.area; }
```

Table 4. Incomplete model of the two cascaded water tanks system.

```
incomplete model WaterTanksIncomplete : WaterTanksLibrary;
//Entities
entity tank1 : Tank {
vars:
        height { role: endogenous; initial: 0.20508;};
consts:
        area = null,
        ca = null;
}
entity tank2 : Tank {
vars:
        height { role: endogenous; initial: 0.38086;};
consts:
        area = null,
        ca = null;
}
entity pump1 : Pump {
vars:
        v { role: exogenous;};
consts:
        k = null;
}

//Processes
process flow (tank1, tank2) : Flow {
consts:
        G = 4.429; }
process outflow1 (tank2) : Outflow {
consts:
        G = 4.429; }
process inflow1 (pump1, tank1): Inflow {
}
```

Table 5. An example task specification file in XML format.

```
<task>
        <library>C:/Users/WaterTanksLibrary.pbl</library>
        <incomplete>C:/Users/WaterTanksIncomplete.pbm</incomplete>
        <data>
                <d separator="," id="1">C:/Users/Data1.csv</d>
                <d separator="," id="2">C:/Users/Data2.csv</d>
        </data>
        <mappings>
                <dimensions>
                        <dim name="time" col="t"/>
                </dimensions>
                <exogenous>
                        <exo name="WaterTanksIncomplete.pump1.v" col="u"/>
                </exogenous>
                <endogenous>
                        <endo name="WaterTanksIncomplete.tank1.height" col="h1"/>
                        <endo name="WaterTanksIncomplete.tank2.height" col="h2"/>
                </endogenous>
                <outputs>
                        <out name="h2" col="h2"/>
                </outputs>
        </mappings>
        <output>
                <variables>
                        <var name="h2">WaterTanksIncomplete.tank2.height</var>
                </variables>
        </output>
        <writeDir>C:/Users/</writeDir>
        <command>exhaustive_search</command>
        <settings>
                <initialvalues>
                        <sameforalldatasets>false</sameforalldatasets>
                        <usedatasetvalues>true</usedatasetvalues>
                </initialvalues>
                <simulator method="CVODE">
                        <abstol>0.001</abstol>
                        <reltol>0.001</reltol>
                        <steps>1000</steps>
                </simulator>
                <fitter method="DE">
                        <restarts>0</restarts>
                        <evaluations>10000</evaluations>
                        <population>200</population>
                        <strategy>rand/1/bin</strategy>
                        <F>0.9</F>
                        <Cr>0.9</Cr>
                        <seed>0</seed>
                        <reg>false</reg>
                        <objectives>
                                <obj>RelativeRMSEObjectiveFunctionMultiDataset</obj>
                        </objectives>
                </fitter>
                <evaluation method="TrainTest">
                        <train>1</train>
                        <test>2</test>
                </evaluation>
        </settings>
</task>
```

Table 6. A process-based model of a two cascaded water tanks system.

```
model WaterTanksModel : WaterTanksLibrary;
entity tank1 : Tank {
vars:
        height { role: endogenous; initial: 0.20508;};
consts:
        area = 19.944,
        ca = 1.087;
}
entity tank2 : Tank {
vars:
        height { role: endogenous; initial: 0.38086;};
consts:
        area = 23.051,
        ca = 3.066;
}
entity pump1 : Pump {
vars:
        v { role: exogenous;};
consts:
        k = 20.305;
}

//Processes
process flow (tank1, tank2) : FlowSQRT{
consts:
        G = 4.429; }
process outflow1 (tank2) : OutflowSQRT {
consts:
        G = 4.429; }
process inflow1 (pump1, tank1): Inflow {
}
```

Evaluation and Prospects of Semi-Automatic Video Distance Measurement in Ski Jumping

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ABSTRACT
Great competitive results of Slovenian ski jumpers in world cup and continental competitions have sparkled a lot of interest for active participation in this attractive sport. In junior levels, national competitions with considerably more than 100 jumpers are becoming the norm. However, due to lack of technologic aids for distance measurement, such competitions can last over half a day. Only at the top-level competitions (world cup, continental cup) expensive and logistically demanding commercial video distance measuring tools are used for this purpose. In a previous project we developed a video distance measuring system from low-cost commercial components, which was not suitable for real-time usage due to technological limitations, but worked great for offline measurement. We analyze the results of offline measurements for several competitions and show that measurement errors are often unacceptably high. This serves as a motivation for an ongoing project, where video measurement is performed in real time and supported by advanced computer vision and deep learning methods.

Keywords
ski jumping, video distance measurement, computer vision, machine learning, deep learning

1. INTRODUCTION
In recent years, we have witnessed a boom in Slovenian ski jumping, mainly as a consequence of excellent results of Slovenian competitors. There is a marked increase in interest at the primary level; the ski jumping clubs have reportedly doubled the number of younger, primary school competitors (7-10 years). This has considerably increased the burden on ski jumping coaches, as well as on organizers and professional staff in competitions, that are carried out even in the youngest categories (from 2018, up to 10 years on only as “animations”).

The administrative support for small competitions is mostly covered by the information system “Spletni Smuško[1]”, while the IT support is virtually nonexistent for style and distance umpires. Only at the highest competitive levels (world cup, continental cups), professional staff — delegates, style and distance umpires — are supported by expensive commercial solutions [6, 2]. In our project, we focus primarily on supporting distance umpires who have a demanding, exposed role, and their mistakes often lead to bad will among coaches, competitors’ parents and spectators, as well as in public opinion.

The aim our previous work [1] was to develop a system for supporting video distance measuring on smaller hills, with accessible hardware requirements (a single video system and a laptop). In this paper we evaluate the system results from ski jumping competitions in younger categories on small hills in regional competitions (Cockta Cup), and provide some directions for future development.

1.1 Ski Jump Distance Measurement
In ski jumping the jump distance is defined as a distance between the edge of the jumping ramp and a point where both ski jumper’s legs have touched the ground with full surface [4, article 432.1]. The middle point between both legs is used when the legs are apart (e.g., Telemark landing style). There are however three exceptions [3]:

1. In one-legged landings (i.e. the second ski is longer in the air than what is typical during the normal landing routine) the correct distance is measured where the first ski touches ground with full surface.
2. In a fall (where the landing does not result on the skis as is normal), the correct distance is measured at the location where the ski jumper contacts first the landing surface with a body part.
3. In arbitrarily delayed landings (i.e. the ski jumper is positioned extremely behind thus delaying the normal landing routine and the touch down of the ski tips to the landing surface) the correct distance is measured where both feet contact first the landing surface.

Even on the smallest competition hills ($HS \leq 15\ m$) it is difficult to measure the exact flying distance by eyes only, since landing speeds exceed 10 m/s (36 km/h), and the angle

[1] http://smusko.adamsoft.si

Figure 1: Offline video distance measuring system. A calibrated measuring grid is overlaid over video stream. Eight distance-measuring umpires can be seen standing along the landing slope.

between the landing slope and landing trajectories of ski jumpers is often very small [5].

Therefore, umpire tower is often built not far from the lower end of landing slope. It allows good view, but is utilized chiefly by style-measuring umpires. During ski jumping competitions, distance-measuring umpires are stationed a few meters apart along the landing slope (Figure 1). Usually they are volunteers from the organizing ski jumping club, and often have no training and very little experience with distance measuring. With speeds exceeding 10 m/s, the umpires have less than 0.05 second (with resolution of 0.5 m) to decide on a particular distance. Also, as declared by ski jumpers, they are almost never able to determine their flying distance with a reasonable accuracy. As a consequence, ski jumpers and their coaches are challenged when evaluating the progress in terms of jump/flight distance. A reasonably automated video distance measuring system therefore has the potential to become an important coaching aid in everyday practice.

2. OFFLINE VIDEO DISTANCE MEASURING

In a recent project cooperation with the Ski Association of Slovenia[2] (SAS) we developed a system for offline video measurement [1]. The aim of the project was to develop a reasonably priced system for video distance measurement based on commercially available components. It utilized a JVC GC-PX100 camcorder[3] that allows recording of up to 600 frames per second (FPS). While the camcorder was great for offline video measurement due to standalone video recording, it was impossible to use it in an online setting due to it's incapability of live video streaming to the computer.

In the offline setting we recorded several competitions on small hills (HS up to 25 m). Two professional ski-jumping coaches utilized specially developed software developed within the project (see [1] and Figure 1) to facilitate offline video measurement. In total, more than 200 ski jumps were video measured. For 86 we identified the jumpers and obtained officially measured distances, that were used for further evaluation. All jumps were either successful or with the ski jumper touching the landing slope with his/her hands. No spectacular falls were included.

[2]https://www.szs.si
[3]https://eu.jvc.com/microsite/eu/gc-px100/index.html

Table 1: Basic statistic of official and video measurements.

	Official distance	Video distance	Abs. diff.	Abs. diff. (centered)
count	86	86	86	86
mean	22.52	21.99	0.62	0.33
st. dev.	2.11	2.23	0.37	0.35
min	17.00	15.50	0.00	0.00
max	26.00	25.50	1.50	1.50

3. EVALUATION OF OFFICIAL DISTANCE MEASUREMENT RESULTS

For 86 jumps we compared the official results (measured by eyes only) and offline video measurements, performed by two professional ski jumping coaches. Figure 2 depicts a scatter plot of official measurements vs. video measurements. From the placement of measurement pairs (almost all are below the diagonal) it is obvious that manually measured distances are bigger than video measured ones. This bias is a result of different positioning of umpires and video camera, resulting in different parallax errors (the camera was mostly positioned slightly higher than umpires and more towards the outrun). In Figure 3 this bias can be clearly seen as nonnegative differences in distances for all but five jumps.

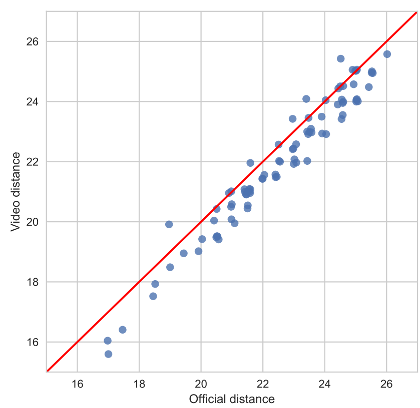

Figure 2: Scatter plot of official vs. video measurements.

Table 1 shows basic statistics of official and video measurements. The difference in means (0.53 m) indicates the need to account for different biases for each method. For this reason we compare the two distance measuring approaches with their values centered around their means (Eq. 1).

$$center_j^{(m)} = d_j^{(m)} - \bar{d}^{(m)} \quad (1)$$

where $\bar{d}^{(m)}$ is the mean value of all measured distance for a particular measuring method m, and $d_j^{(m)}$ is the measured distance for the jump j (again for a particular measuring method m). This allows us to contain the bias within the $\bar{d}^{(m)}$ and focus only on the differences dif_j (Eq. 2).

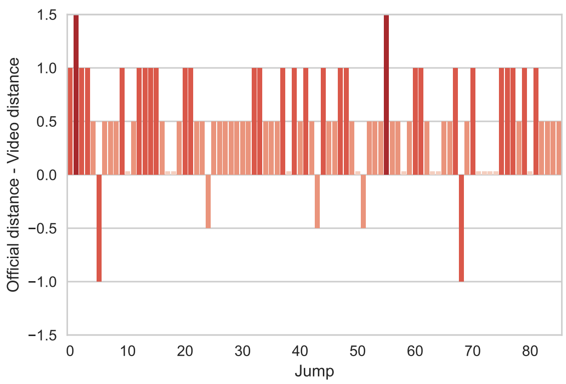

Figure 3: Differences between original official and video measurements.

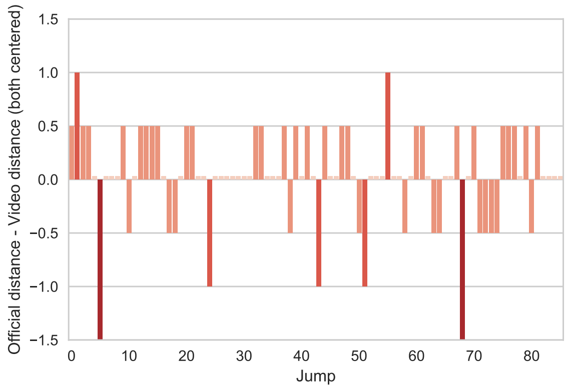

Figure 4: Differences between centered official and video measurements.

Table 2: Frequencies and percentages of absolute differences between centered official and video measurements.

Difference (centered)	Count	%
0.0	39	45
0.5	40	47
1.0	5	6
1.5	2	2

$$dif_j = \Big(\underbrace{d_j^{(manual)} - \bar{d}^{(manual)}}_{\text{centered manual distance}} \Big) - \Big(\underbrace{d_j^{(video)} - \bar{d}^{(video)}}_{\text{centered video distance}} \Big) \quad (2)$$

According to the involved ski jumping coaches, our video measurements are much more reliable than the official manual ones, and can be considered as correct. Figure 4 and Table 2 show a much clearer picture of official measurement errors. 45% of measurements are deemed to be exact (within 0.5 m), 47% are off by ±0.5 m, while additional 8% errors are in the range of 1-1.5 m. For distances around 15 m this means a whopping 10%! To put this in perspective, for a world record jump (253.5 m) this would translate to 25 m! On small hills, 1 m is worth 4.5-6 points, and such errors can easily influence podium places, especially in closely fought competitions. With introduction if video distance measuring system would therefore benefit both umpires (less demanding work) competitors and spectators (less distance measuring errors).

4. BEYOND OFFLINE MEASURING

In the ongoing ŠIPK project we are partnered with the Technix[4] d.o.o company, the biggest provider of traffic surveillance network cameras in Slovenia. They kindly provided various camera models, produced by Axis Communications. We settled for the high frame rate model Q1645[5], that connects to the computer via 100 Mbit Ethernet connection, allows frame rates up to 120 FPS with full HD resolution, and supports low light recording. At the time of paper submission the project is still in progress, therefore we are reporting only partial results. Figure 5 shows the video distance measuring system (camera and laptop) in action.

Figure 5: An online video distance measuring system consisting of a network camera (left) and a laptop computer.

One of the main drawbacks of our original system [1] was the lack of online distance measuring. This is now effectively solved by utilizing the network camera. The video processing pipeline consists of several steps:

- a frame is acquired from the camera (MJPEG or H.264 stream)
- Gaussian blur is used to get rid of noise
- background is subtracted by using the MOG2 algorithm [7], and the image is converted to black (background) and white (moving) pixels, based on the last five frames
- of all the moving contours, the largest is selected as the ski jumper, and the corresponding bounding box is superimposed to the frame (Figure 6).
- once detected, the ski jumper is tracked until he/she has left the camera view

According to [3] and [4, article 432.1], video distance measurement is performed in two steps:

1. determining the correct landing frame
2. determining the correct landing point corresponding to the ski jumper's foot positions.

[4]https://www.technix.si
[5]https://www.axis.com/products/axis-q1645

Figure 6: Trained operator determines the distance by using the calibrated measuring grid in 5-8 s.

A heuristic approach based on the flight curve derivatives is used to approximately detect the landing frame. It works with accuracy of approximately 1 m (on small hills). The human operator is still needed to determine the correct landing frame, and determine the distance based on the superimposed measuring grid (Figure 6).

4.1 Automatic Detection of Landing Point with Deep Learning

We are currently experimenting with two approaches to automate and speed up video distance measuring. The first approach is using a deep convolutional neural network with 10 hidden layers in order to automatically detect the correct landing frame. Its input is a framed ski jumper in resolution 150 × 150 color pixels. Each frame is classified either as "air" or "ground". Due to real time processing requirement (network executes on CPU only) the current topology it is relatively shallow. It consists of two 2D convolutional (C), two pooling (P), four dropout (D), one flattening (F), and three dense layers (De) as follows: C-P-D-C-P-D-F-De-D-De-D-De. A sequence of frames can be classified as shown in Figure 7. The sequence always starts with "air" and ends with "ground". When at least two subsequent "ground" frames are detected, the first is selected as the landing frame. This approach currently achieves 96% classification accuracy for determining the type of frame. However, as the errors always occur near the correct landing frame, human intervention is still necessary. The second approach utilizes classic computer vision image segmentation techniques to acquire positions of ski jumper's skis and legs in order to determine the correct landing point within the frame, and therefore the distance based on the measuring grid (currently with accuracy of 0.5-1 m). Regarding the processing speed, for small hills 30 FPS are sufficient to achieve 0.5 m accuracy, however the process works well even for 100 FPS video stream (tested in laboratory conditions). For deeper neural networks, a gaming laptop with a discrete GPU will be required.

5. CONCLUSIONS

Our evaluation has shown that there is great need for improvement in ski jumping distance measuring, especially for small hills. In order to achieve objective results and reduce errors, video distance measurement is highly advisable. There is considerable interest from ski jumping clubs and

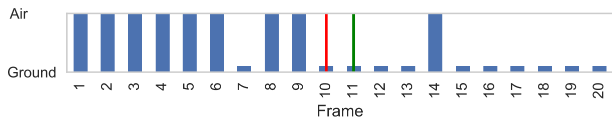

Figure 7: A sequence of frames classified as "air" and "ground". The green line marks the correct landing frame, and the red line the predicted landing frame. Frames 7, 10 and 14 are incorrectly classified.

SAS for widespread testing. For use on larger hills, slight modification of software will be needed in order to allow for two, three or four network cameras. The system still needs further testing (especially the automated components) under artificial lighting conditions (night competitions).

6. ACKNOWLEDGMENTS

Original software for video distance measurement was developed within the PKP project "Video meritve dolžin smučarskih skokov" by T. Ciglarič, K. Gostiša, T. Kovač, D. Peternel, M. Pograjc, N. Stoklas, B. Štempelj and G. Vodan [1]. Advanced automatization is developed within an ongoing ŠIPK project VIDEOMEN in the ski jumping center Menges, Slovenia.

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Opis zmagovalne rešitve na mednarodnem tekmovanju o napovedovanju izida točk v tenisu

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POVZETEK

Januarja 2018 je Avstralska teniška zveza v sodelovanju s Tennis Australia's Game Insight Group organizirala tekmovanje z naslovom *From AO to AI: Predicting How Points End in Tennis.* Cilj tekmovanja je bilo narediti model, ki bi na podlagi podatkov o udarcih in letu žogice, pridobljenih iz kamer, čim bolje klasificiral konec točke v enega od treh razredov; nepotrebna napaka, prisiljena napaka in neubranljiv (*winner*) udarec. Izmed 750 tekmovalcev, ki jih je sodelovalo na tekmovanju sva soavtorja osvojila prvo mesto. V referatu je prikazan postopek razvoja zmagovalne rešitve, ki vključuje generiranje in izbiro spremenljivk, izbiro ustreznega modela za strojno učenje, optimizacijo njegovih hiperparametrov, ter predstavitev rezultatov, dobljenih z zgrajenim modelom.

Ključne besede

Tenis; Tekmovanje; Strojno učenje; Umetna inteligenca; XGB

1. UVOD

Tenis je glede na gledanost eden izmed najpopularnejših športov na svetu. Da bi gledalcem in igralcem zagotovili zanimive statistike, se na vsaki tekmi meri veliko različnih parametrov, od uspešnosti prvega servisa, do števila dobljenih točk na nasprotnikov servis. Ena izmed pomembnejših statistik je tudi število napak in neubranljivih udarcev, ki jih igralec izvede tekom tekme. Te statistike trenutno beležijo ročno, strokovnjaki, ki ob igrišču gledajo tekmo in glede na svoje izkušnje označijo zaključek točke, kot nepotrebna napaka, prisiljena napaka ali pa kot neubranljiv udarec.

Vendar pa tak način zbiranja podatkov ni najbolj primeren zaradi možnosti napak, nekonsistentnih označb s strani različnih ljudi in pa tudi zaradi stroška ter dodatne logistike, saj na večjih turnirjih hkrati poteka veliko število tekem. Če bi hoteli dobiti te vrste podatkov za vse tekme bi morali imeti zaposlenih veliko ljudi. Zato je Avstralska teniška zveza v sodelovanju z Tennis Australia's Game Insight Group organizirala tekmovanje z naslovom *From AO to AI: Predicting How Points End in Tennis*, kjer so kot rešitev iskali algoritem, ki bi na osnovi podatkov pridobljenih iz kamer objektivno in čim bolj natančno lahko avtomatsko določil tip zadnjega udarca.

Tekmovanje je bilo organizirano na platformi CrowdANALYTIX (https://www.crowdanalytix.com/), ki omogoča organiziranje spletnih tekmovanj s področja umetne inteligence. Na tekmovanje se je registriralo 750 tekmovalcev oziroma tekmovalnih ekip.

Analiza in razvoj modelov je temeljila na podatkih pridobljenih iz sistema desetih visoko-resolucijskih kamer imenovanega HawkEye (https://www.hawkeyeinnovations.com/), ki se v tenisu primarno uporablja kot pripomoček za detekcijo oziroma določanja ali je določena žoga padla v avt ali ne. Poleg te primarne funkcije lahko s tem sistemom zelo natančno sledimo letu in hitrosti žogice, ter tako dobimo veliko podatkov, ki so bili nato na voljo za gradnjo modelov.

Po začetni analizi podatkov smo iz obstoječega nabora zgradili veliko dodatnih spremenljivk, ki smo jih nato uporabili za modeliranje. Sledila je optimizacija parametrov algoritmov strojnega učenja in predstavitev dobljenih rezultatov. Končna klasifikacijska točnost napovedi je bila 95% (95% za neubranljive udarce, 89% za prisiljene napake in 98% za neizsiljene napake).

2. OPIS IN ANALIZA PODATKOV

Analiza teniških udarcev se je izvajala na zaključnih udarcih točk pridobljenih iz Australian Open 2017 turnirja. Točke v naši bazi so bile odigrane tako v moški, kot tudi v ženski konkurenci, pogoj pa je bil, da je bila dolžina točke več kot dva (servis in return) udarca.

Podatki, ki so bili na voljo so bili razdeljeni ne učni in testni množici. Učni množici sta vsebovali podatke za 5000 točk odigranih v moški konkurenci in za 5000 točk odigranih v ženski konkurenci. Testni množici sta vsebovali podatke za 2000 točk v moški in 1000 točk v ženski konkurenci. Seveda testni podatki niso imeli določenega tipa zaključnega udarca, saj je bila to naloga našega algoritma.

Podatki so vsebovali 27 spremenljivk in pa tip zadnjega udarca. Imena parametrov, njihovimi opisi in možne vrednosti so predstavljeni v tabeli 1.

Za kreiranje dobrih napovednih modelov so ključni dobri podatki in odlično poznavanje njihovih lastnosti. Zatosmo najprej naredili podrobno analizo podatkov. Ta analiza nam pomaga razumeti podatke, odkrije povezave med spremenljivkami in razredi in identificira izvore šuma ter druge probleme, ki so vezani na kvaliteto podatkov.

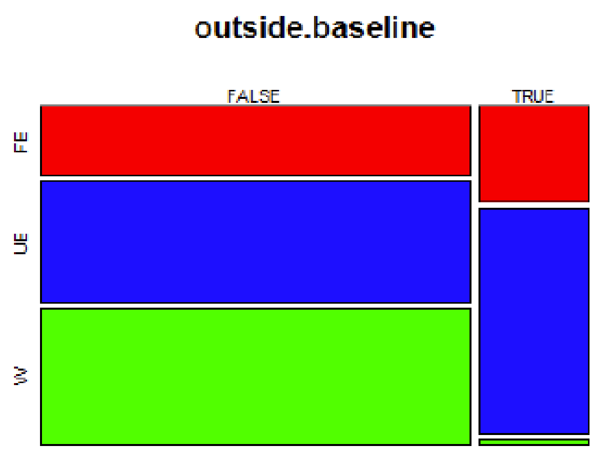
Začeli smo z izračunom distribucije tipov zadnjih udarcev čez celotno učno množico 10.000 točk, ki je sestavljena iz 3,352 (33.5%) neubranljivih udarcev, 2,272 (22.7%) prisiljenih napak in 4,376 (43.8%) nepotrebnih napak. Ta podatek nam pove, da so razredi delno neuravnoteženi, da pa ta neuravnoteženost ni takšna, da bi pri strojnem učenju bilo potrebno uporabiti prav posebne metode namenjene reševanju problemov z neuravnoteženimi podatki.

Tako učna kot testna množica nista vsebovali manjkajočih podatkov, tako da nam ni bilo potrebno uporabiti algoritmov za nadomeščanje praznih vrednosti. Se pa je med podatki pokazalo, da obstajajo netočne vrednosti. Primer je viden na sliki 1, kjer lahko vidimo, da so nekateri udarci, označeni, kot da je žoga padla izven dovoljenega območja a so še vedno označeni kot neubranljivi udarci in ne kot napaka. Razlogi za to so lahko trije:

Spremenljivka	Opis	Vrednosti
outcome	Razredna spremenljivka – tip zadnjega udarca	W=zaključni udarec, FE=prisiljena napaka, UE=nepotrebna napaka
speed	Hitrost zadnjega udarca	Zvezna vrednost (m/s)
previous.speed	Hitros predzadnjega udarca	Zvezna vrednost (m/s)
net.clearance	Razdalja leta žoge nad mrežo za zadnji udarec	Zvezna vrednost (cm). Negativna če je žogica letela nižje od mreže
previous.net.clearance	Razdalja leta žoge nad mrežo za predzadnji udarec	Zvezna vrednost (cm). Lahko negativna če je žogica letela nižje od mreže
distance.from.sideline	Razdalja odboja žoge zadnjega udarca od najbližje črte	Razdalja v metrih (pozitivna tudi če je odboj žogice izven igrišča)
depth	Razdalja odboja žoge od osnovne črte za zadnji udarec	Razdalja v metrih (pozitivna tudi če je odboj žogice izven igrišča)
player.distance.travelled	Razdalja, ki jo je igralec pretekel pred zadnjim udarcem	Euklidska razdalja v metrih
player.impact.depth	Oddaljenost igralca od mreže v trenutku, ko je udaril zadnji udarec	Razdalja od mreže v metrih
player.impact.distance. from.center	Oddaljenost igralca od sredine igrišča v trenutku, ko je udaril zadnji udarec	Razdalja od sredine igrišča v metrih
player.depth	Oddaljenost igralca od mreže v trenutku, ko je udaril predzadnji udarec	Razdalja od mreže v metrih
player.distance. from.center	Oddaljenost igralca od sredine igrišča v trenutku, ko je udaril predzadnji udarec	Razdalja od sredine igrišča v metrih
oponent.depth	Oddaljenost nasprotnega igralca od mreže v trenutku, ko je udaril predzadnji udarec	Razdalja od mreže v metrih
opponent.distance. from.center	Oddaljenost nasprotnega igralca od sredine igrišča v trenutku, ko je udaril predzadnji udarec	Razdalja od sredine igrišča v metrih
previous.distance. from.sideline	Razdalja odboja žoge predzadnjega udarca od najbližje črte	Razdalja v metrih (pozitivna tudi če je odboj žogice izven igrišča)
previous.depth	Razdalja odboja žoge od osnovne črte za predzadnji udarec	Razdalja v metrih (pozitivna tudi če je odboj žogice izven igrišča)
previous.time.to.net	Koliko časa je žoga pri predzadnjem udarcu potrebovala od udarca pa do mreže	Zvezna vrednost v sekundah
server.is.impact.player	Indikator ali je zadnji udarec v točki odigral server	TRUE = DA, FALSE = NE
same.side	Logični indikator, ki pove ali sta se igralca nahajala na isti strani igrišča v času predzadnjega udarca	TRUE = DA, FALSE = NE
outside.sideline	Logični indikator ali je žogica padla znotraj stranskih črt	TRUE = DA, FALSE = NE
outside.baseline	Logični indikator ali je žogica padla znotraj osnovne črte	TRUE = DA, FALSE = NE
train	Indikator ali je točka del učne ali testne množice	1 = Training, 0 = Test
serve	Ali je bila točka odigrana na prvi ali na drugi servis	1= Prvi servis, 2= Drugi servis
gender	Indikator, ki pove ali je bila spol igralcev	mens=moški, womens =ženske
previous.hitpoint	Kateri je bil predzadnji udarec v točki	F = forhend, B = bekend, V = volej, U = neznan tip udarca
hitpoint	Kateri je bil zadnji udarec v točki	F = forhend, B = bekend, V = volej, U = neznan tip udarca
id	10-črkovni unikatni identifikator točke	črkovni niz
rally	Število udarcev v točki	3, 4, 5, …

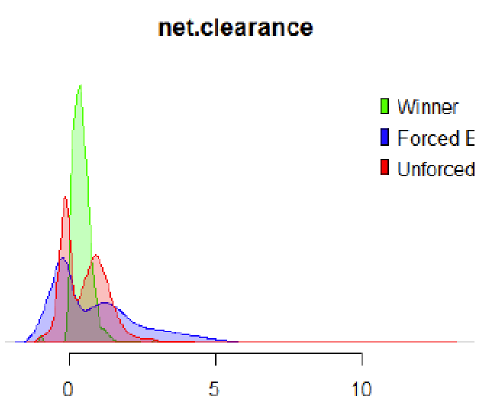
Tabela 1: Opis spremenljivk

(i) človeška napaka pri označevanju, (ii) napačna prepoznava mesta odboja žogice z strojnim vidom iz kamer ali pa (iii) žoga je padla v avt, vendar pa sodniki na tekmi tega niso dosodili, zato je bil udarec dosojen kot dober in zato je v podatkih označen kot neubranljiv udarec. Ker je razlog za take primere neznan in ker je takih primerov manj kot 1% smo jih pustili v testni množici.



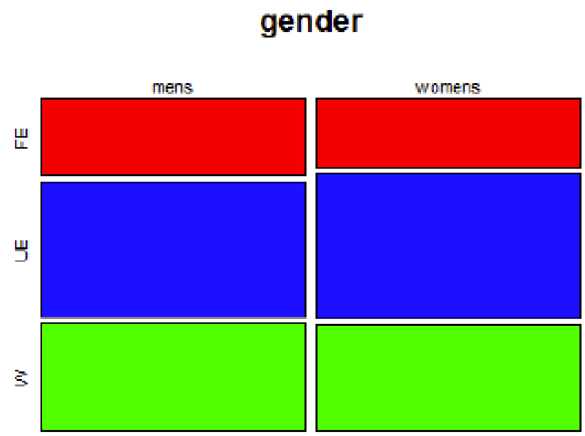
Slika 1: Porazdelitev tipa zadnjega udarca glede na to ali je žoga padla znotraj igrišča po dolžini ali ne.

Nadalje smo analizirali razdaljo leta žoge nam vrhom mreže (net.clearance). Distribucija podatkov je prikazana na sliki 2. Hitro lahko vidimo, kako imamo različne distribucije glede na končni tip udarca. Zanimivo je, da imamo tudi tu udarce, ki so klasificirani kot zaključni udarci in imajo negativno vrednost, kar naj bi pomenilo, da so pristali v mreži, kar je značilnost napak. Podobno kot pri pristanku žoge izven polja, je tudi tu lahko napaka v računalniškem vidu ali pa se lahko zgodi, da se je žogica zaletela v vrh mreže in se odbila čez mrežo v polje. Ne glede na razlog smo tudi tu se odločili, da teh točk ne bomo izločali ampak jih bomo obdržali.



Slika 2:Porazdelitev tipa zadnjega udarca glede na razdaljo leta žoge nad vrhom mreže v metrih

Nadalje smo analizirali kako se točke zaključujejo v moški in ženski konkurenci. Na sliki 3 lahko vidimo, da sta deleža ne glede na spol (gender) zelo podobna, kar je bilo morda malo presenečenje (predvsem) glede na različne hitrosti udarcev, med spoloma. To razumevanje podobne distribucije, nam je dalo zaupanje, da smo se odločili podatke o moških in ženskih točkah združiti. Na ta način smo nato lahko dobili višjo klasifikacijsko točnost, saj smo tako dobili na voljo več učnih podatkov za treniranje in pa predvsem optimizacijo parametrom modelov strojnega učenja.



Slika 3: Porazdelitev tipa zadnjega udarca glede na spol

3. KREIRANJE NOVIH SPREMENLJIVK

Gradnja novih spremenljivk je ključnega pomena pri izboljšanju napovedne točnosti prediktivnih modelov. V našem primeru smo naredili sedem sklopov kreiranja novih spremenljivk.

1. S kombinacijo spremenljivk *distance.from.sideline* in *outside.sideline* smo naredili novo zvezno spremenljivko, ki je bila pozitivna, če je žoga padla v polju in negativna, če je bila žoga v avtu. Na enak način smo združili tudi spremenljivki *depth* in *outside.baseline.*
2. Za spremenljivke, ki so bile vezane na razdaljo in so imele samo pozitivne vrednosti smo izračunali dodatno nove spremenljivke, ki so bile zvezne in so bile lahko tudi negativne. Na primer za *distance.from.center* smo izračunali kot 8,23m (širina igrišča) minus *distance.from.sideline* (popravljena razdalja vključno z negativnimi vrednostmi). Te spremenljivke same po sebi nimajo dodane prediktivne moči, vendar pa nam lahko pomagajo pri delitvi odločitvenega prostora, kar lahko v kombinaciji z drugimi spremenljivkami prinese izboljšanje.
3. Izračun novih spremenljivk glede na položaje igralcev in kote udarcev ter domensko znanje. Kreiranje teh spremenljivk je temeljilo na vednju kakšne lastnosti zadljega udarca gledajo ljudlje, ki notirajo te tipe točk. Tako smo izračunali 8 novih spremenljivk: pretečena razdalja igralca, oddaljenost udarca od odboja žoge, oddaljenost igralca od žoge v času udarca, hitrost žoge pred udarcem, čas, ki ga je imel igralec na voljo za udarec, hitrost teka pred udarcem, kakšen je bil kot udarca in pa pod kakšnim kotom je prišla žoga do igralca. Kot primer oddaljenost udarca od odboja žoge smo izračunali iz kombinacije spremenljivk *previous.distance.from.sideline*, *player.impact.depth*, *player.impact.distance.from.sideline* in *previous.depth*.
4. Izračun skoraj 1000 novih spremenljivk, ki smo jih dobili z izračunom vsote, razlike, zmnožka, delitve, povprečja in standardnih deviacij čez vse kombinacije dveh numeričnih spremenljivk. Ta pristop se izkaže za zelo uporabnega pri *boosted tree-based ensemble algorithms*, saj ta transformacija odločitvenega prostora omogoča algoritmu boljšo zaznamo intaktivnih in nelinearnih relacij med spremenljivkami.

5. Izračuna spremenljivk, ki nam je na podlagi sode ali lihe dolžine točke povedala ali je zadnji udarec izvedel server ali ne.
6. Vse kategorične spremenljivke smo paroma združili, da je algoritem lahko zaznal vsako možno interakcijo (zaporedje) med kategoričnimi spremenljivkami.
7. Odstranitev vseh spremenljivk, ki smo jih dobili po zgornjih postopkih in so imele nič ali pa zelo majhno varianco vrednosti, saj take spremenljivke niso uporabne pri strojnem učenju.

4. IZDELAVA KONČNEGA MODELA

Kot metrika za uspešnost predikcij se je na tekmovanju uporabilo »multi-class logloss« funkcijo, ki se izračuna kot vsota logaritma napake za vsak razred. To pomeni, da mora naš model vračati verjetnosti za vsakega od treh razredov in ne le podatka kateri razred je najbolj verjeten.

Končni model, ki smo ga uporabili za to tekmovanje je bil eXtreme Gradient Boosting algorithm (XGB) [1]. Algoritem je znan po svoji dokazani visoki učinkovitosti, hitrosti in fleksibilnosti zato se je tudi uporabil kar nekajkrat kot zmagovalni algoritem na Kaggle tekmovanjih [2, 3]. Glede na veliko število spremenljivk, ki smo jih imeli v učni in testni množici je bil velik poudarek namenjen optimizaciji hiperparametrov XGB algoritma.

Pri optimizaciji hiperparametrov je bil največji povdarek na optimizaciji parametrov *max_depth* in *min_child_weight.* Začeli smo z višjo vrednostjo prametra *learning_rate* in ko smo dobili pribljižno optimalno vrednost izbranih parametrov smo znižali *learning_rate* in tako še dodatno izboljšali napovedno točnost. Na vsakem koraku optimizacije smo uporabili postopek prečnega preverjanja, da smo lahko dobljenim vrednostim parametrov lahko bolj zaupali. Postopno zmanjševanje parametra *learning_rate* je izboljšalo rezultate zaradi nelinearnosti vhodnjih spremenljivk in hkrati preprečilo, da bi se model preveč prilagodil (naučil) samo na učne podatke (*overfeeting)* ampak, da je ostal dovolj splošen, da se je odlično odnesel tudi na še nevidenih podatkih.

5. REZULTATI

Kot je običaj v spletnih tekmovanjih se rezultate napovedi objavi preko platforme (v našem primeru CrowdANALYTICS). Te napovedi se nato po skritem ključu razdeli in uporabi za prikaz na javni in privatni lestvici. V našem primeru se je 40% napovedi uporabilo za javno lestvico in 60% za privatno. Rezultat na javni lestvici je namenjen primerjavi kvalitete njegove rešitve napram rešitvam ostalih tekmovalcev. Rezultat na privatni lestvici pa se nato uporabi za določanje zmagovalca tekmovanja. Ker se rezultat na privatni lestvici vidi le enkrat ni mogoče, da bi se algoritem prilagodil tako, da bi imel čim boljše napovedi na privatni lestvici.

Z našim modelom smo dobili rezultat (»multi-class logloss«) na javni lestvici 0.179, kar je bilo dovolj za osmo mesto. Ja privatni lestvici pa smo dobili rezultat 0.188, kar je bilo dovolj za prvo mesto.

Za lažjo predstavo kvalitete napovedi smo izračunali tudi klasifikacijske točnosti. Klasifikacijska točnost modela preko vseh razredov je znašala 94.5%, kar je za tak problem visoka številka. Poleg skupne klasifikacijske točnosti pa smo izračunali tudi klasifikacijsko točnost za vsak razred posebej. Rezultati so predstavljeni v tabeli 2.

	Napovedani razredi		
Dejanski razredi	Zaključni udarec	Prisiljena napaka	Nepotrebna napaka
Zaključni udarec	**98.2%**	0.5%	1.3%
Prisiljena napaka	1.8%	**89.0%**	9.2%
Nepotrebna napaka	2.1%	3.2%	**94.6%**

Tabela 2: Klasifikacijske točnosti po razredih

Kot lahko vidimo model najslabše napoveduje prisiljene napake, kar je pričakovano, saj dejansko ne obstaja nekega (nepisanega) pravila kdaj je nek udarec prisiljena napaka, tako da je tu tudi največ šuma v podatkih.

6. ZAKLJUČEK

V referatu smo predstavi tekmovanje z naslovom *From AO to AI: Predicting How Points End in Tennis* na katerem sva avtorja dosegla prvo mesto. Opisali smo postopek priprave podatkov z generiranjem novih spremenljivk in uporabe modela z optimizacijo parametrov ter predstavili rezultate.

Izkušnje, ki smo jih pridobili tekom tekmovanja in bi morda bile uporabne tudi pri drugih podobnih tekmovanjih bi lahko strnili na sledeče točke:

- Če imamo dve učni množici, ki sta si zelo podobni, je smiselno množici združiti, saj tako dobimo več podatkov za učenje in posledično boljše rezultate.
- Če imamo klasifikacijski problem, ki ni primeren za reševanje z globokimi nevronskimi mrežami se za izhodišče lahko uporabi XGB saj se večinoma izkaže kot zelo dober algoritem.
- Optimizacija hiperparametrov XGB algoritma je ključnega pomena za izboljšanje rezultatov.
- Uporaba domenskega znanja za kreiranje novih spremenljivk izboljša rezultate, saj algoritem sam ne zna smiselno povezati spremenljivk. Kot primer lahko navedemo izračunano hitrost teka igralca, ki jo ljudje, ki označujejo točke, (podzavestno) uporabljajo pri ločevanju nepotrebne od izsiljene napake.

7. VIRI

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Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek B

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume B

Kognitivna znanost
Cognitive Science

Uredila / Edited by

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http://is.ijs.si

11. oktober 2018 / 11 October 2018
Ljubljana, Slovenia

PREDGOVOR / FOREWORD

Na letošnji konferenci Kognitivna znanost sodelujejo avtorji/ice z različnih disciplinarnih področij, ki predstavljajo tako empirične rezultate svojih raziskav kot tudi teoretska raziskovanja. Ena izmed osrednjih tem letošnje konference je "Družbene, filozofske in etične implikacije raziskovanja v kognitivni znanosti", avtorji pa se dotikajo tudi drugih področji kognitivne znanosti.

Upamo, da bo letošnja disciplinarno in metodološko bogata kognitivna konferenca odprla prostor za izmenjavo zanimivih misli in idej ter povezala znanstvenike/ice različnih disciplin, ki se ukvarjajo z vprašanji kognitivnih procesov.

Olga Markič
Toma Strle

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Authors at this year's Cognitive Science conference come from numerous disciplines and present their empirical as well as theoretical work. One of this year's main topics is "Social, philosophical and ethical implications of cognitive science" but authors also present research form other areas in cognitive science.

We hope that this year's cognitive conference, being extremely diverse in disciplines and methodologies, will become a welcoming space for exchanging intriguing ideas and thoughts as well as for bringing together scientists from all the different areas exploring the questions of cognitive processes.

Olga Markič
Toma Strle

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Razumevanje odraslih partnerskih odnosov v luči spolne zlorabe v otroštvu

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POVZETEK[1]

Spolna zloraba v otroštvu je travmatična izkušnja s številnimi daljnosežnimi posledicami. Dokler travma ni razrešena, se pojavlja v mislih, čustvih in vedenju. Pojavi se takrat, ko je prebujen spomin iz preteklosti, kar se pogosto zgodi v odraslih partnerskih odnosih. Raziskave kažejo, da so težave v partnerskih odnosih bolj pogoste pri tistih, ki so doživeli spolno zlorabo, kot pri tistih, ki spolne zlorabe niso doživeli. Pari med drugim poročajo o oslabljenem zaupanju, oteženem čustvenem izražanju in težavah na področju spolnosti. Partnerski odnos se tako znajde na preizkušnji, oba v paru pa se spoprijemata z različnimi stiskami, katerih pogosto ne pripisujeta pretekli travmi. Prepoznavanje, razumevanje z elementi dvojnega zavedanja in predelava posledic, so bistvenega pomena za kakovostni partnerskih odnos. S prispevkom želimo poglobiti razumevanje delovanja odraslih partnerskih odnosov kot posledice spolne zlorabe v otroštvu in na podlagi klinične prakse opozoriti na možne oblike strokovne terapevtske pomoči pri predelavi posledic spolne zlorabe v otroštvu v partnerskih odnosih.

Ključne besede

Spolna zloraba v otroštvu, intimni partnerski odnos, zakonska terapija.

1. SPOLNA ZLORABA V OTROŠTVU

Spolna zloraba v otroštvu je travmatični dogodek, kjer je otrok uporabljen kot spolni objekt za zadovoljevanje potreb ali želja odrasle osebe, mladostnika ali starejšega otroka oz. storilca, ki namerno išče in spodbuja zlorabo z grožnjo, silo, ustrahovanjem ali manipulacijo [1]. V navedeno definicijo sodijo vrste vedenj s telesnim stikom ali brez telesnega stika, vključno z navezovanjem stikov za zlorabo, spolno sugestivnim jezikom, pornografijo, vojerizmom, ekshibicionizmom, ljubkovanjem, masturbacijo in penetracijo. Otrok je lahko zlorabljen s strani nekoga v družini ali izven nje, ki zlorabi svoj položaj moči in zaupanja [2], kar pomeni, da se zloraba zgodi znotraj odnosa. V literaturi je navedena kot relacijska travma, ki je bolj psihopatogena kot kateri koli drugi socialni ali fizični stres [3]. Številne posledice so lahko vidne takoj ali pa se pojavijo tekom odraščanja, pogosto pa se manifestirajo v intimnih odraslih partnerskih odnosih.

2. POSLEDICE SPOLNE ZLORABE V PARTNERSKIH ODNOSIH

Raziskave kažejo, da so psihološke posledice in težave v medosebnih odnosih bolj pogoste pri tistih, ki so doživeli spolno zlorabo, kot pa pri tistih, ki zlorabe niso doživeli [4]. Moški in ženske, ki so doživeli spolno zlorabo v otroštvu, v primerjavi s tistimi, ki je niso doživeli, poročajo o več medosebnih težavah na področju zaupanja, kontrole, odgovornosti, asertivnosti in občutku odtujenosti od svojega partnerja [5], kar se kaže kot nezadovoljstvo v zakonskem odnosu [6]. Številne raziskave so pokazale, da travma prizadene intimnost s partnerji [7, 8], npr. oslabi sposobnost zaupanja in oteži čustveno izražanja, izraža pa se tudi v obliki težav na področju spolnosti [9, 10, 11]. Najpogosteje so težave v tuji literaturi opisane kot zasvojenost s spolnostjo, spolne disfunkcije, ki posameznike zaznamujejo na področju spolne želje, vzburjenja in orgazma [12, 13], pogoste pa so tudi bolečinske motnje [13]. Partnerski odnos se zaradi posledic znajde na preizkušnji, oba v paru pa se spoprijemata z različnimi stiskami, katerih pogosto ne pripisujeta pretekli spolni zlorabi. Da bi lahko razmejila preteklost od sedanjosti [14] in kakovostno zaživela v partnerskem odnosu, jima je lahko v pomoč relacijska zakonska terapija.

3. RELACIJSKA ZAKONSKA TERAPIJA

Relacijska zakonska terapija [15, 16, 17, 18] temelji na premisi, da zakonca drug v drugem lahko prebudita najhujše nočne more, ki sta jih že kot otroka doživljala ob pomembnih drugih, in sicer z nezavednim namenom razrešitve [16]. V paru tako prisilno, ponavljata sistemske, medosebne in notranjepsihične zaznave, kjer ponovno nezavedno ustvarita konfliktne situacije, travme, vedenje, mišljenje in čutenje [15]. Tako se spolna zloraba z vso svojo razdiralnostjo ponavlja v intimnih partnerskih odnosih in išče razrešitev. Za boljše razumevanje v nadaljevanju predstavljamo vpogled v *del* kvalitativne raziskave, v kateri smo ugotavljali značilnosti intimnega partnerskega odnosa pri parih, ki so doživeli travmo spolne zlorabe v otroštvu in so bili vključeni v proces relacijske zakonske terapije [19].

[1] Prispevek je nastal v okviru raziskovalnega projekta J5-9349, ki ga financira ARRS.

4. METODOLOGIJA

4.1 Metoda in udeleženci

V raziskavo je bilo vključenih pet parov oz. deset udeležencev, od katerih je vsaj eden izmed partnerjev doživel travmo spolne zlorabe v otroštvu, obenem pa je ob vključitvi v partnersko terapijo njun odnos trajal vsaj leto dni. Raziskavo smo izvedli z metodo osnovane teorije, ki je omogočila sistematično zbiranje, analizo in razvoj teorije na podlagi zbranih in analiziranih podatkov [20].

4.2 Potek raziskave

Zbiranje podatkov je potekalo skozi terapevtski proces relacijske zakonske terapije, ki je trajala 6 mesecev (2 terapevtska cikla po 12 srečanj) oz. 24 srečanj, in sicer enkrat tedensko po 50 minut. Pred vključitvijo v terapijo smo pridobili soglasje za udeležbo v raziskavi z dovoljenjem za snemanje. Posnete terapije smo transkribirali in analizirali, vključili pa smo tudi svoja lastna opažanja, odzive in zapise supervizijskih srečanj. Raziskava je potekala na Družinskem inštitutu Bližina. V nadaljevanju predstavljamo rezultate dela raziskave, ki se nanašajo na področje težav v spolnosti in nekatere posege terapevtke v procesu relacijske zakonske terapije, ki poleg varnega terapevtskega odnosa omogočajo spremembe [19].

5. REZULTATI

5.1 Medosebne težave na področju spolnosti

V obdelavi zbranih podatkov je bilo ugotovljenih šest kategorij, ki predstavljajo težave na področju spolnosti: umanjkanje spolnih odnosov, odsotnost želje po spolnosti, spolnost kot dolžnost, doživljanje telesa v spolnosti, nezadovoljstvo v spolnosti, doživljanje občutij v spolnosti [19].

5.1.1 Umanjkanje spolnih odnosov

M[2]: *»Je bilo že bolš, sedaj pa je »slaba volja« med nama ...«* Ž[3]: *»Spolnih odnosov z možem zaenkrat še nimava, kar me straši, saj to traja že pol leta.«*

Vsi pari so na neki točki v terapiji poročali o umanjkanju spolnih odnosov. Nekateri so poročali o umanjkanju spolnih odnosov že pred pričetkom terapevtskega procesa, pri drugih je do umanjkanja spolnih odnosov prišlo že v prvem delu terapevtskega cikla. Za pare je umanjkanje spolnih odnosov predstavljalo težavo. Spraševali so se, kaj je narobe z njimi, da nimajo spolnih odnosov. Namreč, ko se spolna zloraba prebudi v partnerskem odnosu, pomeni, da je oseba pričela doživljati potlačena čutenja, ki so vezana na samo spolno zlorabo v otroštvu. Preko različnih sprožilcev, kot je lahko pri spolnih odnosih dotik, vonj ali okus [14], so se udeleženci z umanjkanjem spolnosti nezavedno zaščitili pred gnusom, strahom, sramom, jezo in krivdo, ki je povezana s samo zlorabo.

5.1.2 Odsotnost želje po spolnosti

Ž: *»Jaz nimam želje po spolnih odnosih, <u>on pa razume, kot da ga ne maram</u>.«*

O odsotnosti želje po spolnosti so poročale samo ženske, vendar pa je odsotnost želje pri enem v paru povzročila neprijetna občutja pri obeh, kar je povedala ena izmed udeleženk (podčrtano) in kar se je za pomembno izkazalo tudi med samim procesom terapije. Ena izmed udeleženk je npr. povedala, da ji odleže, če gre z otrokom spat, saj nima nobene želje po spolnosti.

[2] moški

[3] ženska

5.1.3 Spolnost kot dolžnost

Ž:*»Spolnost sem jemala, ali pa jo še kot dolžnost, ki jo je potrebno opravljati v zakonu, v smislu brez spolnosti ni zakona.«* Ž:*»Tako sem mislila, nisem vedela, da imam pravico reči ne, in je bilo veliko spolnosti, ki si je nisem želela.«*

Spolnost kot dolžnost je doživljalo vseh pet žensk v paru in dva moška. Nekateri so o doživljanju spolnosti kot dolžnosti poročali retrospektivno, tj. pred prihodom na terapijo, drugi pa so spolnost kot dolžnost doživljali med terapevtskim procesom. Navedeno doživljanje lahko povežemo s samo spolno zlorabo. Storilec je otroka izkoristil za zadovoljevanje svojih potreb in otrok je moral biti storilcu na razpolago za zadovoljevanje njegovih potreb. Storilec je svoje hotenje (moraš, dolžan si mi) prenesel na otroka, ki se je čutil dolžnega. V partnerskih odnosih se občutek dolžnosti prebudi ob partnerju, ki si spolnosti želi, posameznik pa doživlja, da mu mora biti na razpolago in da je dolžan z njim imeti spolni odnos in tako zadovoljiti potrebe partnerja.

5.1.4 Doživljanje telesa v spolnosti

Ž: *»... še vedno me peče, šla sem po antibiotike ... nič, nožnica me še vedno peče.«*

M: *»... vsakič, ko ji samo povem, da čutim vzburjenje, ona pove, da takoj čuti bolečino, ta pekoč občutek, samo da omenim ali najmanjši dotik, ki bi lahko imel to konotacijo, da bo šlo za neko približevanje ali predigra ali spolnost ...«*

Pari so telo doživljali različno, od prisotne fizične bolečine, ki se je pri eni udeleženki konstantno pojavljala, kadar je njen mož čutil vzburjenost. Zaradi pekoče bolečine je pri ginekologinji večkrat iskala pomoč, vendar pa fizičnega vzroka niso odkrili, prav tako ji tudi antibiotična zdravila niso pomagala odpraviti pekoče bolečine. Tudi druga udeleženka je poročala o bolečini med samim spolnim odnosom. Dve udeleženki sta svoje telo doživljali kot breme, ki bi ga bilo potrebno »odstraniti«, ena udeleženka in eden udeleženec med spolnim odnosom telesa nista čutila oz. je prišlo do disociacije le-tega. Trije udeleženci nad svojim telesom niso imeli kontrole. Pri enem ni bilo mogoče kontrolirati odziva telesa, ko je prihajalo do neželenih izlivov, pri dvema pa je bilo izrazito samozadovoljevanje. Samozadovoljevanje se je kazalo kot odraz tesnobe in napetosti, kar je vodilo v občutja krivde.

5.1.5 Nezadovoljstvo v spolnosti

M: *»Odnos je žal zelo neusklajen, saj je tako fizičnega kot spolnega kontakta premalo ... in tudi takrat ko je, je to po njeni odločitvi."*

Ž: *»Spolnost je v bedu.«*

Vsi moški udeleženci so doživljali nezadovoljstvo, ki se je kazalo v obliki prepirov, razočaranja, nesproščenosti, nepredanosti in nezmožnosti vplivanja na to, kdaj bosta imela spolni odnos. Ženske udeleženke so poročale o prepirih, nesproščenosti in razočaranju. Glede na to, da so pari doživljali spominske prebliske, disociacije, bolečinske motnje, strahove, tesnobna razpoloženja, odpor in nezaupanje, je nezadovoljstvo v spolnosti normalni odgovor na nenormalno izkušnjo v otroštvu oz. normalna posledica prebujene zlorabe v partnerskem odnosu.

5.1.6 Doživljanje občutij v spolnosti

Ž: *»Me pa velikokrat prešine misel, da tega ne smem početi, da ne smem uživati v spolnem odnosu, ker bom kaznovana.«* M: *»... Ma me jezi, ja! Najprej ja, potem ne ... daj, odloči se že enkrat!«* V raziskavi se je izkazalo, da so pari doživljali različna občutja, od negotovosti do krivde, strahu, sramu, jeze, žalosti, gnusa, odpora, stiske in zmedenosti. Občutja so bila močno prisotna tudi v terapevtskem procesu, pri katerem je bila osnovna terapevtska intervencija regulacija le-teh. Ženske udeleženke so doživljale močna občutja krivde. Pri treh udeleženkah se je občutje prebudilo po spolnem odnosu, v enem primeru je bilo povezano s kaznijo, pri dveh udeleženkah pa s tem, ko zavrneta spolni odnos. Eden izmed udeležencev moškega spola je prav tako vedno po spolnem odnosu doživljal občutke krivde. Pri krivdi gre za samoobtoževanje, ki je posledica spolne zlorabe. Krivijo se, ker niso preprečili ali ustavili zlorabe, pogosto sebe krivijo, da je do spolne zlorabe sploh prišlo. To se kaže tudi v izjavi ene izmed udeleženk, ki sta jo zlorabljala dva storilca: *»... Ne vem ... nekaj je že moglo biti na meni ... mogoče moje oči ...«* Moški udeleženci so doživljali žalost, jezo in tudi gnus. Eden izmed udeležencev je pojasnil, da zelo pogosto med samim spolnim odnosom doživi gnus, ki ga popolnoma zablokira. Navedeno lahko pojasnimo s sistemsko razsežnostjo travme, ko se na moža prenesejo občutja, ki jih žena nosi globoko v sebi. Ob spolni zlorabi se kot otrok ni smela oz. mogla jeziti, zaradi izdajstva je bila žalostna, doživljala je tudi občutja gnusa. Občutja, ki jih je povzročil storilec in so ostala »zaklenjena v telesu«, so se preko mehanizma projekcijske identifikacije prenesla na moža oz. partnerja, ki prične čutiti in doživljati vsa občutja na svojem telesu. Navedene posledice predstavljajo stiske, ki jih doživljajo pari v partnerskih odnosih. Klinična praksa kaže, da posledic pogosto ne povezujejo s preteklo zlorabo, neredki pa se tudi ne zavedajo, da so določene izkušnje iz njihovega otroštva po svoji naravi pravzaprav bile spolna zloraba. Da bi lahko resnično zaživeli kakovostni partnerski odnos so potrebni prepoznavanje, razumevanje z elementi dvojnega zavedanja in predelava posledic, kar omogoča zakonska oz. partnerska terapija.

5.2 Proces relacijske zakonske terapije

V samem procesu relacijske zakonske terapije smo s posegi terapevtke zasledovali spremembe, ki so tudi cilj terapevtskega procesa in sicer spremembe na vedenjski, kognitivni in čutenjski ravni kot tudi spremembe na intrapsihičnem, medosebnem in sistemskem delovanju.

5.2.1 Zagotavljanje varnosti

Na začetku terapevtskega procesa je bila prva naloga terapevtke zagotavljanje varnosti. Tedenska struktura je parom zagotavljala predvidljivost, ki je v svojem domačem okolju niso bili vajeni, in jim je s tem omogočala spremembo. Obenem smo v terapevtskem procesu naslavljali njihova doživljanja glede vključevanja v raziskavo in načinom, da se srečanja snemajo. Ob tem smo parom obrazložili, da so v svoji odločitvi popolnoma svobodni in v kolikor bi se odločili, da ne želijo več sodelovati v raziskavi, njihova odločitev ne bo vplivala na kakovost terapevtske obravnave ter da že podpisano soglasje lahko tudi med terapevtskim procesom kadarkoli iz kakršnihkoli razlogov prekličejo. S tem smo parom ob zagotavljanju varnosti omogočili tudi možnost kontrole. Namreč ob samem dogodku zlorabe je bil otrok popolnoma brez kontrole, saj je bil odrasli tisti, ki je vse nadziral, so med terapevtskim procesom dobili možnost, da le-tega lahko kontrolirajo, tudi s temami, ki so jih na srečanja prinašali. Terapevtka jim je vedno zagotavljala, da v kolikor o nečem ne želijo govoriti, jim to ni potrebno oz. lahko povedo samo toliko, kolikor se jim zdi varno povedati, obenem pa vedno lahko ustavijo, vprašajo oz. izrazijo svoje želje glede samega procesa terapije. Na koncu vsakega srečanja je bila narejena refleksija v smislu, kako bo oditi po posamičnem srečanju. Pari so imeli tako možnost spregovoriti o svojem čustvenem doživljanju in izraziti svoje misli v samem terapevtskem procesu. Glede same varnosti smo v terapevtskem procesu tudi preverjali, kako je s trenutno varnostjo izven terapevtskega procesa (doma, v širši družini, v službenem okolju). Da bi lahko v polnosti pridobili občutek varnosti in kontrolo nad tem, kar se jim dogaja, so najprej potrebovali vzpostaviti kontrolo nad telesom in čutenji, s katerimi so postopoma prihajali v stik. Terapevtka je tudi kasneje, ne samo na začetnih srečanjih, zagotavljala varnost s terapevtskim odnosom, v katerem je parom ovrednotila njihovo doživljanje in s sočutnimi odzivi nudila občutek sprejetosti.

5.2.2 Priznanje, da se je zloraba res zgodila

Pomemben element v terapiji je bilo razkritje zlorabe. Osebe, ki so doživele spolno zlorabo, težko zaupajo, ne samo partnerju, tudi terapevtu. Najbolj jih ovira sram, ki ohranja negativno podobo o sebi. Ko govorimo o razkritju spolne zlorabe, to ne pomeni, da mora oseba grafično opisovati spolno zlorabo, temveč da spregovori o svojem doživljanju. Prvi korak je bil, da je lahko naglas priznala, da se je zloraba res zgodila. Ne gre samo za besede oz. kognitivno komponento, temveč tudi za afektivni vidik. Ko spregovorijo o čustvenem doživljanju, jim ni več potrebno skrivati sramu, kar jih razbremeni. Navedeno tudi pripomore, da »težkih vsebin« ne odrežejo, temveč se prično soočati tudi s posledicami, kot so npr. spominski prebliski. Do navedenega lahko pride, kadar je v odnosu dovolj varnosti, ki pa jo mora najprej zagotoviti terapevtka. Takrat potem lahko oba v paru sprocesirata žalost, jezo, sram, strah in gnus.

5.2.3 Psihoedukacija

Del terapevtskega procesa je bila psihoedukacija, v kateri je terapevtka pojasnila samo naravo travme spolne zlorabe, vpliv, ki ga je imela na osebo, ki jo je doživela, in posledice, ki jih doživlja spolno zlorabljena oseba ter tudi njen partner. Pari, ki so doživeli spolno zlorabo v otroštvu so doživljali veliko simptomov, kot so nočne more, strahovi, hude stiske in so se spraševali, če so sploh še normalni. Terapevtka je normalizirala njihovo doživljanje v povezavi s preteklo spolno zlorabo. Pomembno je bilo, da oba v paru razumeta, kar se je dogajalo, saj je partnerja, ki je doživel zlorabo sram, da tako čuti in doživlja. Terapevtka je parom omogočala občutek kontrole, da so lahko sami izbirali teme in se pogovarjali o tem, kar so želeli. Če je npr. klientka dejala, da o spolnosti še ne želi govoriti, jo terapevtka nikoli ni silila, temveč jo je zanimalo, kaj bi čutila, če bi govorila. Pogosto je bil sram tisti, ki ji je onemogočal spregovoriti o stiski. Pomembno je, da razumeta oba, da v primeru raznovrstnih težkih simptomov ne gre za patologijo osebe, ki je bila spolno zlorabljena v otroštvu, temveč za normalne odzive na nenormalne, travmatične dogodke. Gre za del pomoči vzpostavljanja kontrole nad situacijo, ko vidi, kaj se dogaja, in ve, da gre samo za simptom, da ni z njo nekaj narobe, da razume najprej na kognitivnem nivoju, kaj se dogaja.

5.2.4 Postavljanje meja

Ena izmed pomembnih tem je bila spoštovanje do lastnega telesa. Kadar je terapevtka čutila, da si ženska ne želi spolnih odnosov, kljub temu pa se vanje spušča, ji je dala dovoljenje, da ji tega ni več potrebno početi. Ženske so v terapiji povedale, da jim je slednje zelo pomagalo, da so lahko pričele poslušati svoje telo, obenem pa je navedeno razbremenilo tudi njihove partnerje.

5.2.5 Razmejevanje preteklosti od sedanjosti

Pomemben poseg terapevtke je bilo tudi razmejevanje preteklosti od sedanjosti oz. dvojno zavedanje. Oba zakonca oz. partnerja v paru sta pogosto doživljala hude čustvene stiske, ki sta jih pripisovala drug drugemu. Preteklost se je preko čustev in telesa prebujala v sedanjosti, drug ob drugem. Navedena dinamika je bila pogosta v spolnih odnosih, pri katerih je žena svojega moža pričela doživljati kot storilca. Ko je žena zavračala spolne odnose, se je mož počutil zavrnjenega. Terapevtka jima je pomagala razumeti, da žena ne zavrača moža, temveč čutenja, kot so sram, gnus v povezavi s ponižanjem in razvrednotenjem, kar se prenaša preko relacijskega mehanizma projekcijske identifikacije iz preteklosti v sedanjost in se odigrava v njunem partnerskem odnosu. V tem delu je bilo pomembno razumevanje, da se zloraba ne dogaja več, so pa čutenja tista, ki se prebujajo v sedanjosti.

5.2.6 Povezovanje v paru

Bistveno v relacijski zakonski terapiji je povezovanja para na nov način. Namreč glavnina procesa poteka na njunem partnerskem odnosu v sedanjosti, ne na pretekli travmi. V kolikor sta se zmožna čustveno povezati na drugačen način, potem partnerski odnos nudi toliko varnosti, da jima ni potrebno več ohranjati obrambnih drž, kot so obtoževanje in umikanje, temveč lahko delita najbolj ranljiva čutenja. Šele, ko sta v polnosti ranljiva drug z drugim, sta sposobna razviti sočutje drug do drugega, do male deklice in malega dečka, ki sta še vedno globoko v njima, povezana s težkimi občutji in moledujeta za pozornost, sprejetost in ljubezen.

6. ZAKLJUČEK

Pari z izkušnjo spolne zlorabe v otroštvu se srečujejo s težavami v medosebenih intimnih odnosih in potrebujejo strokovno pomoč, ki jim pomaga razumeti njihove trenutne težave v luči pretekle spolne zlorabe. Ključni pri pomoči so lahko zakonski terapevti, ki s pomočjo relacijske zakonske terapije, svojim sočutnim odnosom in ustreznim znanjem pripomorejo k zdravljenu preteklih travm in skupni rasti v partnerskem odnosu. Glede prizadevanja pomoči parom bi bilo potrebno več pozornosti nameniti preventivnim programom, ki bi s svojo izobraževalno naravo pripomogli k lajšanju marsikatere stiske, ki jo doživljajo pari.

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Do healthy participants make advantageous decisions? Evidence from the Iowa Gambling Task

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ABSTRACT

Somatic Marker Hypothesis (SMH) suggests that decision making in uncertainty relays on somatic markers – emotional reactions reflected in bodily states which lead person towards advantageous decision making. Authors of SMH created a task aiming to access decision making in uncertainty – Iowa Gambling Task (IGT), suggesting that since healthy participants tend to develop advantageous decision-making strategy, they will have good IGT performance. Recent studies however, question good IGT performance among healthy participants thus imposing question on their advantageous decision-making strategies. The aim of this study was to explore IGT performance among healthy participants. Participants (N=268) filled standard version of IGT, consisting of 100 trials in which participants select cards from four decks: A and B, that bring higher rewards and penalties (good decks) and C and D that bring small rewards and penalties (bad decks). At the beginning of the IGT, participants get 2000$ of play money, with instruction to try to gain as much money as possible. Results show that participants tend to lose rather then gain money, with almost half of participants showing impaired IGT performance. In addition, results indicate that frequency of punishment, rather than overall goodness or decks is factor relevant for specific deck selection. Study results question wheatear healthy participants apply advantageous decision-making strategies when performing IGT, indicating that future studies are needed in order to explore factors contributing to advantageous decision making in uncertainty.

Keywords

Iowa Gambling Task, IGT, Somatic Marker Hypothesis, Decision Making.

1. INTRODUCTION

Numerous studies exploring decision making in uncertainty rely on Somatic Marker Hypothesis (SMH) [3, 5, 9]. This hypothesis suggests that normal decision-making in humans is led by somatic markers - bodily states which represent emotional reactions to different stimuli or to possible courses of action. Authors of SMH suggest that somatic markers, activated in situation of uncertainty can effectively reflect the goodness or badness of the possible outcome, leading a person towards advantageous decision making. Importantly, authors suggest that somatic markers represent a "gut feeling", which can operate both consciously and unconsciously. SMH, thus suggests that somatic markers can lead people to advantageous decision making even though they do not necessarily need to be aware of which decisions are good and which ones are bad [5, 9, 10].

1.1 IOWA GAMBLING TASK

Authors of Somatic Marker Hypothesis created a task aiming to access advantageous versus disadvantageous decision making – Iowa Gambling Task (IGT) [4]. In the IGT, participants are presented with four deck of cards. After selecting a card, participants either win or lose different amounts of play money. Unknown to the participants, selecting cards from two of the decks – C and D will result in eventual gain ('advantageous', or 'good' decks), whereas selecting cards from the other two decks - A and B will result in eventual loss ('disadvantageous', or 'bed' decks). The task has 100 trials, so that, according to authors' idea, participants still could not understand reword-punishment scheme. Authors suggested and demonstrated in several studies that healthy individuals will select more cards from the good than the bad decks, thus showing tendency towards advantageous decision making [4, 17]. Task validation was demonstrated in numerous studies which indicated that impaired IGT performance have persons with problems in advantageous decision making in everyday life [7, 12, 14, 15, 18], as well as patients with lesions in the brain region relevant for the judgment and decision-making in real-life settings [4, 6, 9].

Recent studies, however, question whether healthy persons do prefer good over a bed decks and indicate that healthy controls tend to select bed decks equally or even more frequently than good ones [2, 8, 11, 16]. Moreover, when selection of each deck specifically was analyzed, it was shown that bed deck B is equally or even more frequently selected then good decks C and D [8, 11], while bed deck A represent the least selected deck [11, 13, 19]. Possible explanation can be found in differences among frequency of punishment within good and bed decks, resulting in decks A and C being frequent punishment decks, while decks B and D represent non-frequent punishment decks, which was not taken into consideration in the early IGT studies. Studies that included both criteria into analysis of IGT performance, indicated that frequency of punishments, rather than overall goodness of deck seems to be leading participants towards selection of specific decks [8, 11, 13, 19]. Thus, recent studies indicated that it is not certain whether healthy controls show homogeneous tendency towards advantageous decision making and whether overall goodness of decks, or rather frequency of its punishments will be relevant factor for deck selections.

1.2 PRESENT STUDY

In this study 268 (81.7% females, average age 20 years) participants, completed standard version of Iowa Gambling Task (IGT).

2. RESULTS

On average, participants scored 1475$ on IGT, ranging from -4525 to 6075, indicating that participants tend to rather lose then gain money on IGT, i.e. that participants, on average, do not show advantageous decision-making strategy. Table 1 presents descriptive measures of each deck selection separately.

Table 1. Descriptive statistic of each deck selection, in proportion

Deck	*M*	*SD*	*Min*	*Max*	*zSk*	*zKu*
A	.17	.098	0	.75	8.18**	16.66*
B	.29	.142	0	.72	1.20	.60
C	.23	.156	0	.1	15.21*	27
D	.31	.175	0	.1	9.73**	9.51

M – mean; *SD* – standard deviation; *Min* - minimum; *Max* – maximum; *zSk* – standardized Skewness; *zKu* – standardized Kurtosis; ns - p > .05; * - p <.05; ** - p <.01.

Results show that participants the most frequently selected cards from deck D and deck B subsequently, somewhat less frequently they selected cards from deck C, while they selected cards from deck A the least frequently among all decks. Table 2. presents percentage of participants who selected cards from good versus bed decks at more than 50% of trials, as well as percentage of participants who selected cards from non-frequent punishments decks B, D versus frequent punishments decks A and C at more than 50% of trials. Results indicate that somewhat less than half of participants have impaired performance [4], i.e. they selected more cards from bed then good decks, while more than three quarters of participants selected more cards form non-frequent punishments decks B and D, in comparation to frequent-punishments decks A and C. There is no significant difference in number of participants who selected more cards from good then bed decks [$\chi^2(1) = 2.149$; $p = .143$], while significant difference was found in the number of participants who selected more cards from non-frequent punishment decks B and D in comparation to selection of cards from frequent punishment decks A and C [$\chi2(1) = 75.239$; $p < .001$].

Table 2. Percentage of participants who selected more cards from different decks

<table>
<tr><td colspan="2" rowspan="2"></td><td>% of participants with more cards from good decks</td><td>% of participants with more cards from bed decks</td></tr>
<tr><td>54.5%</td><td>45.5%</td></tr>
<tr><td>% of participants with more cards from non-frequent punishments decks</td><td>76.5%</td><td>39.9%</td><td>36.6%</td></tr>
<tr><td>% of participants with more cards from frequent punishments decks</td><td>23.5%</td><td>14.6%</td><td>9%</td></tr>
</table>

3. DISCUSSION

Study results indicate that, contrary to IGT authors' expectations, participants tend to lose rather than win money on IGT and that almost half of participants have impaired performance, i.e. more choices from bed then from good decks. This result is in line with studies questioning whether healthy controls prefer good over a bad deck and whether they show overall advantageous decision-making strategy [2, 8, 11, 16, 17]. Results also show that majority of participants prefer non-frequent punishment decks B and D in comparation to frequent punishment decks A and C. These results indicated importance of frequency of punishment in deck selection. They are also in line with results of a previous studies that considered both frequency of punishments and overall goodness of decks, indicating that participants tend to the most frequently select cards from deck D (good, non-frequent punishments deck), then B (bed, non-frequent punishments deck), then deck C (good, frequent punishments deck), while they the least frequently select cards from deck A (bed, frequent punishments deck) [1, 8, 11].

Results of this study indicated that healthy controls do not show homogenous IGT performance, nor advantageous decision-making strategy. In addition, results indicated than frequency of punishments rather than overall goodness of deck is relevant for deck selection, showing that immediate reword/punishment seems to be more important than long term consequences in decision making. These results do not question Somatic Marker Hypothesis, just call for additional studies that will improve understanding of factors that contribute to good IGT performance, and overall advantageous decision making in situations of uncertainty.

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Palaeolithic toolmaking and the evolution of cognition and language

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ABSTRACT
This paper reviews in short the current research on the hypothesis of coevolution between Palaeolithic stone tool manufacture on one side, and cognition and specifically language on the other. Of particular interest are behavioral and neuroimaging studies.

Keywords
language evolution, cognitive evolution, Palaeolithic, stone tools, Oldowan, Acheulean, Levallois, cultural transmission

1. INTRODUCTION[1]
In the past two decades great interest has emerged for interdisciplinary discussion on the evolution of cognition and specifically language (e.g. Janković and Šojer 2015). Recent work strongly emphasizes the role of cumulative culture, i.e. products, skills and knowledge created over generations of human lifetimes, in the evolution of specific hominin cognitive abilities, including language (e.g. Lotem et al. 2017).

Moreover, it remains a controversial issue whether evolutionary changes in hominin cognition should be viewed as structural and/or functional novelties, or as exaptations of preexisting primate structures and/or functions (e.g. Stout and Chaminade 2007: 1092). Nevertheless, ample literature now acknowledges that exaptation played a major role in hominin cognitive evolution (e.g. Kolodny and Edelman 2018), but also e.g. in the evolution of hominin musculature underlying bipedalism, tool use and speech (Diogo 2018). For language specifically, it has been e.g. argued that both child first language and adult second language acquisition are served by general-purpose learning systems of declarative and procedural memory (Hamrick et al. 2018), and that linguistic semantic processing is highly dependent on modality-specific processing mechanisms of the sensorimotor system and not only on amodal or "abstract" semantic operations (e.g. Pulvermüller 2013).

Still, empirical research in the evolution of cognition and language remains relatively scarce, mostly due to serious methodological limitations (see §3). One approach has been to find behavioral correlates of specific cognitive functions in the Palaeolithic record, the archaeological period beginning with the appearance of first known hominin stone tools ~3.3 mya (Harmand et al. 2015) and finishing with the end of the last glacial period (Karavanić and Janković 2009).

[1] *Abbreviations*: ESA=Early Stone Age (~Oldowan and Acheulean); IPS=intraparietal sulcus; SMA=supplementary motor area; SMG=supramarginal gyrus; vPrCG=ventral precentral gyrus; vPMC=ventral premotor cortex

Research in this area has been in large part focused on inferring "modern" and "symbolic behavior" from archaeological data, such as ochre and ornament use, figurative art production, subsistence strategies etc. (e.g. d'Errico et al. 2003). The research was led by the premise that such behaviors indicate the existence of a package of "higher" cognitive abilities. However, these discussions have been heavily criticized from a methodological point of view (e.g. Botha 2009, 2012), and they currently struggle to find support in cognitive science (e.g. Garofoli 2014).

2. PALAEOLITHIC STONE TOOLS
Recently, vast literature has appeared supporting the coevolution of cognition and language on one side, and the manufacture of Palaeolithic stone tools on the other (see e.g. Stout and Hecht 2015 for a review). Archaeology has recognized several phylogenetic phases of stone tool manufacture, and research in this topic has tried to correlate these phases with evolutionary developments in cognition, most notably visuospatial processing, executive functioning, social cognition and language.

2.1 Lomekwian
The earliest known hominin stone tools dated to ~3.3 mya come from Lomekwi, Kenya, and consist of various rocks used for pounding, stone anvils and cores from which flakes were struck using a hammerstone (Harmand et al. 2015). The site predates the earliest known *Homo* specimens dated to ~2.8 mya (Villmoare et al. 2015). Cognitive implications of the Lomekwi findings, regarding among others bimanual coordination and lateralization more generally, are discussed in Lewis and Harmand (2016).

2.2 Oldowan
Oldowan represents the next stage of hominin stone technology, ranging from ~2.6 (Semaw 2000) to ~1.42 mya (Toth and Schick 2018: 7). It is generally considered to be characterized by flaked pebble tools, namely choppers and chopping tools, used for pounding or bone splitting. The knapping of these pebbles produced smaller flakes which could have been utilized for meat butchering (Toth 1987). Oldowan is most commonly associated with *H. habilis*, but it is not excluded that australopithecines engaged with Oldowan tools (Karavanić and Janković 2009: 107). Compared to Lomekwian Oldowan is described as entailing greater abundance of flakes and smaller tool dimensions (Hovers 2015). Toth and Schick (2018) argue that Oldowan findings are suggestive of the incorporation of stone tools as a critical adaptive component which presumably led to more complex subsistence strategies, social behavior and communication.

2.3 Acheulean

The oldest Acheulean finds are dated to ~1.7 mya (Diez-Martín et al. 2015) and lasted in some parts of the world up to ~100 kya. Acheulean is most commonly associated with *H. erectus* and Middle Pleistocene hominins, such as *H. heidelbergensis* (Torre 2016). The most commonly recognized Acheulean tool is the handaxe and its iterations, a bifacially flaked stone tool usually of amygdaloidal form (Torre 2016). Furthermore, Acheulean assemblages also contain various flake tools. *H. ergaster/erectus* was the first hominin species to expand out of Africa settling vast areas of Asia and Europe. However, this expansion did not necessarily entail the spread of Acheulean, because the earliest known hominin sites in Europe exhibit a stone industry with an Oldowan tradition (Karavanić and Janković 2009: 120). ~500 kya, many European stone industries start to resemble the later Acheulean with its well-formed handaxes (Karavanić and Janković 2009: 124). It has been argued that Acheulean tool production is more cognitively demanding relative to Oldowan due to its supposed higher hierarchical and sequential complexity (e.g. Torre 2016: 8ff.).

Due to space limitations and the fact that empirical studies almost exclusively focused on Oldowan and Acheulean, later hominin technologies will not be discussed here (but see §3). Additionally, further insights into the cognitive implications of Palaeolithic tools have come from the recent discoveries of primate tool-related behaviors (see Haslam et al. 2017 for a review).

3. EMPIRICAL STUDIES

Empirical studies concerned with the coevolution of cognition and stone tool manufacture include (1) behavioral studies investigating the effects of different cultural transmission conditions on the acquisition of stone tool manufacture, and (2) neuroimaging studies of stone toolmaking or its observation. More detailed and critical analyses of the studies in question are, unfortunately, beyond the limitations of this paper.

Some methodological constraints include (1) difficulties in neuroimaging of stone tool manufacture, e.g. due to the static nature of the conventional methods such as fMRI, or the possibly more harmful effects of FDG-PET on subjects due to longer and more demanding activities (Stout and Chaminade 2007: 1096), (2) small numbers of subjects and/or shorter learning periods due to the need of collecting large amounts of raw material for tool production and the known infrastructural limitations of neuroscientific research on the number or the mere existence of subjects, and (3) recruiting modern humans to study cognitive abilities of extinct hominin species (e.g. Putt et al. 2017: 1).

3.1 Cultural transmission studies

To our knowledge only five such studies have been conducted while interpreting the results has been challenging. All have included subjects in the earliest learning stages. Regarding Oldowan, Morgan et al. (2015) compared transmission efficiency during flaking acquisition across five communication conditions. They found i.a. that the transmission improved with gestural and verbal teaching relative to imitation/eumlation as seen e.g. in flake quality and the number of viable flakes produced. Furthermore, they found that verbal teaching improves performance relative to gestural teaching. Morgan and colleagues argued that ESA technologies possibly generated selection for increasingly complex transmission modes. These results were in some measure replicated by Lombao et al. (2017) who compared the efficiency of imitation/emulation, and gestural and verbal teaching in the acquisition of the alternating flaking method. They reported that both teaching conditions improved performance compared to imitation/emulation and that the effects were most pronounced in the verbal teaching condition. Additionally, Cataldo et al. (2018) found in their study of flaking that subjects instructed with gesture-free verbal teaching underperform relative to subjects instructed by gestural or "full-language" teaching. Cataldo and colleagues thus conclude that while gestural communication was likely under selective pressures in the Oldowan populations, this is not necessarily the case for (spoken) language.

As to post-Oldowan techniques, Putt et al. (2014) compared the efficiency of imitation/emulation and verbal teaching in the acquisition of Acheulean handaxe manufacture. They reported no significant differences e.g. in shape and symmetry of the tools between the groups, but the non-verbal group produced more efficient flakes as seen in higher ratios of platform width to platform thickness and size to mass compared to the verbal group. Putt and colleagues concluded that (spoken) language wasn't necessary for the transmission of handaxe manufacture and that its implementation in the earliest learning stages might hinder progress. Ohnuma et al. (1997) compared the efficiency of "verbal" and "non-verbal demonstration" in the acquisition of Levallois flaking. There were no significant differences between the two conditions in the acquisition rates and mean times, and flaking success from which Ohnuma and colleagues concluded that (spoken) language was not necessary for Levallois flaking. Nonetheless, Levallois has been linked to increased demands in sequential and hierarchical planning as well as self-monitoring (e.g. Schlanger 1996: 246ff.).

It should, however, be noted that there exist considerable methodological variations in the observed studies as in the neuroimaging studies, e.g. in the selection, homogeneity and preparatory modification of raw material, learning duration and rates, presence of an experienced teacher, number of subjects etc.

3.2 Neuroimaging studies

Neuroimaging studies have been mainly trying to determine the cortical structures which would have been under selective pressures, and then tying these structures to specific cognitive functions. Hecht et al. (2014) conducted a longitudinal DTI study with participants who in a two-year program acquired basic Oldowan flaking, Acheulean handaxe manufacture and Levallois flaking. They recorded fractional anisotropy changes in branches of the superior longitudinal fasciculus leading into the left SMG and vPrCG, and right pars triangularis (part of Broca's area). They thus concluded that the acquisition of Palaeolithic stone tool manufacture entails structural remodeling of inferior frontoparietal areas. Stout et al. (2008) further report from their PET study of Oldowan flaking and Acheulean handaxe manufacture by expert subjects that Oldowan and Acheulean manufacture shared increased activation compared to the control condition in specific bilateral parietal clusters in the superior parietal lobule, IPS and SMG, and additionally in BA 17 and 18 in the occipital lobe. Stout et al. (2011) conducted an fMRI study in which subjects with different degrees of experience in Palaeolithic toolmaking viewed 20-second clips of Oldowan flaking and Acheulean handaxe making. Compared to the control condition increased activation during observation of ESA toolmaking was yet again documented in the occipital and inferior parietal areas, and the precentral gyri, and was further found in the inferior temporal cortices and the right Broca's area (BA 44 and 45). These results suggest that early Palaeolithic toolmaking relies largely on motor and visuospatial processing, but two studies have also recorded increased activity in the prefrontal cortex suggesting the involvement of hierarchical and sequential action processing.

Oldowan toolmaking has been described as involving mainly the frontoparietal sensorimotor areas, most notably the vPrCG, SMA and IPS, and the cerebellum while it is not associated with prefrontal activity (Stout 2000, 2007). Studies have concluded that Oldowan toolmaking relies mostly on motor and visuospatial processing with no apparent role of e.g. executive functioning, suggestive of more “ape-like” cognitive abilities (Putt et al. 2017: 4). It is here notable that the parietal cortex has witnessed a significant enlargement during hominin evolution and it is suggested that the most pronounced changes occurred around the IPS as evidenced by an inferior displacement of the lower parietal areas (Bruner 2010). Furthermore, changes in cerebellum size have been noted as well in a computational study comparing Neanderthal and modern human brains (Kochiyama et al. 2018).

Stout et al. (2008) found higher activation during Acheulean relative to Oldowan toolmaking bilaterally in the vPMC, inferior parietal areas and the right Broca’s area. Furthermore, Uomini and Meyer (2013) conducted an fTCD study with expert subjects engaged in the Acheulean handaxe production and silent phonemic fluency. They noted high correlations between the hemodynamic lateralization patterns during the two tasks. It has been argued that there is a strong evolutionary connection between functional lateralization, as seen e.g. in bimanual coordination, and language (e.g. Uomini 2015). However, Putt et al. (2017) reported from their fNIRS study that subjects acquiring Acheulean handaxe manufacture in a verbal teaching condition had increased activation in the right pars triangularis compared to the non-verbal condition. These results cast potential doubt on the validity of previous results regarding Broca’s area. However, comparisons between the toolmaking and control conditions were not reported. Furthermore, the study included only subjects in their early learning phases. Still and all, it has been proposed that Broca’s area poses a possible connection between the evolution of toolmaking and language because of its prominent role in schematic body representation as well as sequential and hierarchical goal-directed action processing (e.g. Ruck 2014). Additionally, Kemmerer (2012) suggested that the cross-linguistically most prevalent word orders (SOV and SVO) reflect the ways Broca’s area processes actions and/or events. Moreover, Putt et al. (2017) found bilateral temporal Acheulean-related activity which they associated with auditory working memory. Finally, Putt and Wijeakumar (2018) conclude based on their earlier study that Acheulean handaxe manufacture and modern language rely on different components of working memory, with Acheulean recruiting visual and auditory working memory components not typically related with modern human linguistic processing. However, this auditory component might represent a precursor to modern verbal working memory. A further point of convergence might have been the vPMC (Putt and Wijeakumar 2018: 282).

Miura et al. (2014) conducted an fMRI study comparing observation of videos of Mousterian toolmaking and a man pronouncing Uzbek words, a language unfamiliar to the subjects. Among others, increased activation during Mousterian observation relative to the perception of Uzbek words was found in the right pars opercularis (part of Broca’s area) and bilaterally in BA 6 (entailing the PMC and SMA).

4. CONCLUSION

Behavioral studies tentatively demonstrate that language was not a prerequisite for early stone tool transmission. However, they suggest that non-linguistic gestures might have been under selective pressure as early as Oldowan. Neuroimaging studies show that Acheulean compared to Oldowan activates prefrontal areas suggesting that Acheulean possibly requires significantly more executive control. While the prefrontal activity is mostly limited to BA 44 and 45 (Broca’s area), the nature of the coevolution of toolmaking and language remains largely unsettled. Future research should include later hominin technologies and seek to determine the particular cognitive functions associated with Acheulean- and Mousterian-related prefrontal activity. Further accumulation of research will hopefully reveal new methodological possibilities in language evolution research.

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Psihonevrobiološka razvojna perspektiva razumevanja nasilja

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POVZETEK[1]

Kompleksnost nasilja se kaže v različnih pojavnih oblikah, vzročnosti, vzorcih, posledicah in kontekstih. Zaradi te kompleksnosti se pojavljajo tudi težave pri preventivi in celoviti obravnavi nasilja. V prispevku so prikazane nekatere dileme pri definiciji in razumevanju nasilja, s poudarkom na psihonevrobiološki perspektivi razvoja pa je prikazana ena izmed možnosti razumevanja agresivnega vedenja oz. nasilja, ki lahko služi kot izhodišče za dolgoročno preprečevanje nasilja.

Ključne besede

agresivnost, nasilje, splošni model agresivnosti, psihonevrobiologija, razvoj, regulacija afekta

1. UVOD

Agresivnost (nasilje)[2] je kompleksen pojav, ki ga srečamo v različnih pojavnih oblikah in v različnih dimenzijah družbene in osebne stvarnosti. Eden od razlogov, zakaj v določenih primerih ostaja ta pojav prezrt, je pomanjkanje jasne definicije, ki ni strogo znanstvena, ampak je velikokrat tudi stvar presoje, ki je pogojena tudi s kulturo, vrednotami in družbenimi normami trenutnega obstoja [1], vse to pa predstavlja tudi težavo pri načrtovanju ukrepov preventive nasilja. Najbolj osnovne definicije nasilje opredeljujejo kot vedenje, ki je namerno usmerjeno k povzročitvi škode in ki dejansko povzroči fizično ali psihično škodo. Svetovna zdravstvena organizacija [2] opredeljuje nasilje kot namerno uporabo fizične sile ali moči, ki obstaja v obliki grožnje ali pa v dejanjih zoper samega sebe, drugo osebo ali proti skupini ali skupnosti, za posledico pa ima visoko verjetnost, da povzroči telesno poškodbo, smrt, psihično škodo, zastoj v rasti (razvoju) ali prikrajšanje (odvzem za razvoj potrebnih stvari). Zaradi škode, ki jo povzroča nasilje, je seveda primarnega pomena razmišljati o preventivi nasilja, pri čemer pa je primarnega pomena razumevanje vzročnosti agresivnega vedenja, česar pa definicije večinoma ne opredeljujejo. Pri tem so lahko v pomoč številni pogledi, teorije in modeli, ki na različne, a sorodne načine razlagajo etiologijo nasilja [3].

2. PROBLEMI DEFINICIJ AGRESIVNOSTI IN NASILJA

Nasilje oz. agresivno vedenje se običajno smatra za nezaželeno, čeprav so pri tem nekatere izjeme glede na to, kakšno vedenje se v določeni situaciji pojavlja. V določenih okvirih se namreč agresivno vedenje lahko smatra kot zaželeno (npr. samoobramba). Zaradi teh različnih okoliščin in vzrokov (motivacija, učinki, dejanja, psihološki, socialni in politični pomen), v katerih se agresivno vedenje pojavlja, imamo o nasilju različne definicije. Ta različnost ustvarja tudi neenotnost pri razumevanju tega, kako se nasilje razume, kateri vzorci vedenja so prepoznani kot nasilni, kako so povezani faktorji tveganja ter tudi katere intervencije in politike so primerne pri preprečevanju nasilja. Pomanjkanje soglasja je ovira za usklajevanje raziskovanja, načrtovanja in oblikovanja učinkovitih ukrepov za preprečevanje in obravnavo različnih oblik nasilja, posledice tega pa se odražajo v splošnem blagostanju družbe. Skoraj vsakdo lahko prepozna, ali je v določeni situaciji neko dejanje ali situacija nasilna. Težje pa je v splošnem določiti, kaj je nasilno in kaj ni [4]. S tega stališča je kljub občutku jasnosti, kaj nasilje je, to vseeno dvoumen pojav, kar se pokaže pri poskusu splošnega označevanja in kategorizacije njegovih pojavov, logike pojavljanja in stopnjevanja, iskanju vzročnih razlag in njegovega vrednotenja, pri tem pa lahko nevarno zaidemo na področje zagovarjanja pravičnosti nasilja [5].

Kljub temu, da obstaja splošno soglasje o tem, da nasilje deluje uničujoče in da za sabo vedno pušča žrtve, pa vseeno ostajajo vrzeli nedoločenosti, saj splošne definicije ne povedo, kdo ali kaj je bilo poškodovano in kako resna je ta poškodba (npr. ali je lahko neko agresivno vedenje zaradi težke psihiatrične diagnoze smatrano kot nasilje?). Učinkov nasilja, glede na kontekst, ni mogoče vedno jasno označiti kot pozitivne ali negativne [6]. Zdi se, da vsak poskus dokončnega določanja, kaj je nasilje, vedno nekomu dela krivico (ali osebi, ki je agresivna, ali pa žrtvi). Kar pa lahko z gotovostjo rečemo pri vseh poskusih definicije nasilja pa je, da se pri vseh pojavlja osnovno načelo prekoračitve meja – določiti, kaj pa so meje, pa se v dobi, ko se pojavlja opuščanje in relativizacija moralnih, spolnih, izobraževalnih, pravnih standardov, zdi spet zelo težka naloga [5].

1 Doseženi rezultati so delno nastali v okviru projekta št. J5-9349, ki ga je financirala Javna agencija za raziskovalno dejavnost Republike Slovenije iz državnega proračuna.

2 V pričujočem prispevku so izmenično uporabljeni različni izrazi, ki so velikokrat (po navedbah različnih avtorjev), razumljeni kot sinonimi: 'nasilje', 'agresivnost', 'agresivno vedenje'. V definicijah se pojma 'nasilje' in 'agresivnost' praviloma istočasno pojavljata in nista vedno razmejena ali pojasnjena. V prispevku tako uporabljamo izraza 'nasilje' in 'agresivno vedenje' kot sinonima, ki sta odraz zunanje manifestacije 'agresivnosti', ki pa označuje bolj notranje stanje oz. notranjo napetost v posamezniku in se nujno ne manifestira v zunanjem 'agresivnem vedenju' oz. 'nasilju'.

3. MODELI AGRESIVNOSTI IN AGRESIVNEGA VEDENJA

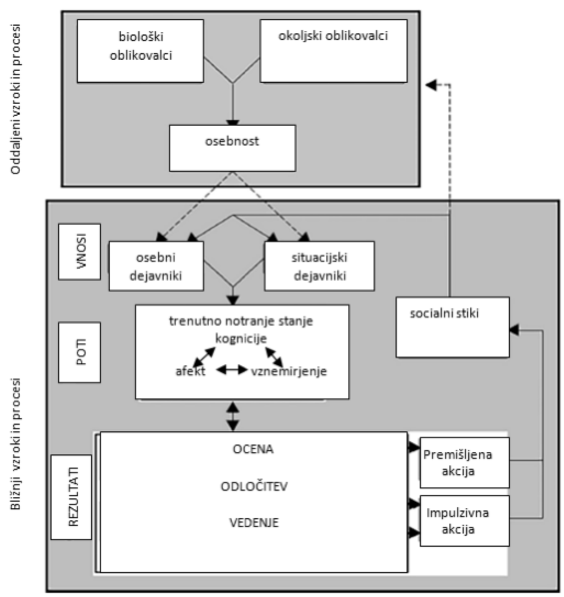
Zaradi omenjene problematike se kot izhodišče razumevanja in načrtovanja ukrepov za preprečevanja nasilja zdi bolj smiselno izhajati iz celostnih perspektiv razumevanja, kakršne predstavljajo različni modeli in ki vključujejo različne vzročne dejavnike tveganja za nasilje. Svetovna zdravstvena organizacija je npr. za razumevanje kompleksnosti narave nasilja izoblikovala t.i. *ekološki model* (angl. ecological) model, ki je dinamičen in odprt nenehnim dopolnitvam, saj upošteva interakcijo in spreminjanje različnih dejavnikov, ki vplivajo na povečanje tveganja za izvajanje nasilja, in dejavnikov, ki rizično vplivajo na to, da je nekdo žrtev nasilja. Ti dejavniki so razvrščeni na štiri ravni. Prva raven obravnava zgodovinske biološke in osebne dejavnike, ki vplivajo na ravnanje oseb in povečujejo možnost, da oseba postane bodisi nasilnež bodisi žrtev nasilja. Druga raven se omejuje na obravnavo bližnjih odnosov (npr. odnosi v družini, s prijatelji, intimnimi partnerji in ljudmi istega stanu) in raziskuje, kako ti odnosi povečujejo možnost, da oseba postane bodisi nasilnež bodisi žrtev nasilja. Tretja raven se osredotoča na organizirane skupnosti, v katerih potekajo družbene interakcije (npr. šole, delovna mesta, soseske) in išče značilnosti, ki povečujejo tveganje za izbruh nasilja. Četrta raven pa proučuje širše družbene dejavnike, ki oblikujejo klimo, ki nasilje bodisi spodbuja bodisi ga zavira [2].

Ekološki model razjasnjuje vzroke nasilja kakor tudi njihovo kompleksno vzajemno delovanje, zato predlaga, kaj je treba na različnih ravneh simultano storiti, da bi se nasilje preprečilo. Temu podoben je *splošni model agresivnosti* (angl. General Aggression Model – GAM), ki predstavlja celovit in integrativen model za razumevanje agresivnosti in agresivnega vedenja, nudi pa tudi razmislek o ključnih vidikih intervencij, ki bi lahko vodile k preprečevanju nasilnih in uničujočih odzivov [7].

Splošni model agresivnosti predpostavlja, da na človekovo agresivnost močno vplivajo zaznavne strukture, ki zaznamujejo veliko socialno-kognitivnih fenomenov, kot so percepcija, odločanje in vedenje. Nekatere teh najpomembnejših struktur vključujejo tudi prepričanja, sheme dojemanja, sheme pričakovanj in vedenjske skripte. Gre za strukture, ki se razvijajo preko izkušenj in lahko vplivajo na dojemanja na različnih nivojih, od preprostega dojemanja predmetov do kompleksnega dojemanja socialnih dogodkov [8].

Splošni model agresivnosti (slika 1) v razlaganju agresivnosti združuje dve skupini procesov: 1. *bližnji procesi* (angl. proximate processes) so tisti, ki so neposredno povezani z agresivnim vedenjem v danem trenutku; 2. *oddaljeni procesi* (angl. distal processes) pa so tisti, ki vplivajo na bližnje procese preko globljih tendenc in struktur (gre za aspekt, kako biološki in okoljski dejavniki sodelujejo in vplivajo na osebnost osebe) [9]. V teh procesih pa splošni model agresivnosti izpostavlja tri glavne faze oz. elemente interakcij med osebo in situacijo, ki se pojavljajo kot 1. *vnosi* (angl. inputs), 2. *poti* (angl. routes) in *rezultati* (angl. outcomes) [8]. Prva faza so vnosi, kjer gre za dejavnike dveh vrst. Prvi so povezani z osebo (*osebni dejavniki*, kot so spol, prepričanja, osebne lastnosti, vrednote, dolgoročni cilji, razpoloženje...) in predstavljajo stanje, v katerem se poveča možnost za agresivnost. Drugi dejavniki so povezani s situacijo (*situacijski dejavniki*, kot so provokacija, socialni stres, socialno zavračanje, frustracija, alkoholiziranost, nasilnost medijev, bolečina ali neudobje, visoka temperatura, hrup, prisotnost orožja, ogrožajoči ali strah vzbujajoči dražljaji...), v kateri se poveča možnost za agresivne reakcije [9]. Posamezni dejavniki ali kombinacija osebnih in situacijskih dejavnikov predstavlja izhodišče za povečevanje ali zniževanje možnosti agresivnosti in agresivnega vedenja, saj vplivajo na kognicije, afekte in stopnjo telesnega vznemirjenja. V splošnem je tako, da več kot je dejavnikov tveganja za agresivnost, večja je možnost agresivnosti in agresivnega vedenja [10].

V drugi fazi se torej odvija vpliv vnosov (osebnih in situacijskih dejavnikov) na poti, ki vodijo v procese ocenjevanja in odločanja (agresivne ali neagresivne rezultate). Osebni in situacijski dejavniki lahko spremenijo *afektivno stanje osebe*, *kognicije* in stopnjo *telesnega vzburjenja*. Vsi ti trije dejavniki oblikujejo trenutno notranje stanje osebe in so med seboj prepleteni. Npr. afektivno stanje lahko vpliva na spoznavne procese in stopnjo fizične vznemirjenosti [11]. Jeza npr. lahko spodbudi nasilno razmišljanje in poveča telesno vznemirjenost. Prav tako lahko spoznavni procesi in vznemirjenje vplivajo na afektivno stanje (npr. če interpretiramo situacijo kot nasilno, se lahko poveča jeza, kar vodi v višjo stopnjo telesnega vznemirjenja) [8].



Slika 1: Splošni model agresivnosti: bližnji in oddaljeni vzroki in procesi [12].

Skupaj te poti ustvarijo notranje stanje, ki poveča verjetnost izida agresivnega vedenja [13]. To je tretja faza, kjer govorimo o *rezultatih* (procesi vrednotenja oz. ocene, ki so lahko tudi avtomatski, procesi odločitve in agresivno ali neagresivno vedenje). V tej fazi torej oseba ovrednoti situacijo in se odloči, kako se bo odzvala. Aktivnost, za katero se odloči, vpliva na socialne stike, ki povratno vplivajo na osebne in situacijske dejavnike, kar vodi v nov začetek cikla oz. epizode agresivnosti. Vsako ponavljanje epizode agresivnosti (ali neagresivnosti) služi kot učni proces, ki lahko vpliva na razvoj agresivnih zaznavnih struktur (in tako osebnosti) skozi čas [8].

4. PSIHONEVROBIOLOGIJA RAZVOJA KOT DEJAVNIK AGRESIVNOSTI

V zgoraj omenjenih dimenzijah agresivnosti in nasilja, ki jih opredeljujejo različni modeli in definicije, se zdi, da so nekateri dejavniki tveganja za nasilno vedenje bolj dostopni posameznikovi kontroli, drugi pa manj. Predvsem zaskrbljujoči so slednji, saj le na te posameznik težko neposredno vpliva, bodisi ker so vkoreninjeni v splošne sheme prepričanja na družbeni ravni, ali pa ker predstavljajo nezavedne sfere njegove osebnosti. Glede na splošni model agresivnosti gre pri tem za oddaljene procese, kamor se uvrščajo biološki dejavniki (npr. ADHD, hormonsko neravnovesje, hipersenzitivnost itd.) in okoljski dejavniki (npr. kulturne norme, ki podpirajo nasilje, nefunkcionalne družine in starševstvo, težki življenjski pogoji, nasilne soseske in vrstniške skupine, nasilni mediji itd.), ki vplivajo na osebnost posameznika [14]. Predvsem pri okoljskih dejavnikih, kjer so vključeni odnosi z bližnjimi in predstavljajo okolje, v katerem se posameznik razvija, se zdi smiselno iskati tudi možnosti interveniranja, ki bi dolgoročno pripomoglo k preprečevanju kasnejšega agresivnega vedenja.

Zgodnje izkušnje s starši vplivajo na razvoj organske podlage naše osebnosti, in sicer se zapišejo v možgane, ki so dogovorni za procesiranje zavednih in nezavednih informacij skozi življenje. Med nosečnostjo in v prvih dveh letih življenja so vzpostavljeni temelji čustvenega delovanja in čustvenih virov odraslega človeka. Takrat se oblikujejo »socialni možgani«, del možganov, ki se uči, kako obvladovati občutke v odnosu z drugimi ljudmi in v različnih situacijah. Primarni odnos otroka, zlasti z materjo (ali drugim primarnim skrbnikom), tako zagotavlja osnovo za to, kako se bodo vzpostavili procesi regulacije afekta v otrokovih možganih. To bo tudi določilo posameznikovo večjo ali manjšo sposobnost za vstop v čustvena in socialna razmerja in situacije pozneje v življenju. Odnos med otrokom in odraslim tako zagotavlja prostor za razvoj otroka [15].

Ob rojstvu je otrok še »nedokončan«. Čeprav ima vse anatomske dele, pa je kot »surov material« z genetskim načrtom in edinstveno paleto možnosti, ki se morajo na določen način še razvijati skozi izkušnje, zlasti socialne [16]. Izkušnje v zgodnjem življenju so lahko še posebej pomembne pri organiziranju načina razvijanja osnovnih regulativnih struktur v možganih. Vsakodnevne izkušnje tako oblikujejo strukturo možganov, ker aktivirajo določene poti v možganih, krepijo obstoječe povezave in ustvarjajo nove. Psihonevrobiološka perspektiva razvoja poudarja, da je zgodnje otroštvo obdobje, ko je določena osnovna »arhitektura« v možganih [17].

Zgodnje socialno okolje (odnosi z primarnimi skrbniki) tako neposredno vplivajo na končno vzpostavljenost krogotokov v možganih otroka, ki so odgovorni za prihodnje družbeno in čustveno življenje. Odnosi navezanosti neposredno oblikujejo zorenje otrokove desne hemisfere, posebej sisteme prefrontalnega dela desne hemisfere, ki so odgovorni za regulacijo čustev, vključno s pozitivnimi čustvi (npr. veselje in zanimanje), pa tudi negativnih čustev, kot sta strah in agresija [18]. Vzorci varne navezanosti vodijo tako v organiziranost primernega regulatornega sistema v prefrontalnih območjih desne hemisfere, učinkovito delovanje v tem delu možganov pa je osrednjega pomena za otrokovo naraščajočo sposobnost samoregulacije, sposobnosti fleksibilnega uravnavanja stresnih čustvenih stanj zaradi interakcij z drugimi ljudmi in samoregulacije v avtonomnih kontekstih. Gre za način, kako varni odnosi navezanosti (epizode nežnosti, uglašenosti, sinhronije) spodbujajo razvoj desne možganske hemisfere, pospešujejo učinkovito regulacijo afekta in gradijo temelje otrokovega psihičnega zdravja. Skrbnikova senzitivnost je tako zunanji organizator otrokove biološke podlage vedenjske regulacije. Na podlagi tega se v določenem trenutku razvije tudi samoregulacija otroka, ko se v relacijskem okolju dogradijo notranji regulatorni mehanizmi [18].

V primeru slabih relacijskih okvirov razvoja lahko govorimo o relacijski travmi, ki v nevrobiološkem delovanju otroka pušča povsem drugačne vzorce, saj negativno vpliva na od izkušenj odvisne razvojne procese v delovanju možganov. To pušča dolgoročen negativen vpliv na sam razvojni proces in tudi strukturo osebnosti posameznika [19]. Travmatični odnosi in čustveno zanemarjanje negativno vplivajo na strukturo in funkcijo desne hemisfere, subkortične strukture in frontalni korteks [18]. Desna možganska hemisfera in subkortične strukture so temeljnega pomena v čustvenem procesiranju, prefrontalni korteks pa igra pomembno vlogo pri regulaciji afekta [20]. Tako ni čudno, da ti ljudje tudi kot odrasli trpijo posledice, ki uničujoče delujejo v njihovem življenju in v življenjih njihovih bližnjih. V poznejših življenjskih obdobjih so otroci z varno navezanostjo v večji meri sposobni razviti in vzdrževati dobre bližnje odnose, zlasti s starši, vrstniki in partnerji kot ne-varno navezani otroci. Pri varno navezanih se v otroštvu, najstništvu in v odraslosti razvijejo različne bolj zaželene osebnostne lastnosti, pri njih je večja verjetnost prisotnosti konstruktivnih oblik čustvovanja in čustvene samoregulacije, izražajo bolj pozitivno samospoštovanje [21]. Različne motnje v odraslosti imajo svoje korenine v otroštvu, npr. motnje hranjenja, zloraba substanc, preveč impulzivno vedenje, pomanjkanje empatije, depresivnost, tesnobnost, agresivnost itd., kar je vse posledica tega, da zaradi slabe razvitosti čustvene regulacije posamezniki niso sposobni primernega upravljanja s svojimi občutki [16]. V povezavi s tem je pomembno poudariti, da so posamezniki, ki niso sposobni primerne regulacije afektov, kot je jeza in druga afektivna stanja, bolj nagnjena k agresivnemu vedenju, da bi s tem spremenili, odstranili ali se izognili neprijetnim čustvenim stanjem (vzniku agresivnega občutja) [22]. Gre za stanje t.i. afektivne disregulacije, o kateri govorimo, ko oseba ni sposobna primerno občutiti čustev, ko jo čustva prevzamejo ali ko ostanejo nerazrešena [23].

Z vidika psihonevrobiološke perspektive razvoja kakovost odnosov s starši v zgodnjem otroštvu vpliva na razvoj možganskih področij, ki so odgovorna za različne vrste regulativnih strategij. Šibko razvit prefrontalni korteks je značilen pri številnih psihopatoloških in negativnih vedenjskih strategijah. Brez močnega prefrontalnega korteksa mehanizmi samokontrole, pomirjanja sebe in občutka povezanosti z drugimi, ne dozorijo [16]. V nezmožnosti uravnavanja močnih čustev zaradi nerazvitih procesov regulacije je tako mogoče prepoznati vir nasilja [24]. Do tega pride zato, ker nedozoreli orbitofrontalni sistem ni sposoben regulirati impulzov (tudi agresivnih) iz nižjih limbičnih struktur, kar povečuje možnost agresivnega vedenja, ki predstavlja neprimerno regulacijo afektivnih stanj, ki vzniknejo v določeni situaciji (jeza, sram, strah...) [18].

5. SKLEP

Sposobnost regulacije čustev (tudi regulacija agresivnih impulzov) od otroštva naprej služi kot zaščitni faktor pred agresivnim vedenjem posameznika. Čeprav se ta sposobnost lahko razvija in dopolnjuje še kasneje, se v prvih dveh letih življenja oblikujejo osnovni vzorci za soočanje z negativnimi in težavnimi čustvenimi situacijami. Človeška bitja so odprti sistemi, ki jih oblikujejo drugi ljudje. Človeški psihološki in duševni sistemi se razvijajo v odnosu z drugimi ljudmi - in to se najbolj intenzivno dogaja v otroštvu. Lahko rečemo, da je človeški otrok najbolj družbeno vplivano bitje (ali biološki sistem) na zemlji [16]. Biološki in socialni dejavniki so v človekovem razvoju zelo prepleteni in povezani, še posebej v obdobju zgodnjega razvoja. Seveda imajo genetika in okoljski dejavniki vpliv na dojenčke, vendar so socialni dejavniki, zlasti senzitivna nega in skrb skrbnika tisti, ki vplivajo in dejansko spremenijo biološke elemente (kot sta kemija možganov in možgansko tkivo). Zelo pomembno je, da ne zanemarjamo razmerja med biologijo, izkušnjami in vedenjem, saj je to lahko škodljivo in uničujoče za našo celotno družbo [24]. Zato je v povezavi s tem bistveno razmisliti in razviti ustrezne programe za zgodnje ukrepanje, ki bi lahko delovali tudi kot zaščitni dejavnik proti tveganju agresivnega vedenja in nasilja. Tovrstno ukrepanje, ki bi spodbujalo zdrave odnose med primarnimi skrbniki in otrokom (preprečevanje relacijske travme in spodbujanje učinkovitega in senzitivnega starševstva), se mora začeti še pred otrokovim rojstvom in ga je treba podaljšati skozi perinatalno in postnatalno obdobje. Programi za učinkovito starševstvo (na katerem koli področju - pediatrija, psihiatrija, psihologija, socialno delo, izobraževanje, pastoralna oskrba ...) lahko ustvarijo razvojni kontekst za preoblikovanje ne-varne navezanosti v varno in na ta način spodbudijo od izkušenj odvisno nevrobiološko zorenje desne hemisfere, ki je ključnega pomena pri primerni regulaciji različnih motivacijskih (afektivnih) stanj, vključno z agresivnimi [18]. Dejstva, ki jih je razkrila (nevro)znanost v preteklih desetletjih, so jasna in jih ni mogoče zanikati: obstaja velika priložnost za nekaj, kar bi posamezniku omogočilo optimalen začetek, da bo bil kar najbolje čustveno opremljen za soočanje z izzivi življenja.

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Emergence of Visual Consciousness in ADHD Children

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ABSTRACT
The nature of consciousness has excited the imagination of scientists and researches for years. In the past, some were of the opinion that a single part of the brain is important fort he emergence of consciousness, while some disagreed, one of the first being the psychologist William James, who claimed that what is important for its emergence is the function of the brain as a whole and that parallel function of different parts is key. In our study we focus mainly on the research of visual consciousness. We want to find out whether there is a difference in the emergence of visual consciousness between healthy participant (children ages 6-16) and children diagnosed with ADHD. We attempt to measure the emergence of visual consciousness using an experimental paradigm designed by dr. Zoltán Nádasdy and his team.

Keywords
visual consciousness, ADHD, visual attention, visual integration

1. INTRODUCTION
The nature of consciousness has puzzled mankind since the beginning of time. What is consciousness, how can our physical brain interpret subjective experience, what are qualia? The question also presents itself as in where in the brain does consciousness lie. All these are questions that scientists have been posing for years and still today.

What is consciousness, where is consciousness formed, which neural correlates are responsible for consciousness, all these are questions that scientists and philosophers are occupied with today and were occupied with in the past. The search for rigorously defined neural correlates has been going on for decades.Some recent studies these days identify the thalamus as a central structure implicated in conscious awareness [4]. The thalamus works as a relay station or a passageway of sensory information into certain parts of the cerebral cortex [4], which means that all information we are consciously aware of (except olfactory) meets the thalamus at some point.

The study we present in the paper, tests visual awareness using an experimental paradigm developed by dr. Nádasdy and colleagues. The task comprised visual integration of image fragments presented on a computer screen. The project connects the neuroscientific and psychological aspects of visual consciousness.

We assume a critical point in time when visual consciousness (of recognition of an image as a whole or non-whole) emerges and we posit that this time of emergence is delayed with certain developmental or neurological (neuropsychological) disorders, namely in ADHD children.

2. THEORETICAL BASIS
As the body of neurological knowledge has dramatically grown in the past few decades, so too has grown the interest in and search for neural correlates of consciousness. While some were occupied with the search of a common center of the brain responsible for conscious awareness, others search for multiple regions or systems that play an important role in the production of consciousness. William James was one of the first advocates of this position. He claimed that consciousness is a result of the common effort of the whole brain (Principles of Psychology, 1890/1950, as cited in [3]). However, an increasing quantity of empirical evidence shows that some parts of the brain are much more important than others when it comes to the production and expression of conscious awareness. These are mainly the thalamocortical system and the reticular system of the brain stem [3].

In the search for brain regions involved in the creation of consciousness there is a structure that has gathered a lot of attention – the thalamus. The thalamus is a structure in the midbrain found at the top of the brain stem. In the mid-1800 the idea already appeared that the thalamus is the sensory center of the brain. Neuroanatomical examinations of patients showed that thalamic regions in an otherwise unaffected brain caused major sensory dysfunction. These neuroanatomical findings showed that the thalamus plays a key role in the processing of sensory information [4]. Later neuroanatomical studies of the thalamus and its connections to other parts of the brain highlighted its function in sensory processing and integration. It is important to note that it was discovered that all sensory information travels through the thalamus before reaching the corresponding parts of the cortex [3].

Francis Crick [1] contributed much to the literature on consciousness by suggesting that the TRN (thalamic reticular nucleus) and the dorsal thalamus play a key role in consciousness by means of controlling and expressing an internal attentional searchlight as first suggested by Treisman and colleagues (1991, as cited in [1]). Crick suggested the TRN produces rapid firing in thalamic relay neurons to control the brain's attentional searchlight, acting on Malsburg synapses to create conjunctions of neurons, expressed by cell assemblies, which Crick believes to be the neural expression of the attentional searchlight.

By researching attentional capacity of the brain at tasks comprising different types of search, researchers noted that the brain searches consecutively, focusing on one object at a time, before moving on to the next [1].

In his attempt to explain how the thalamocortical system controls attention, Crick suggested the following mechanism: when sensory signals pass through the TRN on their way to the cortex, this causes excitation. Crick suggested that the TRN and dorsal thalamus work together to increase activity at the most active thalamocortical pathways and at the same time reduce activity in less active parts of the thalamocortical network. He described this mechanism as "… the heating up of the warmer parts of the thalamus and the cooling down of the colder parts" [1] (page 4587).

3. HYPOTHESIS

Our hypothesis is that there is a certain amount of information needed to be able to put together image fragments with confidence (confidence here not referring to the reported level of confidence by subjects). Hence, the decision point to reach a certain level of confidence for a given image is consistent across healthy subjects. This point can be standardized for a selected set of pictures and the test can be validated. Having the image set standardized, the test should be sensitive to disorders implicated in consciousness, attention, mental focus, and visual integration processes such as functions compromised in ADHD. We also wish to find out whether our test is appropriate for the detection of such disorders.

The main research goal is to test the hypothesis and based on this construct a theoretical framework describing the differences at the emergence of visual consciousness in healthy children and children with ADHD.

4. THE EXPERIMENT

4.1 Method

Participants sit down in front of a computer screen on which four very similar pictures appear, divided by black lines. The participant decides whether the images compose one joint picture or whether they are different. They record their decision by pressing a key on the computer keyboard. At every keystroke the lines between the images thin until the entire picture is revealed and it becomes clear whether the images form a whole. The pictures include themes from everyday life (houses, cars, landscape, furniture etc.), various kinds of animals and abstract pictures, like pictures of the universe, microscopic cells etc.

In our study, visual consciousness is experimentally tested using a between-subjects design. The independent variable is the manipulation of trials. During solving time, the task has seven levels equivalent to every phase of testing. The dependent variable is the judgment of participants about the continuity of the images presented in every phase (by pressing a computer key).

4.2 Progress

So far 48 children have taken part in the study. The control group consists of 20 students of the Kidričevo elementary school, (10 female, 10 male), aged between 8 and 9 years. The participants were primary school children that took part in the research study voluntarily with parental or legal guardian consents. There are 28 children (27 male, 1 female) in the target group, 8 children age 6-8, 15 age 11-14 and 5 age 10-12.

The criterion for inclusion was an age of above 5 years and under 15 years. The final sample of the group of all participants was planned to encompass at least 50 children (25 tested children in the control group and 25 tested children with a psychiatric ADHD diagnosis).

4.3 Procedure

The test is composed of 100 trials, presented in series on a computer screen. In every trial, 4 similar images were shown on the screen, divided by black borders slightly covering the images (in the shape of a cross). Every trial included eight phases where the borders between images diminish in 7 steps from thick to very narrow. Lastly, in the 8^{th} phase, it is revealed whether the four fragments join into a whole or remain different.

By pressing the "S" key it is meant that the subject believed that the presented fragments are part of a continuous picture, pressing "R", the person believed that the images are part of four different pictures and pressing "N", the subject was unsure about the continuity of the presented image fragments.

An exit command was also added to the program in case any participant wanted to stop before finishing the task. In this case, the participant had the option of pressing the "escape" key on the keyboard, which would save their data and immediately leave the program.

4.4 Expected Results

We call the moment during the task when subjects suddenly see and decide that the picture fragments are merging an "aha" experience. We define this moment as the emergence of visual consciousness. The moment when different subjects reach this level of visual consciousness, we predict, should depend on how effectively they process and analyze image fragments. Children diagnosed with ADHD may not be able to integrate the fragments of visual information as effectively as children with normal cognitive control do. Hence, with this task we aim to quantify the execution of visual consciousness.

5. ACKNOWLEDGMENTS

We would like to thank Osnovna šola Kidričevo and Zavod Mavrični bojevnik for their help and support recruiting our participants, and of course all of the children and parents who were willing to work with us.

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European Legal Regulation of Self-learning Systems

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ABSTRACT
Modern technology often gives us an impression of a better life, yet simultaneously raises new risks that have not been present ever before. This paper will present differences between three different 'decision-making processes' that occur as a consequence of three different types of systems, namely, AI can be equipped with a deterministic algorithm, a supervised, or an unsupervised learning algorithm. Through this systematization, concerns regarding foreseeability and certainty of the system's actions will be examined. The scope of the thesis is limited to foreseeability regarding harm caused by physical machines or products, equipped with advanced algorithms. This paradox raises questions regarding the role of scientists in situations when they are facing uncertain risks, and legal scholars when regulating advanced technology.

Keywords
self-learning systems, algorithms, strict liability, development risk defence, product liability, product safety, machine learning

1. INTRODUCTION
Presence of artificial intelligence (AI) in our everyday life will call into question the efficiency of existing legal rules. Yet before we focus on regulating liability concerning the harm caused by a machine equipped with advanced algorithms we should focus on the question 'is risk assessment is even possible, can we even predict (with existing scientific knowledge) potential consequences of these machines?'

When policy makers and judicial authorities are confronted with an uncertain situation they turn to experts for definite answers and conclusive evidences, even though uncertainty and absence of foreseeability clearly precludes definitiveness and conclusiveness.

The following research questions were developed in order to define the research problem and further, to address the gaps in existing legislation.

(i) What is the nature of algorithmic uncertainty?

(ii) How does the European legislation address the concept of uncertainty and un-foreseeability?

2. ALGORITHMS
The algorithmic breakthrough is often connected with Alan Turing, whose one of the most ground-breaking achievements was breaking the German Enigma code during the Second World War. [Roberts 2016] In 1952, he published a set of mathematical equations through which he wanted to explain the pattern we see in nature, such as zebra stripes and leopard spots. [Serna 2017] These algorithms are still in use when describing patterns that emerge in nature. [Deangelis 2014] On 20 February 1947, Alan Turing had a lecture at the London Mathematical Society, where he enlightened the academic public with the statement that "what we want is a machine that learns from experience".[Press 2017, 1] Alan Turing concluded his lecture with these words: "Putting the same point differently, the machine must be allowed to have contact with human beings in order that it may adapt itself to their standards." [Turing 1947, 14]

In these few decades, since Alan Turing first introduced machine learning and algorithms, the latter have become a big and a ubiquitous part of our lives. They are used for data processing, calculations and automated reasoning. [Deangelis 2014]

"To make a computer do anything, you have to write a computer program. To write a computer program, you have to tell the computer step by step, exactly what you want it to do. The computer then 'executes' the program, following each step mechanically, to accomplish the end goal. When you are telling the computer what to do, you also get to choose how it's going to do it. That's where computer algorithms come in. The algorithm is the basic technique used to get the job done". [Deangelis 2014, 1] Pursuant to Deangelis, the point where this explanation could be slightly adjusted is where the text indicates that 'you have to tell the computer step by step what you want it to do'. [Deangelis 2014] Instead of following pre-defined and programmed instructions, some computer algorithms are designed in a way that enable a computer to learn on their own, in fact they facilitate machine learning which may result in a creation of unique corrections between obtained data that sometimes 'produce' unforeseeable outcomes [Deangelis 2014] Legal concerns that have been emphasized in this thesis can be summarized with the statement by Dr. Panos Parpas, who is a lecturer at Imperial College London, that reservations of academics and people around the world are not directed towards the algorithms per se, but towards the structure of a society and its ability/inability to cope with algorithms (data use). [Hickman 2013] At the moment, we are witnessing an awkward marriage between algorithms and data. [Deangelis 2014] Together with technological progress there will be mistakes, but it should be taken into account that machines are just a tool and tools should not be blamed. [Deangelis 2014] Learning as such can present either acquiring or enhancing existing knowledge. As stated by Herbert Simon, machine learning refers to adaptive changes in a particular system that enable the system to perform the same task (or tasks which have been drawn from the same population) more precisely and effectively next time. [Sathya 2013] The text below will introduce different types of algorithms and their main features. Through this systematization, concerns regarding certainty and foreseeability of their actions and consequences will be presented.

2.1. Deterministic algorithms

This algorithm is constructed to prevent a machine from making autonomous decisions, creating new patterns, and consequently creating unpredictable outcomes. [Zapušek 2017] Robots equipped with deterministic algorithms follow predefined paths. [Hildebrandt 2016] The major significance that distinguishes the first group of algorithms from the others is that the final action, machine's response or steps have already been predicted by a human being. [Hildebrandt 2016] In the case of a deterministic algorithm, we will always find someone liable for a robot's actions – as it will be presented in the text bellow, existing legal rules concerning the liability of the producer will suffice.

2.2. Supervised learning algorithms

More advanced forms of algorithms can enable machine learning and supervised learning algorithm is one of them. [Hildebrandt 2016] In the case of supervised learning algorithms, a machine is fed with a so-called training set by human supervisors, which consists of particular data and predefined patterns that provide some sort of a background on what counts as a desired and satisfactory solution or outcome. [Ploj 2013] Hence, in the case of supervised learning, the machine already knows the output of the algorithm, before it even starts learning. [Van Loon 2018] Since the outcome is already known, all that a system needs to do is to execute steps and processes that are needed to get from input to the desired output. In a situation, when algorithms produce completely different and unexpected results, training data serves as a guidance to steer the algorithm back towards the right path. [Van Loon 2018] For this reason, a supervised model can also be called error back-propagation algorithm. [Van Loon 2018] Such error correction-learning algorithms have been thought to train the network based on the input and output samples and to find error signals, which denote the difference of the desired output and output calculated. [Van Loon 2018]

2.3. Unsupervised learning algorithms

This one is, compared to a supervised learning algorithm, not (yet) as widespread and frequently. [Brummette 2017] Although the unsupervised learning algorithm has not been used on a wider scale yet, its capabilities and methodology represent the future of machine learning. [Van Loon 2018] A good illustration of this type of machine learning would be imagining a child who has just started discovering the world. [Brummette 2017] After his first interaction with a four-legged animal, he might hear someone call out the word "dog". [Brummette 2017] After a while, when the child sees other four-legged animals, such as a cow, a cat, or a horse, he thinks they are all dogs. [Brummette 2017] "This is because the natural classification methods installed in a human brain informed him that the trait 'four legs' is associated with a specific animal type. As the child grows and sees more four-legged animals, additional detailed classifications emerge. Dogs, cows, and horses are all discovered to have distinct traits and become a subset of four-legged animals in the child's mind." [Brummette 2017, 1] The idea of comparing machine learning process with a child's brain was also presented by Alan Turing in his paper 'Computing machinery and intelligence'. [Turing 1950] He compared a child's brain with a notebook. According to him there are "rather little mechanisms, and lots of blank sheets". [Turing 1950, 19] Hence, heading back to scientific conclusions about the unsupervised machine learning technique, which makes correlations between obtained data without previously hypothesizing them. [Zapušek 2017] [Hildebrandt 2016] Without the provision of a training set, consisting of data and predefined patterns, the machine cannot familiarize itself with information and what counts as a desirable solution. [Zapušek 2017] A machine that is in the process of unsupervised learning finds input data and classifies it (according to its own criteria) in different categories. [Ploj 2013] We use unsupervised learning algorithms to identify hidden patterns and unlabelled input data, [Sathya 2013] since they are capable of mining new data and creating novel, unexpected patterns. [Ploj 2013] The system is blinded when it goes into an operation. [Van Loon 2018] It carries out its own immense and faultless logical operations that serve as guidance, but still due to the lack of exact input and output data (the system has no reference data at all) the transparency of the process and steps is not clear. [Van Loon 2018] Despite the lack of transparency this algorithm has the powerful ability to interpret limitless amount of data, through its binary logic. [Van Loon 2018]

3. UNCERTAINTY

Uncertainty, as a concept, has been around for a long time, Its roots stretch back to Plato and Socrates, who exposed their doubt whether scientific knowledge, no matter how elaborated and comprehensive, reflects reality. [Tannert 2007] Kant and Prauss extended the idea about uncertainties with the statement that the more detail we have about the mysteries of nature, the more we become aware of limitations of our knowledge about what things as such are, how do they work, etc. [Kant 2013] Limitations to our understanding are the main reason for our inability to foresee future events and their effects. [Tannert 2007] When policy makers and judicial authorities are confronted with an uncertain situation they turn to experts for defined answers and conclusive evidences, even though uncertainty clearly precludes definitiveness and conclusiveness. [Fox 2009] The paradox causes questions regarding the role of scientist and scholars in situations when they are facing uncertain risks when regulating advanced/modern technology. In the analysis of cases of EU risk regulations it has been observed that the uncertainty paradox leads to non-effective and unintelligible policy-making processes. [Fox 2007] As emphasized by Mourik [Mourik 2004], without sufficiently designed infrastructure, not only will questions concerning responsibility eventually emerge, the non-sufficient regulation may also lead to a state called 'organized irresponsibility'. [Fox 2009] Ulrich Beck uses this term when society is ill-prepared and is consequently unable to effectively respond to the "inevitable surprises, negative consequences and/or long-term impacts associated with uncertain risks". [Fox 2009, 1] The idea behind 'risk society' suggests that a world has become more hazardous, yet this is not entirely true. [Giddens 1999] [Beck 2009] The society has become increasingly preoccupied with the future and safety that generate the notion of risk. [Giddens 1999] With the term 'risk' we are describing potential events with particular consequences which are evaluated as negative. [Fox 2009] The economist Knight emphasizes that risk and uncertainty are not synonyms per se. He views a risk as calculable, hence controllable island in the ocean of uncertainty. [Van Asselt 2006] Risk will usually be applied to the situations where all potential future outcomes can be specified, uncertainty as a bare term can be applied in the situations where all potential future outcomes cannot be defined or specified before their occurrence. [Faber 1992] It is natural that whenever we make a decision that contains unpredictable factors, we need to weight not only potential outcomes, but also their benefits and risks. The scale of potential consequences of decisions that are carried out on a national, European or even international level have a much greater influence on people in comparison with individual decisions. Uncertainty as such has no ethical quality, it is inherent to an individual situation. [Tannert 2007] But, if there are concerns regarding dangerousness of a situation, uncertainty itself may trigger ethically adjusted behavior, the main purpose of which is the avoidance of danger and diminution of existing risks – which might be the case when the society is confronted with products, equipped with self-learning algorithms that lead product's actions. [Tannert 2007] "When it comes to decisions that affect people's lives and health [...] carrying out research to diminish uncertainty and, consequentially, risks can become an ethical duty." [Tannert 2007, 892]

4. FORESEEABILITY IN TORT LAW

Cosmologists suggest that the Universe is comprised largely of 'dark matter', for ninety per cent of matter in the Universe does not glow, but is dark. [Baker 2010] Even though we cannot directly see dark matter, we can detect its mass through its gravitational pull on other astronomical objects in the Universe. [Baker 2010] This invisible stuff is powerful enough to bind all things together. According to professor David Owen, foreseeability is the "dark matter" of tort which connects its components, and "gives moral content to the law of negligence, controlling how each element fits together and, ultimately, whether one person is bound to pay another for harm" [Owen 2009, 1277]. From a legal perspective the test of foreseeability can be described with a sentence "whether one can see a systematic relationship between the type of accident that the plaintiff suffered and...the defendant's (by someone/something defendant is responsible for) wrongdoing." [De Villiers 2015, 344] Considering the aspect of foreseeability a defendant may escape liability if scientists could not predict (ex ante) a systematic relationship between wrongdoing and harm. [De Villiers 2015] For many years, in civil law systems of most European countries, tort liability was based on a broadly defined general clause of fault liability. [Werro 2004] However, in the 19th century, Europe was confronted with an increase in technical and industrial risks. [Werro 2004] For this reason, the majority of European legal systems established liability rules which provide some form of strict liability. [Werro 2004] A distinction between fault liability and strict liability lies in their conceptual levels. "The distinctive factor is whether or not liability rests on the judgment that the defendant should have behaved otherwise than he did". [Werro 2004, 7] In order to decide whether a defendant acted with fault, we need to determine all relevant standards of conduct and then establish that a defendant did not meet these standards. [Werro 2004] The determination regarding the standard of care is based on objective criteria. [Werro 2004] Legal systems of other European countries on the other hand focus primarily on the so-called 'what could reasonably be expected of the defendant' standard. [Werro 2004] Therefore, we may conclude that the limitation of negligence liability to so-called foreseeable harm prevents us to hold a defendant liable for not taking precautions with respect to harm which was not reasonably foreseeable. Fault liability can be explained in one sentence as a liability for reasonably foreseeable and avoidable harm. [Werro 2004] Compared to fault liability, strict liability is "concerned with the precautionary consequences of harm not attributable to a lack of precaution on the part of the defendant, or with what may be referred to as 'accidental harm'." [Werro 2004, 9] Besides liability for reasonably foreseeable and avoidable harm, it can also extend to unforeseeable and unavoidable harm. [Werro 2004] [Viney 1998] Even though the concept of reasonably foreseeable and avoidable harm is primarily used in negligence cases, it would be incorrect if we claimed that probability and foreseeability issues are irrelevant to strict liability.

5. DEVELOPMENT RISK DEFENCE

Existing legislation of the majority of European member states regulates strict liability in the way that excludes liability for harm if the latter lies beyond certain limits of foreseeability. Legal regulation on the European level follows the same pattern. The EC Directive on Liability for Defective Products (hereinafter: Liability Directive) [Council Defective Products], adopted in 1985 ensures that producers take responsibility for their products vis-a-vis consumers. It was one of the first pieces of European legislation that explicitly focused on the consumers' protection and which introduced the concept of strict liability, where producers are held liable regardless of whether the defect is their fault. In its article 7(e) the producer can escape liability for harm caused by the defective product by showing that the state of scientific and technical knowledge at the time when they put the product into circulation was not such as to enable the discovery of the existence of the defect. [Council Defective Products] The Liability Directive introduced a new common scheme of strict liability that in comparison with the law of negligence does not require a producer's negligent behaviour. [Alaimo 2014] In negligent cases the claimant has to prove that the defendant knew/ought to have known about the present risk. [Van Dam 2013] However, the new scheme presented by the Liability Directive sets the requirement in its Article 4 regarding proof of the existence of a product's defect, harm, and a causal link between these two. [Council Defective Products] The creators of the Liability Directive wrote the provisions that allow national legislations to limit and dilute strict liability. [Alaimo 2014] One of these provisions is also the "development risk defence" which is still considered one of the most controversial parts of this Directive. [Elliott 2011] The latter is very similar to the 'state of art' defence that has been developed in negligence cases. [Arbour 2014] This so-called development risk defence is enshrined in previously mentioned Article 7(e) of the Liability Directive under which the producer can escape liability for harm caused due to lack of knowledge. According to Stapleton, the above mentioned Article does not refer to risks of a product, rather it is directed at the discoverability of the defect itself. [Stapleton 1994] Consumer associations' opinions believed that it is crucial to protect consumers from unknown and unforeseeable risks, and that the adoption of the mentioned defence (and consequently the exclusion of liability for such risks) would create a gap [Petitpierre 1974] in a general protection of consumers. [Alaimo 2014] The majority of these associations claimed that the development risk defence weakens the principle of strict liability, and due to un-foreseeability it puts an unreasonable burden on consumers. [Alaimo 2014] Producer associations' hold the opposite position and argue that the exclusion of such a defence would significantly discourage scientific and technical research and prevent marketing of new high tech products. [Alaimo 2014] The idea behind the protection of producers against development risks is that despite taking into account all available scientific and technical knowledge it is impossible for the producer of the product to foresee the risk in question. [Van Dam 2013] To sum up, producers cannot be considered negligent if they have (within reasonable limits) analyzed and gathered all available scientific and technical knowledge. [Alaimo 2014] Making a final decision concerning liability and compensation after the occurrence of harm is important, yet not enough. In order to provide comprehensive regulation of modern technologies, filling the liability gaps will simply not be enough. Deciding on liability questions must be carried out simultaneously with controlling such risks before they cause harm. However, the prohibition of the development risk defence, meaning the extension of a producer's liability to development risks would almost certainly cause more harm than benefit [Alaimo 2014], because: (1) complete liability regarding an unforeseeable event would most probably lead producers to irrational decisions in research and development, as well as innovation. [Alaimo 2014] The adoption of the development risk defence suggests that too much liability might chill innovation; [Arbour 2014] (2) holding producers completely liable could become an incentive for excessive litigation because plaintiffs will get compensation as soon as they prove the existence of a defect and a causal link between the cause and harm; [Alaimo 2014] (3) it will cause financial problems, since it will be difficult to provide enough finances to compensate victims.[Alaimo 2014]

The Liability Directive complements European product safety legislation and this is known as the 'New Approach' to product safety. The latter focuses on the prevention of accidents by setting common safety rules which allow single market for goods to reduce administrative burden and to function as smoothly as possible. [Report 2018] In theory, as stated in Section 36 of the preamble of the Safety Directive, [Council Product Safety] "this Directive (the Safety Directive) should not affect victims' rights within the meaning on Council Directive 85/374/EEC of 25 July 1985... concerning liability for defective products (the Liability Directive)." [Council Defective Products] However, in legal practice the provisions and the scope of matters regulated by the Safety Directive affect consumer's liability. A requirement for deeper research results in greater awareness, not only of producers and programmers, but also consumers. It can be claimed that removal of a development risk defence could lead producers towards stricter internal policies on safety. [Alaimo 2014] However, keeping the development risk defence as it is – as a safe legal bubble that allows producers to escape liability for unforeseeable and unpredictable consequences is a risky option as well. In Rosselli's recommendations for the European Commission it has been emphasised that researchers need to focus on the analysis of mutual impact between the development risk defence and general product safety legislation, which has not yet been carried out. [Alaimo 2014] In Europe, we must achieve greater coherence between the Liability Directive and the Safety Directive (and their transpositions in national legislation). In order to provide a comprehensive and an efficient legal response to modern technologies it is necessary to place involve independent scientists and researchers to evaluate product safety. [Alaimo 2014] The latter would help producers and the society avoid the so-called 'junk-science' getting a place in the courtroom. [Arbour 2014] Even though the boundaries of the development risk defence have been set by the judiciary, the courtroom is not an appropriate place for scientific guesswork, Justice Posner concluded in the case Rosen vs Ciba-Geigy Corp. [Rosen 1996]

Requirements in the Safety Directive regarding detailed and thorough evaluation referring to potential consequences (evaluators must foresee the unforeseeable and pass this knowledge to the producers or manufacturers) are very important for further evaluation regarding the liability for harm caused by a machine or a product. Pursuant to the Report of European Commission "2018 is not 1985 (when The Liability Directive was adopted). The EU and its rules on product safety have evolved, as have the economy and technologies. Many products available today have characteristics that were considered science fiction in the 1980s. The challenges we are facing now and even more acutely in the future — to name but a few — relate to digitalization, the Internet of Things, artificial intelligence and cybersecurity." [Report 2018, 1] Absence of detailed safety requirements will leave a lot of potential knowledge about the operation of products undiscovered, and in such situations Article 7(e) of the Liability Directive will protect producers and allow them to exculpate its liability if state of scientific and technical knowledge at the time when he put the product on the market was not such as to enable the existence of the defect to be discovered. We want to avoid a situation when no one will be held responsible for the harm caused by modern technology, especially if we have the capacity (knowledge) to identify the risks and through thorough research predict potential consequences of their operation. According to Arbour "(...) it may not be in a producer's best interest to know too much (...) as too much knowledge could lead to the exclusion of the DRD (development risk defence), and, consequently, expose producers to liability." [Arbour 2014, 932] However, the pile of iron and cables will (in the majority of cases – except 'vis major') not be the main reason for unforeseeable consequences, the major issue is the operation of the machine, its program and its self-learning capabilities. This is why the provisions and the regulatory scope of not only the Safety Directive, but also the Liability Directive needs to pay attention to software and algorithms – How does it work, which factors are relevant for the final outcome, and is the power to monitor these factors in our hands?

6. EU RULES ON PRODUCT SAFETY

For a long time, product safety as a sector has been regulated at a national level as a part of public law (in Germany 'Gerätesicherheitsgesetz' [GESETZ]). [Cafaggi 2009] "These norms provided a set of rules for the producers regarding product safety, supplemented by technical standards for specific products set by hybrid state-private bodies". [Cafaggi 2009, 245] However, the European Commission quickly realized that differences between technical regulations and standards among member states of the European Union presented an obstacle for trade. [Cafaggi 2009] For this reason, in order to improve free movement of goods, the European Community started to follow the concept of 'full harmonization' of technical requirements concerning a specific type of product. [Cafaggi 2009] Despite the effort, the European Commission soon realized that this approach will not be successful due to the inflexibility of the European legislation. The latter was not able to keep pace with fast technological progress and this led to the abolishment of the idea about full harmonization. [Cafaggi 2009] However, the European Commission found a solution through the judgment of the European Court of Justice in the 'Cassis the Dijon' case where the Commission developed a well-known principle of mutual recognition that resulted in a 'New Approach' [ECJ 120/78], which should soon become the main concept for product safety regulations. [Cafaggi 2009] The latter is based on the so-called hybrid regulation, meaning that main/essential requirements regarding product safety, which are in the public interest, are harmonized in EU directives, yet special/unique requirements on the other hand are listed in technical standards (harmonized standards), developed by private European standards organizations (such as CEN, CENELEC, ETSI) and are officially mandated by the Commission. [39] The benefit of keeping manufactured products in conformity with harmonized standards is the presumption that products are in line with the corresponding essential requirements. In other words, conformity with technical standards will relieve the producer of the burden of proof that products meet all the requirements concerning product safety. [Cafaggi 2009] On this point it is important to mention that only the essential safety requirements are mandatory and consequently legally binding in comparison with harmonized standards, the application of which remains optional. [Cafaggi 2009] Compared to harmonized standards, which are set by private organizations, most national non-harmonized regulations (national sector) rely on technical standards set by a mixture of industry (private body) and state representatives. [Cafaggi 2009] Even though a process of standardization is left to private bodies states want to have influence in the standardization process. [Cafaggi 2009] Despite the fact that the process of standardization is organized in private forms they present a guideline for administrative decisions, take into account interests of the general public, want to satisfy common safety expectations and concretize due diligence in civil legislation. [Cafaggi 2009] However, governmental influence and surveillance regarding product standardization is very important from European point of view. The need derives from ‘the obligation to reduce restrictions or measures having equivalent effect on free movement of goods. [Cafaggi 2009] Governments are sending their state representatives to standardization boards in order to provide further suggestions concerning alternative approaches to certain product areas for standardization. [Cafaggi 2009] Private standards (product safety) de facto observe double rules; first, they denote the required level of safety, and second they denote the required level of care. [Cafaggi 2009] The interaction between product safety (outlined in standards) and product liability can be described in the following way: (1) Public law sets a minimum level of safety and formulates basic requirements. Moreover, the administrative procedures are limited and formulated in ways that provide protection to the essential public and private goods like health and life; (2) Technical standards provided by private agencies specify a minimum level of safety that is provided by the public law; (3) Tort (civil) law focuses on individual circumstances and tries to define and attach the obligation on the producer. In addition, it fills the gaps left by technical standards and public law. [Cafaggi 2009] At first sight, it seems that this briefly described structure regarding product safety and liability provides the protection against all types of dangers. However, it fails to cover some crucial products/parts of the product, such as software, especially software equipped with advanced machine learning algorithms; devices connected with the internet, etc. [Cafaggi 2009] Here, product liability rules fail to cover gaps that were left by public law. This is the repercussion of our mistaken perception under which we understand product safety in the traditional sense. If we look at European regulation we will not find any specific legal provisions, even though such embedded systems (ES) are put into robotic machines (such as medicinal products). [Cafaggi 2009] Not only at the European level, the situation at the national level is very similar. There are hardly any safety regulations concerning ES. [Cafaggi 2009] The directive 2001/95/EC on general product safety does not encompass ES and consequently producers/programmers of ES are not obliged by specific product safety regulations, since they do not exist. [Cafaggi 2009] As mentioned before, the gap left by public law (such as lack of safety regulation about ES) cannot be filled exclusively by reorganization or updating of civil liability rules.

7. CONCLUSION

When policy makers and judicial authorities are confronted with an uncertain situation they turn to experts for definite answers and conclusive evidences, even though uncertainty clearly precludes definitiveness and conclusiveness. The uncertainty paradox leads to an ineffective policy-making processes. If authorities want to provide a comprehensive and an efficient legal response to modern technologies and liability for their actions it is necessary to involve sound, independent scientists and researchers to evaluate product safety. Authorities’ decisions about liability questions must be carried out simultaneously with the control of such risks before they cause harm. Such a defence must exist alongside measures (the majority of which must focus on safety regulation) that may help to achieve the following four objectives: (1) “provide industry with unambiguous rules in order to prevent situations of jeopardization of products’ safety due to insufficient knowledge. Industry and sectors will have to accept that such rules will result in a slower pace of innovation; (2) promote continuous transfer of knowledge regarding safety in industry; (3) provide a system to restrict the potentially harmful impact of development risks; and (4) provide sufficient compensation for victims.” [Cafaggi 2009] What seems to be the main problem regarding machines, equipped with programs that due to their algorithms enable self-learning, risk assessment of such programs is not required by the Safety Directive, even though a machine (equipped with such a program) may cause harmful consequences as a result of to the program. Without sufficient and regular evaluation of product’s safety more consequences that will occur in the future will, from a legal perspective, be recognized as unforeseeable and this will prevent the judicial branch to provide satisfaction for harm suffered by victim.

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Legal Practitioners' Views on Neuroscientific Evidence in Court Proceedings

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ABSTRACT

This paper presents the results of an empirical study conducted on a number of legal practitioners in Austria, Romania and Slovenia to measure the relevance of the neuroscientific evidence when determining the legal responsibility of a defendant during court proceedings. The legal practitioners were presented five case scenarios in which they were asked to analyze the admissibility of neuroscientific evidence. The results revealed certain important challenges when interpreting neuroscientific evidence for use in legal proceedings. This study summarizes those challenges and further concludes that the application of neuroscientific data is not a straightforward matter. As such, it also argues that neuroscientific experts must play a greater role in court proceedings in order to provide better guidance to judges and other legal practitioners.

Keywords

Legal practitioners, neuroscience, law, courtroom, criminal responsibility etc.

1. INTRODUCTION

Neuroimaging scans have been used in a variety of cases in order to establish a defendant's mental state. In civil cases, neuroimaging has been requested in personal injury, disability belief and contract cases, while in criminal cases it has been mainly invoked in order to negate the *mens rea* of a crime and to avoid convictions. For instance, statistics show that in some countries such as the USA over 1500 judicial opinions issued during 2005-2012 discuss the use of neuroscience by criminal defendants [1]. However, despite the wide use of scans in courts, there is concern among scientists and legal practitioners regarding the practical consequences of neuroscientific developments. The aim of this empirical study seeks to understand how European legal practitioners relate to "neurolaw cases" and the degree to which they admit neuroscientific evidence in court in order to determine the moral and legal responsibility of an individual.

2. PREVIOUS RESEARCH

To our knowledge this is one of the first studies of its kind to assess the views of legal practitioners regarding neuroscientific evidence and the impact of those views on their decisions when assessing the responsibility of an individual. While a number of studies have concluded that neuroscientific evidence affects legal practitioners, few have attempted to qualify that effect. Therefore, in order to test the degree to which legal practitioners use neuroscientific evidence in the assessment of responsibility, we based our study on a hypothesis tested by Aspinwall et al. in 2012 who argued that there is a "correlation between the inclusion of the biological explanation of neurological disorder with significantly reduced sentence length and increased number of mitigating factors listed" [2]. Though this correlation has seen corroborated by the US president's Council on Bioethics, which claimed that "judges and juries have recognized the persuasive allure of brain scans" [3] and Munro's 2014 study, which concluded that the public is more likely to trust diagnosis when brain imaging evidence is presented [4], our study will step beyond these conclusions to understand *how* neuroscientific evidence affects legal practitioners in legal proceedings.

3. DESIGN OF THE EXPERIMENT

3.1 Participants

The participants selected for this study were legal practitioners (judges, lawyers and attorneys) or graduates of legal studies who were already working in the legal profession. The participants' views were assessed via an online questionnaire that was completed by 91 participants (N=91).

The participants were categorized in three main groups, a group from Slovenia (=Slovenian group comprising 41 practitioners with an average of 28.2 years old); a second group from Romania (=Romanian group comprising 22 practitioners with an average age of 34.1 years old); and a third group (=Mixed group comprising 28 legal practitioners with an average age of 28.6 years old) representing legal practitioners residing in Austria, but coming from other countries in Europe and North America.

3.2 Instruments

The legal practitioners were asked to analyze five case scenarios that were designed in such a way as to determine a) the types of neuroscientific evidence that would be acceptable in courts and b) how the legal practitioners' assessment of the individual's responsibility (i.e. guiltiness, type and length of punishment) would be influenced by this type of evidence. The case scenarios were also designed to assess how legal practitioners view "new science", such as advancements in neuroscience.

Before briefly introducing each case scenario and the results, a few remarks are required to fully understand why each case was formulated as it was. Sloboghin identified five categories of neuroscientific evidence based on the cases presented in American courts [5], which we adopted as the basis for our scenarios. The 5 types of evidence are: (a) evidence of abnormality; (b) cause-of-an-effect evidence; (c) effect-of-a-cause evidence; (d) individualized neuro-psychological findings compared against known performance baselines; (e) individualized neuroscience findings compared against known legal baselines.

4. RESULTS AND DISCUSSION

In the following we will discuss the questionnaire results of each scenario, as well as the main problems that were raised by the respondents. Each case scenario presents an offence and the type of neuroscientific evidence that the defendant invoked in order to either excuse his/her behavior or diminish his/her legal responsibility. The legal practitioners were asked to perform three tasks in order to determine: (i) whether the individual in the scenario should be held responsible for the act; (ii) the kind of punishment or treatment that should be applied to an individual; and (iii) the length of punishment (if any). We will additionally highlight some of the challenges identified by the legal practitioners when analyzing the type of neuroscientific evidence presented in each case scenarios.

4.1 Difficulties demonstrating causality

As reported by legal practitioners, demonstrating causality is among the most important problems that arise in practice when using neuroscientific evidence. The problem of causality was specifically included in one of this first case scenarios, in which the legal practitioners were presented with a "cause-of-an-effect" evidence, and asked to determine whether the evidence showing a link between the damage to the frontal lobe and abnormal sexual behavior is acceptable. They were presented the following scenario:

> *"Mr. Jones, aged 35, was arrested for having raped three young women. In the pre-trial investigation, a scan of Mr. Jones' brain using PET (positron emission tomography) revealed serious damage to his frontal lobe, apparently as a result of a stroke. The medical expert showed that during the stroke, the frontal lobe (which is involved in judgment, impulse control and sexual behavior) has been irreversibly damaged and this explains Mr. Jones' abnormal sexual behavior".*

In principle, a "cause-of-an-effect" evidence could be highly exculpatory in order to decide on a volitional impairment. However, the results indicated that our participants did not generally agree in this case. In fact, some Slovenian legal practitioners reported that this type of evidence is not very useful for them as a basis to decide the legal responsibility of an individual. Though this argument was expressed by only some Slovenian respondents, it could generally explain the answers of the Slovenian Group, which agreed by a large majority (80.2%) that the accused in this case should be held responsible for rape. The same view was expressed in a proportion of 64.3% by the Mixed Group.

Interestingly, the Romanian judges were of a different opinion, with only 41% of them agreeing that the accused should be held responsible. The Romanian legal practitioners believed that the evidence was acceptable to diminish the responsibility of the defendant, but not sufficient to remove it completely. The Romanian legal practitioners did not challenge the evidence *per se* in as much detail as the Slovenians did, but the Romanian legal practitioners that did agree that the accused should be held responsible also reported that they were not convinced beyond any reasonable doubt about the causal link between the stroke and the abnormal sexual behavior.

Additionally, some Slovenian legal practitioners noted disparities in the way scientific conclusions could be interpreted. In their view, the conclusion presented in this case, which argues for a causal link between a stroke and abnormal behavior, could also be interpreted as accepting that a high proportion of people that commit rape had a frontal lobe stroke at some point, which, of course, is not necessarily true. In their view, the evidence submitted does not indicate the probability with which people with strokes would also commit rape, which is the central question that a judge would want to have answered and which was not done in a satisfactory manner here.

Consequently, legal practitioners noted that neuroscientific studies presented in courts can rarely be presumed to be fully conclusive, despite the fact that some researchers often invoke assumptions of cause and effect. In their view, the notion of "cause" presents differences in meaning between the social sciences and the criminal law. It might be that because of this reason the two fields frequently clash. According to many legal practitioners, among which Denno, as well, scientists do not often use terms such as "cause-and-effect", but instead use concepts such as "laws of change", "paradigms", "models and theories", "hypothesis testing" and "falsification" [6]. According to them, these various "jargons" make their work more complicated.

4.2 The effect of methodological weaknesses

There is an awareness among legal practitioners that many scientific studies have methodological weaknesses, which have an unknown degree of impact on the overall results. Because of these methodological weaknesses, many Courts have showed certain resistance in considering certain statistical data in their decision-making. Therefore, when deciding to accept probabilistic results as evidence, legal practitioners generally discard causal links that are assessed as not being fully convincible, regardless of the type of evidence, neuroscientific or otherwise.

This was the solution reached by a majority of legal practitioners when presented the following scenario which contained a type of evidence that can be categorized as an individualized neuro-psychological finding:

> *Mr. Johnson, aged 27, was brought in front of the court for having sold methamphetamines. The defense lawyers informed the judges that the defendant found out 8 years before that he had an unusually large pituitary tumor, which caused irreversible brain tumors. The medical expert showed that pituitary tumors may affect thyroid production, causing mood disorder and damage to the frontal, temporal and thalamic regions, which may cause problems in decision-making, mental flexibility and overall intellectual capacity. The medical expert supported the defense who claimed that because of the tumor, the defendant was more susceptible to be influenced and manipulated by the drugs dealers and that is why he accepted to sell the drugs".*

In general, individualized neuro-psychological findings compared against known performance baselines (such as those in this scenario) are accepted in courts because they provide insight into the particular defendant's biological functioning. Despite this fact, a great majority of respondents across all three groups (average of 87.9%) rejected the evidence presented and agreed that the accused should be held responsible for selling drugs. An argument invoked by the legal practitioners for this conclusion was that it is generally very difficult for scientists to come up with convincing and compelling data relevant for all necessary demographic groups in order to make a useful comparison with the defendant. That is because findings from neurological testing can vary significantly based on a series of variables, including gender, age, and education, among others. In the view of the legal practitioners, interpreting specific results can be very difficult without this baseline information.

Another concern noted by legal practitioners was that even if these baseline measurements would be obtained, a correct determination about relative impulsivity of the defendant at one point in time does not prove anything about the impulsivity of the defendant at the time the crime occurred (in our case when the accused decided to sell the drugs). Consequently, our respondents confirmed conclusions reached in other studies, such as that of Sloboghin who noted "that science cannot currently answer the normative question of how far below the average a defendant would have to register on a particular performance task to be considered legally impaired" [5].

4.3 Limits regarding potential simultaneous effects and interrelationships

Another challenge of neuroscientific evidence noted by legal practitioners was that they were seldom presented studies that examined all the possible variables. By ignoring potential simultaneous effects and interrelationships that may exist among the numerous other biological, social, and economic factors, they concluded that very few of these studies were complete, leaving room for interpretation. Therefore, a majority of judges in our study continue to believe that most biological and environmental studies of crime remain isolated in their particular disciplines, which often makes them unacceptable as evidence in the court.

This was one of the main conclusions reached based on the results obtain for the following case scenario:

> "*Mr. Green, aged 47 is brought in front of the criminal court for assault and injuries on a pedestrian. He assaulted the pedestrian on the reason that he almost generated an accident while walking on the lane destined only for bikers. Mr. Green's lawyer pleaded that the defendant is a peaceful person never having been involved in fights and that his violent behavior was the result of the defendant's level of testosterone which changed its normal level because of the ingestion of some steroids that Mr. Green took during sport training. The medical expert showed that the saliva samples collected from the defendant exhibited abnormal level of testosterone and this generated his aggressive behavior. He also added that there is no unanimity within the scientific community regarding the positive correlation between testosterone level and aggression in general, but that in his opinion, in this particular case, the correlation is evident*".

This case scenario contains "effect-of-a-cause" evidence, which basically compares the prevalence of criminal behavior among individuals presenting a neurological impairment to those that do not have such an impairment. More precisely, the evidence refers to research that indicates a higher prevalence rate of violence among people with high level of testosterone. When asked to evaluate whether the defendant should be held responsible for assault and injuries on a pedestrian, the great majority (94.5%) of respondents from all three groups agreed that he should be held responsible. Compared to the previous two case scenarios, this one contained less divergent views.

As mentioned by the respondents in the comments sections, and confirmed by other studies, evidence of clear association between androgen levels and aggression in human males is currently inconclusive. Legal practitioners took note of studies that noted that behavioral "traits of dominance and aggression in the human male have been associated with higher levels of testosterone" [6]. However, they were also aware that, as Archer concluded, "direct associations between androgen levels, primarily testosterone, and criminality show somewhat conflicting results, possibly because of the different types of hormone measures used" [7]. As such, it seems that legal practitioners view research on some of these factors as statistically weak and believe that more carefully performed studies are needed before they can use this type of evidence in the courtroom.

Nonetheless, the legal practitioners also argued this type of data must be put in context. In their view, without knowing the general base rate for violence in people with normal levels of testosterone, crime prevalence in groups of people with high levels of testosterone is not of much help to legal practitioners.

4.4 Too much focus on incrimination rather than exoneration

Connected to the conclusion above, an interesting view of many legal practitioners was the acknowledgement that current neuroscience evidence is mostly focused on culpability issues (whether an individual is morally and legally responsible for their acts) rather than providing a basis for exoneration. Because of that, in deciding on the relevance of such evidence, legal practitioners and experts are aware that they have to pay attention both to the precise nature of the evidence in question and the specific legal doctrine to be addressed. Though some may argue that neuroscience evidence alone could be sufficient to remove the responsibility of an individual, in reality, in most cases, it is not. This was what the legal practitioners decided in the case of the following case scenario:

> *"Ms. Black, aged 47, accountant, was filed for conducting fraudulent insurance practices for a period of 8 years. She was diagnosed 10 years before with anoxic encephalopathy caused by a myocardial infarction. A SPECT (single-photon emission computed tomography) was performed, which indicated a reduction in blood flow in the temporal and frontal lobes (which are associated with executive functioning and memory). The medical expert showed that her fraudulent behavior could be explained by her impairment".*

For this scenario, the majority of the legal practitioners considered that the SPECT evidence that was included to demonstrate a reduction in blood flow in the temporal and frontal lobe should not be received as an exculpatory evidence. Their main argument was that neuro-abnormalities have minimal relevance for cause in this case, particularly when having to explain a causal link over an extended period of time (a stroke that occurred 10 years before the trial). The causal link between the stroke and the multiple fraudulent acts was impossible to establish. Therefore, the majority discarded this evidence, with 95.2% of the Slovenian, 81.9% of the Romanian respondents and 85.7% agreeing that the defendant should be held responsible for fraudulent practices.

As noted by the legal practitioners, a reason why they believed prison punishment was appropriate was due of the concern that, in this case, improperly used neuroscience evidence could be used to mitigate punishment and thereby present a greater risk of re-offense. It seems thus that judges, when confronted with the public pressure to ensure to that there is no risk of re-offense (like in the scenario presented above), may be more inclined to admit the neuroscientific evidence in order to evaluate one's risk of re-offending. The "double-edge sword" nature of neuroscience evidence is important and was not noted by the respondents prior to this case scenario. Therefore, based on these results, it is important to be aware of the possibility that neuroscientific evidence could be misused in the future to evaluate or predict an individual's potential level of dangerousness.

4.5 Cultural differences in weighing the strength of the evidence

Finally, it is important to note that we believe that some of discrepancies included in our results are attributable to cultural differences. In fact, these cultural differences seemed particularly important in relation to the severity of punishment. This is seen most clearly in the following scenario:

> *"Mr. Smith, aged 37, is a teacher and he is being tried for having made sexual advances on his young stepdaughter. He was found to have a tumor in the right frontal lobe of his brain. His medical results showed that when the tumor was removed, his pedophilic behavior stopped. When the tumor recurred, the behavior also resumed"*.

When asked whether the defendant should be held responsible for the sexual advances committed on his stepdaughter, a majority of the Slovenian and the Mixed groups, with 83% and 60.7%, respectively, agreed that the accused should be held responsible for sexual advances. However, the majority of Romanians (59%) disagreed, believing that in this case, the individual should not be held responsible for sexual advances.

We believe that the difference in the way this defendant was evaluated by the three groups has to do with the type of neuroscientific evidence presented to the participants in the study. In this case, the legal practitioners were asked to evaluate evidence of a brain abnormality. The Slovenian and Mixed Group argued that since hypothetical cases like these are very rare in practice, very few defendants can present such a straightforward connection between neurology and behavior. As such, the majority of the respondents from those two groups believed that the behavior of the defendant could not be excused because this neurological abnormality provides an insufficient basis for making the necessary link to the unlawful behavior.

That was not the case for the Romanian Group, who in a proportion of 59.1% believed that the accused should not be held responsible for sexual advances. In this situation, Romanian legal practitioners admitted the neuroscientific evidence on the presumption that the medical conclusions were correct. Compared to the Slovenian and Mixed Groups, the Romanian Group did not challenge the accuracy of the medical results and/ or of the neuroscientific evidence that was brought to be examined in the case. The reason for this discrepancy is unknown and could warrant further study.

5. CONCLUSION AND FURTHER DIRECTIONS

The results of this experiment are addressed to both scientists and legal practitioners, who, we hope, will be able to draw some practical applications for their work. Our first recommendation for the scientists is to make sure that information they release publicly is valid and clearly states the scientific limitations. Experts in the field of neuroscience should keep in mind that as much as legal practitioners would sometimes want to accept a certain type of neuroscientific evidence, specific constraints of the legal doctrine in which they work prevent them. A second message is addressed to legal practitioners, who should begin considering the best ways to integrate new scientific discoveries. Neuroscientific evidence can provide a more nuanced understanding of neurological impairments in a way designed to humanize the legal system rather than creating motives for discriminating against individuals. This more nuanced understanding can additionally provide a more graded approach for assigning responsibility, by minimizing arbitrary incrimination or full exonerations based only on the premise that "my brain made me do it".

We are also hopeful that the conclusions obtained in this study are sufficient to provide at least a more accurate picture of how various legal practitioners witness, from their positions, the new developments in neuroscience. However, based on the results obtained in this study it is difficult to predict whether neuroscientific evidence will play a more important role in courtrooms in Europe in the future. There are many optimistic voices that see a future for neuroscientific tools, as they may provide a more objective assessment of an individual's responsibility, particularly when compared to legal rules, which are generally insufficient and represent only a translation of the social beliefs in legal terms. Of course, some concerned voices support the view that neuroscientific techniques are still not ready to provide sufficient accuracy, and hence they are not fully reliable in the court. In our view, caution is certainly warranted in regard to neuroscientific evidence. However, with further education and better understanding of neuroscientific evidence by judges and other legal practitioners, we are certain that it holds great potential for the future.

6. ACKNOWLEDGMENTS

Our thanks to University of Ljubljana where an important part of the study was performed, particularly to Prof. Dr. Olga Markic and Assist. Dr. Toma Strle who coordinated this project.

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FROM AI TO OUR FUTURE I

AI and the Drake equation

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ABSTRACT

This paper deals with a question, can we predict the future of the human civilization based on the analysis of the current AI research, and computational models of the Drake equation. The perspective of human civilization is analyzed through two items: report from the AI mega-conference, and the Drake equation/Fermi paradox. The mega-AI conference in Stockholm represents the state of the art in the AI field, demonstrating that major world powers are fast increasing AI funding. The computational models such as recompilations of the Drake equation are gaining attention as one of the means to estimate the longevity of the human civilization.

POVZETEK

To je prvi prispevek od dveh, ki opisujeta isti koncept: ali lahko napovemo bodočnost človeštva na osnovi analize sedanjih raziskav umetne inteligence (AI), računskih modelov na osnovi Drakove enačbe in novi socialni črni scenarij, ki bi lahko zaustavil razvoj človeštva.

V tem prispevku je analizirana bodočnost človeške civilizacije skozi dve temi: poročilo z največje svetovne AI konference in analiza Drakove enačbe oz. Fermijevega paradoksa. Mega konferenca letos v Stockholmu je predstavila trenutne raziskave AI v svetu in pokazala, da svetovne velesile izredno povečujejo financiranje AI področja. Po drugi strani pa narašča število analiz in objav s področja bodočnosti človeštva. Računski modeli med drugim dajejo ocene trajanja človeške civilizacije.

Keywords / ključne besede

Progress of human civilization, Drake equation, Fermi paradox, artificial intelligence

Razvoj človeške civilizacije, Drakova enačba, Fermijev paradoks, umetna inteligenca

1. UVOD

Večina projektov v odseku E9 na Institutu »Jožef Stefan« se ukvarja z izboljšavami življenja in zdravja ljudi, recimo s skrbjo za starejše preko inteligentnega pomočnika na pametni uri, ali pa za srčne bolnike. Del raziskav pa je bolj visoko letečih. Nekaj časa že razmišljamo, kako zgraditi inteligentne asistente iz biblije, korana, slovenske ustave. Asistenti ne bi znali samo odgovarjati na vprašanja s primernim besedilom, ampak bi bili sposobni tudi tolmačiti določen del vsebine, semantike, vrednot. Bi tako ustvarili kopijo npr. krščanskega boga? Ti programi bi bili sposobni demonstrirati svoje avtonomno razmišljanje na osnovi podanih besedil, torej bi bili v nekem smislu »živi«. Za dosego tega pa morajo imeti tudi, ali predvsem kognitivne lastnosti.

Če so trenutne raziskave oz. analize na tem nivoju, ali so v svetu raziskave že blizu superinteligence [1,2,3], ki bi morebiti znala prehiteti ljudi na vseh področjih? V tem prispevku je najprej predstavljena največja svetovna konferenca s področja umetne inteligence, sledi pa še analiza Drakove enačbe z novimi računskimi pristopi. Na osnovi teh analiz skušamo oceniti, kaj nas čaka v bližnji prihodnosti, tj. skušamo napovedati prihodnji razvoj človeške civilizacije.

Letos poleti je bila v Stockholmu največja svetovna konferenca IJCAI, združena z evropsko ECAI [4]. Skupno je bilo preko 6.000 udeležencev. Približno polovica vseh prispevkov je bila kitajskih, pol manj je bilo evropejskih in ameriških. Velesile se zavedajo, da je področje umetne inteligence eno izmed ključnih, kjer se odloča, kdo bo dominiral svetu. Tako Putin kot Trump in Ši Džinping intenzivno povečujejo sredstva za umetno inteligenco, Evropa jih bo v nekaj letih nekajkrat povečala.

Dnevno naredi umetna inteligenca neverjetnih 10 bilijonov odločitev. Dosežkov umetne inteligence samo v lanskem letu je bilo toliko, da jih lahko omenimo le minimalni delež. Recimo na področju varnosti marsikje po svetu uporabljajo sistem, ki vsak dan izdela nov urnik obhodov varnostnikov po letališčih, po pristaniščih in podobno. Kjer so bili uporabljeni, so izmerili bistveno večjo učinkovitost. V skrbi za okolje so raziskovalci pod vodstvom prof. Tambeja (tam je bil tudi naš doktorand dr. Kaluža) tovrstne programe podarili šestdesetim rezervatom po svetu, da se bodo uspešneje upirali krivolovcem. Leta 2015 so programi globokih nevronskih mrež začeli premagovati ljudi pri prepoznavanju vidnih nalog in danes nas prekašajo na mnogo področjih, npr. pri prepoznavanju malignih tkiv. Pri nekaterih nalogah, recimo pri ostrenju slike (dež, megla, sneg itd.) so programi osemkrat boljši kot ljudje. Seveda se takoj pojavi strah, ampak če čakate nekaj tednov na diagnozo, ali imate raka ali ne, v Ameriki pa to naredi umetna inteligenca v nekaj minutah bolje kot katerikoli zdravnik – kaj pravite, ali bi jo uvedli tudi pri nas? Pri nekaterih sistemih kot zamenjavi organov so programi že desetletja v uporabi in so rešila na tisoče življenj. Nekateri so novejši, recimo letos so vpeljali prvi inteligentni program, ki ugotavlja diabetes iz pregleda oči, prav tako prvi program za ugotavljanje abnormalnosti prsnega koša pri slikanju. Neverjeten razvoj je najbolj znan pri avtonomni vožnji – danes imajo povprečni avtomobili kar nekaj avtonomnih inteligentnih funkcij, modernejši kot Tesla pa vozijo praktično sami in jih samo še nadziramo v nenavadnih situacijah. Nesreč je približno stokrat manj, čeprav tistih nekaj mediji toliko bolj napihnejo.

In smo pri »moralnem stroju« - vprašanju, koga naj povozi avtonomno vozilo, če npr. izbira med otrokom ali starejšim: http://moralmachine.mit.edu/. V Nemčiji je prepovedano upoštevati leta (prepovedana starostna diskriminacija), v testih pa se izkaže, da precej ljudi raje ponudi možnost preživetja otrokom. Najpomembnejše je število, torej naj bi avto zavil med dva namesto med tri ljudi. Dobršen del anketirancev pa raje izbere brezdomca kot otroka itd. Preko spleta so zbrali že okoli petdeset milijonov odločitev in izkaže se, da imajo določene države podobne sisteme preferenc, koga povoziti in koga ne.

Tako so ugotovili značilne vzorce vrednosti pri zahodnih državah, spet druge v vzhodni Evropi itd. Anglofilske države kot Anglija, Amerika, Avstralija in Nova Zelandija so svoj skupek s podobnimi vrednotami, čeprav so geografsko precej narazen. Ta grupiranja torej pokažejo, katere države imajo podoben sistem vrednot in kako se razlikujejo od drugih.

V praksi je taka situacija izredno redka, saj imajo ljudje možnost odskočiti, avto se zaleti v oviro in zaradi varnostnega pasu potniki skoraj gotovo preživijo, medtem ko pešec kakšne posebne zaščite nima. Študija, ena izmed mnogih, pa predvsem pove nekaj o nas samih – kakšni smo kot ljudje in kako cenimo življenje drugih. Sistemi umetne inteligence zato ne rešujejo samo pereča inženirska in socialna vprašanja, ampak tudi iz nas delajo boljše ljudi. Marsikdo med nami je prepričan, da je ravno umetna inteligenca tista ključna znanstvena veda, ki bo dvignila človeštvo v novo civilizacijsko ero [11].

2. IJCAI 2018 – KAKO ZGRADITI UM

Julija 2018 v Stockholmu so se združili ICML, AAMAS, ICCBR in SoCS z IJCAI and ECAI v prvo mega-konferenco. Namen dogodka je bil ponovno integrirati področje in se namesto s čedalje bolj specifičnimi problemi ukvarjati z ključnimi splošnimi. Opis v tej sekciji je namenjen skupni IJCAI-ECCAI konferenci [4].

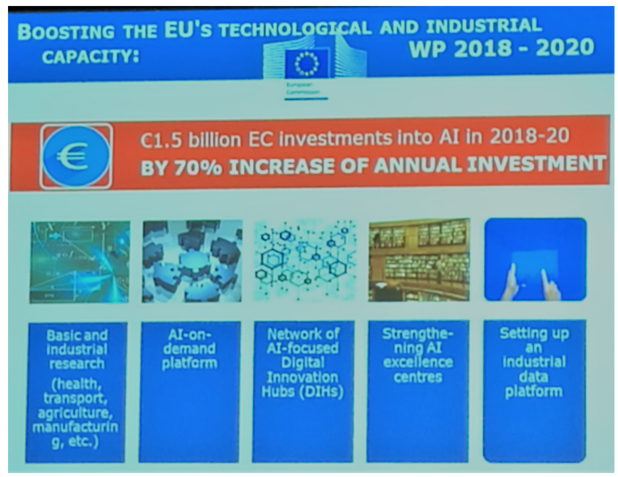
Okoli 7000 udeležencev je 14 dni sodelovalo v mega-konferenci. IJCAI-ECCAI konferenca je doživela ponoven rekord s 3470 poslanimi prispevki: 37 % več kot v letu 2017. Leta 2017 [5] je bilo 37% vseh prispevkov kitajskih, leta 2018 pa 46%. Ameriških in evropskih prispevkov je bilo vsakih po 20%.

Spremembe niso prišle same po sebi, ampak so rezultat ključnega vlaganja kitajskega državnega vodstva v znanost in zlasti v umetno inteligenco. Odgovor Amerike in Evrope je že tu.

Slika 1: AI strategija EU temelji na treh elementih: znanost/tehnologija, socio-ekonomske spremembe in socialno okolje.

Na Sliki 1 je prikazana strateška usmeritev EU glede umetne inteligence. Med drugim bo EU podprla gradnjo nove odprte platforme za AI, malce podobno kot Muskov OpenAI (Slika 2). Na sliki 2 je prikazana usmeritev bodočega financiranja: najprej 70% povečanja in nato 100% in nato še 100%.

Ameriški DoD je ustanovil Joint AI Center (JAIC), ki bo financiral 600 AI projektov v vrednosti \$1.7 milijarde.



Slika 2: Tudi EU bo signifikantno povečala financiranje AI.

Najpomembnejša strateška usmeritev mega-konference IJCAI je bila, kako zgraditi um. Ker umetnega uma odraslih očitno še ne znamo zgraditi, so raziskave usmerjene predvsem v študije uma otrok od rojstva dalje. Čeprav se je vpliv AI na vsakodnevno življenje ljudi izjemno povečal, saj AI vsakodnevno naredi 100 bilijonov odločitev, so koncepti kot razumevanje, semantika, um, kognicija, čustva, »duša«, kvalia itd. ostali nedosegljivi za AI, podobno kot rešitev Turingoveg testa.

Vseeno je razvoj izredno hiter. Nekatere nove aplikacije so vizualno fascinantne – recimo konja znajo nevronske mreže prebarvati v zebro in se na zaslonu premika konj v obliki zebre. Iz seznama obrazov slavnih osebnosti znajo ti programi zgraditi nove obraze neobstoječih ljudi. Sistemi govorijo praktično kot ljudje in tudi razpoznavajo govor na tem nivoju, veliko vidnih nalog pa opravljajo precej bolje kot ljudje. Google je začel uporabljati globoke nevronske mreže za prepoznavanje vprašanj in občasno je na čudna vprašanja generiral vizije, tudi preroške vizije črne prihodnosti človeštva. Vraževerni so začeli govoriti o prebujanju prave inteligence, a so razvijalci Googla pojasnili, da so nevronske mreže prav čudna vprašanja povezala s prav čudnimi odgovori.

Obstaja *plitva*, tj. sedanja uporabna in raziskovalna AI, *globoka* AI, tj. globoke nevronske mreže, za katero velja mnenje raziskovalcev umetne inteligence, da je v resnici plitva, *prava* AI in *lažna* AI. Lažna AI je, ko vskočijo ljudje, tipično v neko komunikacijo med virtualnim asistentom in človekom, in tega ne povedo. Prava AI pa je AI, sposobna rešiti Turingov test, tista, ki da nam ljudem vtis resnične inteligence. V Turingovem testu ljudje še vedno hitro prepoznajo računalnike, čeprav se pretvarjajo, da so ljudje, ker jim manjka prava AI.

S čedalje več raziskavami postaja tudi čedalje bolj jasno, kje se AI razlikuje od prave AI. Recimo pri učenju se otrok (Slika 3) nauči enega koncepta, npr. kako sestaviti kocke, nato pa ga praktično takoj ali z minimalnim učenjem prenese na druge domene, recimo sestavljanje figuric. Pri tem se uči univerzalno, medtem ko mora AI uporabljati specialne programe za posamezne naloge, jih ne uspe posplošiti in ne zna prilagoditi algoritmov podobnim nalogam.

Figure 3: Otroci se učijo bistveno drugače kot sistemi AI. Zakaj se ne bi zgledovali po njih?

Drug pomemben poskus v smeri prave AI je t.i. *splošna* AI, ki skuša razvijati široko uporabne algoritme namesto ozko specializiranih. Tako npr. naj bi obstajal en algoritem za igranje vseh iger, ki bi znal izvajati vse algoritme za različne igre, in prenašal znanje med njimi. Večinsko mnenje med strokovnjaki umetne inteligence je, da bomo to vrsto inteligence razvili čez kakšnih 10 let. Splošno mnenje je, da nam ne manjka denarja ali procesorskih zmogljivosti – iščemo nove, drzne ideje, kako razviti splošno, pravo in super-inteligenco. Bolj ali manj je tudi konsenz, da bo AI pomagala reševati nakopičene socialne težave (Slika 1). Konferenca je ostala strogo znanstvena, vendar je med znanstveniki določena zaskrbljenost zaradi čedalje pogostejših napadov na znanost in prodiranje ideologij med znanstvenike.

3. FERMIJEV PARADOKS - ČRNI SCENARIJ ČLOVEŠTVA

Katere nevarnosti prežijo človeštvu? Skoraj zagotovo so največje in najbližje nevarnosti povezane s hitrim vzponom človeške civilizacije. Prav tako med najbolj perečimi ni nekaterih, ki se pogosto pojavljajo v medijih, npr. globalnega segrevanja. Čeprav se planet Zemlja segreva in čeprav je najverjetnejši krivec za to človek, je ta nevarnost obvladljiva, če se le uspemo dogovoriti. Bolj problematične so neobvladljive, nerazumljene in potuhnjene nevarnosti. V kakšnem iz naslednjih prispevkov bomo predstavili izvirno teorijo, temelječo na socialnem propadu, tu pa bodo na kratko opisane analize Drakove enačbe.

Veliki fizik Enrico Fermi je že leta 1950 med atomskimi raziskavami v Los Alamosu vprašal: »Pa kje so?«, ko je preračunal verjetnosti in ugotovil, da bi že morali vzpostaviti stik z drugimi civilizacijami. Sedaj vemo precej več: število planetov v znanem vesolju je reda velikosti 10 na 22, pregledali smo ogromno več vesolja in nismo našli nobenih znakov civilizacije! Pri tem je minilo 68 let od Fermijevega vzklika in 64 let od njegove smrti. Umrl je istega leta kot Alan Turing, računalniški Einstein in oče umetne inteligence (in se je rodil avtor tega prispevka).

Eno izmed najbolj poznanih ocen števila civilizacij je postavil Drake s svojo enačbo leta 1961 [6]. Ocena števila razvitih zunajzemeljskih civilizacij v naši Galaksiji je (x je znak za množenje) N = R* x fs x fp x ne x fl x fi x fc x L, kjer velja:
R* je razmerje zvezdnih skupin v naši Galaksiji, tj. hitrost nastajanja novih zvezd, število reda velikosti 1.
fs je delež Soncu podobnih zvezd z lastnimi planeti.
fp je delež zvezd z lastnimi planeti.
ne je povprečno število planetov, ki omogočajo življenje v razmerju z zvezdo, ki ima planete.
fl je delež planetov, kjer se domnevno lahko razvije življenje.
fi je delež planetov, kjer se dejansko razvije življenje.
fc je delež tistih, ki bi želeli ali se bili sposobni sporazumevati.
L je pričakovana življenjska doba take civilizacije.

V bistvu ta enačba temelji na oceni števila planetov; pomnoženi z verjetnostjo, da so na planetu ugodni pogoji za razvoj življenja; pomnoženi z verjetnostjo nastanka življenja; pomnoženo z verjetnostjo tehnološko napredne civilizacije; skalirano s časom trajanja civilizacije, saj nas zanima število civilizacij sedaj. V tej enačbi se trajanje naše galaksije pokrajša, ko se pojavi pri R kot produkt in pri L kot imenovalec (glej enačbo).

Ker je izračun odvisen od privzetih vrednosti in ker imajo različni strokovnjaki razne ocene, Wikipedija predlaga tri možnosti za konkretne številke:

- Ena civilizacija v naši galaksiji – komunikacija oz. zaznavanje drugih civilizacij s sedanjimi sredstvi ni mogoče.
- 100 civilizacij naši galaksiji, v povprečju oddaljenih 5000 svetlobnih let med dvema civilizacijama, ki lahko med seboj komunicirata.
- Štiri milijone civilizacij, komunikacija preprosta.

Zvezd in planetov je glede na naše znanje ogromno: galaksij je okoli 10 na 11 do 12 in podobno število je zvezd v galaksiji, torej je skupno število zvezd okoli 10 na 23 do 24. Trenutna ocena planetov je okoli 10 na 22. Če je med temi planeti le na vsakem milijardnem civilizacija, to pomeni 10 na 13 civilizacij, to je deset tisoč milijard. V naši galaksiji je okoli 10 na 11, tj. sto milijard planetov, kar po podobnem merilu prinese sto civilizacij s povprečno razdaljo med njimi pet tisoč svetlobnih let. Na taki razdalji je možno prepoznati močne energijske signale.

Verjetnost, da je življenje edino na Zemlji, je praktično nič, pa če pregledate Googla, Wikipedijo ali sami malce preračunate. Samo – sosednjih naprednih civilizacij gotovo ni, ker bi jih že opazili! Prav daljnih civilizacij trenutno najverjetneje ne moremo prepoznati, niti srednje oddaljenih, če se nočejo razkriti.

Precej vprašanj ostaja odprtih, vendar nekaj lahko vseeno sklepamo: Če so civilizacije prav redko posejane po vesolju, potem so lahko trajale dalj časa, pa se niso opazile med seboj. Če pa so gosteje posejane, tj. če se življenje seli s planeta na planet v obliki trosov ali medzvezdnih poletov, morajo propasti relativno kmalu, drugače bi jih že opazili. Kaj je to »kmalu«, ne vemo, od reda velikosti 100 do 10.000 let. V primeru redke poseljenosti imamo opravka s pojavom, da življenje nastane samo od sebe v primernih pogojih, kar smo v laboratorijih že pogosto postorili, vendar življenje ne uspe poseliti bližnjih planetov. Dovolj daleč narazen pa lahko civilizacije obstajajo dalj časa, tudi stotine milijonov let, a se ne uspejo zaznati zaradi ogromnih razdalj.

Naslednje vprašanje je, zakaj ni starejša in napredna civilizacija poselila vsega vesolja. V grobem ostajajo tri možnosti:

- Potovanje na daljše razdalje je preveč zahtevno, ker ni mogoče potovati hitreje kot s hitrostjo svetlobe
- Trajanje civilizacije je omejeno / Nekaj žre civilizacije [7]
- Napredne civilizacije pustijo razvijajoče se, kot npr. našo, in se nočejo vpletati.

Trije raziskovalci s Future of Humanity Institute (FHI) [8], Oxfordska univerza, med njimi Anders Sandberg, (s katerim je avtor prispevka intenzivno debatiral med konferenčnim izletom na kitajski zid) so objavili drugačno razlago Fermijevega paradoksa [9]. Za vsak parameter v enačbi so vstavili verjetnostni interval in izračunali končno verjetnostno distribucijo. V članku avtorji trdijo, da je verjetnost, da smo edina civilizacija v galaksiji 53 do 99,6%, da smo edini v vesolju pa 39 do 58 %. Torej drugih civilizacij ne zaznamo zato, ker so tako redke. Dokaj verjetno smo edini v galaksiji in morda tudi v vesolju.

Pomemben zaključek njihove raziskave je, da ni posebne nevarnosti, da bo naša civilizacija kmalu propadla. Izračun temelji na verjetnostni porazdelitvi in predvsem pri verjetnosti življenja da nizko oceno – kot da življenje le redko uspe, oz. le na prav posebnih planetih. Tak posebni primer naj bi bil naš planet, ki ima luno, ki je nastal s trkom s planetom velikosti Marsa itd. Tako trdi tudi Gribbin [10].

Naši izračuni še potekajo. Prve ugotovitve bodo predstavljene na konferenci Slovenian Conference On Artificial Intelligence v okviru multikonference Informacijska družba.

4. ZAKLJUČEK

Umetna inteligenca se razvija in se ukvarja z vprašanji reproduciranja osnovnih kognitivnih sposobnosti, ki se pojavljajo pri otrocih. Na ta način pričakujejo, da bodo dosegli izboljšavo sedanjih formalnih metod AI, ki nimajo praktično nobenih najbolj pomembnih človeških lastnosti. Hkrati AI čedalje bolj vpliva na vsakodnevno življenje v pozitivnem smislu – očitno je eden izmed ključnih generatorjev napredka [11].

V zadnjih desetletjih smo odkrili, da ima praktično vsaka zvezda najverjetneje nekaj planetov, torej je planetov ogromno. To je napovedoval že princip mnogoterega znanja [12], ki je tudi napovedal precejšnje število civilizacij. Hkrati pa ne opazimo nobene napredne civilizacije v delu vesolja, ki ga zaznajo naši teleskopi. Čedalje bolj napredne analize in ocene števila civilizacij v vesolju nakazujejo, da je civilizacij malo.

Obstajata dve teoriji: po eni je civilizacij dejansko malo in smo ena redkih civilizacij v tem delu vesolja, vendar hkrati ni posebne nevarnosti, da bomo kmalu propadli. Po drugi teoriji je bilo pred nami že ogromno civilizacij relativno blizu nas, vendar so vse po vrsti propadle. Ta usoda čaka tudi nas, najverjetneje, če se ne bomo pravočasno zavedli problema in potegnili primernih potez.
Zlasti v primeru druge možnosti se je potrebno zavedati, da je čim hitrejše potovanje vsaj na bližnje lune in planete nujnost preživetja, kot večkrat poudarja Elon Musk.

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The Quest for Understanding: Helping People with PIMD to Communicate with their Caregivers.

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ABSTRACT
People with Profound Intellectual and Multiple Disabilities (PIMD) stand for a broad and very heterogeneous spectrum of people that are characterised by some common aspects like a severe intellectual disability usually in combination with a lack of conventional and symbolic communication abilities, coupled with the need for high levels of support due to comorbidities or other possible disabilities (i.e., motor or sensorial impairments). Supporting these individuals is extremely challenging, as their communication signals are atypical and idiosyncratic. Therefore, a plethora of these behaviours are not or not easily readable for the caregivers. Without background information on a specific person with PIMD, it is hard for a caregiver, even a trained professional, to interpret the desires and mental state of the person they are interacting with, which leads to a stressful interaction for both. With advances in computer vision (CV), speech recognition technology (SRT) and artificial intelligence (AI), we are making the first steps in codifying these behaviours and attempting to mechanically extract the meaning of the communication. The INSENSION project aims to use these advancements to catalogue the actions of persons with PIMD and the environment and thus provide feedback to caregivers and enable individuals to control their surroundings. A similar system could be used to analyse the behaviour of healthy individuals so that the generalised and personalised expressions of body language could be codified and compared across cultures and individuals.

Keywords
communication, gesture recognition, PILD, AI

1. INTRODUCTION
People with PIMD experience a lot of trouble when they are attempting to communicate to the outside world. Generally, a profound intellectual disability, which complicates the learning of new skills for them, is combined with other sensory or physical impairments, which lead to an unusual communication in comparison to people without disabilities.

On this occasion, the task of their caregivers (parents, therapists, etc.) is to interpret their communication attempts and teach them to make further attempts more distinct. The problem arises from the fact that the communication attempts of the people with PIMD are indistinct, mostly unique to each individual, and hard to distinguish or interpret for people who are not close to them. The differences stem from different abilities of each person, different reception of the gestures from their caregivers and other external factors.

At present, only close caregivers are able to interpret the desires of people with PIMD in the right way, nevertheless often combined with feelings of insecurity. This makes it difficult to easily expand the circle of communication partners. The INSENSION project faces this issue by aiming to use the advances in computer vision, specifically new ways to extract posture and facial expressions from video to codify them. In the second stage of the processing, the context of the expression will be extracted, i.e. what is the state of the environment around the person. This way, the expression can be coupled with the interaction and the intent of the communication can be interpreted. This would hopefully provide improvements for both sides: for the people in contact with people with PIMD to have a window into their internal states and see their attempts and, of course, for the people with PIMD themselves. However due to their disabilities, the communication attempts of people with PIMD seem simpler and their internal working models are often assumed to be limited to temporally and spatially neighbouring desires that makes the interpretation context smaller.

This research has broader implications as a similar, but more complex, system could be used to interpret communications of individuals so that their behaviour could be objectively determined enabling a more rigid research into the communication of people and their internal state.

The rest of the paper is organised as follows: In Section 2 we look at the state of the people with PIMD and their communication attempts. In Section 3 we take a brief look at the underlying technical advancements that can facilitate the extraction of posture and facial expressions and the vocalisations of the person. In Section 4 we present the annotations that will be the input for the Machine Learning (ML) system. In Section 5 we discuss the implications of this system and present some caveats to the system. In section 6 we look at broader implications of the system as it could be used on a more general population to systematically codify the interactions as well as further fields of inquiry that could be developed based on this system.

2. PEOPLE WITH PIMD

People with PIMD, as the name implies, have multiple disabilities, which makes it even harder for them to participate in the large number of non-barrier-free parts of our society. Generally, PIMD means a profound intellectual disability combined with other sensory (blindness, deafness) or physical impairments (lack of mobility, problems with fine hand movements, etc.). These factors severely influence the person's ability to live without any care, support or therapy of others [1]. Individuals with PIMD have an above average risk to get additional diseases, and frequently require regular medication that also implies administrative aid. Individuals are assumed to attempt to communicate but are often not able to do so successfully, because of the inherent and external limitations [2].

A common denominator in the population we are dealing with is the limited ability to communicate coherently with their caregivers or the other way around. They usually communicate on a pre-symbolic level and their understanding of speech is severely limited. Some individuals have the ability to form joined attention with their communication partner [3] but this is not universal. While they are capable of learning, the acquisition of new skills takes significantly more time and requires frequent repetition. People with PIMD tend to exhibit not or not easily readable behaviours in order to communicate their (dis-)pleasure or to get attention. Examples of these are pushing unwanted objects away, loud vocalisations or banging to gain attention. In general, the communication attempts of people with PIMD are relying on caregivers who have been trained to understand their communications by interpreting their whole body behaviour or specific personal expressions [4].

Communication attempts are very multifaceted based on the specific individual. Some persons are capable of vocalising simple words, such as saying "Hi", but do not consistently use them in a correct manner or they grab towards toys and individuals they want to interact with. Making eye contact is possible for some individuals, which can be an orientation towards desired objects as communication attempt. Others do not have any coherent vocalisations, lack motor skills and require help holding items [3], [5].

Further complicating their behaviour or the interpretation of is stereotypy. These are actions that do not contain communication attempts but can be considered "ticks" that do not carry meaning. There is a correlation between stereotypical behaviours and low level of social interaction and stimulation. This behaviour can escalate over time to aggressive behaviour and sometimes even self-injuring. The level of these problematic behaviours seems to be correlated with communication problems [5] and would presumably point to this being an expression of frustration. These behaviours can range from hand wringing, to hitting legs, head or nearby objects, from purposeful breath holding to screaming etc.

Several attempts were made to bridge the gap of communication of people with PIMD. Some individuals have access to switches that produce specific sounds enabling an easier communication for less experienced communication partners [4], [6]. These switches can take several forms form simple push buttons to systems that attach to the individual muscles. Other systems, such as Picture Exchange Communication where the individuals with PIMD are expected to provide a picture, usually on a card, for the desired communication or Simplified Signalling that draws the inspiration form natural gestures that are taught to the people with PIMD so that their communication is in line with general public [6]. There is also research in using Brain Computer Interface for communication [7] that uses Electroencephalography (EEG) to map the activity of the brains to interpret the desires. The system requires adaptation based on the individual and training of the individual.

3. ANALYSING THE HUMAN

Enabling computers to interpret the desires of its users and their state of mind is a longstanding goal of computer science. The most developed systems focus on speech recognition[8], [9], but other systems are also explored. Eye tracking [10] is becoming more and more robust, moving from specialised hardware to simple web cameras [11].

More advanced systems enable facial features extraction [12], and from this psychological state of the individual can be extrapolated [13]. These systems work extremely well on typical individuals in good conditions, for example in good lighting and direct camera position [14]. In more dynamic conditions, such as unstable lighting these results are less certain but still reach acceptable levels of accuracy. Additional information, such as voice inflection or contact sensor provides additional information and greater accuracy. Research has been conducted in extracting stress of students using only the smartphone, carried by the person[15].

Another advancement in computer vision is the possibility of mapping the body parts of one or more persons from video [16]. This enables extracting of the limb and torso position, the position of fingers and facial markers. This enables researchers to qualify the position of a person and increases the robustness and ease of analysing behaviours of humans. An example of this can be seen in Figure 1.

The position of a person is only part of the puzzle of finding out what the person wants. In order to determine the context of the interaction there is another piece of the puzzle. The environment of the person must be taken into account. There are several systems that can take a video and return the objects present in the scene. One of the fastest open source solutions is YOLO [17]. Other commercial systems also exist, such as Google or Amazon Object recognition API [18].

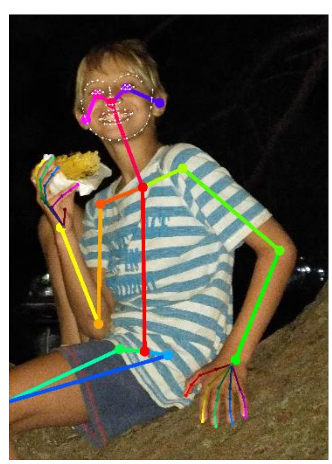

Figure 1. An example of the image processed by OpenPose. The Fingers, arms and facial characteristics are extracted and returned as points.

4. THE EXPRESSIONS OF THE PEOPLE WITH PIMD

In our research we are working with six people with PIMD in order to provide a robust data set that will be used to train the system and extract the state of the individual and the communication they are trying to accomplish. Based on this we hope to extract some rudimentary information, such as their psychological state (pleasure, displeasure or neutral) and the mode of communication they are exhibiting such as protest, demand or comment. Based on this information and the context – the activity that was happening before, the objects that are available for interaction and the estimation of internal needs based on models such as hunger, thirst etc. – the system will propose the action the caregiver should take.

The first step for this is collecting the data. In our case this video is manually annotated in order to provide information for the system. We use several cameras, an infrared camera, a wristband to collect physiological parameters and microphones that collect sounds. The videos are collected in several interactions ranging from meal time, playing (Figure 2) and physical therapy and even some life-skills training.

Figure 1. An image of video recording of a play session with a caregiver.

The videos are annotated to indicate the position of the individuals so that the system can be trained to return the desired information such as arm position, facial expressions and actions such as rubbing parts of the body, interacting with objects or people, presence of

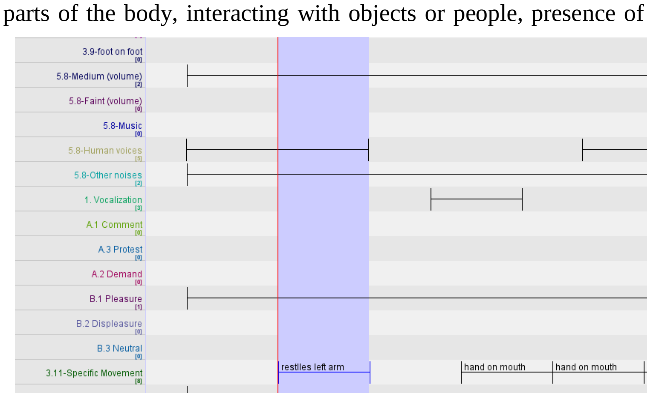

Figure 1. An image of video recording of a play session with a caregiver.

people in the scene and any external disruptions, such as loud noises etc. In Figure 3 we can see an example of the resulting annotation.

5. OVERVIEW OF THE PROPOSED SYSTEM

Our system will take the information collected from the camera, microphone and other sensors, extract the objects in the scene and the information about the communication attempts of the users and, based on this, provide a guess on the presumable mood and communicated content.

In the first round, communication classes will be extracted using unsupervised learning that will return common actions performed by the individual, as annotated or provided by the movement analysing system. This will return meaningful communication clusters. These will be simple like moving the hand from position A (on head) to position B (pointing), interacting with the desk, vocalisation or a combination of these, such as pointing and producing a distinct sound.

All these communication clusters can then be mapped onto the state and communication system. At this stage supervised learning will be used. Some actions will for instance indicate that the user is displeased - providing the information on the internal state of the individual. While others will indicate communication attempts such as demand for something. Together they can indicate to the caregivers what action they should take to provide care for their charges.

The first problem we have to solve is to remove the behaviour that does not carry any communication information. In general, it is expected that action that happen regardless of the state of the individual will be filtered out. This could become problematic as some actions can have several meanings. As such the efficacy of this is considered ongoing research.

In addition, the context, such as presence of strangers or objects in the vicinity, will be used to provide information on the desires and aversions of the individual, creating an internal database of likes and dislikes that can be taken into consideration.

6. CONCLUSIONS

As the system is not yet operational, there are several problems, that are still part of research. For instance, it is unknown which role stereotypy will play, or how accurately we can extract the information if the user is interacting with a specific object or person. The information that the user is interacting with one object may not be enough to infer the actual desire of the user.

Once this, and other problems are resolved the system can be extended to general public. Enabling researchers and others to analyse the behaviour of the individuals and extract the communication desires and psychological state of the individual to further their understanding of the motivations and desires of people, providing standardised analysis of their movements and philological states. This will in turn enable greater rigidity of inquiry providing a faster and reproducible way of analysing behaviour of people.

However, the system could be misused. Organisations and individuals could use the system to determine the state of the individual and use this to manipulate her or him for their gain. A system that can extract the information could be used to associate some products and people with this feeling, thus steering the people to the competition. Furthermore, body language could be important for determining not the information but relationships of people, creating an internal map that could result in an interaction map that could be used to influence certain groups of people or simply to determine the connections between them and their reactions to certain events.

7. ACKNOWLEDGMENTS

Funding: This work was supported by the European Union's Horizon 2020 research and innovation program [grant agreement No 780819 (INSENSION)].

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Kognitivna raven kot del relacijske družinske terapije pri predelovanju spolnega nasilja

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POVZETEK

Posamezniki, ki so v otroštvu doživeli spolno nasilje ter se v odraslosti soočajo s posledicami, potrebujejo za globinsko preoblikovanje vzorcev, odnosov in notranje drže, strokovno pomoč. Brez dela na sebi se pogosto lahko znajdejo nazaj v začaranih krogih nasilja, ali kot žrtve ali kot storilci, in doživljajo neprijetne posledice nasilja, ki jih celo nezavedno prenašajo naprej na otroke. Predno pa je posameznik sposoben iti v globino čustev in nezavednega spomina, je v relacijski družinski terapiji (RDT) s strani terapevta nujno poskrbeti za varen prostor, ki ga med drugim omogoča prav vrednotenje travme na kognitivni ravni, o čemer bomo pisali v prispevku. V tem kontekstu bomo najprej predstavili nekatera teoretična izhodišča v povezavi z RDT in spolnim nasiljem, potem pa bomo bolj natančno osvetlili stopnje procesa RDT na kognitivni ravni.

Ključne besede

Spolno nasilje, relacijska družinska teorija in terapija, kognitivna raven, razreševanje travme.

1. SPOLNO NASILJE

Spolno nasilje je vsako vedenje ali dejanje s spolno vsebino, ki si ga žrtev ne želi in pri njej vzbuja občutek, da je njeno telo le inštrument za zadovoljitev potreb [1]. Pri spolnem nasilju gre za vsa spolna dejanja povezana s spolnostjo, ki jih oseba čuti kot prisilo, ob njih doživlja sram in gnus ter da so bile prekoračene telesne meje in meje osebnega dostojanstva. Na drugi strani pa storilec to stori z namenom spolnega vzburjenja [2, 3]. Nasilje se pojavlja na različnih nivojih, še posebej boleče pa je, kadar nastopa kot relacijska travma, kar pomeni da se izvaja s strani žrtvi bližnje osebe, npr. družinskega člana. Še zlasti težki obliki nasilja, ki se izvajata v družini ali pa neučinkovito razrešujeta, sta fizično in spolno nasilje.

Žrtve nasilja so zaznamovane z dolgotrajnimi posledicami. Raziskave med najpogostejšimi posledicami omenjajo posttravmatsko stresno motnjo, neprimerno regulacijo afekta, depresijo, anksiozne motnje, zlorabo drog in alkohola, kompulzivno vedenjsko ponavljanje travmatičnih scenarijev, občutke sramu in krivde, destruktivnost do sebe in drugih, vedenjsko impulzivnost, agresivne izpade, avtoagresijo, spremenjeno podobo o sebi in podobno [4, 5]. Take izkušnje imajo velik vpliv tudi na telesno zdravje [6, 7].

Samo nasilje je za žrtev lahko tako travmatično, da če se le ta ne zdravi, lahko posledice postanejo in ostanejo doživljenjske [8]. Pomembno je poudariti, da otrok, ki je bil žrtev spolnega nasilja, v obdobju mladostnika ali odraslega posameznika predstavlja veliko tveganje, da sam postane povzročitelj spolnega nasilja nad otroci [9]. Raziskave so pokazale, da je spolna zloraba v otroštvu zelo pogosta med spolnimi prestopniki, saj ponavljajo priučeno vedenje, ki so ga bili sami deležni, torej jih je v otroštvu tako zelo travmatiziral in zaznamoval. Spolni prestopnik se kot otrok nauči pozitivnega odnosa do spolnega vedenja med otrokom in odraslim človekom [10]. Za žrtve posilstva obstaja velika verjetnost, da bodo ponovno žrtve, za deklice, ki so bile telesno ali spolno zlorabljene, pa je velika verjetnost, da bodo ponovno zlorabljene, kot odrasle ali da bodo postale prostitutke [11].

2. RELACIJSKA DRUŽINSKA TEORIJA IN SPOLNO NASILJE

RDT poudarja, da zgodnje travme, kamor sodi tudi spolno nasilje, lahko povzročijo najpogosteje nezmožnost pri reguliranju agresivnih impulzov, strahu, sramu in gnusa [12]. Ti afekti ostanejo zelo globoko ukoreninjeni v psihobiološki strukturi otroka in še v odrasli dobi lahko silovito zaznamujejo posameznika, ki je bil žrtev zlorabe, zlasti pa se prebudijo, ko pride v odraslem odnosu do intime. Zaznamuje pa tudi njegovo okolico, ki se večkrat z velikim nerazumevanjem do njegove bolečine odvrača od njega, saj ne razume, zakaj se vedno znova zapleta v odnose, kjer je spet zlorabljena [13, 2]. Gostečnik [12, 14] meni, da se med spolnim nasiljem vzpostavi izredno močna afektivna povezava med rabljem in žrtvijo. Zato lahko žrtev zlorabe ravno na osnovi tega odnosa, ki je bil kruto vsiljen, v novih situacijah nezavedno išče zlorabo oziroma v zlorabi išče podobne situacije, vzdušja in ljudi, ki jo bodo ponovno zlorabili. Pri tem posameznik podoživlja afekte zlorabe, kot bi se zloraba dogajala tukaj in sedaj, ne pa kot del preteklosti. Nezavedno čutijo, da morajo ostati zvesti tem občutjem, saj bi sicer čutili obupno praznino, močno hrepenenje, ki celo organsko boli, dokler ne pride do ponovitve začaranega kroga in pomiritve. To praznino vsekakor lahko pomirijo tudi z raznimi oblikami zasvojenosti, z avtodestruktivnimi vedenji, kot so samopoškodovanje in motnje hranjenja, ... [15]. Zloraba pomeni odnos, in odpovedati se odnosu za zlorabljenega pomeni izgubiti vse, zato pogosto vztrajajo v še tako bolečih odnosih, v upanju na razrešitev [16].

S področja pomoči pri reševanju posledic spolnega nasilja je sicer veliko različnih tehnik, svetovalnih metod in pristopov, kar pa omogoča le razreševanje na bolj površinski ravni, saj ni dovolj možnosti za naslavljanje vseh dinamik in čustvenih stanj, ki jih pusti travma nasilja. Sodobna relacijska psihoterapevtska paradigma, kamor se uvršča tudi model relacijske družinske terapije (RDT), poudarja prav to: nerazrešene psihične vsebine, ki so zaznane tudi na nevrobiološki ravni, prihajajo na dan v različnih simptomatičnih in velikokrat nefunkcionalnih oblikah vedenja. RTD preko mehanizmov projekcijsko introjekcijske identifikacije (transferja in kontratransferja) prodira v nezavedni spomin in tako z ozaveščanjem le tega pomaga regulirati posameznikova psihobiološka stanja in afekte, ki izhajajo iz teh stanj [12, 17]. Ker je razreševanje travme zelo kompleksen proces, saj potlačene psihosomatske vsebine prihajajo postopno na dan, je nujno v terapiji zagotoviti varen prostor.

3. PROCES RELACIJSKE DRUŽINSKE TERAPIJE PRI RAZREŠEVANJU SPOLNEGA NASILJA

Relacijska družinska terapija postavlja v središče terapevtskega dela odnos, ki omogoča spremembo osnovnih relacijskih struktur. Velik pomen daje ozaveščanju potlačenih vsebin in zagotovitvi manjkajočih zgodnjih doživetij. Vendar pa ne gre zgolj za drugačna doživetja in popravljanje starih, nedokončanih procesov razvoja, temveč za razumevanje temeljnega vzorca odnosov, ki ga živi posameznik, in za spremembo teh temeljnih vzorcev odnosov. Klient zagotovo potrebuje profesionalno pomoč, zlasti pri premagovanju in soočanju s strahom, samoobtoževanjem, krivdo, z jezo in drugimi močnimi čutenji ter afekti, ki jih pusti spolna zloraba [12, 18]. S pomočjo novih izkušenj, ki se zgodijo v terapevtskem odnosu, bo prihajalo pri klientu do sprememb. Te spremembe ne bodo povezane samo z vsakdanjim življenjem, ampak tudi s spremembami v možganih [19], kar posledično vpliva tudi na hormonski sistem ter preusmeritev privlačnosti, kar v praksi pomeni, da zlorabljenemu niso nezavedno več privlačni ljudje, ob katerih bo ponovno podoživljal vzdušje in afekte originalne travme [12, 17].

Rothschildova [16, 20] meni, da mora vsako terapijo, povezano s travmatičnimi doživetji, spremljati deset temeljnih načel, ki so:

1. vzpostavitev varnosti za posameznika, tako na terapiji, kot izven nje; 2. razviti dober in učinkovit terapevtski odnos; 3. sposobnost in zmožnost ustavitve terapevtskega procesa; 4. identificirati in graditi posameznikove notranje in zunanje vire; 5. graditi mehanizme za soočenje s travmo; 6. vedno znižati pritisk; 7. prilagoditi se posameznikovim potrebam; 8. poznati širok spekter psihofizioloških teorij o travmi in PTSD; 9. upoštevati posameznikove svojske razlike in posebnosti ter 10. terapevt mora biti pripravljen opustiti določene ali vse terapevtske tehnike.

V tem kontekstu temeljnih načel dela s travmo, se prepletajo v samem procesu razreševanja različne teme in stopnje, ki pa se pri vsakem posamezniku odvijajo v drugačnem vrstnem redu. Prav tako ni značilno, da bi se neka stopnja zaključila in začela druga, ampak se lahko iste stopnje večkrat ponovijo, vendar vsakič na drugačen način, na drugem nivoju. V tem oziru proces okrevanja spominja na spiralo, kjer se ponovijo isti nivoji, a vsakič raven višje. Pomembno je vedeti, da ima vsak posameznik svojo pot okrevanja. Ni boljših in hitrejših poti, so le različne poti, ki vodijo k istemu cilju. V relacijski družinski terapiji je zagotovo cilj, da se spolno nasilje razrešuje na kognitivni ravni, na ravni čutenj in afektov ter na telesni ravni [2, 21]. V nadaljevanju bomo predstavili kognitivno raven, ki je na nek način najbolj na površini, a brez nje do ostalih dveh naprej ni mogoče prodreti.

4 KOGNITIVNA RAVEN PRI PREDELAVI SPOLNEGA NASILJA

Klinične izkušnje [2] kažejo, da zlorabljeni začnejo predelovati spolno zlorabo najprej na kognitivni ravni . Ko govorimo o kognitivni ravni, imamo v mislih racionalno dojemanje, miselne procese posameznika. V tem okviru se prepletajo različne teme in stopnje procesa, ki pa se ne odvijajo pri vseh v istem vrstnem redu.

a.) ODLOČITEV: Najprej se mora zlorabljeni odločiti, da želi nekaj spremeniti. Do te odločitve jih največkrat pripeljejo posledice spolne zlorabe, ki jih doživljajo na različnih področjih. V večini primerov nihče moči teh posledic ne pripisuje spolni zlorabi ampak sebi, kot tistemu, s katerim je nekaj zelo narobe, saj sicer ne bi doživljal toliko stisk in kriz. Slutijo pa, da tu in tam travmatičen dogodek prispeva del bolečin, vendar nikakor v takem obsegu in s tako intenzivnostjo, kot se kasneje v procesu terapije izkaže.

b.) KOGNITIVNO DOJEMANJE POSLEDIC SPOLNEGA NASILJA: ko terapevt začne na srečanjih vrednotiti te stiske in iskati izvor sedanjih doživljanj, ki se le prebujajo in prihajajo od drugod, začnejo zlorabljeni postopno kognitivno dojemati resnične posledice spolne zlorabe, samo dinamiko, povezave s preteklostjo in sedanjostjo … Čutenja, ki se jim ob tem pojavljajo, in telesne senzacije, ki jih doživljajo, najprej le racionalno povezujejo z zlorabo, in normalno je, da občasno celo podvomijo in zanikajo, da bi lahko zaradi te travme doživljali toliko groz.

c.) GLASNO PRIZNANJE, DA SE JE SPOLNO NASILJE ZARES ZGODILO: velik korak naprej je, ko lahko posameznik glasno pred vsemi v skupini (če je terapija skupinska) ali le pred terapevtom (če je terapija inividualna) po nekaj srečanjih izgovori in prizna, da je bil spolno zlorabljen. Običajno na začetku besedne zveze spolna zloraba sploh še ne zmorejo izreči, če pa že, jo izrečejo zelo disociirano – brez čutenj, bolj racionalno, kot da to ni nič tako zelo hudega.

Zaradi krutosti dogodka je povsem normalno, da se občasno pri posameznikih pojavljajo dvomi, da si morda vse samo domišljajo, da so kaj takega sanjali in da se jim to sploh ni res zgodilo. Vendar se v času terapije prej ali slej pokaže, da grozne sanje pustijo drugačen pečat in ne vplivajo tako močno in tako intenzivno na človekovo doživljanje, vsakdanje življenje. Prav tako se tudi izkaže, da so dvomi le posledica bolečine in stisk ter da obstajajo tudi resnična dejstva, ki ovržejo dvom in potrdijo resničnost doživljanj. Terapevt mora pri tem verjeti, da se bo v času terapije izkazalo in da je možno prepoznati, začutiti, kdaj bi bil nek spomin implantiran ali izmišljen.

Č.) RAZKRITJE SPOLNEGA NASILJA TUDI DRUGIM: občutek olajšanja, da zlorabljeni ne nosi več sam svoje temne skrivnosti, nekatere vzpodbudi, da tvegajo povedati o spolni zlorabi tudi komu drugemu izven terapije – morda enemu od družinskih članov (izkušnje kažejo, da najlažje sestri ali bratu, šele potem mami, očetu redkokdo), ali nekomu od prijateljev. Pomembno pri tem je, da žrtev zlorabe čuti, da je ta oseba vredna zaupanja in da bo razumela zlorabo – da ne bo obsojala, minimalizirala dogodka, opravičevala storilca … Dogaja se tudi ravno obratno – da posamezniki, preden pridejo na terapijo, vsem brez razmejitev razlagajo, kaj se jim je zgodilo, saj na ta način regulirajo bolečino in sproščajo napetost. V času terapij pa kmalu vidijo, da so izbirali predvsem take osebe, ki njihovih klicev na pomoč niso slišali. Tako začnejo postopno postavljati meje in svoje zgodbe ne pripovedujejo več vsakemu, ki jih bolj ko ne iz vljudnosti vpraša, kako so, saj se s tem samo še bolj ranijo in razvrednotijo.

d.) OZAVEŠČANJE TRAVME SPOLNEGA NASILJA IN DVOJNO PREPOZNAVANJE – SPOMINJANJE: naravna pot procesa je, da začne v času terapij postopno prihajati na dan vedno več potlačenih čutenj, afektov, telesnih reakcij … Pri nekaterih se te vsebine prebujajo v odnosih z drugimi ljudmi, pri drugih prek sanj, branja neke knjige, lahko prek močnih telesnih odzivov, gledanja kakega filma, vedenj, ki si jih ne znajo razložiti … Vse te reakcije mora terapevt nenehno vrednotiti in skupaj z udeležencem terapije prek povezav iskati, kam to spada, kje se je že tako počutili, od kod to prihaja … Prve tedne ali celo mesece zlorabljeni te povezave razumejo le na kognitivni ravni – verjamejo, da je to res tako, lahko najdejo povezave, si to ponavljajo, vendar jim to še ne prinaša nekega olajšanja, saj se še niso zmogli tudi čustveno umiriti, telesno sprostiti. Pri tem je bistveno in nujno potrebno **vztrajanje, nenehno ponavljanje in utrjevanje teh povezav** dvojnega prepoznavanja tega, kar se je zgodilo v preteklosti in se sedaj samo prebuja, se ne dogaja več. Spolno zlorabljeni vsa čutenja in afekte, ki so povezani s travmo spolne zlorabe in se v neki sedanji situaciji samo prebujajo, doživljajo na način, kot da se travma dogaja **ravno sedaj** [17, 22]. Njihovo telo, čustva, mimika, ton glasu, vedenje, vse se odzove na podoben način, kot da jih prav sedaj nekdo spolno zlorablja. Ko se jim podobna občutja pojavljajo v okolici, pogosto povedo, da jih drugi označujejo kot »preobčutljive«, »zakomplicirane«, »neuravnovešene«, »čudne« … Prav ponavljanje in utrjevanje teh povezav pa postopno začne spreminjati tudi čustvene in telesne odzive. V pomoč pri tem je lahko tudi obrazec dvojnega prepoznavanja [2, 20], da se prek njega tudi izven terapevtskih srečanj utrjujejo novi vzorci. Na začetku pa udeleženci na terapijah le kognitivno dojemajo dejstva in se čustveno ter telesno stvari kaj bistveno še ne spreminjajo, kar pa je povsem razumljivo; če je namreč nekdo živel dvajset, trideset ali več let z vzorci in posledicami spolne zlorabe, se to čez noč nikakor ne more začeti spreminjati.

V tem kontekstu lahko rečemo, da v prvih tednih ali mesecih na terapijah čustva in afekte dojemajo kognitivno, kar pomeni, da že vedo, da niso bili oni krivi, vendar se krivde še ne morejo znebiti. Prav tako šele postopno lahko priznajo, da se jim je zgodila krivica, vendar jeze na začetku sploh še ne zmorejo začutiti, če pa že, jo usmerjajo na »napačne« osebe in izražajo na neprimerne načine. S strani terapevta korak za korakom v začetnih fazah dojemajo, da je v takem dejanju s strani storilca čutiti ogromno sramu, gnusa, prezira, vendar večinoma ostajajo še indiferentni, včasih prav depresivni in v svojem svetu – ne da bi telesno začutili omenjena čutenja. Običajno ta čutenja začnejo doživljati veliko prej v vsakdanjem življenju, ob osebah, ki niso bile originalen storilec, postopno celo ob terapevtu. V tem se jasno vidi transfer, prenos čutenj prek projekcijsko-introjekcijske identifikacije na neko drugo osebo, kar se za začetek izkaže kot bolj varno, manj tvegano, kot če bi to čutili ob storilcu. Na to kaže tudi najpogostejši odgovor na vprašanje, koliko so jezni in besni na tistega, ki jih je spolno zlorabljal. Ob tem večina samo skomigne z rameni, da jeze ne čutijo, čeprav bi se jim zdelo prav, da bi jo čutili – razumsko torej vedo, da bi »morali« čutiti jezo, gnus, bes, vendar čutenjsko tega še niso »sposobni« oziroma še ne smejo začutiti. Z drugimi besedami, ni še dovolj varno in je v terapiji potrebno prej odkriti še druge plasti, obrambne mehanizme, afektivne psihične konstrukte in simptome kompulzivne retravmatizacije, da lahko pridejo do samega jedra bolečine.

e.) DOŽIVLJANJE KRIZ: spomini in čutenja, ki se začnejo intenzivno prebujati, drugačno gledanje na okolico, ljudi okrog sebe, izvirno družino ter nove in nove teme, ki se še odpirajo, sprožajo obdobja kriz. Posamezniki bodo v takih trenutkih povedali, da se jim zdi, da je sedaj še slabše, da je bilo lažje živeti prej, ko niso ničesar vedeli, da sedaj nenehno razmišljajo samo o zlorabah, da nimajo nobene moči, da bi se ukvarjali s čim drugim, da se jim zdi, da bodo zapravili vse dobre priložnosti, ki se jim ponujajo, da niso sposobni videti drugega, razen svojih stisk in težav, da nimajo energije, da bi si sploh kaj lepega zase privoščili, da se jim zdi, da so nori, da bi se najraje zapili, za vedno zaspali, pustili službo, študij … V takih krizah klinične izkušnje kažejo, da najbolj pomaga, če imajo izven terapije ob sebi vsaj še eno osebo, na katero se lahko obrnejo, včasih tudi to, da si jasno strukturirajo dan, predvsem takrat, ko jim je najtežje in bi samo spali, ter da obvezno naredijo zase vsaj nekaj pozitivnega [23]. Prav tako nekaterim pomaga, če lahko ubesedijo svoje stiske in krize na list papirja in napišejo čisto vse, kar čutijo, brez »cenzure«, samo da dajo ven iz sebe. Taki zapisi se izkažejo za zelo pozitivne tudi kasneje, ko pride morda novo obdobje krize in ko z branjem podoživljajo, kaj vse so že prestali, preživeli, premagali ... Mnogi povedo, da so se najbolj umirili, ko so težka čutenja uspeli umestiti v čas in prostor, jih ovrednotiti kot sestavni del procesa, ki ne traja večno in vedno mine. Četudi se obdobja kriz običajno še ponovijo, nikoli niso več tako intenzivna oziroma so bolj obvladljiva in manj časa trajajo. Ko so posamezniki razmišljali o premaganem obdobju krize, so videli, da so prav zaradi takih »zdravilnih« kriz lahko kasneje šli hitreje in drugače naprej, kot bi šli sicer brez njih. Cilj pri razreševanju travme spolne zlorabe je iti *samo naprej,* *četudi včasih najprej korak nazaj, da lahko gre kasneje dva koraka naprej!*

f.) POVEZOVANJE ELEMENTOV KOMPLEKSNEGA DOŽIVLJANJA – SIBAM: vsako kompleksno doživljanje, dogodek je iz različnih elementov. Levine [24] je za razreševanje travme razvil SIBAM model (S = sensations, I = image, B = behaviour, A = affect, M = meaning), ki temelji na predpostavki, da celoten spomin nekega dogodka vključuje priklic petih elementov: slik, senzacij, vedenja, afektov in pomena. Ko posameznik doživi travmatičen dogodek spolne zlorabe, ti elementi med seboj zaradi hudega stresa niso povezani, ampak so disociirani, zato tudi kasneje lahko doživlja prave napade panik in groz, pa niti ne ve, kaj jih je povzročilo. Slik in vedenja nima, pomena tudi ne, ima pa telesne senzacije in afekt. Pri izogibanju, zamrznitvi in drugih odzivih so prisotne druge kombinacije izmed teh petih elementov. Na terapijah poleg dvojnega prepoznavanja terapevt in udeleženec iščeta tudi povezave vseh petih elementov doživljanja in tako določene odseke spomina sestavljata v celoto. Najprej proces poteka na kognitivnem nivoju, potem pa tudi na čustvenem in telesnem. Potrebnih je veliko ponovitev in vztrajanja, da se začnejo pojavljati novi vzorci vedenja, večji nadzor nad prej na videz neobvladljivimi čutenji in navsezadnje tudi pozitivne spremembe.

g.) VREDNOTENJE SPREMEMB IN NAPREDKA: ob vseh teh doživljanjih, prebujanju bolečih spominov, vzponih in padcih pa je nujno potrebno veliko pozornosti posvetili tudi priznanjem in pohvalam osebi, ki je bila spolno zlorabljena in se trudi s pomočjo terapij v vsakdanjem življenju nekaj spremeniti. Še zlasti, ko pridejo obdobja kriz in takrat običajno človek ne vidi ničesar pozitivnega, je bistveno in pomembno, da terapevt zna podpreti ter ovrednotiti prehojeno pot, pohvaliti tisto, kar je posameznik že naredil, trud in vztrajanje, vložene napore in moči ter verjeti še naprej in še bolj, da bo šlo vse še na boljše in samo naprej. Na skupinskih terapijah se udeleženci podpirajo med seboj in na podlagi svojih izkušenj povedo, kaj jim najbolj pomaga, jih najbolj napolni z energijo, usmeri naprej, daje moč, da vztrajajo. Vsi pa povedo, da jim zelo veliko pomeni, da terapevt zaupa in verjame v njihov napredek, da pohvali in ovrednoti spremembe ter da lahko pokaže in pove, da je ponosen na njihovo »garanje« – prehojeno pot. Prav te spodbude so med drugim zelo ključne pri procesu okrevanja in razreševanja travmatične izkušnje spolne zlorabe.

5. ZAKLJUČEK

Klinične izkušnje terapevtov kažejo, da ne moremo nikoli reči, da pridemo kdaj na konec poti razreševanja travme spolnega nasilja – kajti, ko je dosežen en cilj, se pokažejo potrebe po novi rasti, po novem cilju, in proces postane sestavni del življenja. Kljub vsem posledicam, ki zaznamujejo posameznikovo življenje, lahko v terapevtskem odnosu posameznik tako napreduje, da ga travma nezavedno ne usmerja več, ko pa pridejo sprožilci, ki sprožijo določne organske senzacije, bo prav kognitivna raven tista, ki bo pomagala premostiti obdobja kriz in razmejiti, da se dogodek sedaj ne dogaja več, ampak se le prebujajo določeni segmenti. To kognitivno zavedanje zlorabljenim ne pomaga le preživeti, ampak tudi živeti in zaživeti človeka vredno življenje.

" Doseženi rezultati so delno nastali v okviru projekta št. J5-9349, ki ga je financirala Javna agencija za raziskovalno dejavnost Republike

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Medgeneracijski prenos nasilja

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POVZETEK
Vsak emocionalni odziv na stresne situacije vedno vpliva na celotno psiho-organsko strukturo posameznika. Vsekakor pa le-to najbolj zaznamujejo nasilna, travmatična doživetja, ki se lahko zaradi svojih destruktivnih vplivov, prenašajo iz generacije v generacijo. Nasilna, travmatična doživetja s senzacijami in afekti se namreč usidrajo v posameznikovo psihosomatsko, psiho-organsko strukturo oziroma v njegov implicitni spomin in tam nezavedno bivajo ter lahko dramatično vplivajo na naslednje rodove. V tem prispevku bomo zato skušali prvenstveno pokazati, da težja ko je travma, nasilje, močneje posameznika sili k zunanjemu izrazu ali ekspresiji in to še prav posebej tedaj, ko gre za PTSD, katerih posledice pa lahko zato doživljajo tudi bodoče generacije.

Ključne besede
travmatična doživetja, implicitni spomin, prenos nasilja, PTSD, relacijska družinska terapija

1. UVOD
Mnogi v sodobnosti, kot npr. [1-5], v svojih raziskavah odkrivajo transgeneracijski prenos travme v naslednje generacije in lahko celo na otroke, ki se sploh še niso rodili, ko se je nasilje zgodilo [6]. Nekateri avtorji [7, 8] pri tem ocenjujejo, da npr. približno ena tretjina spolno zlorabljenih oseb naprej zlorablja, približno dve tretjini žrtev pa ne bo nikoli spolno zlorabljalo naprej, predvsem če bodo imele podporo in ljubezen v družini. Johnson [9] ugotavlja, da imajo tisti, ki so bili v preteklosti žrtve čustvene, fizične ali spolne zlorabe, 6-krat večjo možnost, da bodo tudi sami nadaljevali zlorabo, ki so jo izkusili na lastni koži. Druge raziskave Collin-Vezina [10] ugotavlja, da je bila polovica mater, katerih otroci so bili spolno zlorabljeni, tudi sama žrtev spolne zlorabe. In tudi če se dejanje nasilja ne prenaša naprej, to še ne pomeni, da bodo otroci staršev, ki so doživeli nasilje, varni pred osebami, ki izvajajo nasilje.

2. RELACIJSKA DRUŽINSKA TERAPIJA
Relacijska družinska teorija [11-14] govori o nepredelanih afektih, psiho-organskih vsebinah, ki so pri nasilju predvsem strah, prezir, gnus, sram in jeza, ki se globoko vtisnejo v psiho-organsko strukturo posameznika, le-te se prek mehanizma projekcijsko-introjekcijske identifikacije vertikalno prenesejo s travmiranega starša na otroka [2, 3, 15-17]. Četudi skuša ta starš otroka opozoriti na vse nevarnosti nasilja [18], sam pri sebi pa ne bo v stiku z nepredelanimi afekti ter se zato tudi ne bo znal zavarovati in postaviti razmejitev, bo veliko večja verjetnost, da otrok postane žrtev nasilja [11, 13, 14, 19]. Podobno pravi Millerjeva v knjigi Upor telesa [20], ko piše, da se zloraba v otroštvu razrešuje na dva načina: odrasli, ki je bil kot otrok spolno zlorabljen, svoja nepriznana čustva, psiho-organske vsebine prenese na svojega otroka oziroma na druge ljudi okoli sebe, lahko pa posledice plačuje telo zlorabljenega, in sicer s psihosomatiko ali kroničnimi boleznimi [21]. Tako sekundarna travmatizacija kot tudi transgeneracijski prenos pripomoreta k pogostemu razvoju nizke samopodobe otrok [4]. Prav to je raziskovalce še bolj motiviralo, da niso raziskovali le mehanizmov in učinkov prenosa travme, temveč tudi nezavedno in zavedno komunikacijo med starši in otroki. Ugotovili so, da se je komunikacija lahko razlikovala od skoraj popolne tišine do odprtega razpravljanja in pripovedovanja najbolj krutih zgodb in izkušenj. Otroci so v obeh primerih zatirali in potlačili svoja čustva in niso bili gotovi, kaj se je v resnici dogajalo z njihovimi starši. [2, 3, 15, 22, 23] Poleg so tudi ugotovili, da je prekomerna komunikacija in z njo povezano razlaganje vseh izkušenj pri otrocih povzročala manj depresije in anksioznosti, vendar več krivde. Krell [24] trdi, da je bilo za otroke še bolj strašljivo, če starši o svojih izkušnjah niso govorili, saj so si otroci v svojih glavah s pomočjo fantazije ustvarili določene slike, ki so bile zelo patogene. Tako so otroci nezavedno uprizarjali in ponovno doživljali usodo staršev, in če jim je ob tem primanjkovalo informacij in zgodb, je bilo to zanje lahko še hujše in intenzivnejše [5]. Vsi ti prenosi čutenj in afektov, psiho-organskih vsebin pa se odvijajo prek mehanizmov projekcijsko-introjekcijske identifikacije in kompulzivnega ponavljanja.

3. TRAVMA IN NJENA SIMPTOMATOLOGIJA
Tipični znaki travme se odražajo (2, 3, 5, 15-17, 23, 25, 26] predvsem hipervzburjenju v AŽS, le-ta pa je rezultat travmatičnega doživljanja. Tu govorimo predvsem o hitrejšem bitju srca, srčni palpitaciji, hladno-vročih potenjih, hitrejšem, a bolj plitvem dihanju, hiperbudnosti ali pazljivosti, mravljinčavosti, strahu, jezi, avotdestrukciji itd. V kroničnih stanjih pa lahko ti simptomi vodijo v motnje spanja, depresijo, izgubi apetita, anksioznosti, spolnim disfunkcijam, zamrznjenosti, disociaciji in velikokrat lahko ima ta posameznik težave s koncentracijo in posledično s spominom [2, 3, 15, 23, 27-29]. Tako te žrtve lahko ponovno doživljajo travmatični dogodek v senzornih oblikah ali »flashbackih« in se zato začno izogibati vsemu, kar bi jih lahko spominjalo na travmo, ali pa doživljajo kronično hipervzburjenje v avtonomnem živčnem sistemu [16, 17, 25, 30-33].

Z drugimi besedami, na ta način lahko proces disociacije odcepi tako narativne komponente doživetja kakor tudi sosledje dogajanja, vključno s fiziološkimi in psihološkimi skratka psihoorganskimi reakcijami, kar pa pomeni, da ostaja implicitni oziroma organski spomin globoko vrisan v posameznikov organizem in le-ta se lahko prenese v naslednjo generacijo [4]. Govorimo torej o amneziji, ki je v različnih oblikah, poleg ostalih simptomov, lahko vsekakor najpogostejši pojav pri disociativni dinamiki, zato se to nezavedno, psiho-organsko prenaša na naslednje generacije. Posameznik lahko doživi anestezijo in ne čuti nobene bolečine, lahko vsa občutja in afekte odcepi, zopet drugi lahko izgubi zavest ali pa čuti, kakor da je izven telesa. Lahko pa vse to pozneje v najrazličnejših oblikah zaznavajo v naslednjih rodovih [5, 25, 34].

4. PONOVNI VZNIK TRAVME V NASLEDNJIH GENERACIJAH

Podoživljanje travmatičnih dogodkov pa vedno znova omogočajo »flashbacki«, in sicer lahko v celoti ali pa samo v določenih delih; le-ti se lahko pojavljajo v naslednjih generacijah in to brez očitnih travm, ki bi jih ti posamezniki v naslednjih generacijah doživeli [2, 3, 15, 23]. Ti fenomeni so lahko izredno moteči, saj se posameznik, ki je doživel travmatični dogodek, ob teh »flashbackih« počuti tako, kot da se celoten travmatični dogodek ponovno in v vsej intenziteti ponavlja, čeprav se je travma že zdavnaj končala. Še veliko bolj pa so vznemirjajoči za posameznika v naslednji generaciji, ki nima nobenega spomina, da bi se mu karkoli tega zgodilo, občuti pa simptome travme. Drugače povedano, posameznik, ki ni doživel travme, loči, ki ne nujno pozna PTS in PTSD-travmatičnih spominov, saj so le-ti odcepljeni že v samem originalu, se pa zato enostavno lahko pojavljajo v vsakem času in se v obliki »flashbackov« vedno lahko vrinejo v sedanjost [16, 25, 35]. Te »flashbacke« ponavadi spremlja tudi zelo močna anksioznost, ki je v originalu spremljala tudi travmatično doživetje posameznika. Še posebej močno moteči pa so ob tem še panični napadi, ki lahko žrtev tudi po dolgih letih, ko travme ni več, še vedno spremljajo in velikokrat čisto ohromijo tudi naslednjo generacijo.

Pri tem gre za poskus posameznika (njegovega organizma in tudi njegove psihe), da bi pobegnil, ko boj ali upor nista več mogoča [16, 25, 36]. Vsekakor pa gre lahko tu tudi za zamrznitev, ki je še tretja oblika odziva na travmo. Tudi v tem primeru gre za disociacijo, in sicer največkrat v najglobljí obliki, saj se žrtev v teh primerih zelo malo ali pa sploh ne spominja, kaj se je v resnici zgodilo. V tem primeru lahko gre za zelo globoko stanje amnezije ali, kot rečemo, čistega odklopa, vendar pa v posamezniku kljub temu ostajajo elementi travme, in sicer v najrazličnejših afektih, kot so strah, sram, jeza, ki se vedno lahko prebudijo ob podobnih situacijah, ki npr. samo bledo spominjajo na originalno travmo. V posamezniku ostajajo t. i. žarišča, ki še vedno tlijo, in to »tleče stanje« žrtev travme včasih še veliko bolj vznemirja, še posebej tedaj, ko se pojavlja v obliki paničnih napadov ter izjemno močnih anksioznosti ob določenih spodbujevalcih ali sprožilcih, ki so spremljali originalno travmo [37, 38] in se lahko, kot rečeno, ponavlja v naslednjih generacijah.

Če se povrnemo k fenomenu disociacije, potem vidimo, da žrtve med travmatičnimi doživetji izkušajo najrazličnejša občutja: da so zapustile telo, da se je čas ustavil, da so zamrznile, omrtvele in ničesar več doživljale. Žrtev je lahko tudi zelo omejeno videla puško, mučilno orodje, samo silhueto rablja ali napadalca, luč ali avto, ki sta se silovito približevala, in se potem ničesar več ne spomni do prebujenja v bolnišnici, ko je bilo okrog nje polno ljudi v belih haljah itd. [2, 3, 15-17, 23, 25]. Ostaja pa organski, implicitni spomin, ki se lahko vedno znova prebudi v najrazličnejših oblikah vedenj, čutenj, fobij in paničnih napadov. Žrtev je ponavadi tudi po travmatičnem doživetju še vedno disociirana in še dolgo potem, ko se je travma zgodila, še vedno čuti, da je »izven sebe«. To stanje pa se, kot rečeno, lahko nadaljuje še dolge mesece in leta, včasih pa se zgodi, da se šele čez leta prebudi, in sicer v obliki otopelosti, zamrznjenosti, anksioznosti, »flashbackov«, depersonalizacije, delne ali popolne amnezije, doživljanja, kot da je žrtev izven telesa, nezmožnosti kar koli čutiti, pa tudi v obliki nerazumljivih vedenjskih in emocionalnih reakcij, ki nimajo nobenega pravega razloga v konkretnih situacijah. Vse bolj pa raziskave ugotavljajo, da je disociacija tudi vedno zvesti spremljevalec PTS- in PTSD-simptomov in s tem v zvezi paničnih napadov ter napadov anksioznosti [2, 3, 15-17, 23, 25, 39], kar ponuja izjemno možnost, da se travme preteklosti, zaradi svoje intenzitete, ki formira PTSD simptomatologijo, ponovno prebudijo v naslednjih generacijah, in sicer v najrazličnejših oblikah in intenzitetah.

5. ZAKLJUČEK

Za sklep lahko rečemo, da vsako zavestno doživljanje posameznika sestavljeno iz več komponent. Celoten spomin nekega določenega travmatičnega dogodka zato vedno vključuje integrirani priklic vseh elementov posameznikovega doživljanja, ki ga sestavljajo: senzacije, slike, vedenje, afekti in pomen. Kadar situacija ni preveč stresna, vsekakor pa, kadar je prijetna, se ti elementi medsebojno povežejo oziroma ostajajo nedotaknjeni v spominu. Tako se npr. posameznik lahko v vsem spominja lepih in vzhičenih trenutkov svojega življenja, spominja pa se tudi čisto navadnih dogodkov, npr. izleta, kosila, obiska itd. Pri tem se posameznik lahko spomni vseh pomembnejših dejanj oziroma vedenj, prikliče si sliko, še pozna vse bistvene senzacije, znani so mu afekti, ki so jih ta doživetja ustvarila oziroma prebudila, ve pa tudi za pomen – bil je npr. sproščen dan, poln lepega, svežega, sklenili so nova znanstva.

Kadar pa je stres prevelik oziroma ko govorimo o nasilju in travmah, se ti elementi med sabo cepijo oziroma disociirajo. Seveda pa pri tem ni nujno, da vsaka, tudi zelo stresna situacija povzroči disociacijo. Vendar, vedno kadar je stres ali travma v svoji intenziteti premočna, se aktivira dissociativni sistem, ki zavaruje posameznika pred dekompenzacijo. Tedaj lahko govorimo o PTSD simptomatologiji, ki pa lahko vedno pomeni žarišče travmatičnih organskih spominov, ki se neverjetno silovitostjo prenašajo v naslednje generacije.

" Doseženi rezultati so delno nastali v okviru projekta št. J5-9349, ki ga je financirala Javna agencija za raziskovalno dejavnost Republike Slovenije iz državnega proračuna."

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The Other Side of Neurotechnologies

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ABSTRACT
As a response to the overly-optimistic view of technology, I will present some of the obstacles when using new neurotechnologies, specifically cognitive enhancers. Those obstacles come in a form of physical limitations, such as not being able to develop methods sophisticated enough that they would have no (or minimal) negative side-effects, and in a form of ethical limitations, since even if these new technologies were physically possible, the extent to which we should use these technologies is not fully explored. To fully consider such obstacles, I propose an outline of the ethical framework that should be used when thinking of applying new, future or even old cognitive technologies. Furthermore, I pose some questions for further analysis of the intertwining of techno-scientific progress with social dynamics.

Keywords
Neurotechnology, transhumanism, enhancement, cognition, ethics

1. INTRODUCTION
Neurotechnology, technology that has a fundamental impact on how we understand the brain, cognitive processes and consciousness, is rapidly developing. Some of the examples of neurotechnologies are: imaging technology such as magnetic resonance imaging (MRI), electroencephalogram (EEG) or positron emission tomography (PET), brain stimulations such as transcranial magnetic stimulations (TMS) or transcranial direct current stimulation (tDCS), implant technologies, pharmaceuticals, gene editing, cell therapy and brain-computer interfaces. In this article I will be focusing on technologies that aim to improve the cognitive processes - cognitive enhancers. There is not a specific technology that suits this purpose only. It is rather a combination of different technologies that are believed to alter cognitive processes: gene editing, pharmaceuticals and brain stimulations.

My whole stance is formed as a response to the overly-optimistic view of technology – which is that technology can save many of our problems, if not all of them. At no point in this paper will I go into detailed discussion of any topic, but will rather open a broad field of questions that are important to consider when analysing neurotechnology and human enhancement. In the first section of this paper, I will describe what I mean with the term "overly-optimistic view of technology". In the second section, I will describe shorty what are the cognitive enhancers. Then I will continue by presenting some of the physical limitations of the enhancers, namely the limitations for gene editing, pharmaceuticals and brain stimulations. Then I will set the ethical framework that will serve the purpose of considering or questioning any intervention. Finally, I will try to think of the possible connections of the techno-scientific progress with society.

2. OVERLY-OPTIMISTIC VIEW OF TECHNOLOGY AND ENHANCEMENT

As a student of science, I am mainly surrounded by scientific literature and scientists. What I have found is that there is a general lack of interest in interdisciplinary discussion of impacts that techno-scientific progress has on a society. It almost seems that there prevails an opinion of that technology and science cannot be misused – over-optimism or maybe even ignorance. To clarify further, this opinion comes from my student surroundings – University of Ljubljana, Biotechnical faculty. I haven't done any analysis of other universities. Of course, this interdisciplinary topic is not strictly a scientific one, but nonetheless it is important. Therefore, I think that discussions of this kind should be included in the scientific community, especially when it comes to biotechnology that directly addresses and modifies the human condition. On the other hand, beside lack of interest of my academic surroundings, there is also an emerging movement that is overly-optimistic about technology. It is called transhumanism. Max More, philosopher and futurist, defined it:

> " … [as] both a reason-based philosophy and a cultural movement that affirms the possibility and desirability of fundamentally improving the human condition by means of science and technology. Transhumanists seek the continuation and acceleration of the evolution of intelligent life beyond its currently human form and human limitations by means of science and technology, guided by life-promoting principles and values." [1]

A few of the common characteristics of the mentioned philosophy are: a) optimistic view of progress of science and technology, b) aiming at the advancement of humans - to alleviate our biological constrains so that we could live longer and healthier, c) using science and technology as the main means of advancement and d) claiming that enhancement will transform the whole meaning of being human. In other words, they state that technology will help us as a humanity to overcome our current problems, it will help us to be more ethical, healthy, well in both economic and ecologic sense. Transhumanists also believe that by doing so we will transform ourselves into some future form where we will no longer be able to state we are the same as we were before as species – we will become post-human in a transhumanist sense.

For this purpose I want to analyse and present some questions related to the human bio-enhancement, specifically cognitive enhancement. My aim is not to discredit latest scientific development. New knowledge and new technologies are appreciated – but with them comes a responsibility of how and when to use them. My aim is to stimulate an interdisciplinary discourse of the mentioned subject – human enhancement and neurotechnologies. In other words, I want that we take a closer look at the other, darker side of new neurotechnologies that aim at enhancing humans, because the bright side is known to well.

3. COGNITIVE ENHANCERS
Cognitive enhancers are technologies that enhance cognitive processes. Like doping in sports that enhances physical

performance, cognitive enhancers stimulate memory, perception, concentration, motivation, learning, problem solving and computation. [2 3] Most widely known are the so-called "smart drugs" – cognitive enhancers in the form of pharmaceuticals (substances). Those are already used for medicinal and enhancing purposes. [3 4] Besides that, scientists are developing methods for cognitive enhancement in the form of genetic engineering and brain stimulations. In a broader sense, even traditional cognitive training can be classified as one form of cognitive enhancers, but I will rather focus on technological enhancement.[1]

4. PHYSICAL LIMITATIONS

When describing neurotechnological interventions for enhancement purposes, we have mentioned three types of modifications: a) genetic engineering, b) drug intake and c) brain stimulation. In this section I will present some of the (possible) limitations of mentioned technologies.

4.1 Genetic Engineering

Genetic engineering started in 1973 and has very quickly spread onto many fields of industry and research. In our case, genetic engineering would be used for manipulation of certain cognitive trait like attention, IQ, memory and so on. For example, we could genetically modify embryo's DNA, or later in life insert some gene products to tissues or organs (RNA or protein insertions), or "knock out", that is, make inoperative, some genes (gene knockout with DNA cutting proteins), or we could select one out of many embryos with the most preferable genome (prenatal diagnostic or embryo selection). But when it comes to genetics, we often misinterpret that there is a direct link between a gene and a trait. We have to bear in mind that only a few traits are monogenetic, meaning that there is only one gene that influences a certain trait. In most cases, there are multiple genes that affect one trait. Besides that, in many cases one gene also affects many traits. [6] Due to this phenomenon (complex genetic traits) it is very hard to predict the total outcome of such genetic manipulation. This is nicely illustrated by the study when researchers improved mouse's memory and simultaneously increases its sensitivity to pain. [7 8 9]

4.2 Pharmaceuticals

Enhanced cognition can be also achieved with numerous substances, even with dietary supplements, such as caffeine and nicotine, but for our purpose I will describe pharmaceuticals (which are classified as technological interventions). One of such pharmaceuticals is methylphenidate, commercially known as Ritalin. Ritalin is nowadays widely used not just for treating the attention deficit hyperactivity disorder (ADHD), but is popular as a cognitive enhancer among students/academics with the purpose of achieving better study or academical results. [3 4] Other similar substances are: amphetamines, modafinil, atomoxetine, reboxetine, donepezil, galatamine, rivastigmine and memantine. When prescribing these drugs it is important to take into account obstacles that may come with the use of these substances. One such obstacle is that substances often have side effects such as nausea, vomiting or cramps. The second obstacle is that brain responds to the chemicals in such a way that a too high or too low concentration of substance might not produce optimal brain functioning effects.[2] In some individuals one dose may cause a positive effect while in the others the effect would be negative. [3] The third obstacle is that a drug may positively affect one brain function while simultaneously negatively affect the other.[3] Last but not least, it is important to add that we lack long term studies that would tell us how safe is the use of these drugs – in other words, what are the long-term side effects of such enhancers. [3 10 11]

4.3. Brain Stimulation

Brain stimulation is a technology using electrical currents or magnetic field (which induces electric currents) to stimulate certain parts of brain tissue. Methods of brain simulation can be further divided into invasive and non-invasive ones. The invasive method requires application of currents directly to the brain's surface or brain's core. In order to achieve this, we have to be invasive - the skull has to be opened and sometimes even the brain must be cut. Using the non-invasive methods, the currents or magnetic fields are applied over the head's surface. This is called non-invasive brain stimulation (NBS), examples of which are transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS). For our further discussion it is not of a great importance what kind of technique is used.

Opposition to the overly optimistic view towards this form of cognitive enhancement may come from understanding brain's functioning. Key concept in this opposition is net zero-sum framework proposed by Brem et al. (2014). [12] Authors state that this concept is grounded on the physical principle of conservation of energy in a closed system. Furthermore, they clarify that, in this notion, brain operates within the constraints of a finite amount of energy and processing power. Not meaning that all the brains and the same brain through the life span do have equal amount of energy and processing power, but that an x-amount of energy and processing power is distributed throughout the brain at any given time. When demands shift, so does the distribution of energy and processing power. Most importantly, total sum of brain's activity stays the same. In other words, brain operates in net zero-sum framework. If this prediction is correct, NBS would enhance some brain function, but at the same time degrade other (compensation/cost). Some evidence accounting for this hypothesis comes from the phenomena of paradoxical functional facilitation. [12 13] This phenomenon appears when damage to an intact area of the brain normalizes a previously reduced level of functioning (compensation for previous loss – re-establishing balance between functional brain networks) or when a patient with damage performs a certain task better than before or better than healthy control subjects (energy and processing power of damaged brain tissue was distributed to other brain parts that are now enhanced). Authors conclude with raising bioethical concerns: "Is it acceptable to

[1] A special kind of cognitive enhancers are moral enhancers that are more strictly concerned with improving our moral behaviour. [5]

[2] This applies for future drugs too. This molecular dynamics is called U-shaped relationship between substance and receptor. [3]

[3] Example: when rigastimin improves learning on a motor task and making associations between symbols and digits, but can at the same time impair verbal and visual episodic memory. [3 10]

improve certain brain functions at the cost of others and can we take the responsibility for its impact on the individual and on society?” (p.14-15) They also state that “current neuroenhancment studies emphasize positive outcome of specific functions and concentrate on individual improvements, while related topics such as risk and safety, as well as social and moral factors are neglected or restricted to specific inquiries.” (p.15) [12]

5. ETHICAL FRAMEWORK AND INTERTWINING OF TECHNO-SCIENTIFIC PROGRESS WITH SOCIETY

In the previous section I have described some physical limitations that we may encounter when applying neuroenhancing technologies. Now I want to state that even if we do develop better technology, we still have to consider questions from a very broad spectrum of topics.

Firstly, I want to propose an ethical framework consisting of three points that we have to consider in a discussions about any human interventions such as bio-enhancing technologies. (1) First is about personal freedom. (2) Second is about the line between long-term sustainability and short-term solutions. And (3) third is about ecological integrity/sustainability. For example: 1) do enhancers that aim to limit our immoral behaviours, limit our personal freedom? Or, do cognitive enhancers prescribed to children for enhancement of a specific trait, limit their freedom to choose/develop other characteristic that they would love to have? Or 2) are costs and side-effects of bio-enhancing accounted for? Are those short term solutions sustainable or do they just prolong the problem or maybe even worsen the situation? Where is the boundary between enhancement and a disease – former without the need (but with the want), latter with the immediate need? And 3) is this technology ecologically sustainable? Does it produce a non-sustainable mentality – that which is not able to think in a non-selfish way or in an ecological way or in terms of long-term solutions? What will this technology do to overpopulation, species extinction, how many waste will it produce? Those are just a few questions stated to further clarify the mentioned ethical framework.

Secondly, I want to briefly mention how broad the field of investigation in this and similar topics should be. Nature of questioning and regulating techno-scientific progress, especially when we think of interfering with our nature (enhancement), exceeds fields of natural sciences. It includes (or should include) questions from philosophy of science (what is knowledge, what is science, its place and role in modern and future society), philosophy of progress (genealogy of progress, what is progress), intertwining of the techno-scientific progress and the economic system (how is modern free market system influencing techno-scientific progress, business of science), intertwining of the market and the values/ideological system (how does the market with advertising influence the values and how do these values afterwards influence the market) and the application of technology in political systems (possibility of new technologies for achieving political goals, possibility of manipulation and control). Furthermore, we have to ask ourselves why do we want enhancement: is it a by-product of economic system (competition – to be better and to get a better job), or is it a by-product of modern values (for example, value of ideal life – long and healthy with no negativity), or a product of advertisement or political viewpoint. We ought to analyse all of the mentioned subfields before interfering with human nature with the use of enhancers to the extent that would limit our capacity undo the damage.

6. CONCLUSION

Development of new technologies opens up many questions – from physical limitations to ethical considerations. I have focused on neurotechnologies, specifically cognitive enhancers. My general claim is that there is an overly-optimistic view of technology that states that technology can solve many, if not all, of our problems. Hence, we can enhance human beings to be better. Doubt arises, not only because of physical limitations of modifying technologies, such as in genetic engineering, drug intake and brain stimulation, but even more so because of ethical issues. Human condition is a very complex one and it has been, even if this does not seem so, analysed too little for us to drastically modify our nature. In this manner, we need an interdisciplinary and public discourse for discussions about mentioned topics – intertwining of modern values, human condition, society and techno-scientific progress.

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Braincrafting: why playing video games is good for you

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ABSTRACT
In the article I present cognitive, emotional and social benefits of playing video games, suggest simple guidelines for ethical evaluation of gaming, and offer an overview of findings which support the use of video games for cognitive enhancement and social collaboration.

Keywords
video games, cognitive enhancement, attention, complex problem solving, brain plasticity, learning, consequentialism

1. INTRODUCTION
In the past, research has been mostly focused on the negative effects of video games, but in the last decade, a growing number of studies has supported the view that playing video games may significantly enhance our cognitive abilities and agility. These contradicting facts fuel the discussion on whether playing video games is harmful or not. Here I focus on the benefits of gaming and offer an overview of findings which support using video games as tools for cognitive enhancement and social collaboration, while also outlining the ethical framework which is to be followed in order to avoid negative aspects of gaming.

2. PROPOSED ETHICAL FRAMEWORK TO EVALUATE VIDEO GAMES
Up until a few years ago, research has been mainly focused on the potential adverse effects of video games, such as increased aggression [1] [2], addiction to gaming [3] and increased obesity risk [4]. While I do not believe that gaming is inherently bad, I can understand the reservation and caution. For better or worse, playing video games significantly changes our brain [5], which carries serious implications. With our growing understanding of the brain comes greater responsibility about how to apply this knowledge in a benevolent manner. If we consider video games as a tool for self-improvement and cognitive enhancement, they should align with (neuro)ethical guidelines which govern any other means for cognitive therapy. Ethics is a set of principles which prescribe what is right or wrong in terms of rights, obligations, or benefits for individuals and society. The subfield of neuroethics, which is focused particularly on the issues in neuroscience, is less than 20 years old. The concept was first introduced in 2002, when William Safire defined it as "the examination of what is right and wrong, good and bad about the treatment of, perfection of, or unwelcome invasion of and worrisome manipulation of the human brain" [6]. Video games possibly constitute a case of 'worrisome manipulation' and open a window for 'unwelcome invasion' of the brain, but at the same time they can also act as one of the most pleasurable and safe brain enhancement tools. Do benefits warrant the dangers?

To do good, we first have to determine what is good. The ethical framework to help us evaluate the 'goodness' of video games in this article is an epicurean-like teleological/consequentialist theory of ethics with a bit of pragmatism, where we pursue good and pleasurable outcomes, where an action's value is based on the outcome of that action, and where the evaluation whether the outcome is good or bad might shift when new scientific discoveries are made. It appears that this ethical framework fits neuroscience research better than other normative ethical theories, simply because the subjective virtuous conduct of game-designers (virtue ethics) or a scientists' firm belief that undertaking experiments is the right thing to do (deontological ethics) is of little or no importance in comparison to unwanted, but nonetheless possibly detrimental effects a person might suffer as the consequence of her or his invaded and changed brain.

The last conclusion partly rests on the notion of 'fairness' – it is not fair that a player would be harmed for the sole purpose of advancing science, or because the game designer made a mistake despite the designer's moral character being impeccable. Fairness can be fostered by assuming equality of all involved parties and by clear and honest communication, where the gaming industry candidly informs the player about possible effects. Informing the player is also the prerequisite for the player to give their consent to undergo a benevolent cognitive manipulation when playing a game. At the same time, the player should provide feedback, so that the industry can align and improve their practice. This also involves the issue of privacy protection, especially in the case of collecting neurodata in neurogaming[1].

Simply put, for gaming to be ethical, it has to benefit the player and it has to fulfill three criteria: it should result in positive, useful outcome for the gamer and/or society, it should respect and protect gamer's privacy, and the gamer must participate knowingly and willingly. Since new technologies pose difficult ethical questions and could be easily used for ill intentions, it is important to show, why is it worth to undergo the gaming

[1] In neurogaming, the player's heart rate, brain activity, facial expressions, voice, skin conductance, eye movement, pupil dilation, and similar indicators are measured in order to use the input to dynamically adjust the gaming content and provide a completely personalized, immersive gaming experience, which takes into account the player's emotional and cognitive state [7]. In this way, the desired (or feared) cognitive manipulation is perfectly suited to the player. Some game engines allow the players to navigate the game merely by directing their gaze or blinking. Future development also includes different techniques which will simulate certain sensations, e.g. the player holding an object in their hand while there is no object there [7]. The ethical concerns are significant, but in this article I mainly focus on the benefits of gaming and mention neurogaming merely as an interesting new branch of the industry, and my purpose is to show, why it is worthwhile that we acknowledge and tackle these ethical issues to be able to benefit from our gaming experience as much as we can.

experience despite the risk, or even better, while avoiding the risk. In the following sections I offer an overview of beneficial uses of video games and discuss how they affect the brain.

3. BENEFITS OF VIDEO GAMES

Video games have become increasingly diverse and complex, (hyper)realistic, and socially engaging. It has been shown that playing certain types of video games may enhance perceptual, motor, social, emotional and cognitive learning [8]. While scientists still do not know exactly how different brain regions interact, or what is the role of each and every particular neuroanatomical element, some hypotheses have been made in studies researching the impact of gaming on brain plasticity. Below I present the supporting studies in more detail.

3.1 Learning

At a neuroethics conference in 2013 C. Shawn Greene explained that the adult brain does not want to learn anything new, because learning entails costly brain tissue restructuring [9]. So, how do games facilitate learning and foster neuroplasticity? An incentive for the brain to more readily learn something new is the possibility of a reward at the end [9]. A study by Shaowen Bao and his team has shown that when stimulation of the dopaminergic system occurs at the same time as a particular tone is played, over time a larger area of auditory cortex is allocated to process that particular frequency of sound [10]. The brain structurally changes itself in order to more accurately and quickly process the input that will reward it with dopamine release. Games foster learning because they activate the reward system.

Circumstances which bathe the brain in rewarding hormones are also excitement and exploratory behavior [11], which both abound in challenging, but ultimately safe virtual environment of your favorite game. Learning is further encouraged by the fact that you can safely fail – paired with novelty and flexibility of the play, safe environment promotes creativity [12]. In addition, the immediate feedback evaluating the player's game (leveling-up, points, new abilities and tools), present a perfect ground to acquire an 'incremental theory' of players' ability, where the players believe that they can change and actively improve their skills by investing more time and effort [8]. How is this useful in real-life scenarios? The learned skills can be transferred, as illustrated by the examples below.

3.2 Visual attention

Green explains that action games exhibit particular qualities, which sharpen a gamer's visual attention [9], such as: complex 3D environment, fast motion, transient visual stimuli, and heavy perceptual load with several events occurring simultaneously, where not all events are important. 15 years ago Green and Bavelier demonstrated that selective visual attention improves with playing action video games, with effects lasting for 6 months after the last training [13]. In more complex multiplayer first person shooter games, there is also a heavy cognitive load: the player has to observe certain strategy and keep track of other players' actions. While primary visual focus is centrally on the screen, peripheral vision is fully engaged as well, since important elements tend to pop up from the sides.

The causal relationship between playing action games and improved players' ability to coordinate visual input with their motor control was shown in 2016 [14]. Players who played action games for 5 hours per week over 6 months were later re-tested for their driving abilities and they exhibited better lane-keeping and visuomotor-control skills. Cognitive gains acquired in gaming are thus transferable to real-world visual ability.

Another example of induced neural plasticity in the players' visual system is the case of adult amblyopia ('lazy eye') patients, whose fundamental visual functions improved from 16-54% after playing action video games [15]. It was a small scale pilot study, but researchers are optimistic about the possibility to apply the principles to treating other cortical dysfunctions as well. Additional benefits of playing action games in relation to vision are improved visual attentional skills in dyslexic children [16]. Without any direct reading training, the reading abilities of these children improved significantly after only 12 hours of playing action video games.

3.3 Multi-tasking

Each time we switch our attention from one task to another we pay a small cognitive cost and playing action games helps to reduce this cost [9]. In our everyday life we often have to multitask, and the cumulative time spent in task switching is relevant. The positive effects that action games training has on the brain is lasting and can still be observed months after the last gaming session. This effect is also applicable in serious, complex real-life events such as surgery. When novice surgeons played action games for prescribed period of time, the result was a significant improvement in their ability to perform surgery [17]. Even more surprisingly, surgical skills could be better predicted by their screen time than by the number of surgeries performed, or even the amount of time spent practicing the surgery.

3.4 Social and emotional support

Multiplayer online games which engage thousands of people from all over the globe are probably the most exciting, rewarding and productive development in the realm of video games. Immersive social contexts not only provide a playground to develop social skills, but also serve as a solid source of emotional support and resilience, which I present in more detail below.

Massive multiplayer online games (MMOGs) encourage the development of online communities, with associated attachments and social rituals [18]. These communities represent a suitable model for a variety of human societies [19], because they exhibit a strong sense of social connection, identification with other members of the group and a sense of distinguishing themselves from other groups, as well as a strong commitment to the group [18], [19]. On the continuum from *Gemeineschaft* (communal society) to *Gesellschaft* (associational society) [20], where the first originates from solidarity, social union and spontaneous expressions of emotions in personal relationships, and the second is established on rational self-interest with less emphasis on kinship and personal relations, MMOG communities show a greater degree of *Gemeineschaft* [18]. Such social environment promotes cohesion among the members and increases social proximity among them [18], which in turn creates a safe space for establishing personal relationships which offer similar support as real-life interaction [21]. Research on social support from MMOG relationships and associated levels of depression in players demonstrated that higher social involvement in MMOG communities resulted in a greater level of perceived social support, which consequentially led to lower levels of depression [21].

On a different note, but still relevant, because studies have shown that emotional and physical pain share a lot of common properties [22], [23], playing video games might also have an analgesic effect. In patients undergoing treatment for severe burns, playing video games proved successful in their pain management [24]. When conducting a study in treatment of combat-related burns where pharmacological therapy was complemented with VR gaming, the perceived pain intensity score fell from 6.25 to 4.50 out of 10, unpleasant feelings related to pain dropped from 6.25 to 2.83 out of 10, and the time spent thinking about the pain dropped from 76% during no VR to 22% during VR-coupled treatment [25]. It is suggested that inputs from intense, fast-paced immersive virtual environment distract the brain from processing the pain by disturbing the descending pain-control system, which results in pain-attenuating effects [26].

3.5 Collaboration and problem solving

In addition, in the last decade a subset of these games has tried to tackle some of the many problems which trouble our society and attempted to gamify real life problems. One of the first games which was successful in harnessing the gamers' superior spatial and problem-solving skills was Foldit in 2008 [27]. The objective of the game was to predict the native structure of various proteins to help the scientists to better understand the molecules. Over 50,000 players collaboratively interacted with protein models using user-friendly manipulation tools, and at the end of 2010 their results matched or outperformed algorithmically computed solutions. Foldit players achieved 'an epic win' in 2011, when they successfully deciphered the structure of an enzyme which is critical for reproduction of the HIV/AIDS virus – a problem which had been previously unsolved for 15 years [28]. Following in Foldit's steps is Eterna, a similar online gaming tool, which asks players to solve puzzles in order to design molecular medicines in collaboration with Stanford's School of Medicine [29]. The mechanisms which are responsible for the success of gamification in solving difficult tasks are probably the same learning-promoting mechanisms described in 3.1.

4. CONCLUSION

I summarized important benefits of playing video games, which can be mainly characterized as improved motor, cognitive, social, emotional and problem solving skills. Is there something as a benevolent brain manipulation? I dare say there is, and as studies suggest, playing games moderately and in a responsible way can serve as a therapeutic and cognitive enhancement tool despite the dangers inherent to gaming technologies.

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In search of the authentic self: explaining phenomenology of authenticity

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ABSTRACT

There are moments in most people's lives when they feel more or less themselves. This experience is usually caught in people sayings that they need to find themselves or just be who they 'really are'. The purpose of this paper is to provide an explanation for these feelings of authenticity. I first explore this concept and consequently introduce necessary conditions for the phenomenological experience of authenticity. This is followed by the examination of two problems that authenticity faces and two possible ways of explaining the experience of authenticity, which are discovery and creation. I then assess three discovery views and show why they are unsatisfactory in explaining feelings of authenticity. In response I then provide my own creation model of authenticity, which argues that feelings of authenticity are a result of a convergence between our current and ideal self. In this sense, authentic self is created. What we are is a matter of choice.

Keywords

Authentic self, true self, authenticity, phenomenology, ideal self

1. INTRODUCTION

The idea of an authentic or a true self[1] seems to have been present since ancient times, from the Greek "Know Thyself" to Shakespeare's "To thine own self be true" to modern advice to "just be yourself" [11]. One often hears people speaking of their need to find themselves or to discover who they "really are" (ibid). I take it that most people agree with Bialystok that "almost everyone has had an intuitive experience of authenticity that seems to reveal a glimmer of one's true identity" [1]. However, the problem arises how it is possible that a person sometimes feels more or less like herself, when she is never another person, but only herself. However, if that is the case, how can these feelings of authenticity be explained? Do these moments of experiencing authenticity reveal a deeper, truer identity of a person, an unchanging inner core that lies beneath, an authentic self? Or do they reveal something else?[2]

The aim here is to provide a model for specifically explaining the phenomenological (i.e. lived) experience of authenticity, which I will call the authentic-like experience. The main argument will be that feelings of authenticity are (usually positive) momentary experiences, which are a result of a convergence between the current self (beliefs about oneself) and the ideal self (what one wants to be, thinks she should be and what is important to her). On this account, the authentic self comes about as a consequence of creation and not as a consequence of discovery.

2. AUTHENTICITY AND ITS PROBLEMS

The purpose of this section are the following four points: 1) to introduce the concept of authenticity, 2) to examine necessary conditions for its phenomenology 3) to present two problems that authenticity faces and 4) to present two ways of thinking about the explanation of an authentic-like experience.

The concept of authenticity is defined in multiple ways (see [1], [3], [12]). Here, I take authenticity to denote "a convergence between what something is and what it claims it is" [1]. In other words, when a person is being authentic, her statements and thoughts, as well as her beliefs and actions are in accordance with one another.

For a person to undergo an authentic-like experience, I argue there are two necessary conditions that need to be met: 1) a certain degree of enjoyment or dislike of a certain trait or ability and 2) like Bialystok [1] argues, a convergence with *a set of criteria* where, when the convergence with those criteria takes place, the result will be an authentic-like experience. In other words for the second condition, if a person is sometimes authentic, there must be times when she is inauthentic [1] so we need to have a standard that defines when the person is being authentic. Whenever a person's current state converges with those criteria, an authentic-like experience will take place. I will call those criteria the authentic self* (and later on in my model, the ideal self), which specifically denotes *the thing* with which the person converges *with* in an authentic-like experience. It can be thought of as discovered or created. On the other hand, the authentic self denotes the *result* of a convergence between the person and the authentic self*, i.e. the authentic-like experience and what people refer to as their authentic self.

The convergence condition or the authentic self* presents a problem in the discussion of authenticity because it is unclear what the authentic self* represents, which will be the discussion for the rest of the paper. In other words, it is unclear what makes some parts count as the authentic self and how to separate it from the inauthentic parts (see [1] for this issue). Authenticity denotes the harmony between one's beliefs, thoughts and actions (see previous paragraph), but a person rarely identifies with all her

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[1] For clarity purposes, only authentic self is used in this paper, not true or deep self.

[2] I do not differentiate between identity and self and I only take appropriation as a necessary condition for personal identity or self – that we see certain actions, beliefs, etc as ours. For a discussion on personal identity, self (and true self) from a phenomenological point of view, see Jacobs [5].

thoughts and beliefs and declares them as her authentic self (e.g., rarely do we encounter a person that would identify having a thought of strangling somebody who is annoying as her authentic self). However, as Bialystok [1] points out, in current understanding of authenticity the authority on the authentic self is found within ourselves, which is why it is to an extent a matter of self-interpretation. There are no objective criteria against which it could be determined which parts of the person are authentic and which not or any empirical facts that could confirm a person's authentic self [1]. It will therefore always come down to what the person declares as her authentic self. I do not hold that the matter of authentic self depends on self-interpretation is problematic as Bialystok [1] does, since the final decision with what we identify ultimately lies in our hands. However, the problem of separating authentic from inauthentic parts still persists.

There is a second further issue with authenticity, which Bialystok [1] labels as the hard case of authenticity. More specifically, it is impossible to determine when the person is being authentic where one's feelings, thoughts or beliefs change throughout life. To imagine such scenarios, Bialystok refers to religious conversions, career change, divorce, change in party affiliations or simply changes in personality [1]. It is not difficult to imagine such cases where one is different from how one used to be in the past. The dilemma however, is, when is the person then authentic? For instance, is a person authentic before or after a religious conversion? Intuitively one might say that one is authentic after the change, but most people claim they were also authentic before. If a person is authentic in both cases, then authenticity seems impossible [1]. But if a person is inauthentic in both cases, when is he then authentic at all if not in the beliefs that constitute a greater part of his identity (ibid)? I believe this argument mistakenly presupposes that a person's identity should be constant in order to constitute the authentic self. One can still act in accordance with what one feels in that moment, without assuming the authentic self* is constant. Nevertheless, any explanation of authenticity needs to account for such cases as well.

This brings us to two ways of thinking how the authentic self* is to be understood. These are discovery and creation, which I take from Waterman's [14] distinction between different ways of understanding identity formation. The metaphor of discovery denotes that something, which has already *existed before*, has now become known or understood [14]. The discovery entails the process of causing the unknown to become known (ibid). In this case, a person is discovering a prior authentic self* and every time she converges with this authentic self*, she undergoes an authentic-like experience. Creation, on the other hand, involves creating something that has never existed before. In this process, one starts off from a point of unlimited possibilities and among those makes a choice and brings together parts to create something of value [14]. On this view, the assumption would be there is no prior not-yet-discovered authentic self* and it is only a product of our choices [12]. In this way, the authentic-like experience can be either thought of as being a result of a convergence with a discovered prior authentic self* or as a result of a convergence with a created authentic self*. In this way, an authentic self* can therefore be something that has already existed before and is becoming known or understood in moments of experiencing authenticity (or most probably parts of it). Alternatively, the authentic self* has not existed before and is created from unlimited possibilities as a matter of choice (see e.g. [13]). Moments of experiencing authenticity are therefore moments of experiencing something that we have created. I will argue that it is the latter case that takes place when authenticity is felt. In the next part, I will present different ways one can think about the authentic self* as being discovered and why these do not offer a satisfactory explanation for the phenomenal experience of authenticity.

3. AUTHENTIC SELF* AS DISCOVERY

The first question that needs to be asked is if the authentic self* (the criteria) is to be discovered, what exactly is it that is being discovered? I will consider three possible answers to this problem, which are 1) an unchanging ontological substance 2) a unique personality or 3) a daimon. These can be regarded as manifestation of these criteria (or the authentic self*).

The first possibility of what the authentic self* represents is connected to philosophical debates on the concept of self. Metzinger defines it as an enduring individual entity, an unchanging essence or an ontological substance that could exist independently in the world and would represent a basic constituent of reality [6] [7]. He goes on to deny the existence of such a self and argues there is currently no substantive empirical evidence or any theoretical argument that would necessitate the existence of a self [7]. Zahavi, on the other hand, rejects Metzinger's definition and characterizes the self rather as being constituted through the first-person givenness of different experiences [15]. In other words, there is no separate entity, but a self exists simply due to the fact that the world is being experienced from a first-person perspective. Olson [8] goes even so far as to state we should cease to speak of selves due to lack of a common definition and its causing dilemmas that would otherwise be avoidable.

Any of these definitions do not provide any insight into the authenticity of the self. If the authentic self* is understood in Zahavi's terms, such a definition presents a problem for authenticity, since the givenness of a first-person's perspective is always present, regardless whether a person feels authentic or inauthentic. Just having a first-person experience does not solve the issue of why a person sometimes feels more or less like herself. If the authentic self* is understood in the way that Metzinger defines it, the authentic self* is then understood as an unchanging ontologically independent core that is distinct from any characteristic, perception or trait that constitute the person. Furthermore, as Metzinger points out, there is currently no empirical evidence for this notion of self [7]. Additionally, there is also the issue that even if there seems to be the experience of an unchanging self from a phenomenological standpoint (i.e. constant unity of consciousness), we are nevertheless unable to directly access this inner core self if it is a separate and distinct entity, as Hume initially pointed out (see [4]). Therefore, if there is an entity as an authentic self* that is separate and *distinct* from all characteristics or perceptions that constitute the person it still does not help address the problem of authenticity. It is not connected to something that would be over and above the abilities and characteristics that constitute him and which provide him with an authentic-like experience. Hence, feelings of authenticity cannot be disclosing a convergence with an independent entity-like authentic self*, but must be presenting something else. For these reasons it seems viable to conclude that conceptualizing the authentic self* as a separate entity cannot satisfactorily explain the phenomenology of authenticity.

The second model avoids the Hume worry in that it conceptualizes the authentic self* as a unique personality, i.e. a set of characteristics and traits that are unique to every individual and not as something distinct. This model presents the modern conception of authenticity that is especially prevalent in contemporary self-help literature (see [2]). In opposition to older conceptions of authenticity, where the task was to become what one can be, i.e. realizing her potentials and purpose, the contemporary ideal of authenticity requires that the person realizes and becomes what she *already is*, the set of characteristics and traits that are *already situated within* the person ([2, 13], my emphasis). The main idea of this understanding of authenticity is that everyone possesses a deep, authentic self* within – a so-called Real Me – that is distinct from everything else that is not really me. In other words, there is great emphasis on the difference between the inner and outer, where *the outer is false and the inner true* ([2], my emphasis). Authentic self* represents the collection of all feelings, needs, desires, capacities, dispositions and abilities that constitute a person's unique personality and our task is to get in touch with this personality (e.g. through introspection) and to express it (see [2] on this). Here therefore, whenever the person is acting in accordance with this unique personality, she is feeling authentic. The problems here are the assumptions our personality has been shaped at birth and there seems to be disregard for personal experiences on shaping a person's self because this understanding of the authentic self* assumes the authentic self* is within us and not influenced by the environment (the outer), neither it is changed throughout life. With the inner-outer distinction, there is also disregard for societal influences on our identity.

The third model envisions a daimon (= authentic self*) that represents the potentialities and talents within each person which are not yet realized but whose realization represents the greatest fulfilment in life (an ideal) [14]. In other words, the person aims to reach her authentic self* or her daimon by realizing her potentials, not by becoming a person she already is within. The difficulty with this model is still the persisting assumption that daimon is fixed since birth (if daimon is to be discovered with time and lived, it is difficult to know what is being discovered if it consistently changes). And as the hard case of authenticity highlights, nothing about a person's personality appears to be permanent enough that it would remain fixed upon discovery. The person does not stay the same after unearthing the daimon. It might be objected that the daimon is only a set of potentialities and abilities. It presents us with the limitations of our capabilities or reveals in what activities or tasks we find enjoyment in. It is not to be understood as a set of fixed properties. This argument holds some merit, but it must nevertheless be argued that we might become aware of our capabilities, interests and talents, but we are not equal to them. Feelings of authenticity can be out of alignment with one's abilities as in, for example, when a person is highly talented for running but does not enjoy it. Therefore, potentials and abilities are not a sign of an authentic* self.

4. AUTHENTIC SELF* AS CREATION: MY OWN MODEL

The purpose of this section is to present my own model for explaining feelings of authenticity, which views the authentic self* as created. The idea that the authentic self is created is mostly found in existentialist writings. Generally put, according to existentialism, there is no pre-existent essence or a "true self", but one's identity is created through personal choices [14]. Sartre states that "man first of all exists /…/ and defines himself afterwards" and that every person chooses herself [10] (see also Nietzsche and Foucault).

This model is ultimately compatible with the existentialist view of the authentic self, but whereas they focus more broadly on the ontology and the nature of self, I focus specifically on the explanation of feelings of authenticity. I argue this phenomenology of authenticity is best explained by a model on which feelings of authenticity occur as a result of a convergence between the current and the ideal self. As argued above, there must be a convergence between a person and her authentic self* for authenticity to occur. From now on I will refer to the authentic self* as the ideal self in my model. According to this model, feelings of authenticity are (usually positive) momentary emotional experiences. Feelings of authenticity are usually connected to positive traits because the ideal self is generally viewed as intrinsically good (see [8]). However, there can also be instances where the ideal self is connected to negative traits (e.g. unsociable, not funny, etc).

Current self denotes all beliefs one holds about herself at the present time, for example being athletic, not funny enough, etc. The ideal self can be thought of as a collection of all desires of how one wants to be, norms of how one should be and values that constitute what is important in a person's life. It is important to note that what will constitute the ideal self will be highly influenced by what is desirable within the society as well. Both the current and ideal self-beliefs can be either conscious or non-conscious. When one considers one's ideal self, there are four possible scenarios that can take place. First is the scenario where a convergence between a positive current self belief (e.g. I am funny) and the ideal self (I want to be funny) occurs. In those cases, feelings of authenticity will be experienced. In the second scenario there is a lack of convergence between a person's positive belief about the current self and her ideal self. In this case, the person most likely experiences a questioning of her behaviour, or (if such situations happen often enough) an identity crisis if the belief is central to her identity. The third scenario is a case of negative current self belief (e.g. I am not smart) and a lack of convergence with the ideal self. In this case, a person believes she is lacking certain ability or trait (current self) that she wants to possess (ideal self) and situations confirm that it is the case she is lacking them (confirmation of existing current belief). In this scenario, there is no self-acceptance present of how she is at the present time (and oftentimes no self-awareness of what constitutes her ideal self). In such scenarios, possible phenomenology might be one of sadness or disappointment, but for the purposes of this paper it is important that no feelings of authenticity will be experienced. The fourth scenario presents the most complicated scenario where the negative current self belief initially does not converge with the ideal self but can gradually converge with the ideal self if a) negative current self beliefs change to positive or b) ideal self changes (to negative belief). The current negative beliefs can change into positive in two ways: 1) by changing behaviour or 2) by gradually discovering that the negative beliefs were inaccurate. For illustration of 1 and 2, a person named Peter believes he is unsociable (negative current belief) and wants to be sociable (ideal self). There is currently no convergence and no authentic-like experience is present. He can change his behaviour to being sociable, which will in turn change his negative current self belief of unsociable to sociable and a convergence with the ideal self will occur. In those moments, Peter will have an authentic-like experience. Alternatively, Peter is exposed to situations where he receives feedback that he is indeed sociable and like his ideal self, despite his thinking otherwise. In this case, Peter's belief of being unsociable will gradually transform into current self belief of being sociable and a convergence between his current and ideal self will take place. Again, authenticity will be present in such a scenario. In terms of changing the ideal self (option b), Peter comes to accept he is unsociable and realizes that his enjoyment of his alone time is more important to him than being sociable (or some other reason for preferring not to be sociable). In this case, a shift within the ideal self takes place in that it now includes not being sociable. Therefore, if Peter is being reproached for not being sociable, he says "This is who I am" and experiences authenticity because being unsociable is now part of his ideal self.[3] If Peter might be disrespecting the latter desire, this could lead to scenario two.

This model avoids the problems faced by the previous presented models. Firstly, it avoids the problem of having to find an enduring ontologically distinct entity that is over and above the traits and abilities of a person, because the ideal self is constituted by them. Secondly, it avoids the problems of the ideal self being pre-determined and separate from the society. The ideal self is a collection of values, norms and desires that continually develops and changes throughout life. The ideal self is influenced and constituted in interaction with and by society and shaped by personal experiences. Furthermore, the presented model of the ideal self can help address the two problems with authenticity raised in section two. First, it can help explain the hard case of authenticity since I argue that the bar for authenticity is behaving in accordance with the ideal self, not constancy in one's identity. To the second problem, namely how to distinguish between authentic and inauthentic parts, my answer is that it is the convergence with the ideal self (plus enjoyment or dislike as discussed before) that makes the difference. In this way, it could be researched what people aspire to and move away from (i.e. what is part of the ideal self and what not) and how they feel about these characteristics (enjoyment or dislike) by which we could better understand how they perceive their authentic selves and if people act in accordance with the scenarios presented.

Finally, it might be objected that the phenomenology of becoming more and more self-aware with time pushes us more towards the discovery view. There is a sense of "peeling-off" layers and coming to know ourselves better during life. However, I would argue that we are not discovering an authentic self* that is waiting to be discovered in those moments. We are becoming more aware of our ideal self and the latter is becoming more specific and detailed with time. The one other concern is how does one distinguish what is part of the ideal self and what not? I would argue that what the ideal self contains is largely a matter of choice. There is a matter of making the ideal self conscious and more detailed. But once that becomes the case, a person can make a choice in what the ideal self will be. In that way, we decide what we want to be. In that sense this does not simply push the authentic self one step further with the ideal self (instead of an authentic self* we are discovering an ideal self) because the ideal self is not a constant entity, but a collection of our values, beliefs, desires and influences that is simply becoming more and more detailed with time. The more detailed it is, the greater choice we have in what we want to become, i.e. our authentic self.

5. CONCLUSION

The aim of this paper was to provide a preliminary model for explaining phenomenology of authenticity. On this account, authentic-like experiences are a result of a convergence between our current self and ideal self. The ideal self is a collection of our beliefs, thoughts and desires at the present time. The task for further research would be to look deeper into the structure and creation of the ideal self. It would be further useful to empirically examine which situations elicit feelings of authenticity and to investigate what drives people's experiences of authenticity in those moments.

6. ACKNOWLEDGMENTS

Thanks to Dr. Alistair Isaac and Dr. Mog Stapleton for their guidance and advice in preparing this paper.

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[3] I would argue that if a characteristic is seen as fixed and cannot be changed, it is scenario three. If the said characteristic is more a choice, then it is scenario four.

Exploring Features of Cognitive Science as Natural Epistemology

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ABSTRACT

Historically as well as conceptually, epistemology and cognitive science seem to be intimately connected. The overlap between them seems to be rather extensive, and this overlap can be dubbed as natural epistemology, which has been similarly proposed by a few other researchers. In the work, I define natural epistemology as the study of epistemological questions using scientific methods. Due to the particular nature of studying knowing, which is what cognitive science largely does, I identify other important features, hidden behind the definition. To explore such features, I apply Kuhn's 'essential tension' between convergent and divergent thinking to how progress in cognitive science had historically played out, especially regarding its paradigm shifts (cognitivism, connectionism, embodied/embedded cognition, enactivism). I propose that 'essential tension' that fuels progress in cognitive science manifests as a loop between knowing of cognitive science (epistemology of cognitive science) and knowing within cognitive science (epistemological insights in cognitive science). I describe the knowledge loop's importance and relate it to the history of cognitive science. In the end, I discuss future work, pointing to the problem of what is epistemological or not as well as the problem of potential convergence of the knowledge loop with the ideas of second-order cybernetics.

Keywords

cognitive science, epistemology, Kuhn, philosophy of cognitive science, philosophy of science

1. INTRODUCTION

Cognitive science (CS) has been by many characterized by its strong historical [1] and contemporary connection to epistemology [2], despite some opposition to the possibility of expanding philosophical ideas to scientific disciplines [3]. Kvanvig [4] indicates that the question of the relationship between mind and world (and more broadly of 'what it is to know') is the deepest question of epistemology, and some [2] have claimed that this same relationship is the foremost investigative matter of CS. Both CS and epistemology ask certain questions that seem to be the same, especially in terms of sources of knowledge of the external world, e.g., perception [5], where epistemology offers answers through philosophical analysis [6], while CS uses different scientific methods for its answers [7]. For example, both are interested in perception, being one of the sources of knowledge, and how it is used to construe the world. Berkeley [6] argues against material objects using philosophical analysis, while one of the constituent disciplines of CS, artificial intelligence, uses computer vision to examine different ways that the world is constructed. Namely, in computer vision, material objects are largely construed and identified by continually updating the image and comparing it with stored images of that same object [7] – this happens especially when identifying the same object from different perspectives. It therefore seems that CS can offer some sort of answers to epistemological questions. I believe the insight into the deep intertwinings between CS and epistemology is important to be able to discern an overlapping research endeavor that studies epistemological questions with natural scientific methods. This research endeavor, which will be dubbed as natural epistemology, is strongly embodied in CS. By realizing the epistemological background of the latter, it is important to delve into its features as natural epistemology to understand its particular nature, organization and scientific workings, which have significant influences on how research and progress in natural epistemology is manifested.

2. NATURAL EPISTEMOLOGY

While gaining insight from studying epistemological questions with contemplative philosophical work is an extremely valuable endeavor, philosopher and logician Quine followed what Dennett [8, p. 134] colorfully described with the following words: "Just as you cannot do very much carpentry with your bare hands, there is not much thinking you can do with your bare brain." Quine [9] described a view wherein epistemology uses scientific methods and subsequently coined the phrase 'naturalized epistemology'. In parallel, similar views arose from cybernetics and second-order cybernetics circles as well as from the sociological domain. Bateson [10] used the terms 'empirical epistemology' and 'experimental epistemology' when describing an endeavor of researching perceivers' presuppositions built into the product or the final image of perceiving. Keeney [11] used the term 'natural epistemology' to research how living beings make distinctions in the world that construct it while at the same time knowing that these distinctions are wholly dependent on these same living beings. Luhmann [12] used 'natural epistemology' to characterize that knowledge depends on an observer's inner processes and not on the question of what is 'true' or 'false' as such. He notes that there is a certain circularity in this, observing self-reference in natural epistemology, which is hinted by Keeney as well – we supposedly know that the construction of the world is what living beings do, which we want to research, but at the same time we are aware that we are these same living beings who construct the world in the first place. I therefore propose that the base definition of natural epistemology is this: Natural epistemology is the study of epistemological questions with the use of natural scientific methods. However, due to the particular nature of the study, stemming from the fact that the construction of knowledge is studied by constructors of knowledge or that knowing is investigated by others' 'knowings', natural epistemology as manifested in CS possesses some unique features. I try to ascertain some of them in this work. There are some similarities of the ascertained features to those of second-order cybernetics, which is “the study of the organization in autopoietic machines, which are able to build their own components, and possess cognizance which allows them to observe and control other machines” [13, p. 73]. This insight is self-referenced in natural epistemology and it thus determines the progress in CS as such. To identify the features and their influence in the progress of CS, I describe and apply Kuhn’ concept of ‘essential tension’ between convergent and divergent thinking in science[1] [14] to CS.

3. KUHN’S ESSENTIAL TENSION

Kuhn [14] proposed that progress in science is typified by the interplay between convergent thinking and divergent thinking which emerges as ‘essential tension’. According to Kuhn, convergent thinking in science is what scientists usually do and the way they normally operate, where “the research scientist is not an innovator but a solver of puzzles, and the puzzles upon which he concentrates are just those which he believes can be both stated and solved within the existing scientific tradition” [14, p. 234]. The usual research scientist, “the practitioner of a mature science, from the beginning of his doctoral research, continues to work in the regions for which the paradigms derived from his education and from the research of his contemporaries seem adequate” [14, p. 245] and tries to “elucidate topographical detail on a map whose main outlines are available in advance” [Ibid.]. Kuhn believes, partly opposed to usual views on the topic, that convergent thinking is extremely important as it ensures safe, steady, sure and stable production the likes of which cannot be achieved with divergent thinking as prevalent; it is also why, apart from being the norm, convergent thinking is so abound and common. It is exactly its exuberance that eventually leads to encountering “a problem in which the anticipated does not occur, a problem that goes wrong to ways suggestive of a fundamental weakness in the paradigm itself” [Ibid.]. Convergent thinking in established sciences is therefore a prelude to divergent thinking, which has to happen in order to find a solution to the described problem. However, scientists do not always go beyond the prelude as they do not identify the problem as paradigm-breaking. They believe that continuing research in the established paradigm will exhibit desired outcomes. Alas, according to Kuhn, the desired outcome cannot occur, as convergent thinking is “neither intended nor likely to produce fundamental discoveries or revolutionary changes in scientific theory” [14, p. 233]. The scientist therefore has to have “the ability to recognize trouble when confronted by it” [14, p. 235] and to recognize “that something has gone wrong with existing knowledge and beliefs” [Ibid.]. This modus operandi continues into divergent thinking, which means that the scientist must “rearrange the intellectual and manipulative equipment he has previously relied upon, discarding some elements of his prior belief” [14, p. 226] and “lack prejudice” [Ibid.], which is imposed by the established paradigm, “to a degree where [the scientist] can look at the most `self-evident' facts or concepts without necessarily accepting them” [Ibid.]. This is the last step before “one of those shifts in fundamental theory, in problem field, and in scientific standards […], referred as scientific revolutions” [14, p. 234].

I believe that understanding Kuhn’s concept of ‘essential tension’ and its role in scientific progress is necessary to articulate how the self-reference of natural epistemology in CS plays out. This articulation will follow after a short examination of how progress worked historically in CS in relation to Kuhnian scientific revolutions or paradigm shifts.

4. SHORT EXAMINATION OF PROGRESS IN COGNITIVE SCIENCE

Froese [15] distinguishes (roughly) four paradigm shifts in CS so far, which can be seen in the figure below.

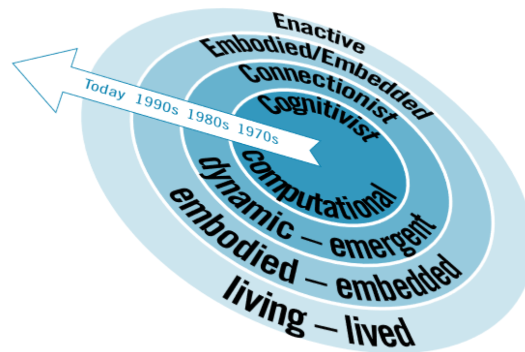

Figure 1. Froese's interpretation of paradigm shifts in CS [from 15, p. 76]. Circles do not represent the end of a paradigm, only emergence of a new one.

The four paradigms are cognitivism, connectionism, embodied/embedded cognition and enactivism. Following Kuhn's 'essential tension', convergent thinking was researchers' modus operandi within these paradigms, while divergent thinking ultimately spawned a paradigm shift. The short overview below is meant as a conceptual validation of Kuhn's ideas rather than a comprehensive and nuanced treatise of the history of CS. It is more focused on the role of artificial intelligence (AI) in it, but it has to be noted that AI was only one wave in the necessary tsunami that caused a paradigm shift. This means that ideas from many other consitutent fields of CS that directly contributed to paradigm shifts are not mentioned.

The insight that cognition is supposedly computation with arbitrary symbols started the cognitive revolution and the era of cognitivism in the 1950s. This idea on cognition has been manifested in most research since. A few decades long prosper, especially in AI, signalled to scientists that their idea about cognition was correct. One of the most publicly known examples of this prosper is the AI chess player, as it symbolized human higher-order cognitive abilities. The artificial chess player's skills grew exponentially, and in 1996, the reigning world champion of the time Kasparov was beaten by it. However, the idea of the top-down, centralized cognition, embodied in the AI of the time proved to have many problems. For example, large domains were a big issue [16], which could not be solved by convergent thinking. It was recognized “that something ha[d] gone wrong with existing knowledge and beliefs” [14, p. 235],

[1] Kuhn described and published his work on ‘essential tension’ as a result of lecturing at a conference on scientific creativity, where the knowledge of creativity, which is gained by scientists who study creative talent, was applied to scientists themselves.

and in the 1980s, the idea on cognition shifted to it being parallel, distributed and bottom-up, which was largely synonymous with the method of artificial neural networks (ANN). Connectionism opened doors to new research in many phenomena where the cognitivist paradigm failed (e.g., natural language processing [16]). ANNs are still predominantly used today and exhibit numerous achievements in mimicking human abilities[2]. However, many scientists [17] felt that connectionism was missing a key point in what cognition supposedly is and how organisms perceive and act by dismissing the constitutive role of bodies in cognition and focusing solely on the brain. Again, convergent thinking shifted the view on cognition that started to incorporate organisms' bodies and how they constitute organisms' cognition. By being aware that cognition is embodied as well as embedded in the environment, research in robotics (as well as using robots to investigate cognition) started to flourish like never before, convergent thinking leading the way again.

The last paradigm shift to enactivism will not be covered here, as its manifestation seems to be a bit more unclear than the previous ones as well as it being harder to delineate from the embodied cognition paradigm [18]. The short overview was meant to be exemplary as to apply Kuhn's 'essential tension' to historical progress in cognitive science as natural epistemology.

In the next chapter, I will build on the manifestation of Kuhn's 'essential tension' in CS by noting the role the circularity of knowing (see chapter 2) plays and relating it to convergent and divergent thinking. In the chapter I will show how, when conceptualized in this way, CS's particular organization works.

5. THE KNOWLEDGE LOOP OF COGNITIVE SCIENCE AS NATURAL EPISTEMOLOGY

From the way the progress in CS was described in the previous chapter, I can outline an abstract step-by-step template:

1. Scientists research a particular cognitive phenomenon with their existing knowledge (Kuhn's 'prior beliefs' or presuppositions from an established paradigm) about knowing.
2. Scientists make great advances, but then encounter an insurmountable problem, which cannot be solved with convergent thinking (current epistemological presuppositions).
3. If the problem is identified as such, scientists have to work through a different set of epistemological presuppositions and new ideas about cognition, therefore exhibiting divergent thinking.
4. The problem is solved, which opens the door to numerous new research not envisioned as such before. A paradigm shift within which research is conducted occurs, changing how the discipline sees knowing and changing epistemological presuppositions of the scientists.

This outline forms a loop, as the last step inevitably leads into the first. The figure below summarizes this process:

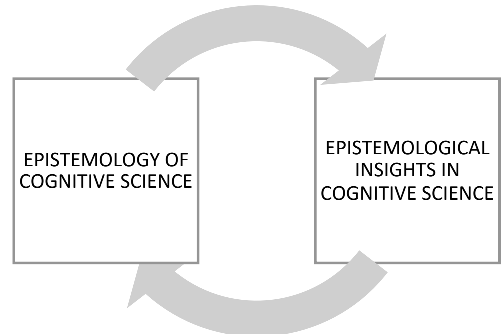

Figure 2. The loop between epistemological insights in cognitive science and epistemology of cognitive science.

Relating this loop to Kuhn's 'essential tension', convergent thinking represents epistemological insights in CS or research on knowing and cognition that occurs on daily basis. Divergent thinking represents epistemology of CS, as this is where a shift has to occur to overcome the problems in epistemological insights in CS. The interplay of knowings is apparent here: epistemology of CS may be dubbed as knowing of cognitive science, while epistemological insights in CS may be dubbed as knowing within cognitive science. One refers to the established paradigm and idea on cognition, from which the other stems. To overcome paradigm-breaking problems in knowing within cognitive science, scientists have to become aware of epistemological presuppositions they hold on knowing and shift them. Knowing within cognitive science can therefore only advance at crucial points when something in knowing of cognitive science happens, and vice versa. The knowledge loop emphasizes the importance researchers play in researching and defining cognition and knowing.

6. DISCUSSION AND CONCLUSION

In this work, I identify and specify certain features of cognitive science as natural epistemology. This is only the first step in a process to try to characterize how scientific studying of knowing manifests itself. There are a few issues that I will explore in future work. First, the issue of what is epistemological and what is not will have to be addressed. Are the crucial questions in cognitive neuroscience like "What is the complete connectome of the human brain?" [19, p. 173] epistemological questions or not[3]? Second, the knowledge loop and the analysis of the interplay between knowing within cognitive science and knowing of cognitive science will have to be taken further to incorporate stronger ideas of second-order cybernetics, as it seems that this is where the concept of Kuhn's 'essential tension' in cognitive science as natural epistemology is gravitating towards. Hopefully, the endeavor will not completely converge into ideas of second-order cybernetics and offer something new to philosophy of CS; if not, the connection between Kuhn's 'essential tension' and second-order cybernetics was somewhat established.

[2] And, interestingly, being used to model game players in more and more complex domains outside of strict-rules based ones as chess (e.g., OpenAI in Dota 2).

[3] Interestingly, some researchers [2] are sceptical of putting neuroscience under the interdisciplinary umbrella of CS for precisely this reason.

As CS is considered as a too loose of a research program by some [20], especially because it lacks its own methods, it seems important to characterize it by its own, unique properties. I believe that the knowledge loop between knowing within cognitive science and knowing of cognitive science may be one such property. What does seem certain is that epistemology works as a sort of glue between the constituents of CS, which gives validity to the latter's interdisciplinary nature.

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Učinki telesne poze na prag termične bolečine za vroče

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POVZETEK

Obvladovanje bolečine je pomembno področje vsakodnevnega življenja, pa tudi klinične in raziskovalne prakse. Ker so novi načini obvladovanja bolečine vedno dobrodošli in je povezava med telesno pozo ter bolečinskim pragom slabo raziskana, smo se namenili preveriti, ali zavzetje naključno dodeljene dominantne ali submisivne poze lahko povzroči akuten dvig ali znižanje praga termične bolečine. Uporabili smo najvišje in najnižje ocenjeno pozo moči iz predhodno izvedene spletne raziskave ter ponovili in nadgradili eksperiment Bohnsove in Wiltermutha [1]. Dobljeni rezultati so pokazali, da je dominantna poza statistično značilno vplivala na dvig praga bolečine za vroče, kar je skladno z izsledki izvirne raziskave [1].

Ključne besede

Neverbalna komunikacija, poza visoke moči (dominantna poza), poza nizke moči (submisivna poza), termični bolečinski prag.

1. UVOD

Moč in nadvlado izražamo poleg besedne govorice tudi skozi nebesedno govorico telesa [2], ki za sporočanje poleg intonacije in barve glasu uporablja telesno držo, geste in obrazno mimiko. Posameznik kaže lastno moč skozi nadrejeno, ekspanzivno držo in asertivne gibe ter podrejenost skozi zaprto, kolabirano držo in skromne gibe.

Nekatere raziskave [1 - 3] nakazujejo, da odnos med nebesedno govorico in počutjem lahko poteka tudi v obratni smeri: namerno zavzeta dominantna poza spodbudno vpliva na dojemanje lastne moči, namerno zavzeta submisivna poza pa ima nanj negativen učinek. Izraz poza moči uporabljamo, ko govorimo o telesnih pozah, ki posnemajo dominantno ali submisivno držo telesa. Glede na njeno sporočilnost in občutenje moči osebe, ki jo vzdržuje, jih imenujemo tudi poze visoke moči (dominantne poze) ali poze nizke moči (submisivne poze), glede na držo telesa ter položaj rok in nog pa tudi ekspanzivne (odprte) in kolabirane (zaprte) poze. Pri dominantnih pozah so udi običajno stran od telesa, hrbtenica je zravnana in brada nekoliko privzdignjena. Pri submisivnih pozah so udi običajno tesno ob trupu ali prekrižani, brada je nemalokrat nekoliko spuščena in drža je skljućena [1, 2]. Čeprav številne raziskave iz zadnjih treh desetletij navajajo učinke telesnih poz na različne parametre [4 - 6], vedno več novejših raziskav [3, 7, 8] oporeka izsledkom predhodnih.

Zaradi kontroverznih izsledkov, vedno dobrodošlih novih načinov obvladovanja bolečine in neraziskanega področja morebitnega vpliva telesnih poz na bolečinski prag smo se namenili ponoviti in nadgraditi predhodni eksperiment. V navedeni raziskavi [1] so udeležencem pred in po vzdrževanju ene od poz izmerili bolečinski prag za ishemično bolečino, ki je bila izzvana z manšeto za merjenje arterijskega tlaka. Rezultati so pokazali, da je dominantna poza zvišala bolečinski prag, pri submisivni pozi pa statistično značilnega učinka ni bilo.

Naša raziskava je potekala tako, da smo najprej izbrali najbolj dominantno in najbolj submisivno pozo, nato pa izbrani pozi uporabili pri preverjanju povezave med naključno dodeljeno pozo in spremembo v pragu termične bolečine. Predhodno raziskavo smo nadgradili z večjim vzorcem, zanesljivejšo metodo merjenja ter z zagotovitvijo nepristranskosti in ponovljivosti navodil za zavzemanje poze.

2. METODOLOGIJA

2.1 Udeleženci

V raziskavi je sodelovalo 130 udeležencev, 56 moških in 74 žensk, starih od 19 do 62 let. En udeleženec je bil naknadno izločen zaradi neupoštevanja navodil.

2.2 Pripomočki in merski instrumentarij

Za merjenje praga termične bolečine za vroče smo uporabili napravo Medoc Pathway Pain & Sensory Evaluation System (PSES, model ATS). S pomočjo spletnega vmesnika je udeleženec odgovorili na nekaj vprašanj, si kasneje ogledal naključno dodeljeno fotografijo poze, sledil navodilom za njeno zavzemanje ter jo ob koncu ocenil glede na zaznani občutek moči oziroma nemoči.

2.3 Postopek

Udeleženec je ob prihodu podpisal soglasje o sodelovanju in prek spletnega vmesnika odgovoril na nekaj demografskih vprašanj. Za zagotovitev anonimnosti podatkov mu je bila avtomatsko dodeljena štirimestna koda, pod katero so bili obravnavani vsi nadaljnji podatki. Sledile so testne meritve s termodo na koži palčne kepe nedominantne roke. Po testni meritvi je sledila prva eksperimentalna meritev na enakem mestu dominantne roke.

Meritve bolečinskega praga za vroče so bile izvedene trikrat, pri čemer je bila izhodiščna temperatura termode vedno 32 °C. Po meritvah je bil udeleženec povabljen pred namizni računalnik. Naročeno mu je bilo, naj po odhodu eksperimentatorja iz prostora na spletnem vmesniku nadaljuje na naslednjo stran, kjer mu bodo podana nadaljnja pisna navodila, fotografija naključno dodeljene poze ter posnetek glasovno predvajanih navodil za zavzetje poze. Pozo je udeleženec izvêdel in v njej vztrajal 3-krat po 20 sekund, pri čemer je glasovno navodilo oznanilo iztek 20 sekund, začetek in konec premora, ponovno zavzemanje ter konec preizkusa.

Po vrnitvi v prostor je eksperimentator povabil udeleženca k drugi eksperimentalni seriji meritev na predelu palčne kepe dominantne roke, ki so potekale enako kot prej. Vrednosti eksperimentalnih meritev so se shranjevale preko spletnega vmesnika ter bile kasneje povprečene za vsak sklop treh vrednosti.

Po drugi meritvi je udeleženec ocenil, s kolikšnim občutkom moči oziroma nemoči ga je na lestvici od 1 do 11 navdala zavzemana poza.

2.4 Analiza podatkov

Učinek poze smo analizirali z univariatno primerjavo razlik v srednji vrednosti med skupinama. Za analizo podatkov smo uporabili programje IBM SPSS Statistics 23 za okolje Windows.

3. REZULTATI

Sprememba v pragu bolečine za vroče se je med skupinama z dominantno in submisivno pozo pred in po vzdrževanju poz statistično značilno razlikovala ($t(127) = -3{,}11$, $p = 0{,}002$). Pri udeležencih z dodeljeno dominantno pozo je bila povprečna vrednost temperature praga bolečine za vroče na začetku 44,79 °C (*SD* 3,55 °C) in po vzdrževanju poze 45,97 °C (*SD* 3,51 °C). Pri udeležencih z dodeljeno submisivno pozo je bila povprečna vrednost temperature praga bolečine za vroče pred vzdrževanjem poze 46,40 °C (*SD* 3,14 °C) in po vzdrževanju 46,34 °C (*SD* 3,17 °C).

Udeleženci, ki so vzdrževali submisivno pozo, so na lestvici od 1 do 11 v povprečju poročali o manjšem občutku moči ($M = 3{,}8$, $SD = 1{,}4$) v primerjavi z udeleženci, ki so vzdrževali dominantno pozo ($M = 8{,}7$, $SD = 1{,}5$; $t(127) = -19{,}06$, $p < 0{,}001$). Rezultati so primerljivi z ocenami udeležencev v spletni raziskavi za izbrani dve pozi.

4. RAZPRAVA

Namen naše raziskave je bil ugotoviti, ali imata izbrani pozi učinek na dvig oziroma spust praga termične bolečine za vroče. Rezultati so pokazali, da je dominantna poza vplivala na dvig praga za bolečino in da submisivna poza nanj ni imela učinka. Tovrstni izsledki so skladni s predhodno raziskavo, v kateri so prag bolečine merili z izzivanjem ishemične bolečine [1]. Avtorja slednje sta domnevala, da je višji bolečinski prag dominantne poze povezan z višjo aktivacijo mišic med njenim vzdrževanjem ter da to lahko vpliva na fiziološke procese v telesu, ki so povezani z zaznavo bolečinskega praga. V naši raziskavi mišične aktivnosti nismo neposredno merili, zato o tovrstnem učinku ne moremo argumentirano razpravljati. Lahko pa izpostavimo, da je bila izbrana dominantna poza iz naše raziskave v primerjavi s submisivno razmeroma enostavna za zavzetje, bila je bolj stabilna in je verjetno zahtevala manj vzdrževane mišične aktivnosti. Zato dvomimo, da bi odsotnost vpliva submisivne poze in prisotnost vpliva dominantne poze na prag termične bolečine za vroče lahko pojasnili z večjo aktivnostjo mišic pri vzdrževanju dominantne poze.

Nekateri raziskovalci [2] so poročali, da je vzdrževanje dominantne poze privedlo do zvišanja testosterona v slini in vzdrževanje submisivne poze do njegovega znižanja. Drugi so poročali o višjem bolečinskem pragu po zvišani ravni testosterona pri živalskem modelu [9]. Raziskovalci študije o učinkih testosterona na moške, ki so bili razdeljeni v skupine glede na kronično izpostavljenost eksogenemu ali endogenemu testosteronu, pa so poročali o zmanjšani občutljivosti na taktilne dražljaje pri skupini moških z najvišjo ravnijo testosterona [10]. Iz tovrstnih raziskav bi lahko sklepali o povezavi med vzdrževanjem poz, zvišanjem ravni testosterona in zaznavanjem bolečine, vendar novejše raziskave takšnim povezavam oporekajo [3, 7]. V naši raziskavi se namenoma nismo odločili za meritve koncentracij hormonov. Z nepristransko metodo smo želeli preveriti domnevo o učinku poze na bolečinski prag in se pri tem namerno izognili dodatnim virom variabilnosti. Poleg tega so bili v raziskavo vključeni udeleženci obeh spolov in med spoloma razlik v spremembi praga nismo zaznali. Čeprav bi nevroendokrini dejavniki lahko prispevali k vplivu, bi za vpogled v njihovo vpletenost morali izvesti novo, kompleksnejšo raziskavo, kjer bi na ustrezen način vrednotili tudi morebitno spreminjanje nevroendokrinih parametrov.

5. ZAHVALA

Zahvaljujemo se prostovoljcema Mateji Drolec Novak in Janu Zibelniku za pomoč pri izvajanju raziskave.

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The effect of distractors in lateralized change detection working memory task

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ABSTRACT

The capacity of working memory to maintain visual information is highly limited and varies significantly across individuals. An important research effort is to understand the mechanisms of its limitation, one being the efficient selection of the relevant items from the immediate external environment to encode and maintain in working memory stores, while preventing the irrelevant items to occupy it's capacity. Recently, a series of EEG studies using lateralized change detection task, in which the participants only have to maintain items presented on one visual hemifield, while irrelevant items are also presented on the opposite hemifield, identified a neurophysiological correlate of storage capacity in the form of contralateral delay activity (CDA) wave. Moreover, studies revealed that low-capacity participants maintain irrelevant items along the target items, when both are presented in the same visual hemifield, indicating a reduced ability to filter irrelevant stimuli from visual working memory. These studies, however, do not consider the possibility that participants might also maintain the irrelevant items presented to the opposite visual hemifield. To address this concern, we designed an experiment in which we directly manipulated the presence of distractors in the irrelevant visual hemifield to estimate and control for their effect. Twenty-eight participants took part in a visual working memory experiment in which they were asked to maintain orientation of items presented to the left or right visual hemifield, while the distracting items were either present or absent in the opposite visual hemifield. The results revealed significantly lower estimates of the capacity in the presence vs. absence of distractors, suggesting that participants were not able to ignore the distracting items presented to the opposite visual hemifield, challenging the validity of the estimates of visual working memory capacity in CDA and other studies employing lateralized change detection task.

Keywords

Change detection task, capacity, contralateral delay activity, distractors, visual working memory.

1. INTRODUCTION

In everyday life, access to immediate external environment obtained through different sensory systems is crucial not only to respond to the sources of threat, being one of the basic functions of sensory systems, but also to guide complex mental tasks needed to carry out goal directed behavior. For example, when driving a car, one must have access to the visual environment at all times, in order to follow the driving rules and avoid potential obstacles, such as pedestrians and other vehicles in the traffic. Frequently, however, sensory input from the relevant visual information is either interrupted by short events, such as eye-blinks or saccades, or redirected to irrelevant visual stimuli, such as a phone screen when receiving a call. In such cases, a temporary memory buffer known as visual working memory (VWM) [1], which allows us to actively maintain and integrate relevant visual information in the absence of the external environment, is needed to carry out the tasks at hand.

An important effort of VWM research is to understand the reasons for the highly limited capacity to maintain visual representations, which spans from 3 to 5 meaningful items in young adults, varies significantly across individuals and declines in healthy aging [2]. Recently, a series of EEG studies [5, 3] focused on the neural substrates of VWM processes and identified a neurophysiological index of storage capacity in the form of the slow negative ERP difference wave, known as contralateral delay activity (CDA). Studies have shown that CDA is sensitive to the number of objects maintained in VWM [3]—its amplitude increases as the number of objects maintained in VWM increases, but reaches an asymptote at around 3-4 items (Figure 1F), depending on each individual's memory capacity. Interestingly, the extent of the increase in amplitude in CDA when working memory load is increased from two to four items was found to strongly correlate with individual's VWM capacity and is therefore considered a neurophysiological index of VWM capacity [5]. Moreover, studies have shown [3] that low-capacity participants find it hard to ignore irrelevant distractors when presented either concurrently with or successively to the target items [6]. The authors suggested that irrelevant items burden the limited VWM capacity, leading to lower working memory performance.

A typical paradigm used to study CDA is lateralized change detection task [5] (Figure 1A), in which participants are presented with a number of items on both sides of the screen, but only have to focus on the side that was previously indicated with a cue (usually an arrow pointing either left or right), encode and maintain the relevant item information (e.g. colors or orientations), while keeping their eye-gaze focused at the fixation point in the middle of the screen. Such tasks evoke an increase in electrical activity above the parietal-occipital cortex of the hemisphere contralateral to the visual hemifield in which the target items were presented (Figure 1C). CDA is computed as the difference in EEG activity between contralateral and ipsilateral hemispheres (Figure 1E). In this way, any nonspecific, task-general bilateral activity such as perceptual responses (Figure 1D), is removed and the remaining signal should be solely related to working memory processes [3].

While this logic seems well reasoned for eliminating task-irrelevant activity, we have identified a potential issue in the experimental design that could lead to false conclusions. When testing VWM capacity, researchers usually don't consider the possibility that participants might be either distracted by or also encode and maintain the items presented to the irrelevant hemifield. Encoding and maintenance of irrelevant distractors was demonstrated in previous studies [6, 3], however, in these studies the irrelevant distractors were present in the same visual hemifield interspersed between relevant targets. In this study we considered the possibility that the distractors significantly affect VWM performance even when presented to the irrelevant visual

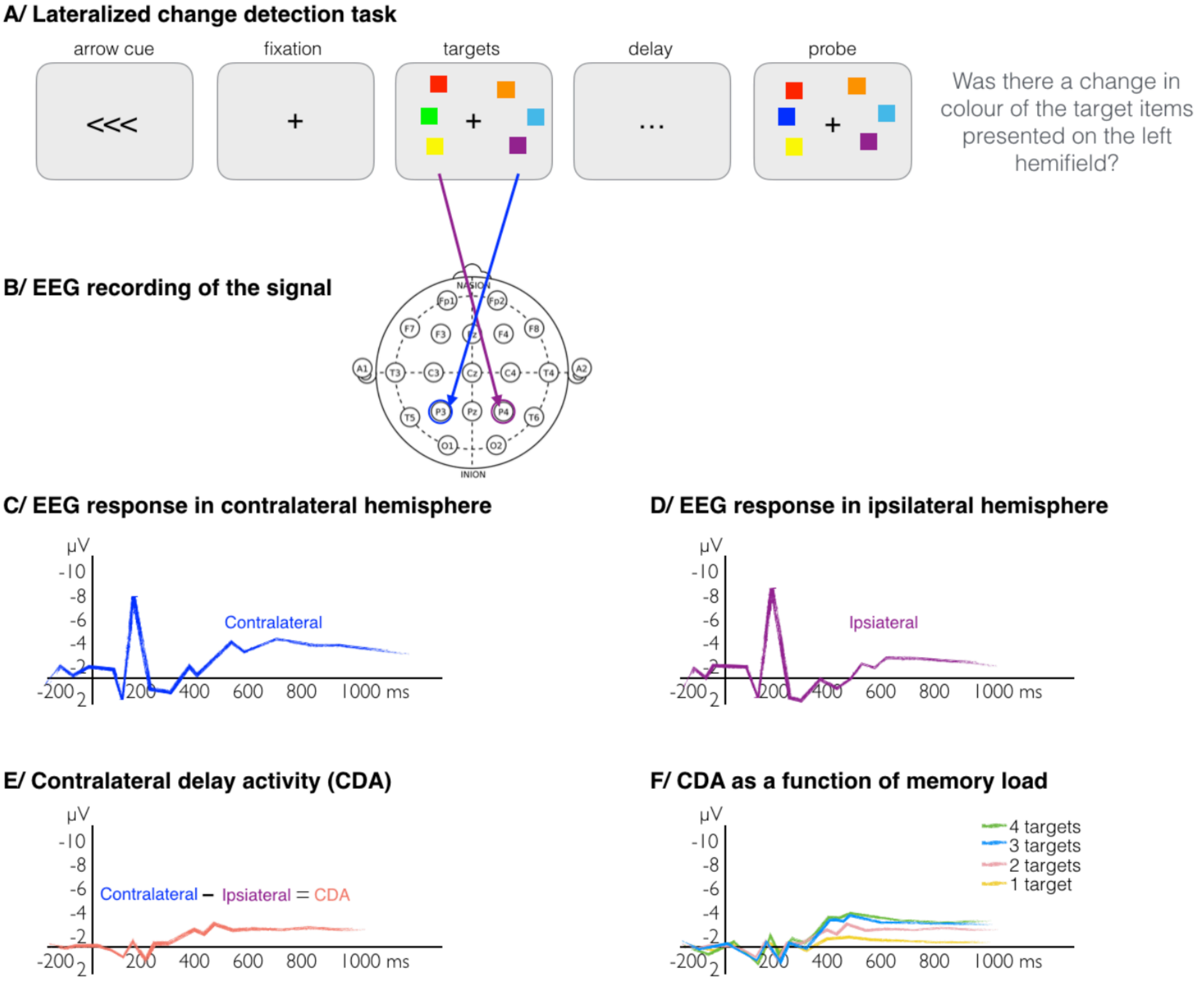

Figure 1: Contralateral delay activity as induced by a change detection task. A: Lateralized change detection task. B: EEG recording of the signal obtained while a participant is performing the task. C: EEG response to the target items in the contralateral hemisphere. D: EEG response in the ipsilateral hemisphere. E: Contralateral delay activity (CDA), computed as the difference in EEG signal between contralateral and ipsilateral hemisphere. F: CDA increases as a function of memory load and reaches an asymptote around participant's working memory capacity. Adopted from [3, 5].

hemifield. In this case, the participants might try to encode items from both hemifields, spreading the VWM resources across both relevant and irrelevant items and reducing the ability to maintain the items from the relevant visual hemifield. If that is the case, in such studies the results would underestimate the VWM capacity for the relevant hemisphere.

To address this concern, we designed an experiment in which we directly manipulated the presence of distractors in the irrelevant visual hemifield, which enabled us to estimate and control for their effect.

2. METHOD

2.1 Participants

Twenty-eight students (22 females) aged between 19 and 25 (M = 20.5, SD = 1.6) signed an informed consent to participate in an 1.5-hour experimental session. Five participants were excluded from the analysis due to inadequate performance in the VWM task (accuracy was lower than chance in one of the task conditions).

2.2 Task and procedure

Participants completed multiple trials of the VWM task (Figure 2). On each trial they were shown a brief array of black rectangles of different orientations (*targets*) presented either on one or both sides of the screen and were asked to remember the items presented in either left or right hemifield only, as indicated with an arrow (*initial cue*). Following a brief delay a *second cue*, which matched the initial cue and reminded the participants which objects they will need to base their response on, was presented. After another delay, the *probe* items were shown on both sides of the screen and the participants had to indicate by a button-press, whether there was a change in the orientation of any of the rectangles on the relevant, previously indicated side of the screen, ignoring a possible change on the other side of the screen.

Two main factors were manipulated: *side*, which corresponded to the side of the screen from which the participants had to remember orientation of the presented items (*left, right*) and *distractors,* corresponding to whether the items were presented to both or the relevant visual hemifield only (*distractor* and *no-distractor condition*). Overall we tested 4 experimental conditions: 4 target items presented to the left (L4N) or right (R4N) visual hemifield with no distractors on the opposite

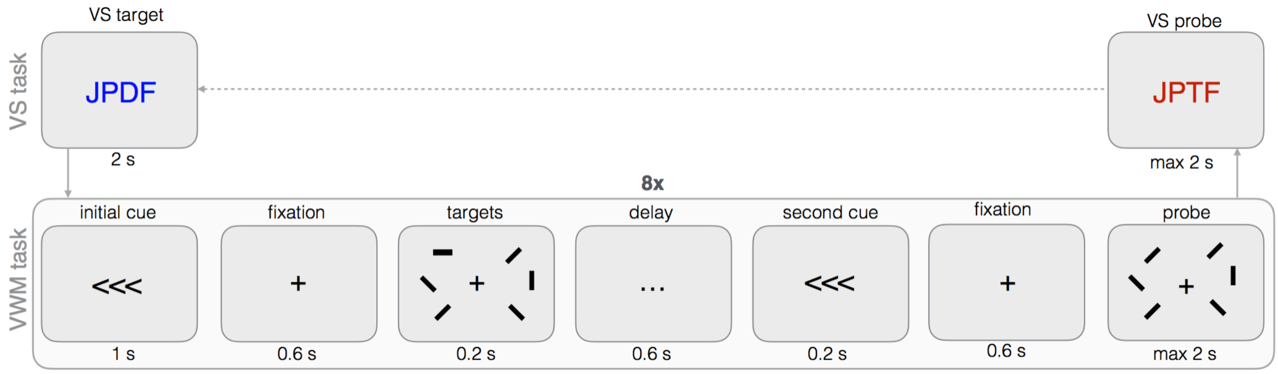

Figure 2: Task progression and trial structure. See main text for full description.

hemifield; and 4 target items presented to the left (L4D) or right (R4D) visual hemifield, with distractors present.

In order to hinder verbal recoding of the visually presented stimuli, in addition to the VWM task, participants also performed a concurrent verbal suppression (VS) task, which was embedded between the trials of the main VWM task (Figure 2). Before the start of the VWM task, a suppression stimulus (VS target) consisting of blue-colored letters was presented for 2 s. Participants were instructed to maintain the letter sequence while performing the VWM task. After every eight VWM trials a VS probe was presented in red and the participants had to indicate by pressing the appropriate key, whether the probe was the same or different from the target.

Data were collected in a sound-isolated room, allowing participants to attend to the task without any interruption. To control for eye-movements, we used an EyeLink 1000 system.

2.3 Data analysis

Statistical analyses are based on estimates of working memory capacity (K). The capacity estimates were computed with Pashler's formula [4]:

$$K = N\frac{h-f}{1-f},$$

where h and f are the observed *hit* and *false alarm* rates and N is the number of to-be-remembered items.

3. RESULTS

The goal of this study was to assess the effect of distractors in lateralized change detection task on the VWM capacity. A repeated measures ANOVA with within-subject factors *side* (left vs. right) and *distractor* (distractors vs. no-distractors) revealed a main effect of distractor, $F(1, 22) = 19.7$, $p < .001$, $\eta^2 = .06$, reflecting lower capacities in the presence of distractors (see Figure 3). Neither the effect of side, $F(1, 22) = 0.754$, $p = .394$, nor its interaction with distractor, $F(1, 22) = 1.36$, $p = .254$, were significant.

4. DISCUSSION

The aim of this experiment was to identify a potential shortcoming of lateralized change detection tasks used in the CDA studies in assessing VWM capacity, by manipulating the presence of distractors in the irrelevant visual hemifield. Specifically, our concern was, that the presence of distractors could result in reduced estimates of VWM capacity, when defined as the number of remembered target items.

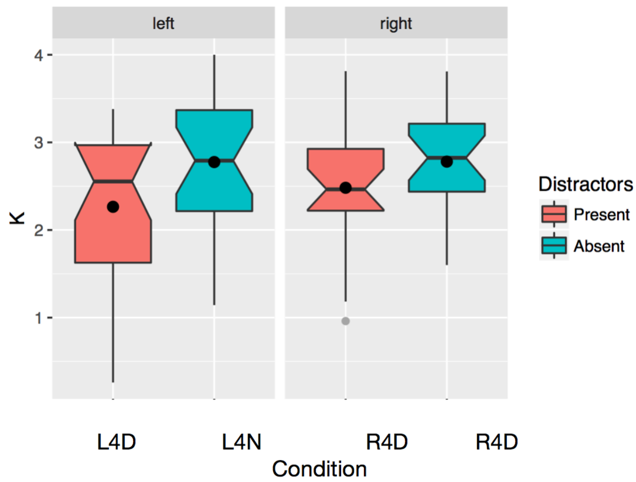

Figure 3: Estimated number of successfully maintained items (K) in the four experimental conditions. L4D: four targets presented to left visual hemifield with distractors present in the right hemifield, R4D: four targets presented to the right visual hemifield with distractors present in the left visual hemifield, L4N and R4N, four targets presented to the left and right visual hemifield, respectively, with no distractors shown in the contralateral visual hemifield. Box plot: The bottom and top of the box plot are Q1 and Q3, the line between them is the median. The lower whisker is Q1 +1.5*IQR. The upper whisker: Q3 + 1.5*IQR. The black circle is the mean.

Whereas the estimated VWM capacity did not differ between left and right hemispheres, the results indeed revealed significantly lower estimates of VWM capacity in the presence vs. absence of distractors. This suggests that participants were not able to ignore the distracting items in the irrelevant contralateral visual hemifield, which resulted in lower estimate of successfully remembered items (K) in the distractor present conditions. These results are in line with prior studies using CDA [3], which have shown that participants find it hard to ignore irrelevant distractors when presented along the target items [6]. These studies, however, assessed the effect of distractors presented in the same visual hemifield, while not taking into consideration the possibility that the distractors can significantly affect working memory performance even when presented to the irrelevant visual hemifield.

The effect of the distractors could be explained either by a reduced ability to encode the target items, or—as suggested by previous research [3]—by leading the participants to encode and maintain also irrelevant distractors, thereby reducing the effective capacity for encoding of the relevant items.

Though confirming the negative effect of the distractors, the results do not enable unequivocal explanation of the mechanism underlying their effect. One possibility is that, similar to the observations of the CDA studies [3], participants fail to ignore the irrelevant stimuli and maintain them along the relevant items occupying limited working memory resources and leaving less of them available to successfully encode and maintain target items. The second possibility is that distractors do not occupy the limited capacity working memory store, but rather disrupt the initial encoding of the relevant items, so that the active maintenance system fails to successfully engage and then sustain the activity of the representations in the first place.

Whereas our experiment does not provide sufficient information to distinguish between these two possibilities, future studies tracking the magnitude of the CDA in the presence and absence of distractors in the contralateral visual hemifield, could help resolve the dilemma.

5. ACKNOWLEDGEMENTS

This research was supported by the Slovenian Research Agency grant J7-5553, J3-9264 and P5-0110.

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Zmota luči v hladilniku in značilnosti opazovanja fenomenov z obrobja zavesti

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POVZETEK
V prispevku predstavljamo delne rezultate študije, v kateri smo poskušali odgovoriti na vprašanje, kaj se zgodi s fenomeni, ki se nahajajo na obrobju zavedanja, ko vanje usmerimo luč pozornosti. Osredotočamo se na fenomen srži, ki je del širšega doživljanja udejanjanja znanja. V uvodnem poglavju predstavimo tako imenovano zmoto luči v hladilniku – vprašanje, ali so doživljajska stanja, ki se jih zavedamo, ko o doživljanju reflektiramo, prisotna tudi takrat, ko o njih ne reflektiramo. Na podlagi empiričnih podatkov o doživljanju fenomena srži in transformacijah tega doživljanja pod lučjo refleksivnega preiskovanja, poskušamo sklepati o možnostih reflektiranja fenomenov na obrobju in veljavnosti empiričnih podatkov o fenomenih iz predrefleksivne dimenzije zavesti.

Ključne besede
Doživljanje, empirična fenomenologija, refleksija

1. UVOD
Raziskovanje doživljanja, torej subjektivne (oziroma fenomenološke) dimenzije zavesti, predstavlja za uveljavljene paradigme empiričnega raziskovanja kopico problemov. Med njimi je verjetno največji pa tudi epistemološko najbolj zanimiv, problem, ki ga Dehaene in sodelavci [1] imenujejo *zmota luči v hladilniku* (angl. refrigerator light fallacy)[1].

Po Dehaeneju, vsakič, ko se vprašamo o doživljanju, metaforično odpremo hladilnik in pogledamo ali je luč še vedno prižgana. Takoj, ko na določen del doživljajskega polja usmerimo pozornost, lahko opazimo bogato doživljajsko pokrajino, naseljeno z čustvenimi, miselnimi, telesnimi in drugimi fenomeni. O opaženem doživljanju lahko razmišljamo in poročamo. Vemo, da hladilnikova luč ugasne, ko vrata zapremo. Kako je s tem pri doživljanju? So doživljajska stanja, ki se jih zavedamo, ko o njih reflektiramo, prisotna tudi takrat, ko o njih ne reflektiramo? Je akt raziskovanja (refleksivni akt) samo odprtina, skozi katero opazujemo doživljanje takšno *kot je*, ali refleksija nekaj »naredi« doživljanju – prispeva k konstrukciji bogate fenomenološke pokrajine?

Vprašanje, ki si ga zastavljamo, ni novo. Navajajo ga že avtorji kot so Comte [2] in James [3], ki tok zavesti deli na na osrednjo, jasno vsebino in območje, ki to glavno vsebino spremlja – t. i. obrobje. Poskus opazovanja obrobja James [3, str. 244] primerja s snežinko ujeto v tople roke: »snežinka namreč ob stiku z rokami spremeni svojo kvaliteto – ni več kristal, temveč le še kapljica«.

V nadaljevanju vprašanje naslovimo iz vidika treh raziskovalnih področij: kognitivne znanosti, fenomenološke filozofije in empiričnega raziskovanja doživljanja.

Kognitivna znanstvenica Blackmore, podobno kot Dehaene, uporablja metaforo luči v hladilniku [4]. Blackmoreova meni, da je naš občutek tekočega, neprekinjenega toka zavestnega doživljanja »velika iluzija« [4, str. 26] - vsakič ko se vprašamo »sem zdaj zavesten?« se seveda ponudi pozitiven odgovor. Napaka, ki jo delamo je, da iz tega sklepamo, da smo zavestni tudi, ko tega ne preverjamo. Refleksivni akt oz. *preizkušanje* (angl. probing) je vedno na voljo, zaradi tega ni nikoli lukenj v našem (iluzornem) občutku neprekinjenega toka zavesti.

Po drugi strani, Rosenthal [5] ne vidi nobene iluzije. Njegovo stališče je, da zavestno izkustvo sovpada z zmožnostjo poročanja o njem. Ob tem pa poudarja, da je pogosto prisotna tudi vsebina, ki ni zavestna in o kateri udeleženci ne morejo poročati. Rosenthal zagovarja t.i. plitko konceptualizacijo zavesti [6], katere stališče je, da se je možno zavedati le doživljanja, ki je prej že bilo predmet refleksije. To kar je 'zavestno' je vselej neposredno doživeto med procesom refleksije.

Sodobni fenomenologi, na primer Zahavi [7], so po večini mnenja, da je zavestno izkustvo takoj na voljo, ko se po njem vprašamo, ravno zaradi predrefleksivnega samo-zavedanja. Pojasnjuje, da refleksivno samo-zavedanje temelji na predrefleksivnem samo-zavedanju in da ravno zaradi tega lahko neposredno poročamo o svojem izkustvu. Za ponazoritev predlaga naslednji primer:

»Če sem vključen v določeno zavestno dejavnost, kot je na primer branje zgodbe, moja pozornost ni usmerjena name ali na aktivnost branja, temveč je na zgodbi. Če bi me nekdo v tem trenutku povprašal o mojem početju, bi takoj lahko odgovoril, da sem (že kar nekaj časa) bral. Samo-zavedanje, na podlagi katerega lahko odgovorim na to vprašanje, ni nekaj, kar je bilo pridobljeno v tistem trenutku, temveč je bilo prisotno v sami zavesti že ves čas« [7, str. 21]. Zahavi trdi, da se vselej predrefleksivno zavedamo lastnega doživljanja in se lahko ponavadi takoj odzovemo »brez sklepanja ali opazovanja, če nas kdo vpraša, kaj počnemo, razmišljamo ali vidimo, ali kaj smo občutili neposredno pred vprašanjem« [prav tam].

[1] Zmotna domneva, da je luč v hladilniku prižgana tudi, ko so vrata hladilnika zaprta – saj je vedno prižgana, ko odpremo vrata in pogledamo.

Za Zahavija je ključno sklicevanje na trenutek refleksivnega samo-zavedanja, ki razkriva obstoj (vselej prisotnega) predrefleksivnega samo-zavedanja. Jasno zanika možnost, da akt refleksije spremeni doživljanje. Zanj akt refleksije le razpira to, kar je vselej že bilo implicitno (predrefleksivno) zaznano.

1.1. Vloga akta opazovanja v raziskovanju doživljanja

Kot vidimo, filozofska razprava o vplivu akta refleksije razkriva problematiko luči v hladilniku, in z njo povezane različne epistemološke možnosti pogleda na problematiko. Problem vpliva akta opazovanja na opazovano pa ni le teoretski – razumevanje vloge akta refleksije pri opazovanju doživljanja je ključno v empiričnem fenomenološkem raziskovanju, saj sta z njim bistveno povezani vprašanji vloge raziskovalnega aparata pri raziskovanju doživljanja in narave s takšnim raziskovanje dobljenih (fenomenoloških) podatkov.

Vodilni predstavniki prvoosebnega raziskovanja doživljanja priznavajo, da združevanje akta opazovanja z vsebinsko komponento opazovanja predstavlja pomemben izziv za empirično raziskovanje doživljanja [8]. Podobno kot vodilni predstavniki sodobne fenomenološke filozofije, večina empiričnih raziskovalcev doživljanja verjame, da je mogoče pridobiti doživljajske podatke o pristnem, z refleksijo neomadeževanem doživljanju.

Sodobno empirično prvoosebno raziskovanje vključuje celo vrsto metodoloških pristopov opazovanja doživljanja, ki poskušajo ujeti neokrnjeno, pristno (angl. pristine) doživljanje (npr. [9]). Raziskovalci, povezani s tehniko elicitacijskega in mikro-fenomenološkega raziskovanja [10, 11] verjamejo, da njihova metoda omogoča razširitev pozornosti na predrefleksivno dimenzijo doživljanja. Z drugimi besedami, verjamejo, da lahko vedno artikulirajo vsebine, ki se jih udeleženec v trenutku, ko so nastale ni zavedal (oziroma se jih je zavedal samo v predrefleksivnem »obrobju«). Dotični raziskovalni pristop Froese, Gould in Seth [6] imenujejo globoka konceptualizacija zavesti, kar pomeni, da sta raziskovalno dostopni tako predrefleksivna kot refleksivna dimenzija zavesti.

Mikro-fenomenološki intervju poskuša kultivirati posameznikovo refleksijo in retrospekcijsko poročanje o doživljajskih podatkih. Predrefleksivno dimenzijo opisujejo kot skrito, obrobno, skoraj že nezavedno raven zavesti, refleksivno pa kot zaznano vsebino, na katero je usmerjena pozornost [10]. Skozi proces izvedbe intervjuja raziskovalec vodi udeleženca do ponovnega podoživetja izkustva in pozornost udeleženca poskuša preusmeriti z eksplicitnega, refleksivnega dela, na implicitni, predrefleksivni, »obrobni« del doživljanja [12].

Avtorji torej svojo metodo gradijo na predpostavki, da je možno reflektirati doživljanje s predrefleksivne dimenzije. Njihovo razumevanje razdelitve zavesti in vloge akta opazovanja je bistveno za razumevanje podatkov, ki jih producira njihova metoda. Je vera avtorjev v sam obstoj predrefleksivne dimenzije zavesti in v možnost razširitve pozornosti na to dimenzijo upravičena?

2. ŠTUDIJA: FENOMEN SRŽI

Vprašanje veljavnosti in pomena prvoosebnih podatkov seveda presega okvire tega prispevka. Upamo pa, da bo opis rezultatov empirične študije lahko pomenil droben korak na poti k razumevanju fenomenalne zavesti. V tem razdelku predstavljamo izsek iz raziskave, usmerjen na vprašanje, kaj akt opazovanja (refleksije) »naredi« fenomenom, ki se navadno izmikajo fokusu pozornosti.

Predstavljen izsek je del širše študije doživljanja udejanjanja znanja, v kateri smo z uporabo tehnike drugoosebnega globinskega fenomenološkega raziskovanja [13] zasledili fenomen *srži.* Gre za posebno vrsto doživljanja, ki ga Kordeš in Demšar [14] opišeta kot občutek, da imamo na voljo védenje o določeni stvari oziroma občutenje bistva vsebine. Odgovor še ni jasno opredeljen v zavesti – imamo pa občutek, da je na voljo in da vemo kam je treba usmeriti pozornost, da se vsebina razkrije. Bistvena značilnost srži je, da se nahaja na obrobju zavedanja – kot taka je idealni poskusni zajček za raziskovanje vpliva akta refleksije. Kaj se zgodi, če na ta obrobni fenomen posvetimo z lučjo pozornosti? Odgovor na to vprašanje lahko pomaga pri oceni veljavnosti predpostavk raziskovalnega pristopa globoke konceptualizacije zavesti (ki trdi, da je možno raziskovati tudi fenomene, ki se po svoji naravi nahajajo na predrefleksivni dimenziji zavesti).

2.1. Opis metode

Osnovo drugoosebnega globinskega fenomenološkega raziskovanja predstavljata mikro-fenomenološki intervju, opisan v Petitmengin [10] in metodološki obrat, pri čemer udeleženec postane raziskovalec svojega doživljanja. S tem se njegova vloga spremeni iz udeleženca v soraziskovalca. Bistvena značilnost raziskovanja te vrste je, da udeleženec ni več samo vir informacij, ampak postane dejaven sodelavec v študiji. Metodološki obrat udeleženca v soraziskovalca pa je možen samo, če udeleženca zanima raziskovanje in opazovanje lastnega doživljanja. Globinsko raziskovanje postane zares »globinsko« šele, ko udeleženci vzamejo raziskovalno vprašanje za svoje in se raziskovani tematiki posvetijo. Takrat postanejo soraziskovalci [15].

Raziskava je razdeljena v dve fazi. Prva faza vključuje začetne intervjuje in je primarno namenjena urjenju udeležencev v samoopazovanju lastnega doživljanja. Udeleženci prve faze, ki skozi izvedbo začetnih intervjujev ugotovijo, da jih raziskovalna tema in opazovanje doživljanja zanimata, postanejo aktivni soraziskovalci in preidejo v drugo fazo raziskovanja. Na tej točki so soraziskovalci že dovolj izurjeni v samoopazovanju in lahko začnejo samostojno raziskovati doživljanje fenomena v vsakodnevnem življenju. V drugi fazi se tako začenja razvijati dialog v smislu skupnega participatornega sodelovanja med raziskovalcem in soraziskovalcem [13].

2.2. Poskusna teorija

Osredotočamo se na dobljene doživljajske opise, ki se nanašajo na primere, kjer je soraziskovalec poskušal pri sebi opaziti in opredeliti srž v intervjujih.

2.2.1. Neoprijemljivost srži

Soraziskovalci so poročali o velikih težavah pri poskusih reflektiranja na srž. Pogosto so se pojavljali opisi, da se srž izmika pozornosti, da jo poskus opazovanja ne ujame, ali da izginja s poskusom opazovanja. Tipična poročila soraziskovalcev so bila v obliki občutkov, ki jih niso znali konkretizirati. Soraziskovalec

K01[2] je občutek neoprijemljivosti srži opisal kot: »bolj kot ga skušam opisat, bolj ga ne morem«, »bolj ko ga poskušam najt, bolj mi izginja«. V istem intervjuju je v nadaljevanju poročal, da se doživljanje srži začenja pojavljati, ko srži aktivno ne poskuša iskati in opazovati: »ko pa neham tko na en način to iskat, ko pa doživljam, pa se pojavi«.

2.2.1.1. Opisi srži med udejanjanjem znanja

Nekateri soraziskovalci so poročali tudi o srži znotraj udejanjanja znanja – kako se je občutek, da imajo védenje na voljo, kazal med procesom udejanjanja (pojavljanja znanja v zavesti).

Bistven skupni imenovalec soraziskovalcev, ki so poročali o srži med udejanjanjem znanja, je zaznavanje srži na obrobju, ko je pozornost usmerjena na pojavljanje vsebin v zavesti. Srž se kaže kot občutek še neoprijemljivih možnosti oziroma nejasnih vsebin v ozadju. Pozornost je že na določeni vsebini, obenem pa so soraziskovalci zmožni zaznati srž kot oblak potencialnih novih vsebin, v katere se lahko misli nadaljujejo: »Torej poleg tega, da je bil zvok grmenja, je bil hkrati kokr v ozadju blazno ene vsebine, take neoprijemljive. [...] Kot neke ne zares predstave, ampak možnosti. Gist [srž] možnih predstav, kaj bi ta zvok lahko bil. [...] Takrat je bilo samo kot neko ne zares oprijemljivo ozadje« (F01).

Soraziskovalec F01 je poročal o udejanjeni vsebini, ki je bila v središču zavedanja in občutku prisotnosti srži, ki jo je zaznaval na robu »kot neko ne zares oprijemljivo ozadje«, občutek, da je »v backgroundu [ozadju] že nekaj«. Podobno so drugi soraziskovalci govorili o občutku, »kot da se nek proces dogaja zadaj«.

2.2.1.2. Razpiranje srži v vsebino

Naslednji primer soraziskovalca F01 ilustrira, da z usmeritvijo pozornosti na občutek védenja vsebina začne postajati vedno bolj dostopna. Soraziskovalec obenem nima občutka, da sam aktivno povzroča to razpiranje vsebine, ampak da vsebina sama nastaja, vse, kar je potrebno, je ohranjanje pozornosti:

»Da sam usmerim fokus nanj in potem se mi itak razvije samo od sebe. [...] To razpiranje srži. Ko iz srži nastaja neka vsebina. Kjer v bistvu nimam občutka, kokr da jaz to nekaj razpiram, da jaz povzročam to. Jaz samo držim pozornost na tem in pol se zadeva razvije in pol, ker imam pozornost na tem, vem, kaj to je.«

Prepletanje srži in pojavljanja vsebin (udejanjanja znanja) opiše soraziskovalec F01 v naslednjem primeru:

»Kokr, da začne se samo z eno vsebino, enim vedenjem. In pol se to začne razvijat v neko artikulirano misel. Ampak hkrati, ko se to počas artikulira, ko se iz tega razvijajo neke besede, ki jih nek moj notranji glas izgovarja, je hkrati skoz še ta, ta srž tega, kar prihaja pol.«

Opis sledi poteku udejanjanja, ki se začenja s sržjo in nadaljuje v udejanjanje znanja in njegovo artikulacijo. Srž se v podanem primeru opazi kot občutek možnosti vsebine, ki je lahko zanj na voljo, kot prisotnost nečesa, kar še prihaja. Vsebina, ki je na voljo in se lahko pojavi v zavesti, je zaznana na obrobju kot »srž tega, kar prihaja pol« in lahko preide v središče pozornosti, kjer bo ilustrirana in se bo lahko razvila »v neko artikulirano misel«.

[2] Šifriranje soraziskovalcev jemljemo iz širše študije, kjer je vsak kodiran z določeno črko in zaporedno številko po principu X01.

3. ZNAČILNOSTI OPAZOVANJA OBROBNIH FENOMENOV

Ugotovitve o srži predstavljajo težavo predpostavki, na kateri temeljijo svoja spoznanja raziskovalni pristopi, ki trdijo, da sta raziskovalno dostopni tako predrefleksivna kot refleksivna dimenzija zavesti (tj. globoka konceptualizacija zavesti [6]).

Naši podatki kažejo, da je refleksivna dimenzija zlahka dostopna poročanju, na predrefleksivno pa ima raziskovanje transformirajoč učinek. Srž so soraziskovalci namreč uspeli zaznati, ampak se je razprla v vsebino ali izginila takoj, ko je prešla v fokus pozornosti. Ko so se soraziskovalci pričeli osredotočati na fenomen srži, ga niso bili več zmožni opisati, saj ga je pozornost izničila ali spremenila. Pokazalo se je, da reflektiranje vodi v spreminjanje fenomena – namesto jasnejšega zaznavanja fenomena srži se zgodi razpiranje vsebin v obliki slik, besed itd.

Reflektiranje izbranega izkustva ne omogoča jasne zaznave ali razširitve pozornosti na predrefleksivno dimenzijo, temveč ustvari novo vrsto doživljanja. To vzbuja dvom v konceptualizacijo zavesti, ki jo zagovarja Petitmengin [10, 12], da je možno pozornost preusmeriti na predrefleksivno doživljanje in le-to opazovati nedotaknjeno s strani refleksije.

Najbližje poskusu opisa predrefleksivnega doživljanja smo prišli z opisi »neoprijemljivosti srži«, kamor spadajo poročila soraziskovalcev, ki so srž zaznali, a se je ta izmikala opazovanju. Srž, zaznano v predrefleksivni dimenziji, so soraziskovalci opisali, kot da izginja, ko poskušajo nanjo usmeriti pozornost. Doživljanje srži pa se spet pojavi, ko soraziskovalec preneha vanjo posegati z aktom refleksije.

Opisi srži med udejanjanjem znanja in razpiranjem srži v vsebino kažejo, da ni jasnega prehoda med fenomenom na obrobju in reflektiranjem o tem fenomenu. Nekateri soraziskovalci so uspeli med reflektiranjem in poročanjem o vsebini na obrobju zaznati fenomen srži, a le, ko je bila pozornost osredotočena na drugih vsebinah v zavesti.

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Zemljevid prepričanj – od propozicije do doživljanja

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POVZETEK
V prispevku predstavimo nekaj izsledkov iz še odvijajoče se raziskave doživljanja udejanjanja prepričanj, natančneje iz ustvarjanja t.i. zemljevida prepričanj, ki naj bi služil razjasnitvi pojma prepričanje in s prepričanji povezanih ekoloških situacij, za namene empirične raziskave. Na splošno opredelimo pogled analitične filozofije in ga primerjamo z opisi vsakodnevnih situacij, kot jih soraziskovalci beležijo v dnevnik. Na koncu predstavimo, katera vprašanja o naravi prepričanj in možnosti njihovega empiričnega raziskovanja je zemljevid prepričanj razčistil, in katera ostajajo še odprta.

Ključne besede
prepričanje, doživljanje, propozicija, fenomenologija

1. UVOD
V prispevku predstavimo nekaj izsledkov iz še odvijajoče se raziskave doživljanja udejanjanja prepričanj. Celotna raziskava temelji na predpostavki, da se med pozivom po nekem prepričanju in njegovo manifestacijo odvija vrsta vsebinsko bogatih doživljajskih procesov. Naš raziskovalni cilj je te doživljajske procese raziskati. Na primer, če nas nekdo vpraša (pozove po prepričanju), kaj je voda, se odgovor ne pojavi takoj, temveč se morda najprej izzove spomin na učbenik kemije iz osnovne šole, v katerem piše »voda je tekočina brez vonja in okusa«; ali pa morda predstava kozarca vode in pričakovanje, da ob njenem zaužitju ne bo ne vonja ne okusa. Drug primer: v raziskavi je soraziskovalec[1] poročal o tem, da je poslušal predavanje v angleščini kjer je bil omenjen organ »adrenal gland« (slov. nadledvična žleza). Občutil je radovednost po tem, kje se ta organ v telesu nahaja in hkrati tudi zavedanje, da on to vé, četudi se mu 'odgovor' v tem trenutku ne pojavi v zavesti[2]. Z vztrajnim upiranjem pozornosti v ta občutek se mu je le pojavila predstava trupa in občutek določene lokacije v njem.

Osnovna metodologija, ki jo uporabljamo za raziskovanje je intervju, kjer poskušamo pridobiti iz konkretnih primerov čim bolj natančne doživljajske podatke o procesu manifestacije prepričanj (več o metodologiji v Kordeš in Klauser [1]). Pri načrtovanju raziskave smo se tako soočili z vprašanjem, kakšni morajo biti ti konkretni primeri, oziroma katere vrste prepričanj je za nas najbolj smiselno raziskovati. Hitro je postalo jasno, da vprašanje izbora vrste prepričanj ni le tehničen problem, ampak da kaže na širšo (in morda usodno) nejasnost: kaže nam, da je – pred empiričnim preverjanjem – dobro razčistiti, kaj sploh mislimo s pojmom *prepričanja*. Prvi poskusi določitve nabora ustreznih vrst prepričanj so namreč pokazali na ogromno širino situacij, ki jih lahko povežemo s prisotnostjo prepričanj. Nabor možnih primerov je tako raznolik, da utemeljuje dvom v smiselnost obravnavanja pojma prepričanje kot jasno opredeljenega (kljub vsakodnevnim intuicijam, skozi katere ga navadno vidimo kot neproblematičnega ali celo očitnega).

Pričujoč prispevek predstavlja del našega poskusa odgovoriti na to vprašanje. Poudarjamo, da iščemo odgovor za potrebe fenomenološke raziskave (torej: kaj so prepričanja z vidika empirične fenomenologije in katera od teh so najustreznejša za raziskovanje?) in ne splošnega odgovora, ki bi predstavljal dokončno zamejitev pojma.

2. SPLOŠNA PREDSTAVITEV POGLEDA ANALITIČNE FILOZOFIJE
V zadnjem stoletju je bilo brez dvoma največ povedanega o prepričanjih v sklopu analitične filozofije, zaradi tega smo predvidevali, da bi to področje moralo služiti kot dobra izhodiščna točka za naše iskanje (za raziskovalno delo) uporabne razmejitve pojma.

Schwitzgebel [4] predstavi pregled splošno sprejetih pogledov in glavnih tokov razmišljanja analitične filozofije o prepričanjih, ki jih opredeli kot *propozicionalno naravnanost* – kot to, ko neko propozicijo vzamemo za resnično. Te propozicionalne naravnanosti pa služijo kot vzrok za vedênje. Schwitzgebel opozori, da sam obstoj propozicionalnih naravnanosti kot vzrokov za delovanje ni splošno sprejeto gledišče. Izpostavi, da je polje razmišljanja o prepričanjih zelo široko in se ukvarja z različnimi povezanimi problematikami [4].

Ena od teh je, na primer, vprašanje *reprezentacij*: ali so prepričanja propozicije, ki so na kakšen način reprezentirane v umu; ali bi bilo bolj primerno misliti prepričanja kot samo stanje, da je dana propozicija reprezentirana v umu. Ne glede na to, ali gre za reprezentacije prepričanj, ali prepričanja kot reprezentacije sveta, je vprašanje, v kakšni obliki se te reprezentacije nahajajo v umu. Ali se pojavljajo v obliki notranjega jezika misli, ali gre morda za bolj kompleksne sisteme zemljevidov. Med tem ko se z reprezentacijami in njhovo strukturo ukvarja struja reprezentacionalistov, drugo strujo, dispozicionalisti (in interpretacionalisti), bolj zanimajo vzorci dejanskega in potencialnega vedênja. Ti t.i. dispozicionalisti (in

[1] Izraz soraziskovalec nadomesti sicer uveljavljen izraz udeleženec. Izbiro pojasnjujeta Kordeš in Klauser [1].

[2] Občutek, ki je v tovrstnih doživljajskih procesih tako pogost, da si je zaslužil svoje ime – *srž.* Več o *srži* in nekaterih drugih izsledkih raziskave v Kordeš in Demšar [2], glej tudi Kordeš in Klauser [1] ter Kordeš in Lipič [3] v tej publikaciji.

interpretacionalisti) analizirajo, kakšno vedênje mora oseba izkazovati, da zanjo lahko rečemo, da je prepričana. Nekateri predstavniki – podstruja liberalnih dispozicionalistov – dopušča tudi zasebne mentalne epizode (doživljanje?) kot relevantne za določanje prepričanja [4].

Pojavi pa se tudi vprašanje o tem, ali prepričanja res obstajajo (kot to zanikajo eliminitavisti), in ali so, tudi če ne obstajajo, prepričanja še vedno smiseln (ali celo nepogrešljiv) koncept za razlaganje vedênja [4].

Schwitzgebel [4] predstavi tudi pogosto sprejeto tipifikacijo prepričanj v *pojavne* (angl. occurent) in *dispozicijske* (angl. dispositional). Če se prepričanje le nahaja v spominu ali t.i. »škatlici prepričanj« je to prepričanje dispozicijsko (i.e. subjekt ima dispozicijo ali nagnjenost k temu, da izrazi to prepričanje). Ko pa subjekt prepričanje prikliče iz spomina za uporabo pri načrtovanju, sklepanju ali aktivnemu izjavljanju, pa je to prepričanje pojavno. Schwitzgebel [4] navede primer subjekta Harryja, ki meni, da so kariraste kravate grde. O tem le redko razmišlja, tako da je to prepričanje večino časa dispozicijsko. Ko pa le privre na površino njegovega uma, bi ga označili kot pojavno.

Schwitzgebel [4] izpostavi tudi podobno delitev na *eksplicitna* in *implicitna* prepričanja. Če je dani subjekt eksplicitno prepričan, da P, se v njegovi »škatlici prepričanj« nahaja reprezentacija z vsebino P. Če pa je subjekt prepričan implicitno, tovrstne raprezentacije tam ni, a bi to prepričanje lahko hitro izpeljal iz že obstoječih. Schwitzgebel [4] to ilustrira s primerom števila planetov. Subjekt S sicer ni eksplicitno prepričan, da je planetov manj kot 9, in manj kot 10, in manj kot 11; a ker ima eksplicitno prepričanje, da je planetov 8, lahko hitro izpelje vsa omenjena prepričanja o tem, da je število planetov manjše od katerega koli števila, ki je večje od 8. Ko za dano prepričanje to stori, prav to prepričanje sicer postane eksplicitno, a pred tem ostaja implicitno.

Iz analitične filozofije pridobljeno znanje nam že pomaga zožiti nabor prepričanj, ki bi bila primerna za empirično raziskovanje – dispozicijskih ali implicitnih prepričanj, na primer, ni mogoče direktno preiskati, saj jih naša na ozaveščanju in eksplikaciji doživljanja temelječa metoda takoj spremeni v pojavna ali eksplicitna.

Pojem (propozicionalna) *naravnanost* vsekakor namiguje o doživljajskem fenomenu (naravnanosti do določenega intencionalnega sistema; [5]). Ni pa jasno kakšne vrste doživljanje naj bi takšna naravnanost bila, še manj pa – če je možno v doživljajskem polju opaziti intencionalni sistem ali vsebino propozicije do katerega/katere smo naravnani. Po drugi strani mnogi analitični avtorji podajajo vedênjske primere za svoje razprave o prepričanjih – nekdo vzame s seboj dežnik, ker je prepričan, da bo deževalo. Predhodni izsledki raziskav [1][2] kažejo na to, da eno in isto vedênje lahko spremlja mnogo različnih doživljanj in obratno – kateri vidik je torej relevanten za raziskovanje? Če pri blagajni sežem v žep po denarnici, katero prepričanje se tu manifestira: prepričanje, da imam v žepu denarnico; prepričanje, da je v denarnici denar; prepričanje, da žep in/ali denarnica obstajata; prepričanje, da svet obstaja; prepričanje, da jaz obstajam; prepričanje, da blagajničar od mene pričakuje plačilo;…? Po večini pregledanih razprav sklepamo, da je odgovor: prepričanje, ki ga v opisanem vedênju želi videti avtor opisa.

Z vidika analitične filozofije je očitno pomembna predvsem vsebina propozicije – tisti element torej, ki ga lahko preiskujemo z orodji logike. Zgoraj omenjen govor o t.i. implicitnih prepričanjih, na primer, da vedeti, da ima vsak posameznik nešteto prepričanj (da planetov ni 10, da planetov ni 11 itd.). To pomeni, da so (vsaj implicitna prepričanja) konstrukt logike in ne morejo imeti (ne fizične, ne mentalne) reprezentacije – z vidika empirije jih torej ni. V analitičnih razpravah (e.g. [4], [5]) nismo našli jasnejše nastavke za možno empirično preizpraševanje predstavljenih argumentov in ugotovitev.

Ni tudi povsem jasno, kaj predstavlja enoto prepričanja. Analitična filozofija se najpogosteje sklicuje na eno prepričanje kot povezano z eno propozicijo. A, kot že Schwitzgebel [4] sam izpostavi, se lahko dve propozicionalno izraženo identični prepričanji med seboj razlikujeta v kontekstu spremljajočih prepričanj. Tako Ani kot Sanjay sta, na primer, prepričana, da so lososi ribe. A Ani je poleg tega prepričana, da so tudi kiti ribe, med tem ko je Sanjay prepričan, da kiti niso ribe. Sta prepričanji od Ani in od Sanjaya o tem, da so lososi ribe, potem identični? Mnenja se delijo: zagovorniki holizma bi to zanikali, zagovorniki atomizma pa pritrdili [4].

3. ZEMLJEVID PREPRIČANJ

Ker pregled razprav analitične filozofije ni zadovoljil naše potrebe po razmejitvi prepričanj za raziskovalne namene, smo se odločili sami zgraditi zemljevid situacij, povezanih s prepričanji. Namen je bil preiskati čim več čim bolj ekološko veljavnih tipov primerov situacij, ki jih soraziskovalci povezujejo z obstojem prepričanj. Dobljenemu naboru, ki smo ga kasneje poskušali na različne načine razmejiti, pravimo *zemljevid prepričanj.*

Primere za zemljevid smo začeli zbirati s pomočjo skupine soraziskovalcev – kolegov, ki jim je tema znana in so bili pripravljeni opazovati ter beležiti dogodke iz svojega življenja, za katere sodijo, da govorijo o prisotnosti prepričanja. V zemljevid smo dodali tudi nekatere primere iz tekstov analitične filozofije (predvsem iz Schwitzgebel[4]), za katere sklepamo, da so predstavniki posameznega tipa situacij, povezanih s prepričanji.

Vsak primer smo razdelili v tri komponente: situacijsko, ki opisuje širši kontekst dogajanja in/ali vedênje osebe; fenomenalno, ki opisuje doživljanje osebe; in propozicionalno, ki (skladno s tradicijo analitične filozofije) navede vsebino prepričanja v obliki povedi 'S je prepričan, da P'. Če iz primera katera od komponent ni bila razvidna, je njen razdelek ostal prazen. Vsakemu primeru smo tudi dodelili ime, za lažje kasnejše nanašanje.

Nad zbranimi primeri smo izvedli več kategorizacij in tako izdelali zemljevid z grupiranji opisov situacij, ki kažejo na razne vrste prepričanj. Zemljevid smo razdelili na več podzemljevidov, ki predstavljajo različne kategorizacije primerov, kot na primer na implicitna in eksplicitna prepričanja, na primere z opisano fenomenološko komponento in primere brez. Edina razdelitev, ki skoraj v celoti pokrije ves prostor zbranih primerov je delitev na »občutek, artikulacija, vedênje«, ki jo predstavljamo v nadaljevanju.

Delitev je osnovana na treh deskriptorjih. Vsak deskriptor predstavlja eno možno raziskovalno perspektivo na prepričanja: fenomenalno, verbalno in vedênjsko. Fenomenalni deskriptor *občutek* označuje prisotnost »občutka, da tako je.« Verbalni deskriptor *artikulacija* označuje prisotnost artikulacije prepričanja (v propozicionalni obliki) – »izrekanja, da…«. Vedênjski deskriptor *vedênje* pa označuje prisotnost »vedênja, kot da…« – torej obnašanja, ki namiguje na vpletenost določenega prepričanja[3]. Vsak primer lahko vsebuje od enega do vseh treh deskriptorjev.

Tabela 1. Primer za samo *občutek*:

PRIMER »Bambus«

Vedenjski in kontekstualni opis:	Hodim po cesti in za sekundo pogledam desno v neka drevesa in nato spet drugam.
Fenomenološki opis:	Vidim dve tanjši debli, desno od njiju pa še dve zeleni podolgovati navpični stvari – ena ima vodoravno rumenkasto črto. Ob trenutku kot preblisk védenje, da je to tak debel in visok bambus. Občutek triumfa.
Propozicionalni opis:	

Tabela 2. Primer za samo *artikulacija*:

PRIMER »Robot«

Vedenjski in kontekstualni opis:	Človeku podoben robot ima v sebi shranjeno, v strojnem jeziku, stavek katerega prevod je »kemijska formula za vodo je H2O«. Če ga vprašamo, »iz katerih elementov je sestavljena voda?«, Robot dostopa do omenjenega stavka in ga manipulira tako, da poda odgovor, kot bi ga podal človek.
Fenomenološki opis:	
Propozicionalni opis:	*Robot je prepričan, »da je kemijska formula za vodo H2O.«*

Tabela 3. Primer za samo *vedênje*:

PRIMER »Bakterija«

Vedenjski in kontekstualni opis:	V vodi živeča bakterija ima v svojem telesu magnet, ki se odziva na Zemljino magnetno polje. Na severni polobli magnetni sever kaže navzdol, tako se bakterija, pod vodstvom magneta, giblje navzdol proti globlji vodi in sedimentu, stran od kisika, ki je zanjo škodljiv.
Fenomenološki opis:	
Propozicionalni opis:	*Bakterija je prepričana, »da je v smeri, v katero jo vodi magnet, manj kisika.«*

[3] Zavedamo se, da je strogo gledano artikulacija tudi le oblika vedênja, a akt izrekanja ocenjujemo za pomembno drugačnega od drugih načinov vedênja.

Tabela 4. Primer za *občutek* in *artikulacija*:

PRIMER »Voda«

Vedenjski in kontekstualni opis:	Janeza nekdo vpraša, kaj je voda. Janez odgovori s »tekočina brez vonja in okusa.«
Fenomenološki opis:	Janezu se pojavi vizualna predstava telesa vode, na katerem so valovi – ki ga pa še nikoli ni videl. Skupaj s to predstavo se pojavi splošen občutek o lastnostih vode, od teh se najbolj izpostavijo, nebesedno, »tekoče«, »brez vonja«, »brez okusa«.
Propozicionalni opis:	*Janez je prepričan, »da je voda tekočina brez vonja in okusa.«*

Tabela 5. Primer za *občutek* in *vedênje*:

PRIMER »Deževalo bo«

Vedenjski in kontekstualni opis:	Janez se odpravlja od doma. Na nebu vidi temne oblake. S seboj vzame dežnik.
Fenomenološki opis:	Ko že stopi ven opazi temne oblake in čuti védenje, da bo deževalo. Nameni se vzeti dežnik.
Propozicionalni opis:	*Janez je prepričan, »da bo deževalo.«*

Tabela 6. Primer za *artikulacija* in *vedênje*:

PRIMER »Filozofski zombi«

Vedenjski in kontekstualni opis:	Filozofski zombi je po vedenju identičen navadni osebi, le da ničesar ne doživlja. Tako kot Janez v prejšnjem primeru se zombi od doma odpravlja z dežnikom. Ko ga vprašamo, zakaj s seboj nosi dežnik, odvrne: »ker bo deževalo.«
Fenomenološki opis:	
Propozicionalni opis:	*Filozofski zombi je prepričan, »da bo deževalo.«*

Tabela 7. Primer za vse tri:

PRIMER »Deževalo bo 2«

Vedenjski in kontekstualni opis:	Janez se od doma odpravlja z dežnikom. Ko ga vprašamo, zakaj ga nosi s seboj, odvrne: »ker bo deževalo.«
Fenomenološki opis:	Janez se ob vprašanju spomni na občutek, ki ga je čutil ob pogledu na temne oblake – na védenje, da bo deževalo.
Propozicionalni opis:	*Janez je prepričan, »da bo deževalo.«*

4. ZAKLJUČEK: V KOLIKŠNI MERI PROPOZICIJE RES ODRAŽAJO PREPRIČANJA

V zaključku navajamo nekaj spoznanj, ki nam jih je prinesel razmislek o možnostih empiričnega raziskovanja prepričanj. Lista je razdrobljena in ni popolna – gre bolj za nastavke oziroma smeri za nadaljnjo razpravo.

Prvo presenečenje, ki smo ga opazili po razmejitvi prostora situacij, povezanih s prepričanji je, da so primeri, ki vključujejo propozicionalno komponento skoraj izključno tisti, ki prihajajo iz teoretskih logov analitične filozofije. Izjemno malo ekološko veljavnih primerov (torej tistih, nabranih iz dnevniških zapiskov soraziskovalcev) ima jasno definirano propozicionalno vsebino. Fenomenalna komponenta tovrstnih primerov največkrat ne vključuje artikuliranih propozicij (e.g. PRIMER »Bambus«). Propozicionalni opis prepričanja bi lahko bil venomer podan šele post hoc in arbitrarno – v skladu s pričakovanji in razumevanjem interpreta.

Zanimivo vprašanje povezano z ugotovitvijo, da ne iz vedênja, ne iz doživljanja, ne moremo enoznačno sklepati na propozicionalno vrednost prepričanja je: kakšno vrednost ima razprava o propozicijah za empirična razmišljanja o duševnosti? Sestavljanje zemljevida prepričanj je pokazalo na izziv fenomenološkega aspekta tovrstnih fenomenov (in morda s tem pojasnilo izogibanje tej temi v analitični filozofiji) – fenomenologija drže (angl. *attitude*), še bolj pa fenomenologija tistega, na kar se drža nanaša (torej propozicije), odpira zelo zapletena vprašanja. Kako se lotiti raziskovanja doživljanja fenomena, ki ga bistveno (izključno?) določa vsebina (oz. propozicionalna vrednost) ni jasno. Kljub temu ocenjujemo, da se odgovor skriva v natančni empirični preiskavi.

Kako nam lahko pomaga dobljeni zemljevid pri nadaljnjem raziskovanju doživljajskih procesov, povezanih z manifestacijo prepričanj? Vsekakor smo jasno razmejili področja, ki niso dosegljiva našim raziskavam (npr. celotno področje z vedênjem določenih situacij). Ostajata še področji artikuliranih prepričanj in tistih situacij, ki jih opredeljuje doživljajski občutek, »da tako je« (oz. – z besedami analitične filozofije – propozicionalna naravnanost).

Pomembno je opaziti, da med tema področjema ni popolnega prekrivanja. Ne le, da mnogokrat propozicionalna naravnanost ni artikulirana (ampak je prisoten le občutek takšnosti); še bolj zanimivo je neujemanje v nasprotno smer: velikokrat je enaka artikulacija pospremljena z različnimi doživljajskimi vsebinami. Vrnimo na primer odgovarjanja na vprašanje »kaj je voda?«, kjer smo predstavili dva možna doživljajska procesa, ki lahko spremljata manifestacijo odgovora »tekočina brez vonja in okusa.« Recimo, da Janez doživlja predstavo kozarca vode in pričakovanje, da ob njenem zaužitju ne bo ne vonja ne okusa; in Jože doživlja spomin na učbenik kemije iz osnovne šole, v katerem piše »voda je tekočina brez vonja in okusa.«

Pripisovanje enake propozicionalne vrednosti obema primeroma (»voda je tekočina brez vonja in okusa«) bi bilo najverjetneje napačno. Če bi že morali pripisati propozicionalno vrednost (zavedajmo se, kako arbitrarno je to dejanje), bi bili dejanskemu stanju še najbližje naslednji propoziciji:

1) Janez je prepričan, da je voda tekočina brez vonja in okusa.

2) Jože je prepričan, da je ustrezen odgovor na vprašanje »kaj je voda?« zapisan v učbeniku kemije iz osnovne šole in se glasi »voda je tekočina brez vonja in okusa.«

V obeh primerih je možno govoriti o propozicionalni naravnanosti. Razlika je, da je prva naravnana na stališče do narave elementa sveta. Druga pa na stališče o izjavi avtoritete (v takšni ali drugačni obliki).

Takšna analiza odpre nova vprašanja, nekatera zelo praktična in povezana z vsakodnevnim življenjem. Na primer vprašanje o naravi in možnostih preverjanja znanja (imajo res vsi, ki opravijo test z enakim rezultatom, enako znanje – oziroma bolje: enako vrsto znanja?).

5. VIRI

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Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek C

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume C

Odkrivanje znanja in podatkovna skladišča - SiKDD
Data Mining and Data Warehouses - SiKDD

Uredila / Edited by

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http://is.ijs.si

11. oktober 2018 / 11 October 2018
Ljubljana, Slovenia

PREDGOVOR

Tehnologije, ki se ukvarjajo s podatki so v devetdesetih letih močno napredovale. Iz prve faze, kjer je šlo predvsem za shranjevanje podatkov in kako do njih učinkovito dostopati, se je razvila industrija za izdelavo orodij za delo s podatkovnimi bazami, prišlo je do standardizacije procesov, povpraševalnih jezikov itd. Ko shranjevanje podatkov ni bil več poseben problem, se je pojavila potreba po bolj urejenih podatkovnih bazah, ki bi služile ne le transakcijskem procesiranju ampak tudi analitskim vpogledom v podatke – pojavilo se je t.i. skladiščenje podatkov (data warehousing), ki je postalo standarden del informacijskih sistemov v podjetjih. Paradigma OLAP (On-Line-Analytical-Processing) zahteva od uporabnika, da še vedno sam postavlja sistemu vprašanja in dobiva nanje odgovore in na vizualen način preverja in išče izstopajoče situacije. Ker seveda to ni vedno mogoče, se je pojavila potreba po avtomatski analizi podatkov oz. z drugimi besedami to, da sistem sam pove, kaj bi utegnilo biti zanimivo za uporabnika – to prinašajo tehnike odkrivanja znanja v podatkih (data mining), ki iz obstoječih podatkov skušajo pridobiti novo znanje in tako uporabniku nudijo novo razumevanje dogajanj zajetih v podatkih. Slovenska KDD konferenca pokriva vsebine, ki se ukvarjajo z analizo podatkov in odkrivanjem znanja v podatkih: pristope, orodja, probleme in rešitve.

INTRODUCTION

Data driven technologies have significantly progressed after mid 90’s. The first phases were mainly focused on storing and efficiently accessing the data, resulted in the development of industry tools for managing large databases, related standards, supporting querying languages, etc. After the initial period, when the data storage was not a primary problem anymore, the development progressed towards analytical functionalities on how to extract added value from the data; i.e., databases started supporting not only transactions but also analytical processing of the data. At this point, data warehousing with On-Line-Analytical-Processing entered as a usual part of a company’s information system portfolio, requiring from the user to set well defined questions about the aggregated views to the data. Data Mining is a technology developed after year 2000, offering automatic data analysis trying to obtain new discoveries from the existing data and enabling a user new insights in the data. In this respect, the Slovenian KDD conference (SiKDD) covers a broad area including Statistical Data Analysis, Data, Text and Multimedia Mining, Semantic Technologies, Link Detection and Link Analysis, Social Network Analysis, Data Warehouses.

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Preparing multi-modal data for natural language processing

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ABSTRACT

In education we can find millions of video, audio and text educational materials in different formats and languages. This variety and multimodality can impose difficulty on both students and teachers since it is hard to find the right materials that match their learning preferences. This paper presents an approach for retrieving and recommending items of different modalities. The main focus is on the retrieving and preprocessing pipeline, while the recommendation engine is based on the *k*-nearest neighbor method. We focus on educational materials, which can be text, audio or video, but the proposed procedure can be generalized on any type of multi-modal data.

KEYWORDS

Multi-modal data preprocessing, machine learning, feature extraction, recommender system, open educational resources

ACM Reference Format:

Erik Novak, Jasna Urbančič, and Miha Jenko. 2018. Preparing multi-modal data for natural language processing. In *Proceedings of Slovenian KDD Conference (SiKDD'18).* ACM, New York, NY, USA, Article 4, 4 pages. https://doi.org/10.475/123_4

1 INTRODUCTION

There are millions of educational materials that are found in different formats – courses, video lectures, podcasts, simple text documents, etc. Because of its vast variety and multimodality it is difficult for both students and teachers to find the right materials that will match their learning preferences. Some like to read a short scientific papers while others just like to sit back and watch a lecture that can last for hours. Additionally, materials are written in different languages, which is a barrier for people who are not fluent in the language the material is written in. Finding a good approach of providing educational material would help improving their learning experience.

In this paper we present a preprocessing pipeline which is able to process multi-modal data and input it in a common semantic space. The semantic space is based on Wikipedia concepts extracted from the content of the materials. Additionally, we developed a content based recommendation model which uses Wikipedia concepts to find similar items based on the model input. Throughout the paper we focus on educational material but the approach can be generalized to other multi-modal data sets.

The reminder of the paper is structured as follows. In section 2 we go over related work. Next, we present the data preprocessing pipeline which is able to process different types of data – text, video and audio – and describe each component of the pipeline in section 3. A content based recommendation model that uses Wikipedia concepts to compare materials is presented in section 4. Finally, we present future work and conclude the paper in section 5.

2 RELATED WORK

In this section we present the related work which the rest of the paper is based on. We split this section into subsections – multi-modal data preprocessing and recommendation models.

Multi-modal Data Preprocessing. Multi-modal data can be seen as classes of different data types from which we can extract similar features. In the case of educational material the classes are video, audio and text. One of the approaches is to extract text from all class types. In [6] the authors describe a Machine Learning and Language Processing automatic speech recognition system that can convert audio to text in the form of transcripts. The system can also process video files as they are also able to extract audio from it. Their model was able to achieve a 13.3% word error rate on an English test set. These kind of systems are useful for extracting text from audio and video but would need to have a model for each language.

Recommendation models. These models are broadly used in many fields – from recommending videos based on what the user viewed in the past, to providing news articles that the user might be interested in. One of the most used approaches is based on collaborative filtering [16], which finds users that have similar preferences with the target user and recommends items based on their ratings. Recommender systems now do not contain only one algorithm but multiple which return different recommendations.

Authors of [10] discuss about the various algorithms that are used in the Netflix recommender system (top-*n* video ranker, trending now, continue watching, and video-video similarity), as well as the methods they use to evaluate their system. A high level description of the Youtube recommender system is found in [3]. They developed a candidate generation model and a ranking model using deep learning. Both Netflix and Youtube recommend videos based on users' interaction with them and the users history. To some extent this can be used for educational resources but cannot be generalized on the whole multi-modal data set since we cannot acquire data about users' interaction with, for instance, text.

SiKDD'18, October 2018, Ljubljana, Slovenia

ACM ISBN 123-4567-24-567/08/06.
https://doi.org/10.475/123_4

A collaborative filtering based recommendation system for the educational sector is presented in [8]. They evaluated educational content using big data analysis techniques and recommended courses to students by using their grades obtained in other subjects. This gives us insight into how recommendations can be used in education but our focus is to recommend educational materials rather than courses. In a sense courses can be viewed as bundles of educational material; thus, our interest is recommending "parts of courses" to the user.

3 DATA PREPROCESSING

In this paper we focus on open educational resources (OER), which are freely accessible, openly licensed text, media, and other digital assets that are useful for teaching, learning and assessing [21]. These are found in different OER repositories maintained by universities, such as MIT OpenCourseWare [12], Università di Bologna [7], Université de Nantes [4] and Universitat Politècnica de València [5], as well as independent repositories such as Videolectures.NET [20], a United Nations award-winning free and open access educational video lectures repository.

For processing the different OER we developed a preprocessing pipeline that can handle each resource type and output metadata used for comparing text, audio and video materials. The pipeline is an extension of the one described in [11]; its architecture is shown in figure 1. What follows are the descriptions of each component in the preprocessing pipeline.

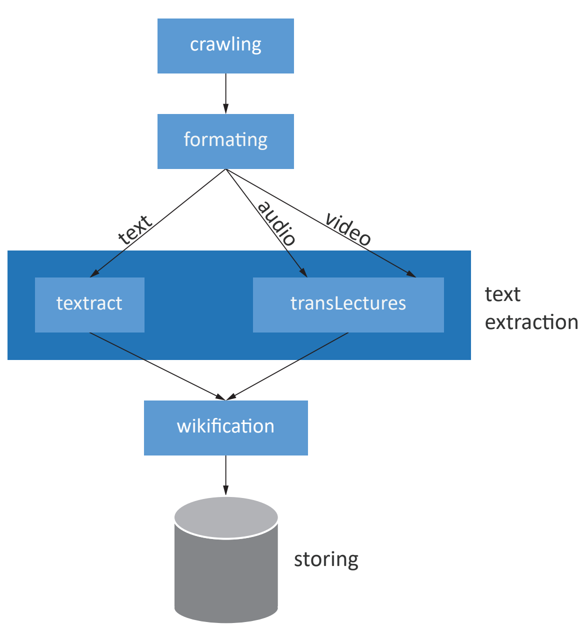

Figure 1: The preprocessing pipeline architecture. It is designed to handle each data type as well as extract features to support multi- and cross-linguality.

Crawling. The first step is to acquire the educational materials. We have targeted four different OER repositories (MIT OpenCourseWare, Università di Bologna, Université de Nantes and Videolectures.NET), for which we used their designated APIs or developed custom crawlers to acquire their resources. For each material we acquired its metadata, such as the materials title, url, type, language in which it is written and its provider. These values are used in the following steps of the pipeline as well as to represent the material in the recommendations.

Formatting. Next, we format the acquired material metadata. We designate which attributes every material needs to have as well as set placeholders for the features extracted in the following steps of the pipeline. By formatting the data we set a schema which makes checking which attributes are missing easy. We do not have a mechanism for handling missing attributes in the current pipeline iteration but we will dedicate time to solve this problem in the future.

Text Extraction. The third step, we extract the content of each material in text form. Since the material can be a text, video or audio file to handled each file type separately.

For text we employed *textract* [1] to extract raw text from the given text documents. The module omits figures and returns the content as text. The extracted text is not perfect - in the case of materials for mathematics it does not know how to represent mathematical equations and symbols. In that case, it replaces the equations with textual noise. Currently we do nothing to handle this problem and use the output as is.

For video and audio we use the subtitles and/or transcriptions to represent the materials content. To do this, we use *transLectures* [18] which generates transcriptions and translations of a given video and audio. The languages it supports are English, Spanish, German and Slovene. The output of the service is in dfxp format [17], a standard for xml caption and subtitles based on timed text markup language, from which we extract the raw text.

Wikification. Next, we send the material through wikification - a process which identifies and links material textual components to the corresponding Wikipedia pages [15]. This is done using Wikifier [2], which returns a list of Wikipedia concepts that are most likely related to the textual input. The web service also supports cross- and multi-linguality which enables extracting and annotating materials in different languages.

Wikifier's input text is limited to 20k characters, because of which longer text cannot be processed as a whole. We split longer text into chunks of at most 10k characters and pass them to Wikifier. Here we are careful not to split the text in the middle of a sentence and if that is not possible, to at least not split any words.

We split the text as follows. First we make a 10k characters long substring of the text. Next, we identify the last character in the substring that signifies the end of a sentence (a period, a question mark, or an exclamation point) and split it at that character. If there is no such character we find the last whitespace in the substring and split it there. In the extreme case where no whitespaces are found we take the substring as is. The substring becomes one chunk of the original text. We repeat the process on the remaining text until it is fully split into chunks.

When we pass these chunks into Wikifier, it returns Wikipedia concepts related to the given chunk. These concepts also contains the Cosine similarity between the Wikipedia concept page and the given input text. To calculate the similarity between the concept and the whole material we aggregated the concepts by calculating the weighted sum

$$S_k = \sum_{i=1}^{n} \frac{L_i}{L} s_{ki},$$

where S_k is the aggregated Cosine similarity of concept k, n is the number of chunks for which Wikifier returned concept k, L_i is the length of chunk i, L is the length of the materials raw text, and s_{ki} is the Cosine similarity of concept k to chunk i. The weight $\frac{L_i}{L}$ represents the presence of concept k, found in chunk i, in the whole material. The aggregated Wikipedia concepts are stored in the materials metadata attribute.

Data Set Statistics. In the final step, we validate the material attributes and store it in a database. The OER material data set consists of approximately 90k items. The distribution of materials over the four repositories is shown in figure 2.

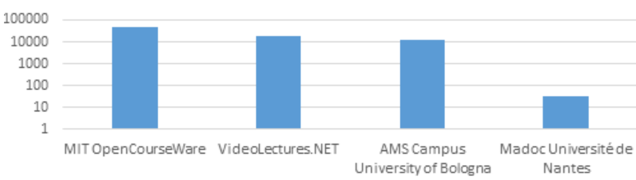

Figure 2: Number of materials per repository crawled in logarithm scale. Most materials come from MIT OpenCourseWare followed by Videolectures.NET.

Some of the repositories offer material in different languages. All repositories together cover 103 languages, however for only 8 languages the count of available materials is larger than 100. The distribution of items over languages is shown in figure 3 where we only show languages with more than 100 items available. Most of the materials is in English, followed by Italian and Slovene. The "Unknown" column shows that for about 6k materials we were not able to extract the language. To acquire this information, we will improve the language extraction method in our preprocessing pipeline.

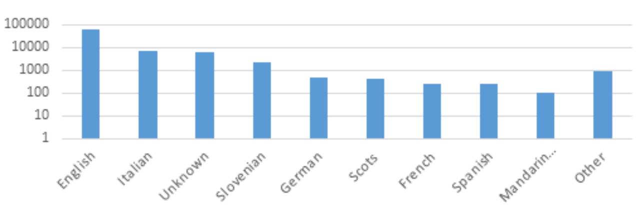

Figure 3: Number of materials per language in logarithm scale. Most of the material is in English, followed by Italian and Slovenian.

As shown in before the preprocessing pipeline is designed to handle different types of material - text, video and audio. Each type can be represented in various file formats, such as pdf and docx for text, wmv and mp4 for video, and mp3 for audio. We visualized the distribution of materials over file types in figure 4, but we only show types with more than 100 items available.

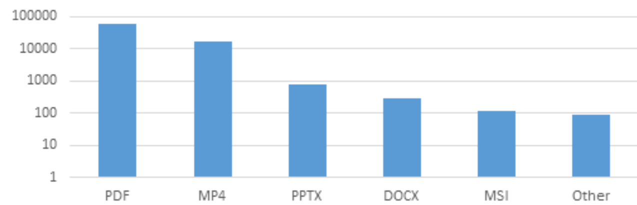

Figure 4: Number of items per file type in logarithm scale. The dominant file type is text (pdf, pptx and docx), followed by video (mp4).

As seen from the figure, the dominant file type is text (pdf, pptx and docx) followed by video (mp4). The msi file type is an installer package file format used by Windows but it can also be a textual document or a presentation. If we generalize the file type distribution over all OER repositories we can conclude that the dominant file type is text. This will be taken into count when improving the preprocessing pipeline and recommendation engine.

4 RECOMMENDER ENGINE

There are different ways of creating recommendations. Some employ users' interests while other are based on collaborative filtering. In this section we present our content based recommendation engine which uses the k-nearest neighbor algorithm [13]. What follows are descriptions of how the model generates recommendations based on the user's input, which can be either the identifier of the OER in the database or a query text.

Material identifier. When the engine receives the material identifier (in our case the url of the material) we first check if the material is in our database. If present, we search for k most similar materials to the one with the given identifier based on the Wikipedia concepts. Each material is represented by a vector of its Wikipedia concepts where each value is the aggregated Cosine similarity of the corresponding Wikipedia concept page to the material. By calculating the Cosine similarity between the materials the engine then selects k materials with the highest similarity score and returns them to the user. Because of the nature of Wikipedia concepts this approach returns materials written in different languages - which helps overcoming the language barrier.

Query text. When the engine receives the query text we search for materials with the most similar raw text using the bag-of-words model. Each material is represented as a bag-of-words vector where each value of the vector is the tf-idf of the corresponding word. The materials are then compared using the Cosine similarity and the engine again returns the k materials that have the highest similarity score. This approach is simple but it is unable to handle multilingual documents. This might be overcome by first sending the query text to Wikifier to get its associated Wikipedia concepts and use them in a similar way as described in the *Material identifier* approach.

4.1 Recommendation Results

The described recommender engine is developed using the QMiner platform [9] and is available at [14]. When the user inputs a text query the system returns recommendations similar to the given text. These are shown as a list where each item contains the title, url, description, provider, language and type of the material. Clicking on an item redirects the user to the selected OER.

We have also discussed with different OER repository owners and found that they would be interested in having the recommendations in their portal. To this end, we have developed a compact recommendation list which can be embedded in a website. The recommendations are generated by providing the material identifier or raw text as query parameters in the embedding url. Figure 5 shows the embed-ready recommendation list.

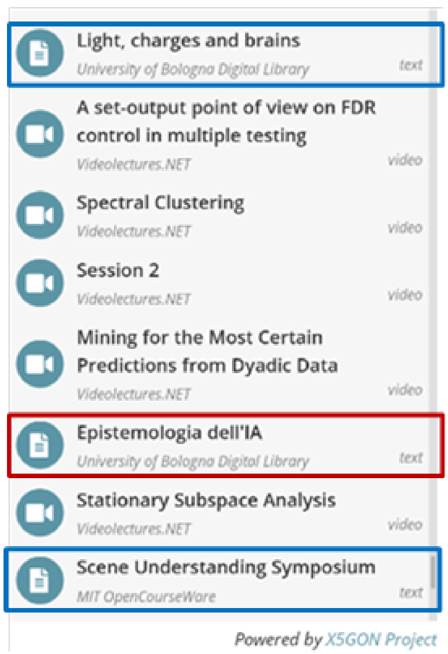

Figure 5: An example of recommended materials for the lecture with the title "Is Deep Learning the New 42?" published on Videolectures.NET [19]. The figure shows cross-lingual, cross-modal, and cross-site recommendations.

The recommendation list consists of the top 100 materials based on the query input. As shown in the figure the recommendation contain materials of different types, are provided by different repositories and written in different languages. We have not yet evaluated the recommendation engine but we intend to do it in the future.

5 FUTURE WORK AND CONCLUSION

In this paper we present the methodology for processing multimodal items and creating a semantic space in which we can compare these items. We acquired a moderately large open educational resources data set, created a semantic space with the use of Wikipedia concepts and developed a basic content based recommendation engine.

In the future we will evaluate the current recommendation engine and use it to compare it with other state-of-the-art. We intend to use A/B testing to optimize the models based on the user's interaction with them. We wish to improve the engine by collecting user activity data to determine what materials are liked by the users, explore different deep learning methods to improve results, and develop new representations and embeddings of the materials.

We also aim to improve the preprocessing pipeline by improving text extraction methods, handle missing material attributes, and adding new feature extraction methods to determine the topic and scientific field of the educational material as well as their quality.

ACKNOWLEDGMENTS

This work was supported by the Slovenian Research Agency and X5GON European Unions Horizon 2020 project under grant agreement No 761758.

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TOWARDS SMART STATISTICS IN LABOUR MARKET DOMAIN

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ABSTRACT

In this paper, we present a proposal for developing smart labour market statistics based on streams of enriched textual data and illustrate its application on job vacancies from European countries. We define smart statistics scenarios including demand analysis scenario, skills ontology development scenario and skills ontology evolution scenario. We identify stakeholders – consumers for smart statistics and define the initial set of smart labour market statistical indicators.

KEYWORDS

Smart statistics, labour market, demand analysis.

1. INTRODUCTION

An essential feature of modern economy is the appearance of new skills, such as digital skills. For instance, e-skills lead to the exponential increases in production and consumption of data.

While job profiles vary and are still in the process of being defined, organizations agree that they need the new breed of workers.

Accordingly, the European institutions take major initiatives related to digitalization of labor market, training of new skills and meeting the labour demand.

Historically, the labour market statisticians use standard measures of the labour demand and labour supply based on traditional surveys – job vacancy surveys, wage survey, labour force surveys. The unemployment rate provides information on the supply of persons looking for work in excess of those who are currently employed. Data on employment provide information on the demand for workers that is already met by employers.

The data-driven smart labour market statistics intends to:

- use the available historical job vacancies data,
- use the available real-time job vacancies data,
- use the available real-time and historical dataset of additional data (described below),
- align data sources,
- construct models and obtain novel smart labour market indicators that will complement existing labour market statistics,
- provide a system for delivering results to the users.

The smart labour market statistics approach will combine advanced data processing, modelling and visualization methods in order to develop trusted techniques for job vacancies analysis with respect to defined scenarios – demand analysis, skills ontology development and skills ontology evolution.

2. BACKGROUND

The development of smart labour market statistics touches a number of issues from labour market policies area and would provide contributions to questions related to:

- job creation,
- education and training systems,
- labour market segmentation,
- improving skill supply and productivity.

For instance, the analysis of the available job vacancies could offer an insight into what skills are required in the particular area. Effective trainings based on skills demand could be organized and that would lead into better labour market integration.

A number of stakeholder types will benefit from the development of smart labour market statistics. In particular, the targeted stakeholders are:

- Statisticians from National and European statistical offices who are interested in the application of new technologies for production of the official statistics.
- Individual persons who are searching for new employment opportunities. In particular, individuals are interested in the job vacancies that are compatible with their current skills and in the methods (like trainings) providing the possibilities to obtain new skills in demand.
- Public and private employment agencies interested in up-to-date employees profiles.
- Education and training institutions from different levels and forms of education - general/vocational education, higher education, public/private, initial/ adult education. Educational institutions are interested in relevant skills and topics that should be part of the curriculum programs.
- Ministries of labour/manpower, economy/industry/trade, education, finance, etc. The policy makers, such as ministries, are interested in the overall labour market situation, with respect to location and time, in the labour market segmentation and in the processes of improving supply and productivity.
- Standards development organizations. National or International organizations whose primary activities are developing, coordinating, promulgating, revising, amending, reissuing, interpreting, or otherwise producing technical standards that are intended to address the needs of some

relatively wide base of affected adopters. Interested in new technologies developed in relation to labour market.

- Academic and research institutes. Public and private entities who conduct research in relevant areas. Research institutions are interested in the development of novel methodologies and usage of appearing new data sources.

3. RELATED WORK

The European Data Science Academy (EDSA) [1] was an H2020 EU project that ran between February 2015 and January 2018. The objective of the EDSA project was to deliver the learning tools that are crucially needed to close the skill gap in Data Science in the EU. The EDSA project has developed a virtuous learning production cycle for Data Science, and has:

- Analyzed the sector specific skillsets for data analysts across Europe with results reflected at EDSA demand and supply dashboard;
- Developed modular and adaptable curricula to meet these data science needs; and
- Delivered training supported by multiplatform resources, introducing Learning pathway mechanism that enables effective online training.

EDSA project established a pipeline for job vacancy collecting and analysis that will be reused for the purpose of smart statistics.

An ontology called SARO (Skills and Recruitment Ontology) [2] has been developed to capture important terms and relationships to facilitate the skills analysis. SARO ontology concepts included relevant classes to job vacancy datasets, such as Skill and JobPosting. Examples of instances of class Skill would be skills, such as “Data analysis”, “Java programming language” et al.

ESCO [3] is the multilingual classification of European Skills, Competences, Qualifications and Occupations. It identifies and categorizes skills/competences, qualifications and occupations relevant for the EU labour market and education and training, in 25 European languages. The system provides occupational profiles showing the relationships between occupations, skills/competences and qualifications. For instance, one example of existing ESCO skill is “JavaScript” (with alternative labels “Client-side JavaScript”, "JavaScript 1.7" et al.).

Both SARO and ESCO ontologies are useful for the aim of smart statistics, in particular for skills ontology development and skills ontology evolution scenarios. However, the ontologies usually are manually manipulated, and the methods developed for smart labour market statistics should overcome the difficulties related to this issue. The ontology evolution scenario of smart labour market statistics envisions automatic identification of emerging and decreasing skills from the data perspective.

4. PROBLEM DEFINITION

4.1 DATA SOURCES

The main data sources available for the development of smart labour market statistics are historical and current data about job vacancies in the area of digital technologies and data science around Europe (~5.000.000 job vacancies 2015-2018).

Additional data sources may include:

- Social media data, such as news, Twitter data that might be relevant for labour market.

- Labour supply data (based on user profile analysis).

Open job vacancies can be found using job search services. These services aggregate job vacancies by location, sector, applicant qualifications and skill set or type. One such service is Adzuna [4], a search engine for job ads, which mostly covers English-speaking countries.

For data acquisition and enrichment, dedicated APIs, including Adzuna API, are used, as well as custom web crawlers are developed. The data is formatted to JSON to aid further processing and enrichment. The job vacancy dataset is obtained with respect to trust and privacy regulations, the personal data is not collected.

Job vacancies usually contain the information, such as job position title, job description, company and job location. In such way, job vacations that are constantly crawled/web-scraped present a data stream. The job title and job description are textual data that contain information about skills that employee should have.

On the obtained data wikification - identifying and linking textual components (including skills) to the corresponding Wikipedia pages [5] is performed. This is done using Wikifier [6], which also supports cross and multi-linguality enabling extraction and annotation of relevant information from job vacancies in different languages. The data is tagged with concepts from GeoNames ontology [7]. To job postings where latitude and longitude have been available, GeoNames location uri and location name are added. To the postings where only location name has been available, the coordinates and location uri are added.

The job vacancy data representation level depends on the specific country. For the United Kingdom, France, Germany and the Netherlands there is a substantial collection of job vacancies in the area of digital technologies.

4.2 CONCEPTUAL ARCHITECTURE

The labour market statistics conceptual structure is built upon the following major blocks:

1. Data sources related to different aspects of smart labour market. The main data source aggregates historical and current job vacancies in the area of digital technologies and data science around Europe.

2. Modelling smart labour market statistics takes central part of the smart labour market statistics approach, where the goal is to construct models based on different data sources, updated in business-real-time (as needed or as data sources allow). Models shall bring understanding of the smart labour market statistics domain and shall be used for aggregation, ontology development and ontology evolution.

3. Targeted users are smart statistics consumers. There are several major groups of users (described above). The example users might include statisticians, policy makers, individual users (residents and non-residents), training and educational organizations and other.

4. Finally, applications of smart labour market statistics are multiscale - they can be presented at cross-country level (around

Europe) country level (UK, France, the Netherlands etc.), city/area level and conceptual level (ontology).

Figure 1 illustrates the conceptual architecture diagram for smart labour market statistics.

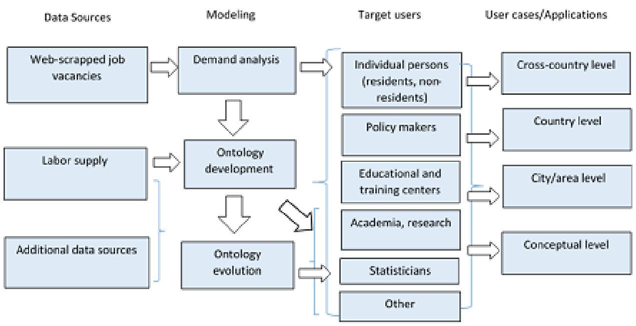

Figure 1: Conceptual Architecture

The key characteristics of the development techniques will include:

- Interpretability and transparency of the models – the aim is, for a model to be able to explain its decision in a human readable manner (vs. black box models, which provide results without explanation).

- Non-stationary modelling techniques are required due to changing data and its statistical properties in time. For instance, the ontology evolution process will be modeled taking to the account the incremental data arriving to the system.

- Multi-resolution nature of the models, having the property to observe the structure of a model on multiple levels of granularity, depending on the application needs.

- Scalability for building models is required due to the nature of incoming data streams.

4.3 SCENARIOS

The smart labour market statistics proposal includes three scenarios - demand analysis scenario, ontology development scenario and ontology evolution scenario described below.

4.3.1 DEMAND ANALYSIS

Demand analysis scenario suggests production of statistical indicators based on the available job vacancies using techniques for data preprocessing, semantic annotation, cross-linguality, location identification and aggregation.

Job vacancies in structural and semi-structural form are the input to into the system, while statistics related to overall job demand, job demand with respect to particular location, job demand with respect to particular skill (skill demand) and time frame are the outputs of the system.

Figure 2 presents an example of crawled and processed job vacancies.

4.3.2 SKILLS ONTOLOGY DEVELOPMENT

Ontologies reduce the amount of information overload in the working process by encoding the structure of a specific domain and offering easier access to the information for the users. Gruber [8] states that an ontology defines (specifies) the concepts, relationships, and other distinctions that are relevant for modeling a domain. The specification takes the form of the definitions of representational vocabulary (classes, relations, and so forth), which provide meanings for the vocabulary and formal constraints on its coherent use.

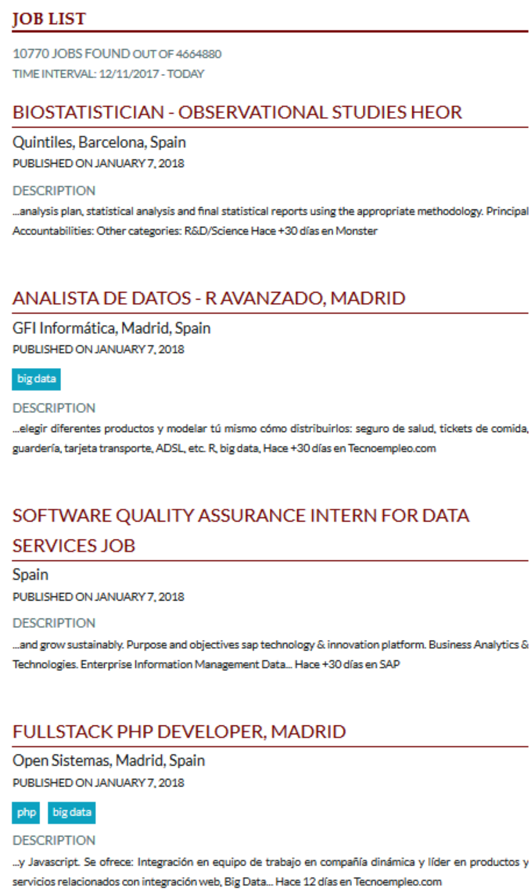

Figure 2: Example of Job Vacancies Crawled and Processed

Ontologies are often manually developed and maintained, what requires a sufficient user efforts.

In the ontology development scenario an automatic (or semi-automatic) bottom-up process of creating ontology from available job vacancies will be suggested.

The relevant skills (extracted from the job vacancies) will be defined and formalized. Using semantic annotation and cross-linguality techniques for skills extraction based on JSI Wikifier tool [6] will enable the possibility of including the newest available skills “on the market” that are not yet captured in the ontologies, taxonomies and classifications that are manually developed. The input to the ontology development scenario is a set of job vacancies and the output is ontology of skills presenting the domain structure that can be compared to or used for official classifications.

4.3.3 SKILLS ONTOLOGY EVOLUTION

Ontology Evolution is the timely adaptation of an ontology to the arisen changes and the consistent propagation of these changes to dependent artefacts [9]. Ontology evolution is a process that combines a set of technical and managerial activities and ensures that the ontology continues to meet organizational objectives and users' needs in an efficient and effective way.

Ontology management is the whole set of methods and techniques that is necessary to efficiently use multiple variants of ontologies from possibly different sources for different tasks [10].

Scenario 3 will suggest an automatic (or semi-automatic) ontology evolution process based on the real-time job vacancy stream. With respect to the nature of job vacancy data stream and skills extracted from job it will be possible to see the dynamics of evolving skills – when the new skills (not included into the current ontology versions appear) and how the skills ontology is changing with time.

In particular, it could be possible to observe appearing new skills and suggest them for inclusion into official skills classifications. In addition, it could be visible how fast the ontology changes, which could be the indicator of the technological progress on the relevant market.

For instance, the current version of ESCO classification does not contain "TensorFlow" skill (TensorFlow [11] is an open-source software library for dataflow programming across a range of tasks, appeared in 2015). TensorFlow, which is already present in job vacancies, could be captured during ontology evolution process and suggested as a new concept for official classifications.

5. STATISTICAL INDICATORS

Traditionally the indicators related to labour market have been based on survey responses. The smart labour market statistics proposal introduces a possibility to complement standard statistical indicators, such as job vacancy rate with novel "data inspired" knowledge.

The smart labour market statistics indicators use data sources, previously not covered by official statistics, and in such way complementary to traditional data sources. The smart labour market statistics indicators are based on real-time data streams, which makes possible to obtain not only historical, but also current values for job vacancies that could be used for different purposes, such as nowcasting. In addition, the smart labour market statistics indicators take into the account data cross-lingual and multi-lingual nature of streaming data and can be produced at the multiscale levels – cross-country, country, city (area) levels.

The scenarios described above would result into a number of smart labour market indicators with multiscale options. In particular:

- Up-to date job vacancies statistics on a cross-country/country/city(area) level. Example: job vacancies in UK and France in the last month
- Up-to date skills statistics on a cross-country/country/city(area) level. Example: top 10 skills in UK in the last month
- Up-to date location statistics. Example: top locations for specific skill
- Ontology development statistics. Example: number of concepts in the ontology
- Ontology evolution statistics. Example: emerging skills in the ontology in the last 3 months

Since the data has a streaming nature, different kinds of multiscale and aggregation options can be handled with respect to time parameters.

6. CONCLUSION AND FUTURE WORK

In this paper, we presented a proposal for developing smart labour market statistics based on streams of enriched textual data, such as job vacancies from European countries. We define smart statistics scenarios, such as demand analysis scenario, skills ontology development scenario and skills ontology evolution scenario. The future work would include the implementation of the smart labour market scenarios, quality assessment and evaluation of the produced statistical outcomes.

7. ACKNOWLEDGMENTS

This work was supported by the Slovenian Research Agency and EDSA European Union Horizon 2020 project under grant agreement No 64393.

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Relation Tracker - tracking the main entities and their relations through time

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ABSTRACT
In this paper, we present Relation Tracker, a tool that tracks main entities [people and organizations] within each topic through time. The main types of relations between the entities are detected and observed in time. The tool provides multiple ways of visualizing this information with different scales and durations. The tool uses events data from Event Registry as a source of information, with the aim of getting holistic insights about the searched topic.

KEYWORDS
Information Retrieval, Visualization, Event Registry, Wikifier, Dmoz Taxonomy

1. INTRODUCTION
Every day, tremendous amounts of news and information are being streamed throughout the Internet, which is requiring the implementation of more tools to aggregate this information. With technology advancement, those tools have been increasing in complexity and options provided. However, there has been a demand for tools that give simple yet holistic summary of the searched topic in order to acquire general insights about it.

Hence, we provide the Relation Tracker tool that tries to achieve this goal; it is based on the data from Event Registry [1], which is a system for real-time collection, annotation and analysis of content published by global news outlets. The tool presented in this paper takes the events and groups them into topics, and within each topic, it provides an interactive graph that shows the main entities of each topic at each time and the main topic of relations between those entities. In addition, a summary information about entities and their relationship is visualized through different graphs to help understand more about the topic.

The remainder of this paper is structured as follows. In section 2, we show the related work done in this area. In section 3, we provide a description of the used data. Section 4 explains the methodology and main challenges that were involved in this work. Next, we explain the visualization features of the tool in section 5. Finally, we conclude the paper and discuss potential future work.

2. RELATED WORK
Similar works have been done in the area of visualizing information extracted from news. We see in [2] a tool for efficient visualization of large amount of articles as a graph of connected entities extracted from articles, enriched with additional contextual information provided as characteristic keywords, for a quick detection of information from the original articles.

Regarding classifying news, we observe in [3] a new technique that uses Deep Learning to increase the accuracy of prediction of online news popularity.
In the paper explaining Event Registry [1], we see how articles from different languages are grouped into events and the main information and characteristics about them are extracted. Additionally, a graphical interface is implemented which allows search for events and visualize the results in multiple ways that together give a holistic view about events.

This work begins with the events as a starting point, and it is one more step on the same path; it groups events further into topics and trends, then it focuses on tracking how some entities are appearing as main entities regarding the selected topic, and how the relationship between them is changing through time.

3. DESCRIPTION OF DATA
We used part of the events from Event Registry as our main source of data. We obtained a dataset of ~ 1.8 million events as a list of JSON files, with event's dates between Jan 2015 and July 2016. Each event consists of general information like title, event date, total article count, etc., and a list of concepts that characterize the event, which is split into entity concepts and non-entity concepts. Entity concepts are people, organizations, and locations related to the event. Whereas non-entity concepts represent abstract terms that define the topic of the event, like technology, education, and investment. Those concepts were extracted using JSI Wikifier [4] which is a service that enables semantic annotation of the textual data in different languages. In addition, each concept has a score that represents the relevancy of that concept to the event.

4. METHODOLOGY

4.1 Clustering and Formatting Data
To group the events into topics, we used K-Means clustering algorithm, where each event is represented as a sparse vector of the non-entity concepts it has, with the weights equal to their scores in that event. The constant number of topics is set experimentally to be 100 clusters, in a balance between mixed clusters and repeated clusters. Each cluster describes a set of events that fall under the same topic, whereas the centroid vector of each cluster represents the main characteristics of it. To name

the clusters, we used category classifier service from Event Registry, which uses Dmoz Taxonomy [5], a multilingual open-content directory of World Wide Web links, that is used to classify texts and webpages into different categories; for each cluster, we formed a text consisting of the components of its centroid vector, taking into account their weights within the vector. The resulted cluster names were ranged from technology and business to refugees and society, and clusters were exported as a JSON file for processing them in the visualization part.

4.2 Choosing the Main Entities

Under any topic, the top entities at each duration of time has to be chosen. At first, the concepts were filtered from outliers like publishers and news agencies. Then, an initial importance value has been set for each concept based on two parameters: the TF-IDF score of concept with respect to each event, and the number of articles each event contains. If we denote the set of events that occur in the interval of time D by E_D, the number of articles that event e contains is A_e, the TF-IDF score of concept c at event e by $S_{c,e}$, then the importance value of each item with respect to the interval D is calculated by the formula:

$$Imp_{init}(c)_D = \sum_{\substack{e \in E_D \\ e\ has\ concept\ c}} S_{c,e} \; * \sum_{\substack{e \in E_D \\ e\ has\ concept\ c}} A_e$$

The TF-IDF function is used to give importance to the concept based on its relevance to the events, and the number of articles is used to give more importance to the events that have more articles talking about it, and hence, more importance to the concepts that it has. We decided on using the product of summation rather than summation of product because of its computation efficiency while still producing good results. However, to prevent the case where all the chosen entities get nominated because of one or two big events (which results in a bias towards those few events), a modification to the importance value formula has been made by introducing another parameter, which is the links between concepts (whenever two concepts occur in the same event, there is a link between them). Each concept now affects negatively the other concepts it is linked to by an amount equal to the initial importance value divided by the number of neighbors. If we denote the set of neighbors of concept c during the interval of time D by $N_{c,D}$, then the negative importance value is defined by:

$$Imp_{neg}(c)_D = \sum_{c' \in N_{c,D}} \frac{Imp_{init}(c')_D}{|N_{c',D}|}$$

The final score is just the initial importance value minus the negative importance value, which is then used to sort and nominate the top entities.

$$Imp_{final}(c)_D = Imp_{init}(c)_D - Imp_{neg}(c)_D$$

4.3 Detecting the Characteristics of Relationship

The main goal was to model the relationship between any two entities through a vector of words where two entities are collocated. Since the relationship between two entities at any given time is based on the shared events between them, and each event is characterized by a set of concepts, we decided on using those concepts - specifically the abstract or the non-entity concepts - to characterize such relationships. For each pair, we aggregated all the non-entity concepts from the shared events between them, and each one of them was assigned a value based on the number of events it is mentioned in and its score in those events. Those concepts were sorted and ranked depending on their values, and the top ones were chosen as the main features of the relationship. In addition, these values of the concepts were used to rank the shared events and extract the top ones; by giving each event a value equal to the aggregated values (the ones calculated in previous step) of all non-entity concepts it has. To summarize the set of characteristics, we classified them using Dmoz category classifier in a similar way to what we have done in determining the names of the clusters. These categories were used to label the relationship between the entities, indicating the main topic of the shared events between them.

5. VISUALIZING THE RESULTS

To access a topic, a search bar is provided to select among the list of extracted topics from clustering step. Once the user selects a topic, a default date is chosen and a network graph is shown explaining the topic.

5.1 Characteristics of the Main Graph

Since the tool's main goal is to show the top entities and their relations, the network graph is the best choice for this matter. Following that, we have built an interactive network graph that has the following features:

- The main entities within that topic at the selected interval of time are represented by the vertices of the graph.
- The size of the vertices reflects the importance value of each entity, scaled to a suitable ratio to fit in the canvas.
- The colors represent the type of the entity, whether it is a person [red] or an organization [blue].
- The links between the entities represent the existence of shared events in that interval of time between them under that topic, and hence indicating some form of relations. The thickness of the links is proportional to the number of shared events, whereas the labels are the ones calculated in previous section.

Figure 1 presents top companies with relevant relations in July 2015 found among business news.

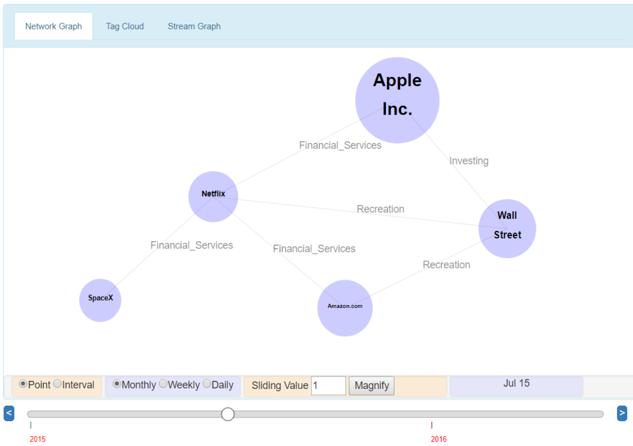

Figure 1: Top companies in July 2015 and their relations under the business topic.

5.2 Main Functionality

As the tool is concerned about tracking the changes with time. The graph is supported with a slide bar that allows the user to choose from the dates where there is at least one event occurred with respect to the selected topic. Different scales for moving dates are also provided; the user can choose to move day by day, week by week, or month by month and see the changes accordingly. In addition, the user can choose a specific interval of time, and track how the entities and their relations are changing when the interval moves slightly with respect to its length. An interval magnifier is also given if the user wants to get a closer look at the changes that happen in a small interval.

An example illustrating that can be seen in Figures 2 and 3. In Figure 2, we see the top 10 entities under the refugee topic in the last two months of 2015. When the interval is moved by 15 days, we notice that some of the entities disappear, like European Commission, indicating that they are no longer among the top 10 entities, whereas "United States House of Representitive" entity emerges and connects to "Barack Obama" and "Repulican Party". The change in size indicates the change in the importance value of each one, while Society is the general theme among all labels.

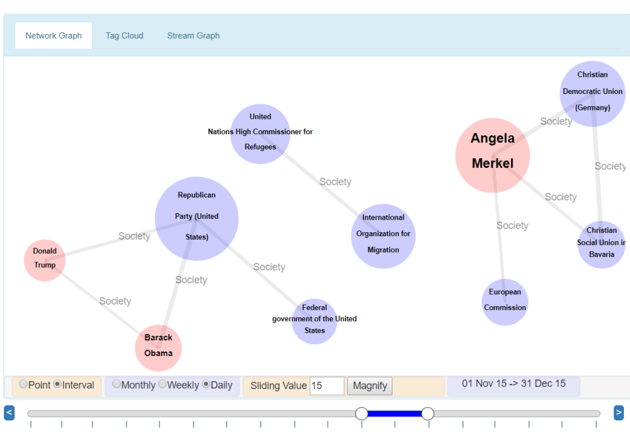

Figure 2: Top entities for the last two months of 2015 under the refugee topic.

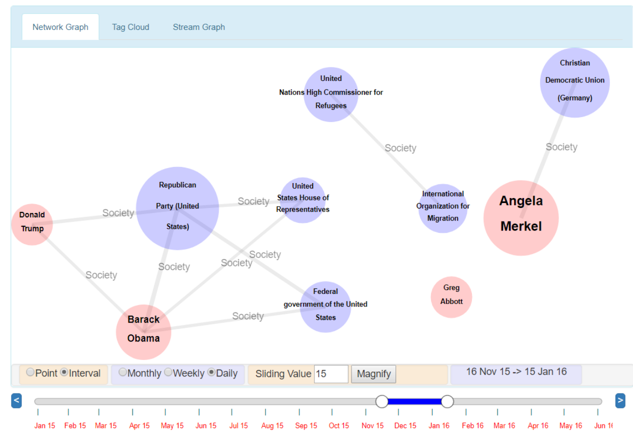

Figure 3: The changes in top entities under the same topic after moving the interval for 15 days.

5.3 Displaying Relation Information

Whenever the user selects a pair of entities, detailed information about their relationship in the selected interval of time is given, such as the number of shared events and articles, along with the top events both concepts were mentioned in. Also, the top shared characteristics that shape the relationship between them at this period is shown and sorted by percentage of importance. As seen in Figure 4; when selecting Jeff Bezos and Elon Musk under the space topic between January and September 2015, we see a list of the top events that involve both of them during this period. We see also that the relationship between them is mainly about sending astronauts by rockets to the international space station, as it can be understood from the top shared characteristics.

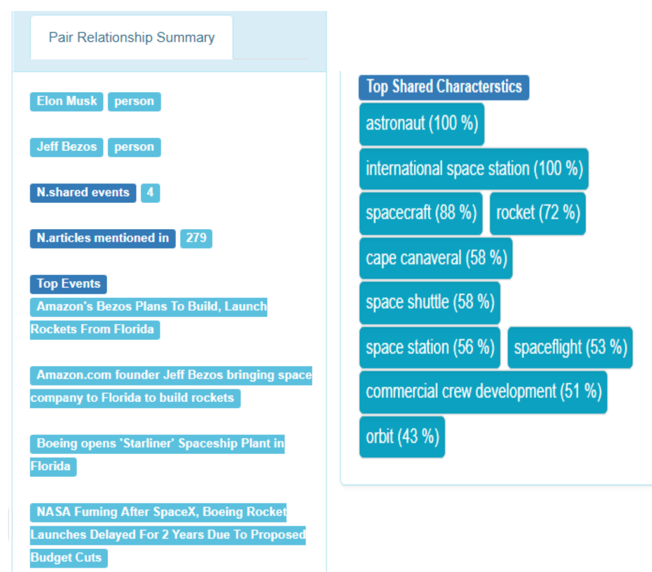

Figure 4: Relationship summary about Jeff Bezos and Elon Musk between January and September 2015 under the Space topic.

To illustrate how the importance of those top features with respect to the relationship is changing through time, a stream graph is used as shown in Figure 5.

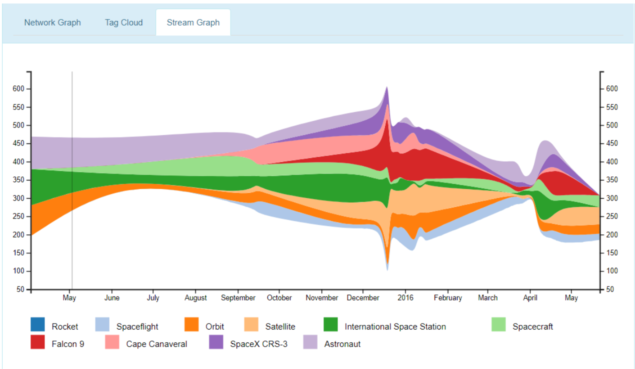

Figure 5: Stream graph showing how the effect of the main features on the relationship between Jeff Bezos and Elon Musk is changing through time.

Finally, the set of all characteristics that affect the relationship is visualized in a tag cloud to give a big picture about it. Figure 6 shows the tag cloud of the same relationship mentioned above.

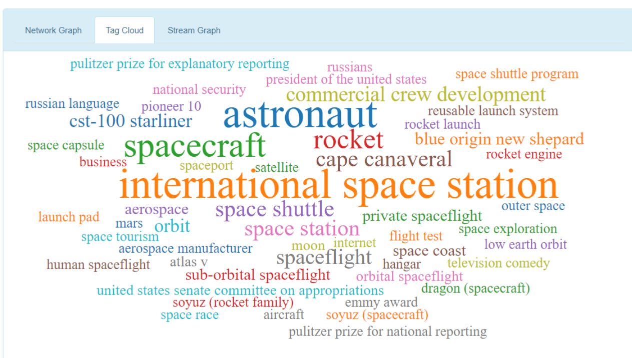

Figure 6: Tag cloud illustrating a general view about all the characteristics that affects the relationship between Jeff Bezos and Elon Musk under the space topic.

6. CONCLUSION AND FUTURE WORK

In this paper, we provide a tool that uses events data from Event Registry to show the main entities within each topic, and how the characteristics of relationship among them is changing through time. However, there are a couple of limitation to the tool that we want to improve in the future. Although we were able to detect the characteristics of the relationship between entities and how they are changing through time, the main type of relation that we used to label the links were very broad and hence rarely changing-improving the methodology for relation extraction and observation of relations in time will be the subject of future work. In addition, we limited the search space for topics for the 100 topics we obtained from clustering, we would like to generalize the search by enabling searches for any concept or keyword with different options to filter the search.

7. ACKNOWLEDGMENTS

This work was supported by the euBusinessGraph (ICT-732003-IA) project [6].

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Cross-lingual categorization of news articles

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ABSTRACT
In this paper we describe the experiments and their results performed with the purpose of creating a model for automatic categorization of news articles into the IPTC taxonomy. We show that cross-lingual categorization is possible using no training data from the target language. We find that both logistic regression and support vector machines are good candidate models, while random forests do not perform acceptably. Furthermore, we show that using Wikipedia-derived annotations provides more information about the target class than using generic word features.

General Terms
Algorithms, Experimentation

Keywords
News, articles, categorization, IPTC, Wikifier, SVM, Logistic regression, Random forests.

1. INTRODUCTION
The JSI Newsfeed [1] system ingests and processes approximately 350.000 news articles published daily around the world, in over 100 languages. The articles are automatically cleaned up and semantically annotated, and finally stored and made available for downstream consumers.

One of the annotation tasks that we would like to perform in the future is to automatically categorize articles into the IPTC "Media Topics" subject taxonomy [2]. IPTC – the International Press Telecommunications Council – provides a standardized taxonomy of roughly 1100 terms, arranged into a 5 level taxonomy, describing subject matters relating to daily news. The vocabulary is accessible in a machine readable format – RDF/XML and RDF/Turtle – at http://cv.iptc.org/newscodes/mediatopic.

There are two relations linking concepts in the vocabulary – the 'broader concept' taxonomical relation, and a 'related concept' sibling relation. The 'related concept' links concepts both to other concepts from the same taxonomy, and directly to external Wikidata [3] entities.

The purpose of this work is to evaluate multiple machine learning algorithms and multiple sets of features with which we could automatically perform the categorization. As we would like to categorize articles in all the languages the Newsfeed system supports, but we only have example articles in English and French, the method needs to be language independent.

2. EXPERIMENTAL SETUP
The dataset that we have access consists of 30364 English and 29440 French articles, each of which is tagged with 1 to 10 categories. We consider each document belonging to all categories that are explicitly stated, and all of their parents. We will compare the performance of model predictions on the same language and in the cross-lingual setting, where we train the model on the entire dataset available for one language, and measure its performance on the other language.

Basic features of the dataset can be seen in the following 2 figures. Figure 1 shows the distribution of number of articles in each category, and Figure 2 shows that most categories contain a roughly even number of articles in both languages, but there are some outliers. We ignored categories with less than 15 examples per language, which resulted in 308 categories.

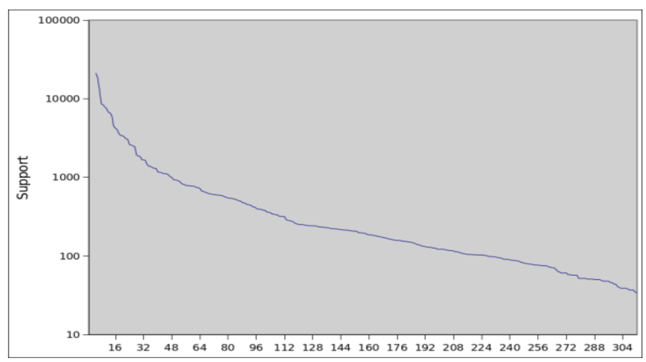

Figure 1. Number of articles in each category. Discrete categories on x axis are ordered by descending number of articles.

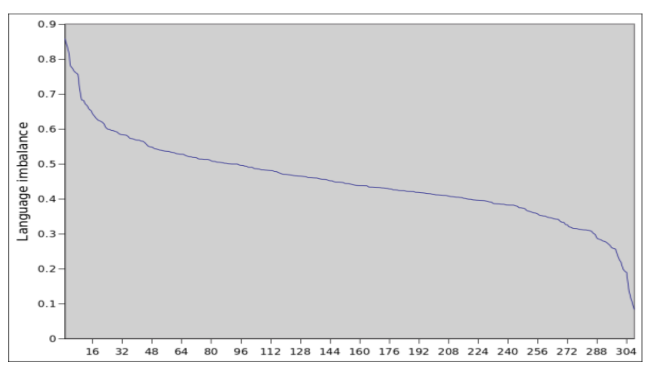

Figure 2. Language imbalance for each category. Discrete categories on x axis are ordered from "mostly English" to "mostly French".

We compare three different machine learning models – random forests, logistic regression (LR), and Support Vector Machines (SVM).

We try two different types of features, and their combinations.

The first kind of a feature set we use is a projection of the bag-of-words representation of the document text into a 500 dimensional vector space. The KCCA [4] method uses an aligned multi-lingual corpus to find such a mapping, that words with similar meanings map to a similar vector, regardless of their language. We represent a document as a sum of all word vectors.

The second set of features we use is the output of the JSI Wikifier [5] system. The Wikifier links each word in a document to a set of Wikipedia pages that might represent the meaning of that word. For each such annotation, we also get a confidence weight.

We consider these annotations as a classical vector space model -- as a bag-of-entities. We use two versions of the TF-IDF [7] scheme: in the first case, we use the number of times an entity annotation is present for any word in a document as the TF (term frequency) factor, and in the second version, we use the sum of annotation weights of an entity across the document. In both cases, we perform L1 normalization of the vector containing TF terms. For IDF terms, we use $\log\left(1+\frac{N}{n}\right)$ where N is the number of all documents and n the number of documents where an annotation was present at least once.

Finally, we use a combination of both KCCA-derived and Wikifier-derived features as the last feature set option.

For model training, we use Pythons scikit-learn [6] software package. In the case of logistic regression, we use L2 penalty, with automatic decision threshold fitting, using the liblinear library backend.

For the SVM model, we use a stochastic gradient descent optimizer. We performed a grid search for the optimal regularization constant C, but since there were no significant accuracy changes, we used the default of 1.0 in all other experiments.

For the random forest model, we used 4 different parameter combinations:

- default – 10 trees, splitting until only one class is in the leaf
- 30 trees, maximum tree depth of 10
- 50 trees, maximum tree depth of 10
- 30 trees, maximu tree depth of 20

In all cases, GINI index was used as the node splitting criterion.

Since the majority of categories only have a small number of documents, we automatically weighed training examples by the inverse of their class frequency. We also performed some experiments without this weighting scheme, but got useless models in all cases except for the couple largest categories.

All reported results are the average of a 3-fold cross-validation.

So far, we only created one-versus-all models for each category independently, and only used the taxonomy information of categories to select all examples from sub-categories when training the more general category.

3. RESULTS

Table 1 shows ROC scores for cross-validation of all three models on four sets of feature combinations, for English and French separately. SVM and logistic regression are comparable in behavior and promising, while the random forest model performs significantly worse. "Wiki-W" denotes the weighted version of Wikifier annotations, and "Wiki-K" the combination of KCCA-derived features and Wikifier annotations. Every second line in the table is the standard deviation of the result when averaged across all categories.

Table 1. ROC scores by model and feature type, cross-validation

	Rand. Forest		Log. Reg.		SVM	
	EN	FR	EN	FR	EN	FR
KCCA	0.75	0.71	0.96	0.95	0.95	0.94
(stdev)	0.11	0.11	0.04	0.04	0.05	0.04
Wiki	0.70	0.70	0.95	0.95	0.94	0.94
(stdev)	0.12	0.12	0.04	0.04	0.05	0.04
Wiki-W	0.71	0.71	0.95	0.95	0.94	0.94
(stdev)	0.12	0.11	0.04	0.04	0.05	0.04
Wiki+K	0.71	0.69	**0.97**	**0.96**	0.96	0.95
(stdev)	0.12	0.11	0.03	0.03	0.03	0.04

Looking at the feature selections, we see almost no significant difference -- both kinds of features -- KCCA and Wikipedia annotations have useful predictive value. The combination of both feature types slightly improves the ROC score.

Table 2 shows F1 cross-validation scores of all three models. Logistic regression scores much higher than SVM here, possibly indicating that the SVM model would benefit from a post-processing step of optimizing the decision threshold on a separate training set.

Table 2. F1 scores by model and feature type, cross-validation

	Rand. Forest		Log. Reg.		SVM	
	EN	FR	EN	FR	EN	FR
KCCA	0.16	0.12	0.30	0.25	0.20	0.18
(stdev)	0.21	0.18	0.21	0.20	0.21	0.19
Wiki	0.07	0.07	0.41	0.44	0.25	0.29
(stdev)	0.15	0.15	0.21	0.21	0.22	0.22
Wiki-W	0.08	0.08	0.40	0.43	0.24	0.28
(stdev)	0.17	0.17	0.21	0.21	0.21	0.22
Wiki+K	0.09	0.07	**0.44**	**0.46**	0.27	0.30
(stdev)	0.16	0.15	0.21	0.21	0.22	0.22

The combination of both feature sets performs significantly better than either alone, with generic word-based features providing the least amount of information.

The feature usefulness changes when looking at cross-lingual classification performance. Table 3 shows the ROC score for all three models, when the model trained on English is used to predict categories of French articles, and vice versa. Decision trees give essentially a random result, and SVM scores somewhat higher than logistic regression.

Table 3. ROC scores - cross-lingual classification

	Rand. Forest		Log. Reg.		SVM	
	EN	FR	EN	FR	EN	FR

KCCA	0.50	0.50	0.50	0.50	0.50	0.51
(stdev)	0.00	0.00	0.01	0.03	0.04	0.08
Wiki	0.51	0.51	0.76	0.80	0.81	0.84
(stdev)	0.04	0.04	0.12	0.11	0.11	0.10
Wiki-W	0.51	0.52	0.78	0.82	**0.82**	**0.84**
(stdev)	0.04	0.05	0.11	0.10	0.10	0.10
Wiki+K	0.50	0.50	0.57	0.70	0.66	0.81
(stdev)	0.01	0.01	0.10	0.13	0.14	0.12

The biggest change here is the influence of KCCA cross-lingual word embedding: by itself it provides no informative value, as indicated by ROC value of 0.5 in all cases, and it even reduces the performance of the combined Wikifier + KCCA model.

In the Table 4, F1 scores from the same experiment are shown. Logistic regression still has a big advantage over SVM, as in the same-language categorization setting. The change from previous experiments is the influence of weighting of Wikipedia features -- it increases the performance of all models.

Table 4. F1 scores - cross-lingual classification

	Rand. Forest		Log. Reg.		SVM	
	EN	FR	EN	FR	EN	FR
KCCA	0.00	0.00	0.00	0.01	0.00	0.02
	0.02	0.02	0.02	0.06	0.01	0.06
Wiki	0.03	0.04	0.48	0.44	0.30	0.26
	0.10	0.11	0.21	0.20	0.22	0.22
Wiki-W	0.03	0.05	**0.49**	**0.44**	0.29	0.26
	0.11	0.13	0.20	0.21	0.22	0.22
Wiki+K	0.00	0.00	0.18	0.40	0.20	0.23
	0.04	0.04	0.22	0.22	0.19	0.21

An interesting observation is that the performance of the cross-lingual model is occasionally higher than that of the baseline cross-validation experiment. This anomaly however disappears for categories with large amount of positive training examples. It also disappears if we reduce the amount of training examples in the cross-lingual experiment by 1/3 – the effect seems to be caused by cross-validation reducing the training dataset size.

KCCA cross-lingual word embedding feature generation used here was tested in other experiments and systems and gives a useful feature set for comparison of documents across languages, so its negative impact on the performance of these models needs to be investigated in the future.

As the weighted Wikipedia feature set appears to be the best for the stated goal of cross-lingual article categorization, the results of next experiments are shown only for it, but we performed the same experiments on all other combinations, and the results broadly follow the conclusions from the previous section.

The following figures show correlation of testing and cross-lingual performance of logistic regression and SVM models. Both F1 score and area under ROC curve are shown for each of 308 categories in the experiment, since they provide complementary information. As the figures show, there is a good agreement between the cross-validation and the cross-lingual classification performance, giving us an ability to estimate cross-lingual performance based on the cross-validation score in the production environment. The difference between distributions for French and English language models is consistent with the class imbalance for each of the categories.

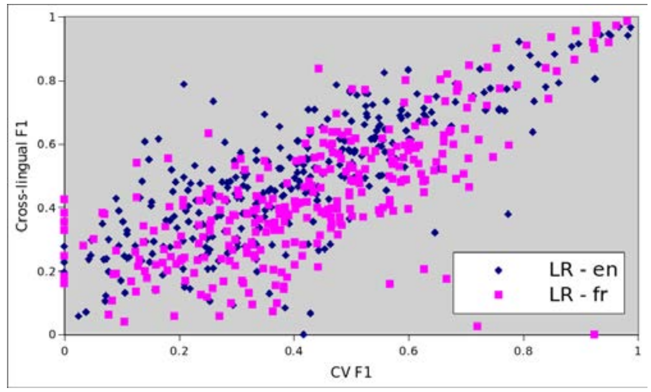

Figure 3. F1 score correlation for logistic regression

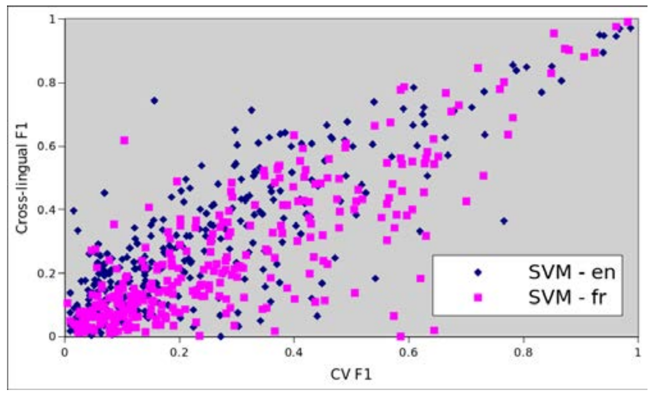

Figure 4. F1 score correlation for SVM

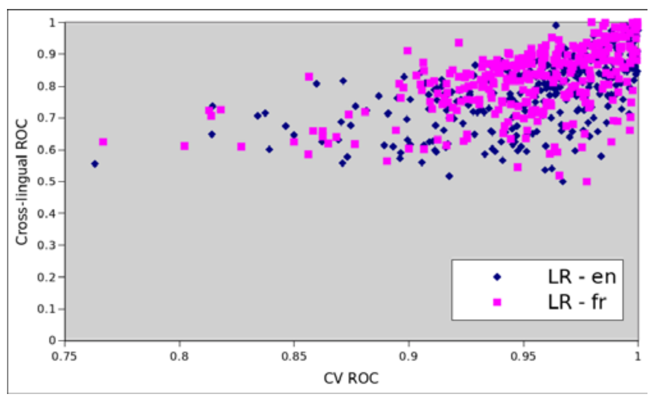

Figure 5. ROC score correlation for logistic regression

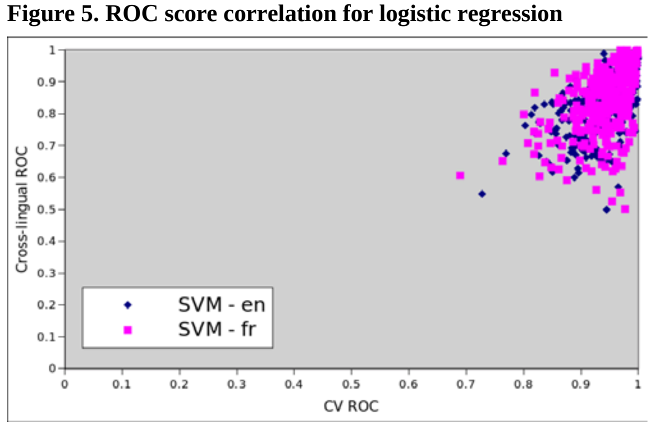

Figure 6. ROC score correlation for SVM

The SVM model seems to have a more consistent behavior, so we will use it in the final application instead of logistic regression.

Figures 7 through 10 show the F1 and ROC score behavior of logistic regression and SVM models for cross-validation and cross-lingual classification with regard to the number of positive examples in the category, separately for English and French language. While the SVM model underperforms on the F1 metric on average, it produces a better ranking of documents with respect to a category, as seen on ROC plots, especially for smaller categories. This further indicates the need for decision threshold tuning in the SVM model before we use its predictions.

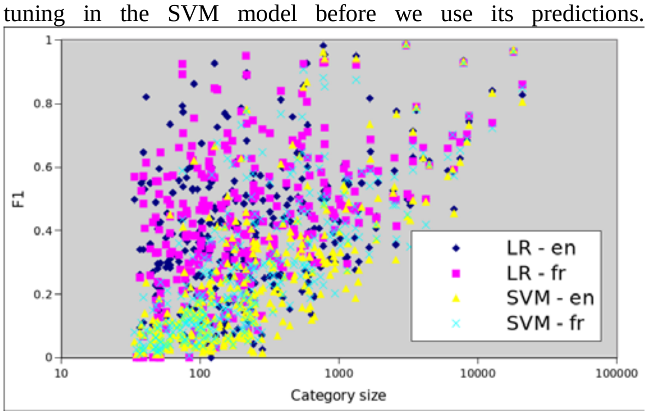

Figure 7. F1 score with respect to category size, cross-validation

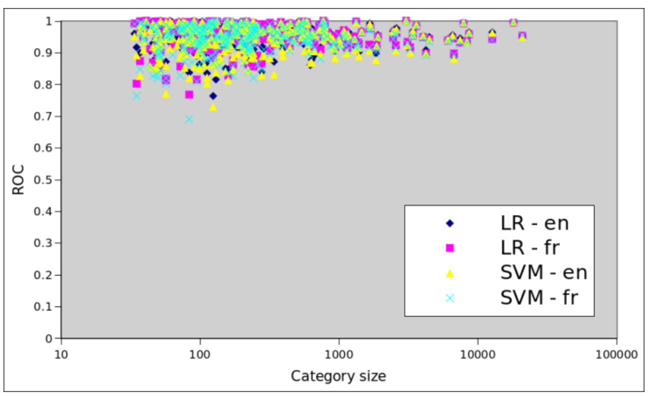

Figure 8. ROC score with respect to category size, cross-validation

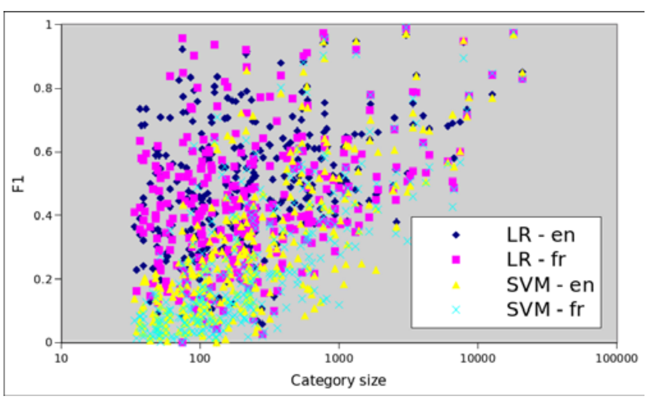

Figure 9. F1 score with respect to category size, cross-lingual prediction

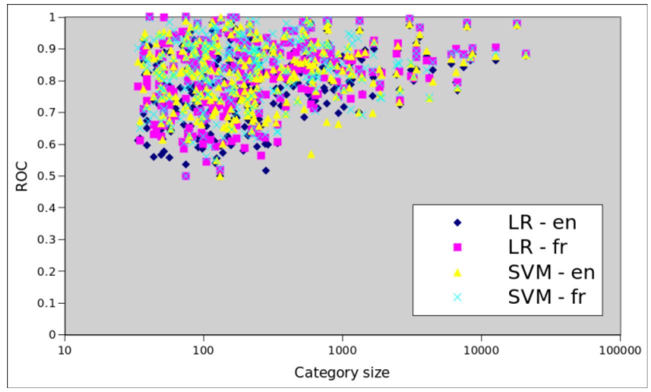

Figure 10 ROC score with respect to category size, cross-lingual prediction

As expected, classification performance of all models improves with the number of training examples, but in cases of small categories, it appears that some are much easier to learn than others.

4. CONCLUSIONS AND FUTURE WORK

We found that using a logistic regression model with weighted Wikifier annotations gives us a good enough result to use IPTC category tags as inputs for further machine processing in the Newsfeed pipeline. Before we can use this categorization for human consumption, we need to investigate automatic tuning of SVM decision thresholds on this problem, and add an additional filtering layer that takes into consideration interactions between categories beyond the sub/super-class relation. Additionally, the negative effect of KCCA-derived features for cross-lingual annotation needs to be examined.

5. ACKNOWLEDGEMENTS

This work was supported by the Slovenian Research Agency as well as the euBusinessGraph (ICT-732003-IA) and EW-Shopp (ICT-732590-IA) projects.

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Transporation mode detection using random forest

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ABSTRACT
This paper addresses transportation mode detection for a mobile phone user using machine learning and based on mobile phone sensor data. We describe our approach to data collection, preprocessing and feature extraction. We evaluate our approach using random forest classification with focus on feature selection. We show that with feature selection we can significantly improve classification scores.

1. INTRODUCTION
In the recent years we have witnessed a drastic increase in sensing and computational resources that are built in mobile phones. Most of modern cell phones are equipped with a set of sensors containing triaxial accelerometer, magnetometer, and gyroscope, in addition to having a Global Positioning System (GPS). Smart phone operating system APIs offer activity detection modules that can distinguish between different human activities, for example: being still, walking, running, cycling or driving in a vehicle [2, 3]. However, APIs cannot distinguish between driving in different kind of vehicles, for example driving a car or traveling by bus or by train. Recognizing different kind of transportation, also known as transportation mode detection, is crucial for mobility studies, for routing purposes in urban areas where public transportation is often available, for facilitating the users to move towards more environmentally sustainable forms of transportation [1], or to inspire them to exercise more.

In this paper we discuss the use of random forest in transportation mode detection based on accelerometer signal. We focus on

1. feature extraction, and
2. feature analysis to determine the most meaningful features for this specific problem and the choice of classifier.

Our main contribution is feature analysis, which revealed the impact of each feature to the classification scores.

2. RELATED WORK
While the first attempts to recognize user activity were initiated before smart phones, the real effort in that direction begun with the development of mobile phones having built-in sensors [10], including GPS and accelerometer sensors. There are still some studies that use custom loggers to collect the data [11, 17] or use dedicated devices as well as smart phones [5]. Although GSM triangulation and local area wireless technology (Wi-Fi) can be employed for the purpose of transportation mode detection, their accuracy is relatively low compared to GPS [11], so latest state of the art research is focused on transportation mode detection based on GPS tracks and/or accelerometer data.

Machine learning approaches for transportation mode detection often rely on statistical, time-based, frequency-based, peak-based and segment-based [8] features, however in most cases statistical features and features based in frequency are used [10, 11, 16]. Feature domains are described in Table 1. Statistical, time-based, and spectral attributes are computed on a level of a time frame that usually covers a few seconds, whereas peak-based features are calculated from peaks in acceleration or deceleration. On the other hand, segment-based features are computed on the recordings of the whole trip, which means that they cover much larger scale. Statistical, time-based, and spectral features are able to capture the characteristics of high-frequency motion caused by user's physical movement, vehicle's engine and contact between wheels and surface. Peak-based features capture movement with lower frequencies, such as acceleration and breaking periods, which are essential for distinguishing different motorized modalities. Additionally, segment-based features describe patterns of such acceleration and deceleration periods [8].

Machine learning methods that are most commonly used in accelerometer based modality detection include support vector machines, decision trees and random forests, however naive Bayes, Bayesian networks and neural networks have been used as well [11, 12]. Often these classifiers are used in an ensemble [16]. The majority of algorithms additionally use Adaptive Boosting or Hidden Markov Model to improve the performance of the methods mentioned above [16, 8, 11, 10]. In the last years, deep learning has also been used [6, 14].

Accelerometer-only approach where only statistical features have been used reported 99.8% classification accuracy, however users were instructed to keep the devices fixed position during a trip. Furthermore, only 0.7% of data was labeled as train [11]. State of the art approach to accelerometer-only

Domain	Description
Statistical	These features are include mean, standard deviation, variance, median, minimum, maximum, range, interquartile range, skewness, kurtosis, root mean square.
Time	Time-based features include integral and double integral of signal over time, which corresponds to speed gained and distance traveled during that recording. Other time-based features are for example auto-correlation, zero crossings and mean crossings rate.
Frequency	Frequency-based features include spectral energy, spectral entropy, spectrum peak position, wavelet entropy and wavelet coefficients. These can be computed on whole spectrum or only on specific parts, for example spectral energy bellow 50Hz. Spectrum is usually computed using fast Fourier transform, whereas wavelet is a result of the Wavelet transformation. Entropy measures are based on the information entropy of the spectrum or wavelet [7].
Peak	Peak-based features use horizontal acceleration projection to characterize acceleration and deceleration periods. These features include volume, intensity, length, skewness and kurtosis.
Segment	Segment-based include peak frequency, stationary duration, variance of peak features, and stationary frequency. The latter two are similar to velocity change rate and stopping rate used by [17]. Segment-based features are computed on a larger scale than statistical, time-based or frequency-based features.

Table 1: Feature domains and their descriptions adopted from [8].

transportation mode detection relies on long accelerometer samples. It uses features from all five domains for classification with AdaBoost with decision trees as a weak classifier and achieves 80.1% precision and 82.1% recall [8].

The performance of transportation mode detection systems depends on the effectiveness of handcrafted features designed by the researchers, researcher's experience in the field affects the results. Thus, there have been approaches that use deep learning methods, such as autoencoder or convolutional neural network, to learn the features used for classification. Using a combination of handcrafted and deep features for classification with deep neural network resulted in 74.1% classification accuracy [15].

3. PROPOSED APPROACH

Work flow of the proposed approach is visualized in Figure 1. The first task is data collection. To collect data we use *NextPin* mobile library [4] developed by the Artificial Intelligence Laboratory at Jožef Stefan Institute. Library is embedded into two free mobile applications. The first one is *OPTIMUM Intelligent Mobility* [1]. *OPTIMUM Intelligent Mobility* is a multimodal routing application for three European cities — Birmingham, Ljubljana, and Vienna. The second one is *Mobility patterns* [4]. *Mobility patterns* is essentially a travel journal. Both applications send five second long accelerometer samples every time OS's native activity recognition modules, Google's ActivityRecognition API [2] for Android and Apple's CMMotionActivity API [3], detect that the user is traveling in a vehicle. We use that accelerometer samples for fine-grained classification of motorized means of transportation.

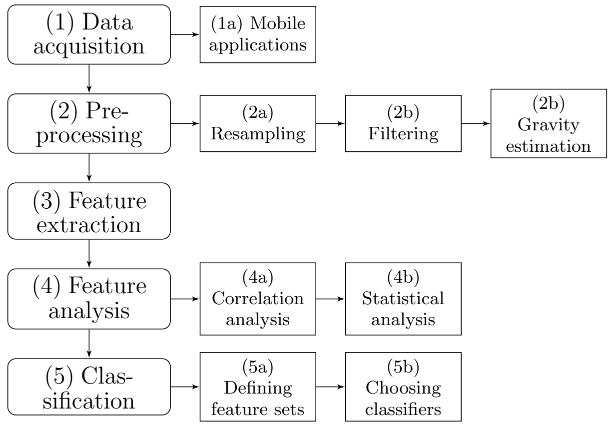

Figure 1: Detailed work flow diagram of the proposed approach. We stacked general, high-level tasks common in other approaches vertically, whereas subtasks specific to our approach are pictured horizontally.

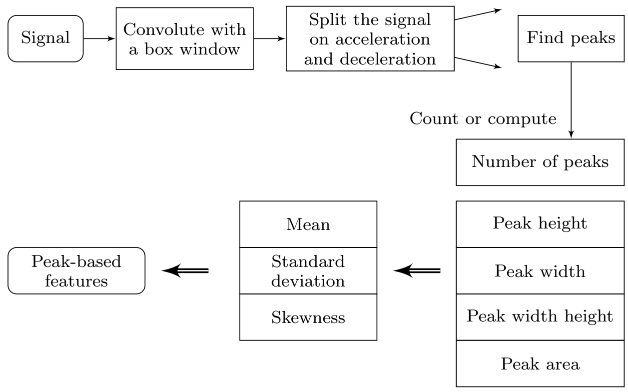

Figure 2: Work flows for extraction of peak-based features.

We collect five second samples of sensor data and resample them to sampling frequency 100 Hz in the preprocessing phase. Resampling ensures us that our samples all contain 500 measurements. The most prominent problem we face in preprocessing concerns the correlation of acceleration measurements with the orientation of the phone in the three dimensional space. Practically this means that gravity is measured together with the dynamic acceleration caused by phone movements. To eliminate gravity from the samples we perform gravity estimation on raw accelerometer signal. We follow an approach proposed by Mizell [9]. Gravity estimation splits the acceleration to static and dynamic component. Static component represents the constant acceleration, caused by the natural force of gravity, whereas dynamic component is a result of user's motion. Furthermore, using this approach we are able to calculate vertical and horizontal components of acceleration.

We use preprocessed signal to extract features for classification. Features are divided into five domains, based on their meaning and method of computation. We have listed the domains in Table 1. We extract features from three domains — statistical, frequency, and peak. We extract statistical features (maximal absolute value, mean, standard deviation, skewness, 5th percentile, and 95th percentile) from dynamic acceleration and its amplitude, horizontal acceleration and

Set	Accele.	Features	Size
D-S	Dynamic	Statistical	54
D-SF	Dynamic	Statistical, Frequency	94
D-SFP	Dynamic	Statistical, Frequency, Peak	172
H-S	Horizontal	Statistical	54
H-SF	Horizontal	Statistical, Frequency	94
H-SFP	Horizontal	Statistical, Frequency, Peak	172
ALL			376

Table 2: Predefined feature sets used for classification.

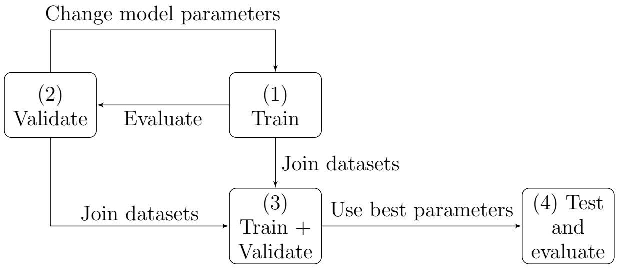

Figure 3: Schema of evaluation scenario.

its amplitude, amplitude of raw acceleration, and amplitude of vertical acceleration. From the same signals we extract frequency-based features using fast Fourier transformation. As frequency-based features we use the power spectrum of the signal aggregated in 5 Hz bins. Pipeline for extraction of peak-based features from dynamic and horizontal in acceleration is pictured in Figure 2. To extract peak-based features we first smooth out the signal with convolution with a box window and split it into moments of acceleration and moments of deceleration. Then we find peaks and compute peak heights, peak widths, peak width heights, and peak areas. As there is usually more than one peak we aggregate these values using mean, standard deviation, and skewness. All together we extract 376 features. We organize features into seven predefined feature sets we use for classification. Feature sets are listed in Table 2.

To evaluate the capabilities and performance of the proposed approach, we divide our dataset in 3 subsets — train, validation, and test set — based on the date the samples were recorded on. By doing so we avoided using in this domain methodologically questionable random assignment of samples collected during the same trip to different subsets. The reason why we did not apply cross-validation is similar. Using samples from the same trip in train and test set would result in significantly higher evaluation scores. For

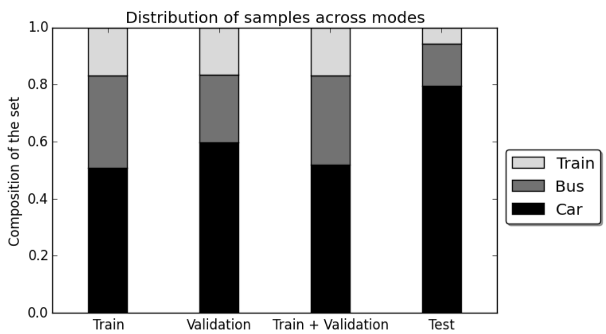

Figure 4: Distribution of modes in train, validation, and test set. We also added joint train and validation set, which we use to train the final model.

Feature set	CA	RE	PR	F1
D-S	0.48	0.41	0.39	0.37
D-SF	0.60	0.41	0.41	0.39
D-SFP	0.46	0.39	0.40	0.35
H-S	0.64	0.40	0.43	0.41
H-SF	0.53	0.39	0.43	0.36
H-SFP	0.50	0.37	0.40	0.34
ALL	0.47	0.35	0.40	0.33

Table 3: Classification metrics for classification with random forest on predefined feature sets.

the training set we use the data from [13], whereas validation and test sets were obtained during Optimum pilot testing in 2018. During validation step we are trying to maximize F1 score as our data set is imbalanced. We visualized the evaluation scenario in Figure 3, while the composition of the sets in pictured in Figure 4.

4. RESULTS

We trained random forest classifier on the predefined feature sets from Table 2. Classification metrics we report on include classification accuracy (CA), recall (RE), precision (PS) and F1 score (F1) Results are listed in Table 3. Table 3 shows that we achieved the highest F1 score of 0.41 using H-S feature set. This feature set consists of statistical features calculated on the horizontal acceleration vector. Classification accuracy in that case is also high, compared to other feature sets. The peak features seems to be the source of noise in the data, as using peak features in combination with the other features sets decreases the performance, for example F1 drops from 0.39 for D-SF to 0.35 for D-SFP.

F1 score and classification for dynamic acceleration increase when we add frequency-based features, whereas these two measures decrease in case of similar action for horizontal acceleration. This offers two possible interpretations. One is that frequency-based features of dynamic acceleration carry more information compared to frequency-based features of horizontal acceleration. The second one is that statistical features of horizontal acceleration are much better than statistical features from dynamic acceleration.

We noticed that smaller feature sets generally perform better than larger so we focused on feature selection. We initially train the model with all features and evaluate it on validation set. Then we remove each feature one by one, train the model, evaluate it on the validation set and compare all F1 scores. We eliminate the feature with the highest F1 score, as this means that when the model was trained without that feature if performed better than when the eliminated feature was included. We repeat this procedure until the feature set consists of one feature. Similarly, we do feature addition — we start with an empty feature set and gradually add features one by one.

Using the described process of forward feature selection and backward feature elimination we selected two feature sets that performed the best — in case of forward selection the best feature set has 10 features, whereas feature set produced with backward elimination has 28 features. Feature set obtained by forward selection mostly contains statistical features, followed by peak-based. Only one frequency-based features appears in that set. Additionally, features are in vast majority extracted from dynamic acceleration. On the other hand feature set obtained by backward elim-

Feature set	CA	RE	PR	F1
Forward selection (10)	0.70	0.50	0.47	0.48
Backward elimination (28)	0.73	0.50	0.48	0.49

Table 4: Classification metrics for classification with the selected features in feature selection.

Forward selection				Backward elimination			
T \P	Car	Bus	Train	T \P	Car	Bus	Train
Car	0.78	0.27	0.05	Car	0.83	0.12	0.05
Bus	0.51	0.40	0.09	Bus	0.55	0.35	0.10
Train	0.47	0.21	0.32	Train	0.45	0.23	0.32

Table 5: Confusion matrix for classification with the selected features in feature selection.

ination contains more peak-based features than statistical, again only one frequency-based feature appears. Dynamic acceleration and horizontal acceleration appear in similar proportions. We evaluated the models trained with that feature sets against the test set. Results are listed in Table 4. Both feature sets achieve better F1 scores than any previous feature sets. Confusion matrix in Table 5 reveals what are the differences between these two feature sets. We can see that in case of eliminating features there is less cars missclassified as buses and more buses missclassified as cars. Classification of trains is fairly consistent. For buses and trains the largest part of samples is still missclassified as cars.

5. CONCLUSIONS

We showed that while transportation mode with random forest is possible, careful feature selection is necessary. Using feature selection we were able to improve classification scores for at least 0.04, in some cases even over 0.10. Although classification scores improved, most of non-car samples were still misclassified as cars. We observed that even though peak-based features did not perform as well in predefined feature sets, they appeared consistently among selected features in feature selection. That does not hold for frequency-based feature only one feature appeared among selected features. For the future work we suggest maximization of another classification score as we focused on maximization of F1 score.

6. ACKNOWLEDGMENTS

This work was supported by the Slovenian Research Agency under project *Integration of mobile devices into survey research in social sciences: Development of a comprehensive methodological approach* (J5-8233), and the ICT program of the EC under project *OPTIMUM* (H2020-MG-636160).

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FSADA, an anomaly detection approach

A modern, cloud-based approach to anomaly-detection, capable of monitoring complex IT systems

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ABSTRACT

Modern IT systems are becoming increasingly complex and inter-connected, spanning over a range of computing devices. As software systems are being split into modules and services, coupled with an increasing parallelization, detecting and managing anomalies in such environments is hard. In practice, certain localized areas and subsystems provide strong monitoring support, but cross-system error-correlation, root-cause analysis and prediction are an elusive target.

We propose a general approach to what we call *Full-spectrum anomaly detection* - an architecture that is able to detect local anomalies on data from various sources as well as creating high-level alerts utilizing background knowledge, historical data and forecast models. The methodology can be implemented either completely or partially.

Keywords

Anomaly detection, Outlier detection, Infrastructure monitoring, Cloud

1. INTRODUCTION

Modern IT systems need several key capabilities, apart from tracking and directing the underlying businesses. They need to manage errors and failures - predict them in advance, detect them in their early stages, help limit the scope of the damage and mitigate their consequences. All this is achieved by analyzing past and current data and detecting outliers in it.

Anomaly detection must happen in near-real time, while simultaneously analyzing potentially thousands of data points per second. Incoming data that such a system can monitor is very diverse. Data can come in different shapes (numeric, discrete or text), in regular time intervals or sporadically, in huge volumes or just a few data points per day. Designing a system that can cope with such diverse situations can be challenging.

Another important aspect is *"actionability"* of the reported anomalies. When human operator is presented with a new alert, the message as to what is wrong needs to be clear. The operator must be able to immediately start addressing the problem. Sometimes all we need is a different presentation of the result, but most often the easy-to-describe algorithms and models are used - e.g. linear regression or nearest neighbour.

This high velocity of data (volume and rate) makes some of the algorithms less usable in such scenarios - specifically batch processing that requires random access to all past data is not desired. Ideally, we would only use *streaming algorithms* - algorithms that live on the stream of incoming data, where each data point is processed only once and then discarded.

The contribution of this paper is a hollistic approach to anomaly detection system that clearly defines different parts and stages of the processing, including active learning as a crucial part of the processing loop. The design addresses modern challenges in IT system monitoring and is suitable for cloud deployment.

2. ANOMALY-DETECTION

The most common definition of an anomaly is *a data point that is significantly different from the majority of other data points.* See [2] for a detailed explanation. This definition is strictly analytical. But most often the users define it within the scope of their operation, such as finding abnormal engine performance in order to prevent catastrofic failure, flagging unexpected delays in manufacturing pipeline in order to prevent shipment bottlenecks, detecting unusual user behavior that indicates intrusion and identifying market sectors that exibit unusual trends to detect fraud and tax evasion.

The anomaly-detection process is thus heavily influenced by the target domain. It also needs process-specific way of measuring the detection efficiency. For instance, in classification problems we can use several established measures such as *accuracy*, *recall*, *precision* or $F1$. In anomaly detection, on the other hand, we often don't have classes to work with and secondly, we need strong user feedback to evaluate our results. Sometimes anomaly detection looks more like a forecasting and optimization problem. We measure how much the current state of a complex system is different from the optimal or predicted value.

2.1 Actionability

It is not sufficient for algorithms to just detect unusual patterns. Human operators that get notified about them must clearly understand the detected problems and be able to act upon them - we call this property of alerts *actionability.* For instance, it is not enough to report "the euclidian distance between multi-dimensional vectors of regularized input values is too big" - end-users will have no clue about what is wrong here. Instead, the system should report something like "The average processing time of customer orders is well above its usual values. This situation will very likely result in a significant drop of daily productivity." Some algorithms produce models that are easier to translate into human language than others. This feature needs to be taken into account when an anomaly-detection system is being implemented.

2.2 Modern challenges

In the era of big data there are many systems that produce data and a lot of the generated data can be used to monitor, maintain and improve the target system. The data volumes are staggering and need to be addressed properly within the system implementation.

Users expect results to be available as soon as possible - within hours, sometimes even minutes or seconds. In cases where automated response in possible, this time-frame shortens to miliseconds (e.g. stock trading, network intrusion).

Current systems for anomaly detection are developed as add-ons to the existing systems for collecting and processing data. This makes sense, since they developed organically, during the usage by the competent users, which identified areas that require advanced monitoring. We belive this provides necessary business validation of anomaly detection systems. However, there are limitations of such approach.

- Data that is available in one part of the system might **not be available** in another part, where anomaly-detection could greatly benefit from it.
- **Data volume** could prove to be too big for effective anomaly detection analysis, because needed resources might not be available (e.g. computing power is needed for main processing and anomaly detection should not interfere with it).
- Anomaly detection has **local scope** as it only processes data from one part of the system. The alerts are thus not aware of the potential problems in other parts of the system, so resolving issues takes longer and involves more people from several departments to coordinate during problem escalations.
- There is no systematic way of collecting the **user feedback** that would guide and improve the anomaly detection process.

3. THE SYSTEM ARCHITECTURE

To create a system that is able to ingest such huge amount of different data streams, detect anomalies in them and present user with a manageable amount of actionable alerts we propose a reference architecture of such system (figure 1). The acronym **FSADA** stands for *Full-Spectrum Anomaly Detection Architecture*, is based on the Kappa architecture [5] and comprises the components described below.

- **Storage module** contains historical data (raw and derived), background knowledge as well as generated alerts and incidents.
- **Stream-processing module** performs incoming-data pre-processing, as well as signal- and incident-detection.
- **Batch processing module** calculates aggregations, pattern discovery as well as background knowledge refresh.
- **User-interface module** (commonly abbreviated as GUI) displays raw-data, generated alerts along with feedback and active learning support.

3.1 Terminology

From now on we will be using the following terminology:

anomalies - any kind of abnormal behavior inside the system, regardless of the effect on the system performance.

signals - low-level anomalies that have been detected on single data-stream.

incidents - complex anomaly or a group of them with major impact on the system. Its time duration is usually limited to several minutes or hours. They are closely related to the way users perceive the system problems and outages.

alerts - an anomaly that is reported to the user, self-contained with explanation and basic context.

3.2 Storage module

The system needs to store several types of data that perform different functions. Each part of the storage layer can be located in separate system that best matches the requirements.

Measurement data represents raw values that were observed and processed in order to monitor the system. This data is strictly speaking not necessary when our algorithms are designed to work on a stream, but they are required for batch algorithms, for model retraining, active learning and for ad-hoc analytics. **Generated signals and incidents** are stored, additionally processed and viewed by the user. The storage needs to support flexible format of alerts, since each one of them is ideally an independent chunk of data that can be visualized without additional data retrieval. The algorithms can use **domain knowledge** to guide their execution. To facilitate this, the data needs to be stored in a storage system that provides fast searching, in order to be used in stream processing steps for enrichment, routing and aggregation. The algorithms inside the system create and

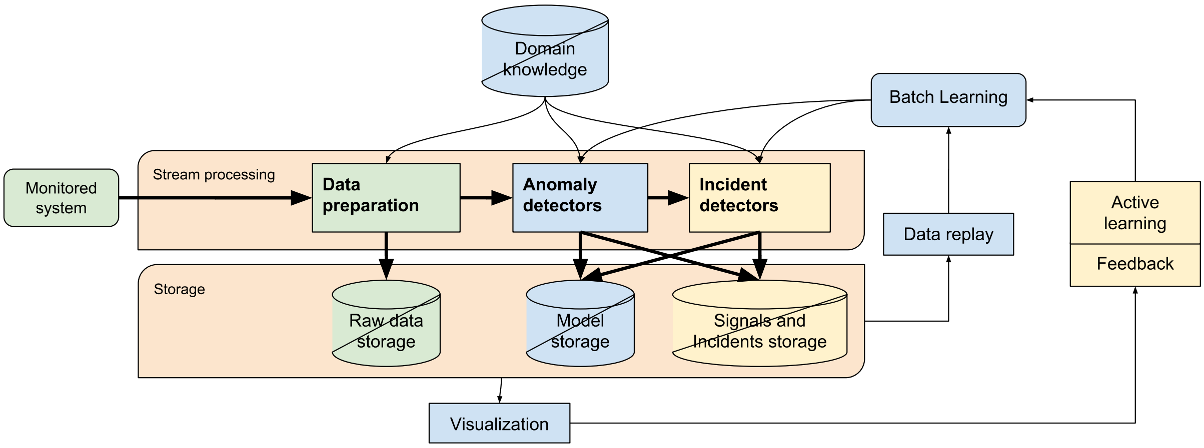

Figure 1: The big picture - displays the main building layers such as stream processing and storage, as well as the flow of the data between different components of the system.

update their **models** all the time, so this part of the storage needs to support reliable and robust storing of possibly large binary files.

3.3 Stream processing module

This module contains the most important part of the system - the components that transport the data, run the processing and generate alerts.

3.3.1 Incoming data pre-processing

Incoming data that the system analyses arrives at different volumes and speeds (*high-velocity*), as well as in many different types and formats. This data needs to be pre-processed before it reaches any anomaly detection algorithms.

Coping with such high-volume data stream requires special technologies. Streaming solutions such as Apache Kafka [4] have been developed and battle tested for processing millions of data records per second in a distributed manner. This step needs to perform several functions.

Data formatting and enrichment - transform messages from the input format into a common format that is accepted by the internal algorithms. Also, additional data fields can be attached, based on background knowledge.

Data aggregation - sometimes we want to measure characteristics of all the data within some time intervals (e.g. average speed in the last 10 minutes).

Data routing - send the transformed and aggregated data to relevant receivers. There may be several listeners for the same type of input data.

3.3.2 Signal detectors

When data is ready for processing, it is routed to signal detectors. They operate on a single data stream, often only on a small partition of it - e.g. single stock, group of related stocks. They handle huge data volumes, so they need to be fast, using very little resources. To achieve great flexibility regarding input data a dynamic allocation of such processors is required. This enables handling of previously unseen data partitions as well as scalability in parallel processing.

These anomalies (signals) have simple models and consequently alert explanations. But they are local in nature - their scope is most often very limited. They also operate on single-data stream, so they don't take into account the anomalies in '*'the neighbourhood"*. To overcome this deficiencies, we propose the third step of stream processing, to which signals should be sent.

3.3.3 Incident detectors

This stage of the processing receives signals from different parts of the system, performing scoring of their importance, combining them into *incidents* and thus achieving several advantages.

The scoring algorithm provides option to assign user-guided *subjective importance* to signals - e.g. two statistically equally important anomalies can have completely difference perceived value to the user. This step can also can correlate data across data-streams, a step that is hard to achieve and that proves to be very valuable. Given data from differnt parts of the system it can create more complex constructs that better evaluate the impact of the current problem on the whole system.

This **level of abstraction** is the main access point for end-users - it more closely follows their way of addressing system malfunctions (e.g "if module A breaks, it will have impact on modules B and C, but module D should remain unaffected").

3.3.4 Background knowledge

To help guide the algorithms during the signal detection we can provide additional background knowledge in different forms, such as metadata, manual thresholds and rules, graphs and other structures. All this data can be used to perform various enhancements of basic algorithms, such as creation of **additional features** in data pre-processing, **up- and down-voting** of results (e.g. estimated impact of detected anomaly), **pruning of search space** in optimization steps, **estimation of affected entities** for given anomaly or **support for complex simulations** when current performance is measured against historical values. These rules and metadata can be acquired by analyzing historical data as well as collecting knowledge from end-user, e.g. manual feedback/sign-off and active learning.

3.4 Improving actionability

The system modules presented so far are mostly established components that are used also in normal processing steps of modern, cloud-based systems (see [1]). We propose that they should be upgraded with the following functionalities in order to achieve the goal of high-quality actionable alerts, empowering users to manage their complex systems in the most efficient way.

3.4.1 Feedback

Historical incidents are very valuable for learning of informative features that aid detection of anomalies. They are also used for calibrating scoring algorithm that assigns relevance scores to generated signals and incidents. It is common for the organization to require every major detected incident to be manually signed off - a *relevance tag* (e.g. high-relevant, semi-relevant, not-relevant, noise, new-normal) has to be assigned to it by the operators. These tags are used for training of incident-classification algorithms, but we can also construct a more complex setting where a form of backtracking is used to *calibrate* signal detectors.

3.4.2 Active learning

The *active learning* approach [3] can be used to make the manual classification effort more efficient. The system provides untagged examples/incidents where the criteria function returns the value that is the closest to the decision boundary. The user then manually classifies the incident and the classification model is re-trained with this new data. By guiding users in this way the system requires relatively small number of steps to cover the search space and obtain good learning examples.

Our proposed approach incorporates this continuous activity in several areas. GUI module should contain appropriate pages where user can enter his feedback and active-learning input. Storage module contains alerts historical data that can be used for re-training of incident detectors. Storage module also contains old and new incident-detector models that can be picked up automatically by the processing module.

4. VALIDATION AND DISCUSSION

Based on our extensive experience with practical anomaly detection implementation, we identified several new requirements for these systems. The presented approach satisfies them by supporting big-data real-time analytics on one side and actionability via active-learning support on the other.

The system architecture is deployable to cloud environment by design. We also employ modern streaming and storage technologies for transporting and storing of different input data and alerts.

We observed that users appreciate our notion of incidents - a grouping of alerts that occur in certain small time interval. Users feel comfortable with seeing the big picture (an indcident) in then drill down into specific data (individual signal). They reported this feature enables them to cut down time for understanding the problem by an order of magnitude (from hours to minutes).

Active-learning component was well received, as it made manual work more efficient. The users noticed how the algorithm was choosing more and more complex learning examples for manual classification. This helped them feel productive and engadged. They also reported positive impact of active learning on their problem understanding, as they were presented with some potentially problematic situations that went unnoticed in the past.

Based on above observations were conclude that our proposed approach has positively impact on the organization, both for technologies as well as human operators. Additional ideas that were collected from users are listed under future work.

5. CONCLUSIONS AND FUTURE WORK

The focus of our future work is on several advanced scenarios where a lot of added value for users is expected, mixing anomaly detection, optimization and simulation. Main gains are expected to come from feedback collection and active learning. Apart from monitoring IT systems, the target domains are also manufacturing and smart cities. We also collected some features that users commonly inquired about:

- **Root-cause analysis** - when a major incident occurs, many parts of the system get affected. To resolve issues as quickly as possible, the operators should be pointed to the origin of the problem. The anomaly detection system should thus have a capability to point to the first signal with high-impact on the final relevance score.
- **Predictions** - The goal for all monitoring systems is to detect problems as soon as possible. The system must that not only be able to detect signals, but also forecast them, based on past behavior. In order to do that, the algorithms require more metadata and structure to properly model inter-dependencies between signals. Mere observation is much easier than simulation of a complex system with many moving parts. But it is possible and is what users expect from a *modern AI-based system*. Our future reserach will be oriented towards providing and efficiently integrating these functionalities into our anomaly-detection approach.

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Predicting customers at risk with machine learning

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ABSTRACT

Today's market landscape is becoming increasingly competitive as more advanced methods are used to understand customer's behavior. One of key techniques are churn mitigation tactics which are aimed at understanding which customers are at risk to leave the service provider and how to prevent this departure. This paper presents analyzes accounts renewal rates and uses easily applicable models to predict which accounts will be decreasing spend at the time when they are due to renew their existing contract based on number of attributes. Key questions it tries to explore is if customer behavioral or customer characteristic data (or combination of both) is better at predicting accounts that will renew at lower than renewal target amount (churn rate).

Categories and Subject Descriptors

F.2.1 **[Numerical Algorithms and Problems]:** Data mining, Structured prediction

General Terms

Algorithms, Management, Measurement, Documentation, Performance

Keywords

Data Mining, Analysis, Churn prediction.

1. INTRODUCTION

The main issue of business is how to make educated decision with support of analysis that dissect complex decisions on addressable problems using measurements and algorithms. Where there are many disciplines are researching methodological and operational aspects of decision making, at the main level, we distinguish between decision sciences and decision systems [1]. With increasing number of companies trying to use machine learning to assist in their decision-making process we examined how decision science can be supplemented by applying machine learning models to the company's customer data. We partnered with the medium sized B2B business operating in Europe and Africa with the aim to help them better understand their 'customers at risk' segment of clients.

To this end we developed two easily applicable performance algorithms designed to highlight customers at risk and company can address to mitigate their risk of leaving as clients.

The paper has the following structure: in section 2 we are presenting related work to the area recorded historically. Next, data acquisition is explained in section 3 followed by results acquired from the tested algorithms in section 4. We then conclude our observations in section 5.

2. RELATED WORK

Improvements in tracking technology have enabled data driven industries to analyze data and create insights previously unavailable to the business. Data mining techniques have evolved to now support the prediction of behavior of customers such risk of leaving due to the attributes that are trackable [2]. The use of data mining methods has been widely advocated as machine learning algorithms, such as random-forest approaches have several advantages over traditional explanatory statistical modeling [3].

Lack of predefined hypothesis makes algorithms excel in these tasks as it is making it less likely to overlook predictor variables or potential interactions that would otherwise be labelled unexpected [4]. Models are often labelled as business intelligence models aimed at finding customers that are about to switch to competitors or leave the business [5].

Key classifications are observed in work related to churn that we will use in our data set for review [6]:

- Behavioral data - will consist of attributes that we have historically observe that play a role in whether the account will renew or not: product utilization, activity levels of the account, number of successful actions in the account and number of upsells done ahead of renewal.
- Characteristic attributes - will consist of size of the account in terms of spend, number of members in the company, number of active users of the products in the company, payment method and how they renew the contract, geography and what level of support the product is given (number of sales visits and interactions with the customer).

3. DATA ACQUISITION

3.1 Data understanding

Working with the customer we have arranged a set of interviews with the leadership to better understand their business and challenges they are experiencing together with ambitions they have in the business. After the interview rounds we focused on reviewing 2 hypotheses flagged in the examination process:

- What is driving churn numbers: behavior of the customers or better structure of the base?

- Does acquisition of new accounts represent a risk in churn number with historic observation of accounts renewing lower / not renewing in their first-year renewal?

3.2 Data pre-processing

The data we used derives from company's internal customer bookings and customer databases we consolidated. As customers are on yearly renewals we have taken the renewal and the data on the account before the renewal as the key building block for analysis.

3.3 Feature engineering

We enriched the data using SQL joins on the customer numbers to include key characteristics of accounts, tenure of the client, products utilization information, behavior of the customer before the renewal and their usage of the product.

In terms of regional split of the market the dataset consists of 4 key geo and segment regions in Europe and Africa:

- Medium-business segment
- UK & Ireland market
- Europe Enterprise segment
- Eastern Europe, Middle-East and Africa

Through feature engineering and reviewing descriptive statistics key attributes we nominalized are 11.

For the machine learning purposes for the calls we have selected 3 possible outcomes related to the outcome of customer spend after it's renewal:

- Customer_Renew (Not renew, Partial renew, Full renew)

3.4 Data Set Statistics

We selected bookings period from 2016 to end of 2017 including 23,043 instances in above selected renewal of 12,872 accounts. The attributes that were nominalized are listed below:

- (nom) Has main product – has product 1
- (nom) Has_assisting_product – has product 2
- (nom) Has_media_product – product 3
- (nom) Account_potential – size and potential of the account
- (nom) Is_Auto_Renew – auto renewal option enabled
- (nom) First_renewal – is the client renewing first time
- (nom) Upsold_Before_renewal – was there an upsell before
- (nom) JS_Utilization – utilization of product 2 - indicator
- (nom) Score_Engagement – engagement of the recruiter
- (nom) LRI_Score – savviness of the user of the product

4. RESULTS

4.1 Brief description of the methods used

Where multiple algorithms were used during the testing due to important feature that the result needed to have at least one interpretable model, so we went in the direction of nominalizing attributes and decided to use J-48 model and Random forest classifier on the data set.

J48. Decision trees C4.5 (J48 in Weka) algorithm: deals with continuous attributes as observed in the related work.

Where the method is classification-only the main machine learning method applied is J48 pruned tree or WEKA-J48 machine learning method. Tree tries to partition the data set into subsets by evaluating the normalized information gain from choosing a descriptor for splitting the data. The training process stops when the resulting nodes contain instances of single classes or if no descriptor can be found that would result to the information gain.

Random Forest. We assume that the user knows about the construction of single classification trees. Random Forests grows many classification trees. To classify a new object from an input vector, put the input vector down each of the trees in the forest. Each tree gives a classification, and we say the tree "votes" for that class. The forest chooses the classification having the most votes (over all the trees in the forest) [7]. Both methods were applied to imported dataset numerous times with continuous testing of parameters to improve performance.

4.2 Application of J48

Working with Weka on the dataset of the customer we tried to launch the model to tune the parameters. Key modifications:

- "10-fold cross validation" used to improve accuracy
- Minimum number of objects moved to 100

As Figure 2 shows this reduced the number of leaves to 16 which was something comprehendible enough.

Summary of results below:

```
=== Summary ===

Correctly Classified Instances       16789               72.8626 %
Incorrectly Classified Instances      6253               27.1374 %
Kappa statistic                          0.249
Mean absolute error                      0.2759
Root mean squared error                  0.3716
Relative absolute error                 88.6325 %
Root relative squared error             94.189  %
Total Number of Instances            23042
```

Figure 1: J-48 model error estimates

4.3 Application of Random forest

We ran several tests on Random forest vs Random trees. When tuning parameters Random tree tended to not respond well to pruning so Random forest was a preferred option. Like J48, application with key modifications was focused on validation and additionally on setting maximum depth of the random forest:

- "10-fold cross validation"
- Max. depth set at 3

Summary of results below:

```
=== Summary ===

Correctly Classified Instances       16635               72.1943 %
Incorrectly Classified Instances      6407               27.8057 %
Kappa statistic                          0.1852
Mean absolute error                      0.28
Root mean squared error                  0.3685
Relative absolute error                 89.9598 %
Root relative squared error             93.401  %
Total Number of Instances            23042
```

Figure 2: Random forest model error estimates

4.4 Comparisons of models

Overall the J48 model has surprisingly 0.7pp points higher Classification Accuracy than the Random forest model.

Validation Measures	J48	Random Forest
Classification Accuracy	72.9%	72.2%
Mean absolute error	0.276	0.280

Table 1. Baseline benchmark validation measures

Key observation analyzing the data was that neither model was predicting any partially churned accounts after we forced their trees to be pruned.

J48 predictions:

a	b	c	<-- classified as
0	2745	285 |	a = PARTIAL_RENEW
0	1528	789 |	b = FULL_RENEW
0	2434	1504 |	c = NOT_RENEWED

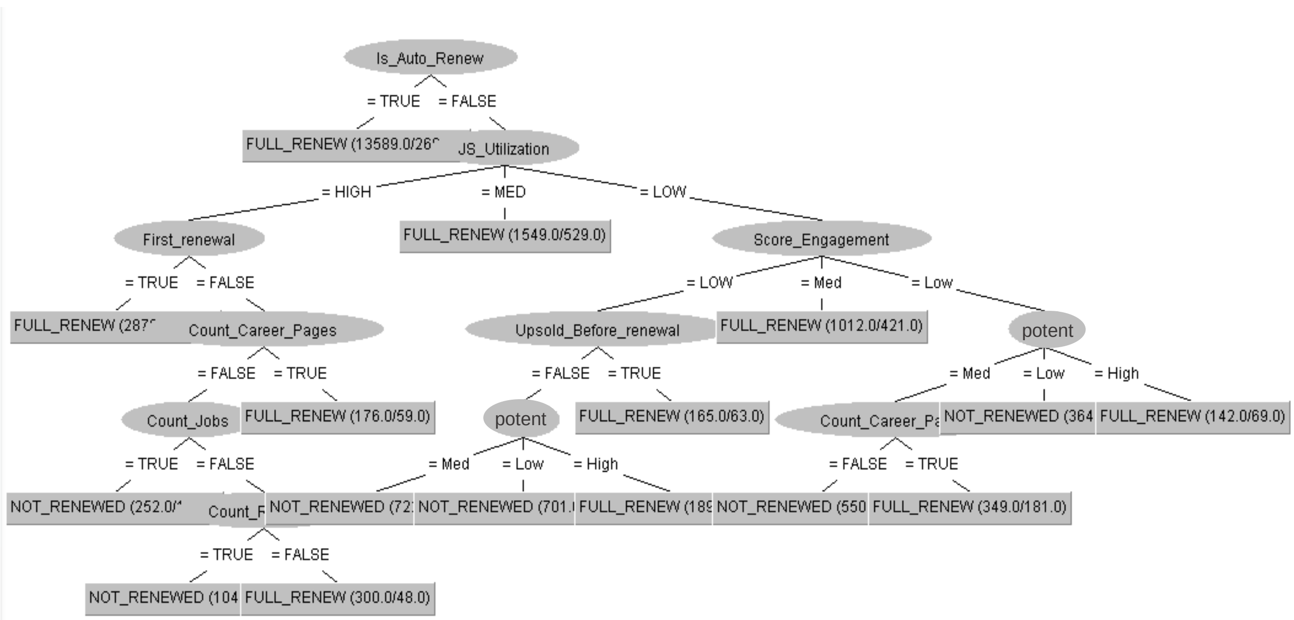

Figure 3: The J48 decision tree

Random forest predictions:

a	b	c	<-- classified as
0	2857	173 |	a = PARTIAL_RENEW
0	15591	483 |	b = FULL_RENEW
0	2894	1044 |	c = NOT_RENEWED

Even though Random forest has a lower classification accuracy J48 offers significantly higher interpretability with tree pruning offering valuable insights, short description below and discussed in evaluation of models.

J48 provided a significantly better interpretability and classification accuracy than the Random forest or any test on the Random tree model. Some additional tests were done on Naïve Bayes model and J48 was superior in the results. Key area it accelerated was in predicting accounts that will not renew. Where the precision is just above 38% this is almost double comparing to Random forest model.

3 key takeaways observed that the company found the most insightful were:

- One of the new features designed by the product team that encouraged the auto-renew of their clients played the most important at predicting the renewal rate
- Customer behavior is a better signal for probability of renewal vs general account characteristics
- Account potential which is the predictor of account potential and size plays the role only after product utilization and engagement of the account with our products

5. CONCLUSION AND FUTURE WORK

For the acceleration of performance, the decision tree is of paramount importance and value. Insight that Auto renew as a feature is one of the key predictors if the account will renew fully is truly remarkable based on the simplicity of the models and how easily applicable they are.

Applications of this models will be of great foundation for driving the discussion on different account features and metrics. This is especially true as it is tackling one of the key challenges observed in hypothesis as in how important ‘account potential’ is for the account ahead of the renewal.

Observing the attributes added into the analysis scope and optimizing them for the J48 we were able to get valuable insight which account characteristics vs account behaviors ahead of the renewal are the best predictors for the account to renew at the full amount.

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Text mining MEDLINE to support public health

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ABSTRACT

Today's society is data rich and information driven, with access to numerous data sources available that have the potential to provide new insights into areas such as disease prevention, personalised medicine and data driven policy decisions. This paper describes and demonstrates the use of text mining tools developed to support public health institutions to complement their data with other accessible open data sources, optimize analysis and gain insight when examining policy. In particular we focus on the exploration of MEDLINE, the biggest structured open dataset of biomedical knowledge. In MEDLINE we utilize its terminology for indexing and cataloguing biomedical information – MeSH – to maximize the efficacy of the dataset.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Measurement, Performance, Health.

Keywords

Big Data, Public Health, Healthcare, Text Mining, Machine Learning, MEDLINE, MeSH Headings.

1. MEANINGFUL BIG DATA TOOLS TO SUPPORT PUBLIC HEALTH

The Meaningful Integration of Data, Analytics and Service [MIDAS], Horizon 2020 (H2020) project [1] is developing a big data platform that facilitates the utilisation of healthcare data beyond existing isolated systems, making that data amenable to enrichment with open and social data. This solution aims to enable evidence-based health policy decision-making, leading to significant improvements in healthcare and quality of life for all citizens. Policy makers will have the capability to perform data-driven evaluations of the efficiency and effectiveness of proposed policies in terms of expenditure, delivery, wellbeing, and health and socio-economic inequalities, thus improving current policy risk stratification, formulation, implementation and evaluation. MIDAS enables the integration of heterogeneous data sources, provides privacy-preserving analytics, forecasting tools and visualisation modules of actionable information (see the dashboard of the first prototype in Figure 1). The integration of open data is fundamental to the participatory nature of the project and core ideology, that heterogeneity brings insight and value to analysis. This will democratize, to some extent, the contribution to the results of MIDAS. Moreover, it enables the MIDAS user to profit from the often powerful information that exists in these open datasets. A point in case is MEDLINE, the scientific biomedical knowledge base, made publicly available through PubMed. The set of tools described in this demonstration paper focuses on this large open dataset, and the exploration of its structured data.

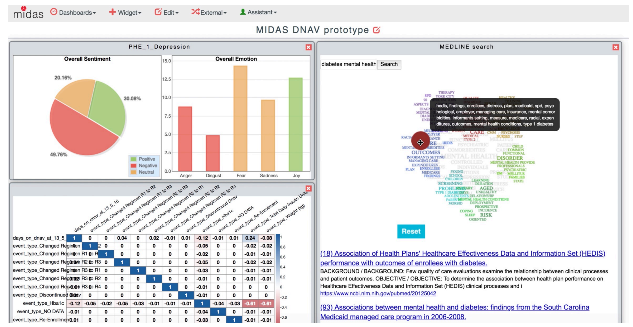

Figure 1. MIDAS platform dashboard, composed of visualisation modules customized to the public health data sourced in each governamental institution, and combined with open data.

2. THE MEDLINE BIOMEDICAL OPEN DATA SET AND IT'S CHALLENGES.

2.1. MEDLINE DATASET.

With the accelerating use of big data, and the analytics and visualization of this information being used to positively affect the daily life of people worldwide, health professionals require more and more efficient and effective technologies to bring added value to the information outputs when planning and delivering care. The day-to-day growth of online knowledge requires that the high quality information sources are complete, high quality and accessible. A particular example of this is the PubMed system, which allows access to the state-of-the-art in medical research. This tool is frequently used to gain an overview of a certain topic using several filters, tags and advanced search options. PubMed has been freely available since 1997, providing access to references and abstracts on life sciences and biomedical topics. MEDLINE is the underlying open database [7], maintained by the United States National Library of Medicine (NLM) at the National Institutes of Health (NIH). It includes citations from more than 5200 journals worldwide journals in approximately 40 languages (about 60 languages in older journals). It stores structured information on more than 27 million records dating from 1946 to the present. About 500,000 new records are added each year. 17.2 million of these records are listed with their abstracts, and 16.9 million articles have links to full-text, of which 5.9 million articles have full-text available for free online use. In particular, it includes 443.218 full-text articles with the key-words string "public health".

2.2. MEDLINE STRUCTURE.

The MEDLINE dataset includes a comprehensive controlled vocabulary – the *Medical Subject Headings* (MeSH) – that delivers a functional system of indexing journal articles and books in the life sciences. It has proven very useful in the search of specific topics in medical research, which is particularly useful for researchers conducting initial literature reviews before engaging in particular research tasks. Humans annotate most of the articles in MEDLINE with MeSH Heading descriptors. These descriptors permit the user to explore a certain biomedical related topic, which relies on curated information made available by the NIH. MeSH is composed of 16 major categories (covering anatomical terms, diseases, drugs, etc) that further subdivide from the most general to the most specific in up to 13 hierarchical depth levels.

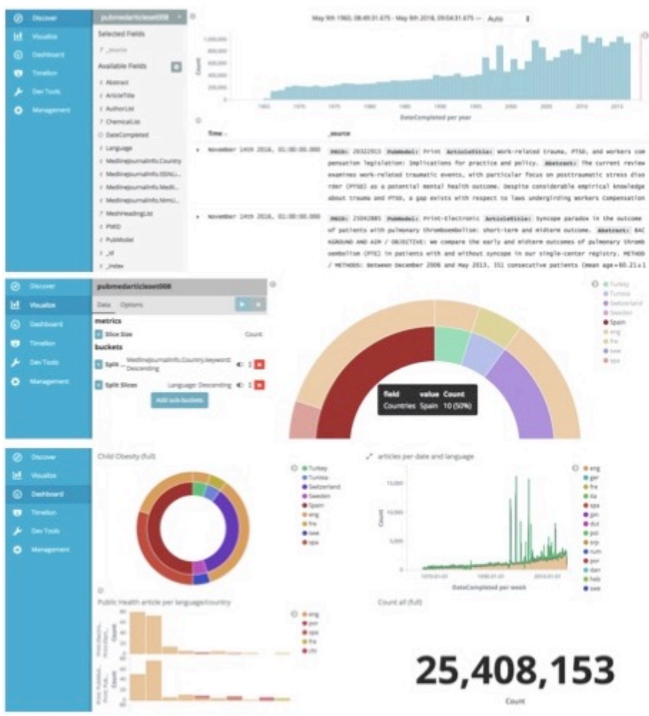

Figure 2. *MEDLINE data visualisation tool enabling exploration of that open dataset in its full potential, based on data representations easy to understand and to communicate. It provides an interactive public instance that can be managed at the dashboard management tool (below) for which the visualisation modules are constructed (in the center) based on the queries made to the MEDLINE dataset (above).*

2.3. MEDLINE INDEX.

This paper demonstrates the interactive data visualisation text-mining tools that enable the user to extract meaningful information from MEDLINE. To do that we are using the underlying ontology-like structure MeSH. MEDLINE data, together with the MeSH annotation, that is indexed with ElasticSearch and made available to data analytics and visualisation tools. This will be discussed in more detail in the next section.

The manipulation and visualization of such a complete data source brings challenges, particularly in the efficient search, review and presentation when choosing appropriate scientific knowledge. The manipulation and visualisation of complex text data is an important step in extracting meaningful information from a dataset such as MEDLINE. Although powerful, the online search engine provided by the NLM does not provide suitable tools for in-depth analysis and the emergence of scientific information. As one of the main goals of MIDAS is to experiment with advanced visualisation techniques in support of public health policy making, a suitable MIDAS PubMed repository had to be developed. This repository has to allow exploration of a wide range of different visualisation techniques in order to evaluate their applicability to policy-making tasks within the policy cycle. Therefore, there was a need for a selection of a powerful, semi-structured text index, that would allow free text searches, but also allow the creation of complex queries based on available metadata. An obvious choice is elasticSearch, which combines features provided by NoSQL databases with standard full text indexes, as it is based on the Apache Lucene Index. The main design challenge when choosing this particular toolset was that querying based on arrays or parent-child relations are not supported, meaning that for complex use-cases different indexes based on the same source dataset have to be created. Nevertheless, excellent results, particularly with regards to the area of performance have been obtained.

2.4. MEDLINE DASHBOARD.

One of the identified needs motivating this work is assuring the availability of a dynamic dashboard that permits the user to explore data visualisation modules, representing the queries to the MEDLINE dataset through pie charts, bar charts, etc [5]. The dashboard that we made available (in Figure 2) feeds on that dataset through the elasticSearch index earlier discussed. It is composed of several interactive visualisation modules that utilises the mouse hover when interacting and provide information through pop-up messages on several aspects of the data based on particular queries of interest (e.g. a pie chart representing the “public health” citations that talk about “childhood obesity” during a selected period of time; or a bar chart showing different concepts included in the articles related to “mental health” in Finnish scientific journals). The MEDLINE dataset is mostly in the English language but includes a significant volume of translated abstracts of scientific articles that were written in several other languages. The open source data visualisation Kibana is a plugin to elasticSearch that supports the described dashboard. Thus, it is the data visualisation dashboard of choice for elasticSearch-based indexes, such as the one we present here. It is used in the context of MIDAS for fast prototyping and support of part of MIDAS use-cases. While the dashboard itself serves the less technical user to explore the data available (over a subset of the data generated by a topic of interest), other options are available that permit more control of the data by the data scientists at a more operational level. These are: (i) the management dashboard, where the technical user can perform the appropriate subsampling based on the topics of interest and the required advanced options over the available data features; and (ii) the visual modules creator permitting the technical user to easily create new interactive visualisation modules. Moreover, this tool enables one to query large datasets and produce different types of visualisation modules that can be later integrated into customized dashboards. The flexibility of such dashboards permits the user to profit from data visualisations that feed on his/her preferences, previously set up as filters to the dataset. The MIDAS data visualisation tools permit the user to explore the potential of the MEDLINE dataset, based on pie charts and other representations that are easy to comprehend, interact with, and to communicate. It also enables a public instance based on a particular query to the dataset, which includes different types of data visualisation modules that can later integrate a customised dashboard, designed in agreement with the workflows and preferences of the end-user. This live dashboard can easily be integrated through an iframe in any website, not showing the customization settings but maintaining the interaction capability and the real-time update. *It permits a complete base solution to further explorer the MEDLNE index and the associated dataset [6]*.

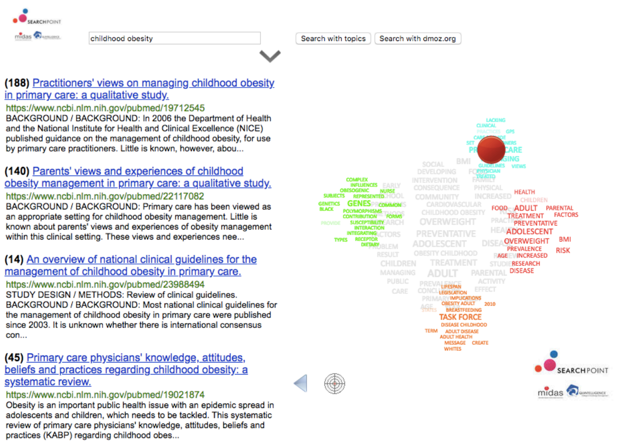

Figure 4. A screenshot of the MEDLINE SearchPoint, with groups of keywords (on the right) extracted from the search results, represented by different colors, and on the left the reindexed search results themselves with the number that they appear in the original index *[6]*.

4. MEDLINE SEARCHPOINT.

The efficient visualisation of complex data is today an important step in obtaining the research questions that describe the problem that is extracted from that data. The MEDLINE SearchPoint is an interactive exploratory tool refocused from the proprietary open source technology *SearchPoint* [8] (available at searchpoint.ijs.si) to support health professionals in the search for appropriate biomedical knowledge. It exhibits the clustered keywords of a query, after searching for a topic. When we use indexing services (such as standard search engines) to search for information across a huge amount of text documents – the MEDLINE index described in Section 2 being an example – we usually receive the answer as a list sorted by a relevance criteria defined by the search engine. The answer we get is biased by definition. Even by refining the query further, a time consuming process, we can never be confident about the quality of the result. This interactive visual tool helps us in identifying the information we are looking for by reordering the positioning of the search results according to subtopics extracted from the results of the original search by the user. For example, when we enter a search term ‘childhood obesity, the system performs an elasticSearch search over the MEDLINE dataset, extracts groups of keywords that best describe different subgroups of results (these are most relevant, and not most frequent terms). This tool gives us an overview of the content of the retrieved documents (e.g. we see groups of results about prevention, pregnancy, treatments, etc.) represented by: (i) a numbered list of 10 MEDLINE articles with a short description extracted from the first part of the abstract; (ii) a word-cloud representing the k-means clusters of topics in the articles that include the searched keywords; (iii) a pointer that can be moved through the word-cloud and that will change the priority of the listed articles. The word-cloud in (ii) is done by taking a set of MEDLINE documents S and transforming them into vectors using TF-IDF, where each dimension represents the "frequency" of one particular word. For example, lets say that we have document D_1: "psoriasis is bad" and document D_2: "psoriasis is good". This could be transformed as $D_1 = (1, 1, 1, 0)$ and $D_2 = (1, 1, 0, 1)$. Then the documents are clustered into k groups $G_1, G_2, ..., G_k$ using the k-means algorithm. For each group we compute the "average" document (centroid), which is the representative of the group. The most frequent words in the "average" document are drawn in the word cloud - the central grey word cloud is the "average" of all the documents in S. We can calculate how similar a particular document d is to a group G_i by calculating the cosine of the angle between the vector representation of d and the "average" document (centroid) of the group G_i. By dragging the red SearchPoint ball over the word-groups, we provide the relevance criteria to the search result, thus bringing to the top results the articles we are most interested in (see Figure 4). When that ball is moved, for each document, we calculate the similarity to each of the word-groups and combine it with the distance between the ball and the group. The result is used as the ranking weight where the document with the highest cumulative weight is ranked first. When having the mouse over the word-clouds we get a combination of the most frequent words shown in the tag clouds that change based on how close the ball is to a particular group. After getting to a position with the SearchPoint over the word cloud highlighting “primary care”, a qualitative study in primary care on childhood obesity that occupied the position 188 is now in the first position. The user can read its title and first lines of abstract, and when clicking on it, the system opens the article in the browser at its PubMed URL location.

3. MeSH CLASSIFIER

This rich data structure in the MEDLINE open set is annotated by human hand (although assisted by semi-automated NIH tools) and therefore is not available in the most recent citations. However, in the context of MIDAS we made available an automated classifier based on [2] that is able to suggest the categories of any health related free text. It learns over the part of the MEDLINE dataset that is already annotated with MeSH, and is be able to suggest categories to the submitted text snippets. These snippets can be abstracts that do not yet include MESH classification, medical summary records or even health related news articles. To do that we use a nearest centroid classifier [3] constructed from the abstracts from the MEDLINE dataset and their associated MeSH headings. Each document is embedded in a vector space as a feature vector of TF-IDF weights. For each category, a centroid is computed by averaging the embeddings of all the documents in that category. For higher levels of the MeSH structure, we also include all the documents from descendant nodes when computing the centroid. To classify a document, the classifier first computes its embedding and then assigns the document to one or more categories whose centroids are most similar to the document’s embedding. We measure the similarity as the cosine of the angle between the embeddings. Preliminary analysis shows promising results. For instance when classifying the first paragraph of the Wikipedia page for “childhood obesity”, excluding the keyword “childhood obesity” from the text, the classifier returns the following MeSH headings:

> *"Diseases/Pathological Conditions, Signs and Symptoms/Signs and Symptoms/Body Weight/Overweight",*
> *"Diseases/Pathological Conditions, Signs and Symptoms/Signs and Symptoms/Body Weight/Overweight/Obesity".*

The demonstrator version of the MeSH classifier is already available through a web app, as well as through a REST API using a POST call, and is at the moment under qualitative evaluation. This is being done together with health professionals with years of practical experience in using MeSH themselves through PubMed. In addition, we aim to further explore the potential of the developed classifier in several public health related contexts including non classified scientific articles of three types: (i) review articles; (ii) clinical studies; and (iii) standard medical articles. The potential impact of this technology will also include electronic health records and the monitoring health related news sources. We believe that his approach will address an identified recurrent need of health departments to enhance the biomedical knowledge, and motivate a step change in health monitoring.

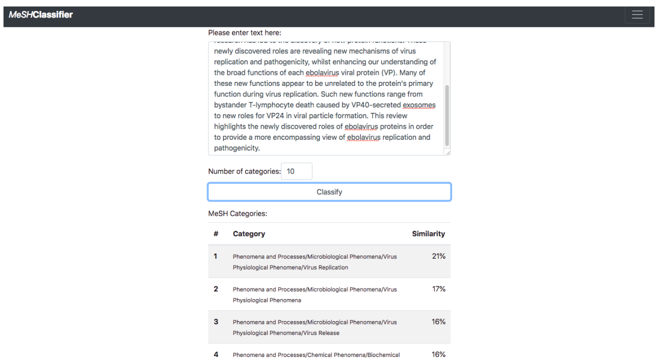

Figure 3. *A screenshot of the web app to the MEDLINE classifier, when requesting the automated MeSH annotation of a scientific review article abstract extracted from PubMed (in the body of text above) and the results as MeSH headings descriptors including their tree path in the MeSH ontology-like structure (center), their similarity measure (right) and their positioning in the classification (left).*

5. CONCLUSION AND FUTURE WORK

To further extend the usability of the MEDLINE SearchPoint, we are developing a data visualisation tool that permits the user to plot the top results mostly related with a topic of interest, as explored with SearchPoint. Based on the choice of a time window and a certain topic, such as “mental health”, the user is able to view the clustered MEDLINE documents, rolled over the plot or click to view the plotted points, each of which represents an article in PubMed. This will be done through multidimensional scaling, plotting the articles in the subsample using cosine text similarity. The difficulties to plot large datasets using these methods, and the lack of potential in the outcomes of that heavy computation, provided a focus for the team to only plot the first hundred results of the explorations done within MEDLINE SearchPoint. With this extended tool the healthcare professional will be able to: (i) explore a certain area of research with the aim of a more accessible scientific review, in identifying the evidence base for a medical study or a diagnostic decision; (ii) identify areas of dense scientific research corresponding to searchable topics (e.g. the evaluation of the coverage of certain rare diseases that need more biomedical research, or the identification of alternative research paths to overpopulated but inefficient research); and (iii) exploration of the research topic over time windows that enable filtering to avoid known unreliable results.

In line with this work we have been developing research to contribute to the smart automation of the production of biomedical review articles. This collaborative research lead by Raghu T. Santanam at Arizona State University, aims to provide a wide knowledge over a restricted topic over the wider knowledge available at MEDLINE. We utilize the deep learning algorithm Doc2vec [4] to create similarity measures between articles in our corpus. In that we built a balanced test dataset and three different representations of the corpus, and compared the performance between them. The implementation currently builds a matrix of similarity scores for each article in the corpus. In the next steps, we will compare similarity of documents from our implementation against the baseline for a randomly chosen set of articles in the corpus.

The further development of the MeSH classifier will consider the feedback of the usability of health professionals working in partner institutions, profiting of their years of experience with MEDLINE and MeSH itself, to tune the system to ensure the best usability in the domain. Furthermore, we will use the outcomes of the final version of this classifier to label health related news with the MeSH Headings descriptors, potentiating a new approach on the processing and monitoring of population health, population awareness of certain diseases, and the general public acceptance of public health decisions through news.

ACKNOWLEDGMENTS

We thank the support of the European Commission on the H2020 project MIDAS (G.A. nr. 727721).

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Crop classification using PerceptiveSentinel

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ABSTRACT
Efficient and accurate classification of land cover and land usage can be utilized in many different ways: ranging from natural resource management, agriculture support to legal and economic processes support. In this article, we present an implementation of land cover classification using the PerceptiveSentinel platform. Apart from using base 13 bands, only minor feature engineering was performed and different classification methods were explored. We report an F_1 and accuracy score (80-90%) in range of state of the art when using pixel-wise classification and even comparable to time series based land cover classification.

Keywords
remote sensing, earth observation, machine learning, classification

1. INTRODUCTION
Specific aspects of earth observation (EO) data (huge amount of data, widespread usage, many different problem settings etc.), coupled with the recent launch of ESA Sentinel mission that provides a huge volume of data relatively frequently (every 5-10 days), present an environment that is suitable for current machine learning approaches.

Efficient and accurate land cover classification can provide an important tool for coping with current climate change trends. Classification of crops, their location and potentially their yield prediction provide various interested parties with information on crop resistance, adapting to changes in temperature and water level changes. Along with direct help, accurate crop classification tools can be used in a variety of other programs, from government based subsidies to various insurance schemes.

Along with previously highly promising features of EO data, data acquisition and processing pose some specific challenges. Satellite acquired data is highly prone to missing data due to various reasons; mostly cloud coverage, (cloud) shadows, atmospheric refraction due to changes in atmospheric conditions. Additionally, correct training data, either for classification or regression, is hard to come by, must be relatively recent, and regularly updated due to changes in land use. Furthermore, correct labels and crop values are almost impossible to verify and usually self-reported, which often means that quality of training data is not perfect. Valero et al. [13] raise the problem of incorrect (or partially correct) data labels, which will become apparent when interpreting results.

Another class of problems is posed by the spatial resolution of images. Since satellite images provided by the ESA Sentinel-2 mission have a resolution of $10\,\mathrm{m} \times 10\,\mathrm{m}$ on most granular bands and $60\,\mathrm{m} \times 60\,\mathrm{m}$ on bands used for atmospheric correction, land cover irregularities falling in this order of magnitude might not be detected and correctly learned on. This problem is especially prevalent in smaller and more diverse regions, where individual fields are smaller and land usage is more fragmented.

The current state of the art land classification focuses heavily on the temporal dimension of acquired data [1], [13], [14]. The time-based analysis offers clear advantages since it considers growth cycles of sample crops, enables continuous classification etc., and generally produces better results, with reported F_1 scores for crop/no-crop classification in a range from 0.80-0.93 [14]. One major drawback of time-based classification is the problem of missing data. In our test drive scenario, 70% of images are heavily obscured by clouds [9], a problem which removes a lot of the advantages of time-based classification and demands major compensations with missing data imputation.

In this paper, we present a possible approach on a land cover classification of single time image acquired using the PerceptiveSentinel [1] platform, using multiple classification methods for tulip field classification in Den Helder, Netherlands.

2. PERCEPTIVESENTINEL PLATFORM
2.1 Data
Data used in this article is provided by ESA Sentinel-2 mission. The Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same orbit, phased at 180° to each other [2]. Sentinel-2A was launched on 23rd June 2015, while the second satellite was launched on 7th March 2017. Revisit time for equator is 10 days for each satellite, so since the launch of the second satellite, each data point is sampled at least every 5 days (a bit more frequently when away from the equator).

Each satellite collects data in 13 different wavelength bands presented in figure 1, with varying granularity. Data obtained for each pixel is firstly preprocessed by ESA where

[1] http://www.perceptivesentinel.eu/

atmospheric reflectance and earth surface shadows are corrected [4].

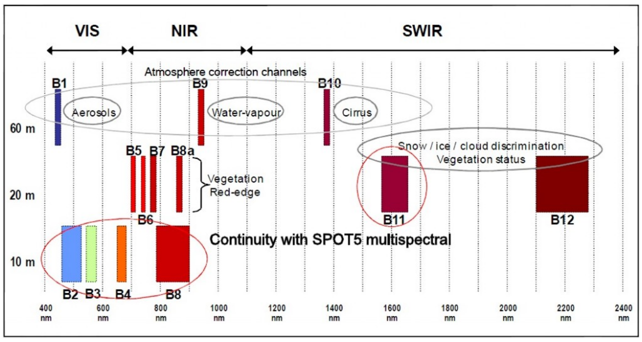

Figure 1: Sentinel 2 spectral bands [12]

2.2 Data Acquisition

Satellites provide around 1TB of raw data per day, which is provided for free on Amazon AWS. Images are then processed and indexed by Sinergise and subsequently provided for free along with their SentinelHub [11] library. As part of the PerceptiveSentinel project, a sample platform was developed on top of SH library, which eases data acquisition, cloud detection and further data analysis on acquired data.

The whole dataset currently consists of images captured from the end of June 2015 till August 2018. Images are available for use in a few hours after being taken. Since working with data for the whole world is impractical, smaller geographical regions are usually queried and analyzed on their own. One important aspect when analyzing larger regions that must be taken care of is the fact that EO data is acquired in swaths with the width of approximately 290 km [3]. Since the swaths overlap a bit, care must be taken when sampling larger areas (in a size of small state), as the area might be chopped into a few irregular tiles covering only part of an area of interest.

Corrected images are available using the SentinelHub library. PerceptiveSentinel platform provides an easy to use framework that combines satellite data acquisition, subsequent cloud detection enables an easy way to pipeline machine learning framework. They also provide an easy way to integrate (vectorized or rasterized) geopedia layers as a source of ground truth for classification.

2.3 Data Preprocessing

Most of the preprocessing is already done by ESA (atmospheric reflectance, projection ...). The data is mostly clean and presented as a pixel array with dimensions H×W×B, where W and H are image dimensions (in our case 589 and 590) and B is number of bands selected (in our case 13, but we may individually preconfigure the Sentinelhub library to return variable number of bands and even custom calculations based on other bands).

When preprocessing we only need to consider one part of problematic data, namely clouded parts of images. ESA provides some sort of cloud detection, but our experiments proved it unsatisfactory, so we used the s2cloudless library developed by Sinergise for this task [10].

3. METHODOLOGY

3.1 Sample Data

For purpose of this article, a sample patch of fields in Den Helder, Netherlands, with coordinates: (4.7104, 52.8991), (4.7983, 52.9521) was analyzed. Three different datasets were considered: tulip fields in year 2016 and 2017 and arable land in 2017. For each of these datasets, the first observed date with no detected clouds was selected and binary classification (tulips vs no-tulips and arable vs non-arable land) was performed on the image from that date. The date selection was based on the fact that tulips' blooms are most apparent during late April and beginning of May [9].

3.2 Feature Vectors

Three additional earth observation indices that were used as features are presented in Table 1 as suggested by [8].

Name	Formula
NDVI	$\frac{B08 - B04}{B08 + B04}$
EVI	$\frac{2.5(B08 - B04)}{(B08 + 6B04 - 7.5B02 + 1)}$
SAVI	$(1 + 0.5)\frac{B08 - B04}{B08 + B04 + 0.5}$

Table 1: Additional indices

For each selected image, all 13 Sentinel2-bands were considered as feature vectors for each pixel, in the second experiment, additional land cover based classification indices from Table 1 were added.

3.3 Experiment

The experiment was conducted in the Den Helder region to asses the effectiveness of classification and improvement with additional features. The same region is also used as a test drive location for the PerceptiveSentintel project. One important characteristic to keep in mind is the fact that classification classes are not uniformly distributed. Tulip fields constitute 17.1% and 17.7% of all pixels in the year 2016 and 2017 respectively, while arable land accounts for 64% of pixels in 2017 data set. Care must, therefore, be taken when assessing the predictive power of a model.

For each dataset, multiple classification algorithms were tested on base band feature vectors and feature vectors enriched with calculated indices from Table 1. Experiments were carried out using python library `scikit-learn` and default parameters were used for each type of classifier. For each data set and each classifier (Ada Boost, Logistic regression, Random Forest, Multilayer perceptron, Gradient Boosting, Nearest neighbors and Naive Bayes), 3-fold cross-validation was performed. Folds were generated on a non-shuffled dataset with balanced classes ratios.

4. RESULTS

Results of selected classifiers are presented in Tables 2–4 (ind column indicates additional indices as features) are comparable with results from related works [5], [6] which report accuracy results from 60-80%, although our experimental dataset was quite small and homogeneous, which might offer some advantage over larger plots of land.

Alg.	Ind	Prec	Rec	Acc	F_1	T
Logistic Regression	No	**0.895**	0.551	0.912	0.682	2.8
	Yes	0.877	0.564	0.912	0.686	3.6
Decision Tree	No	0.640	0.697	0.881	0.667	7.9
	Yes	0.629	0.698	0.878	0.662	11.3
Random Forest	No	0.870	0.675	**0.927**	0.760	15.0
	Yes	0.867	0.680	**0.927**	0.762	21.7
ML Perceptron	No	0.875	0.720	**0.935**	**0.790**	184.2
	Yes	0.835	0.740	**0.931**	**0.784**	241.3
Gradient Boosting	No	0.878	0.657	0.926	0.751	84.8
	Yes	0.856	0.657	0.923	0.743	120.6
Naive Bayes	No	0.343	**0.800**	0.704	0.480	0.4
	Yes	0.316	**0.808**	0.669	0.454	0.6

Table 2: Tulip fields in 2016 results

Alg.	Ind	Prec	Rec	Acc	F_1	T
Logistic Regression	No	0.514	0.561	0.829	0.537	2.8
	Yes	0.545	0.615	0.841	0.578	4.0
Decision Tree	No	0.574	0.633	0.852	0.602	7.3
	Yes	0.565	0.634	0.849	0.598	11.2
Random Forest	No	0.786	0.599	0.900	0.680	13.8
	Yes	**0.788**	0.604	0.901	0.683	20.5
ML Perceptron	No	**0.790**	0.673	**0.911**	0.727	375.9
	Yes	0.780	0.693	**0.911**	**0.734**	419.8
Gradient Boosting	No	0.786	0.613	0.902	0.689	84.4
	Yes	0.785	0.614	0.902	0.689	120.3
Naive Bayes	No	0.330	**0.861**	0.666	0.477	0.4
	Yes	0.318	**0.858**	0.649	0.464	0.6

Table 3: Tulip fields in 2017 results

For each test, precision, recall, accuracy, and F_1 score were reported along with the timing of the whole process. As seen from the tables, multilayer perceptron achieved best results when comparing F_1 score across all data sets, but its training was considerably slower than all other classification methods (in fact, it's training time was comparable to all other classification times combined). Multilayer perceptron was followed closely by random forest, which achieved just marginally worse results, but was way less expensive to train and evaluate, while still retaining score that was higher or comparable with related works.

Adding additional features to feature vector did not significantly improve classification score and has in some cases even hampered performance while having a significant impact on the training time.

Using classifier trained on 2016 tulips data and predicting data in 2017 yielded an F_1 score of 0.57, while classifier trained on 2017 data yielded an F_1 score of 0.67 on 2016 data, indicating the robustness of the classifier.

Graphical representation of classification errors can be seen in Figure 2 and 3 which show true positive (TP) pixels in purple color, false positive (FP) in blue color and false negative (FN) in red. Looking at the images it can easily be

Alg.	Ind	Prec	Rec	Acc	F_1	T
Logistic Regression	No	0.853	0.913	0.843	0.882	2.7
	Yes	0.854	0.908	0.841	0.880	3.2
Decision Tree	No	0.878	0.868	0.837	0.873	9.6
	Yes	0.885	0.868	0.842	0.876	14.5
Random Forest	No	0.928	0.889	0.884	0.908	17.3
	Yes	**0.934**	0.891	0.889	0.912	26.3
ML Perceptron	No	**0.929**	**0.932**	**0.911**	**0.931**	522.4
	Yes	0.926	**0.940**	**0.913**	**0.933**	586.2
Gradient Boosting	No	0.899	0.921	0.883	0.910	82.6
	Yes	0.905	0.926	0.890	0.915	118.4
Naive Bayes	No	0.823	0.830	0.776	0.827	0.4
	Yes	0.814	0.806	0.757	0.810	0.6

Table 4: Arable land in 2017 results

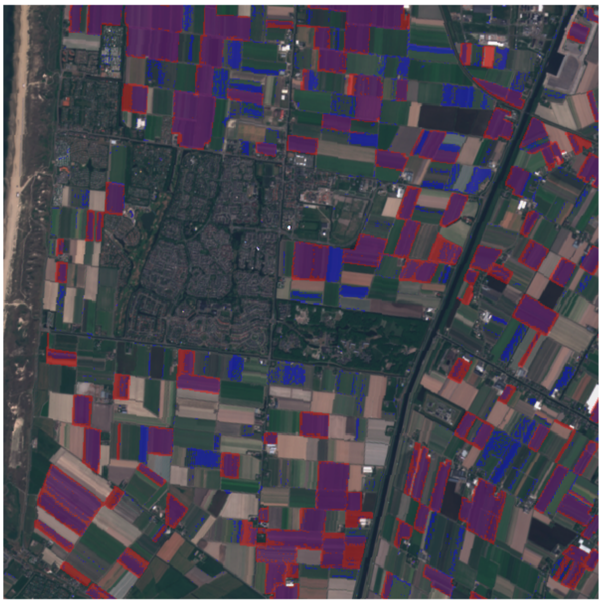

Figure 2: Graphical representation of errors in ML perceptron classification of tulip fields in 2017 (TP in purple, FP in blue, FN in red)

seen, that classification produced quite satisfactory results. An important thing to notice when inspecting Figure 2 is that the true positive pixels were classified in densely packed groups with clear and sharp edges, which correspond nicely to field boundaries seen with the naked eye (both RF and Gradient boosting decision trees produced visually very similar results). This might suggest that algorithms have detected another culture similar to tulips and classified it as tulips (or conversely, that the ground truth might not be that accurate). A lot of FN pixels can also be spotted on field boundaries, which may correspond to different quality or mixing of different plant cultures near field boundaries.

Similarly, observing results of arable land classification, one immediately notices small (false positive) blue patches and some red patches. Most notably, a long blue line is spotted in the left part of the image (near the sea), which may indicate some sort of wild culture near the sea that was not

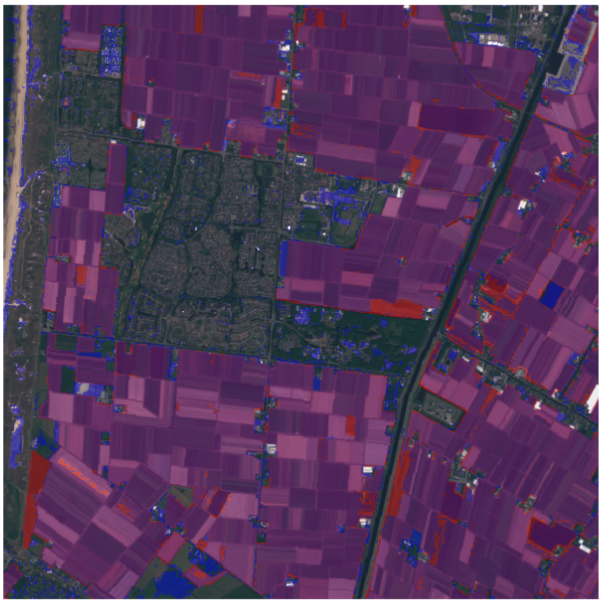

Figure 3: Graphical representation of errors in ML perceptron classification of arable land in 2017 (TP in purple, FP in blue, FN in red)

included in the original mask. Further manual observation of misclassified red patch in the middle of arable land suggests that this field is barren (easily seen in Figure 2) and possibly wrongly classified as arable land in training data.

5. CONCLUSIONS

In our work, we have examined the use of different classification methods and additional features for land cover classification problem on a single image. Our results are comparable with results from the related literature. We propose that classification strength and adaptability be further improved by considering time series and stream aggregates for each pixel as researched in [14] [7]. Additionally, pixels might be grouped together into logical objects to enable object (field) level classification as proposed by [13].

Furthermore, results have shown, that correct ground truth mask is essential for good classification performance. As seen from our results, even seemingly correct labels might miss some cultures or classify empty straits of land as crops.

6. ACKNOWLEDGMENTS

This work was supported by the Slovenian Research Agency and the ICT program of the EC under project PerceptiveSentinel (H2020-EO-776115). The authors would like to thank Sinergise for it's contribution to sentinelhub and cloudless library along with all help with data analysis.

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Towards a semantic repository of data mining and machine learning datasets

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ABSTRACT

With the exponential growth of data in all areas of our lives, there is an increasing need of developing new approaches for effective data management. Namely, in the field of Data Mining (DM) and Knowledge Discovery in Databases (KDD), scientists often invest a lot of time and resources for collecting data that has already been acquired. In that context, by publishing open and FAIR (Findable, Accessible, Interoperable, Reusable) data, researchers could reuse data that was previously collected, preprocessed and stored. Motivated by this, we conducted extensive review on current approaches, data repositories and semantic technologies used for annotation, storage and querying of datasets for the domain of machine learning (ML) and data mining. Finally, we identify the limitations of the existing repositories of datasets and propose a design of a semantic data repository that adheres to FAIR principles for data management and stewardship.

1. INTRODUCTION

One of the main use of data is in the process of knowledge discovery, where scientist employ ML and DM methods and try to solve various real-life problems from diverse fields, from systems biology and medicine, to ecology and environmental sciences. In order to obtain their objectives, they need high-quality data. The quality of the data is crucial to a DM project's success. Ultimately, no level of algorithmic sophistication can make up for low-quality data. On the other hand, progress in science is best achieved by reproducing, reusing and improving someone else's work. Unfortunately, datasets are not easily obtained, and even if they are, they come with limited reusability and interoprability.

A key-aspect in advancing research is making data open and **FAIR**. FAIR are four principles that have been recently introduced to support and promote good data management and stewardship [17]. Data must be easily findable (**Findability**) by both humans and machines. This means data should be semantically annotated with rich metadata and all the resources must be uniquely identified. The metadata should always be accessible (**Accessibility**) by standardized communication protocols such as HTTP(S) or FTP, even when the data itself is not. Data and metadata from different data sources can be automatically combined (**Interoperabiliy**). To do so, the benefits of formal vocabularies and ontologies should be exploited. Data and metadata is released with provenance details and data usage licence, so that humans and machines know whether data can be replicated and reused or not (**Reusabiliy**).

The benefits of publishing FAIR data are manifold. It speeds up the process of knowledge discovery and reduces the consumption of resources. When the FAIR-compliant data at hand does not contain all the information needed it can be easily integrated with data from external sources and boost the overall KDD performance [12].

Semantic data annotation, being very powerful technique, is massively used in some domains, i.e. medicine, but it is sill in the early phases in the domain of data mining and machine learning. To the best of our knowledge, there are no semantic data repositories that adhere to the FAIR principles. We recognize the ultimate benefits of having one and we are going in depths of the research covering semantic data annotation, ontology usage, storing and querying of data.

2. BACKGROUND AND RELATED WORK

The Semantic Web (Web 3.0) is an extension of the World Wide Web in which information is given semantic meaning, enabling machines to process that information. The aim of the Semantic Web initiative is to enhance web resources with highly structured metadata, known as semantic annotations. When one resource is semantically annotated, it becomes a source of information that is easy to interpret, combine and reuse by the computers [13]. In order to achieve this, the Semantic Web uses the concept of Linked Data. Linked data is build upon standard web technologies [7] including HTTP, RDF, RDFS, URIs, Ontologies, etc.

For uniquely identifying resources across the whole Linked Data, each resource is given a **Unified Resource Identifier (URI).** The resources are then enriched with terms from controlled vocabularies, taxonomies, thesauruses, and ontologies. The standard metadata model used for logical organization of data is called **Resource Description Framework (RDF).** Its basic unit of information is the triplet compiled from a subject, a predicate, and an object. These three components define the concepts and relations, the building blocks of an ontology.

In the context of computer science, **ontology** is "an explicit formal specifications of the concepts and relations among them that can exist in a given domain" [3]. As computational artifacts, they provide the basis for sharing meaning both at machine and human level. When creating an ontology, there are multiple languages to choose from. **RDF Shema (RDFS)** is ontology language with small expressive power. It provides mechanisms for creating simple taxonomies of concepts and relations. Another commonly used ontology language is the **Web Ontology Language (OWL).** OWL supports creation of all ontology components: concepts, instances, properties (or relations). Finally, **SPARQL**[1] is standard, semantic query language used for querying fast-growing private or public collections of structured data on the Web or data stored in RDF format.

There are diiferent technologies for storing data and metadata. The most broadly used are **relational databases**, digital databases based on the relational model of data organized in tables, forming entity-relational model. Another approach that became popular with the appearance of Big Data are **NoSQL** databases [5], which are flexible databases that do not use relational model. **Triplestores** are specific type of NoSQL databases, that store triples instead of relational data. Triplestores use URIs and can be queried over trillions of records, which makes them very applicable.

Data in an information system can reside in different heterogeneous data sources, both internal and external to the organization. In this setting, the relevant data from the diverse sources should be integrated. Accessing disparate data sources has been a difficult challenge for data analysts to achieve in modern information systems, and an active research area. **OBDA** [1, 11] is much longed-for method that addresses this problem. It is a new paradigm, based on a three-level architecture constituted of the ontology, the data sources, and the mappings between the two (see **Figure 1**). With this approach, OBDA provides data structure description, as well as semantic description of the concepts in the domain of interest and roles between them.

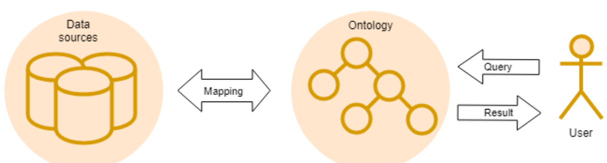

Figure 1. The OBDA architecture

In the context of semantic ML data repository, we group ontologies in three categories, i.e., ontologies for describing machine learning and data mining, ontologies for provenance information, and domain ontologies. **OntoDM** ontology describes the domain of data mining. It is composed of three sub-ontologies: OntoDT [10] - generic ontology for representation of knowledge about datatypes; OntoDM-core [8] - ontology of core data mining entities (e.g., data, DM task, generalizations, DM algorithms, implementations of algorithms, DM software); OntoDM-KDD [9] - ontology for representing the knowledge discovery process following CRISP-DM process model. **The Data Mining OPtimization Ontology (DMOP)** [6] has been designed to support automation at various choice points of the DM process, i.e., choosing algorithms, models, parameters. **The PROV Ontology (PROV-O)**[2] **and Dublin Core vocabulary** [16] facilitate the discovery of electronic resources by providing a base for describing provenance information about resources.

[1]`https://www.w3.org/TR/rdf-sparql-query/`
[2]`https://www.w3.org/TR/prov-o/`

There are numerous repositories of ML datasets available online. The UCI repository[3] is the most popular repository of ML datasets. Each dataset is annotated with several descriptors such as dataset characteristics, attribute characteristics, associated task, number of instances, number of attributes, missing values, area, etc. Similarly, Kaggle Datasets[4], Knowledge Extraction based on Evolutionary Learning (KEEL), and Penn Machine Learning Benchmarks (PMLB)[5] are well-known dataset repository that provide users with data querying based on the descriptors attached to the datasets. OpenML[6] is an open source platform designed with the purpose of easing the collaboration of researchers within the machine learning community [14]. Researchers can share datasets, workflows and experiments in such a way that they can be found and reused by others. When the data format of the datasets is supported by the platform, the datasets are annotated with measurable characteristics [15]. These annotations are saved as textual descriptors and are used for searching through the repository.

In contrast to the above mentioned repositories, there are frameworks in other domains that offer advanced techniques for describing, storing and querying datasets. One cutting-edge framework in the domain of neuroscience is **Neuroscience Information Framework(NIF)** [4]. Its core objective is to create a semantic search engine that benefits from semantic indexes when querying distributed resources by keywords. **The Gene Ontology Annotation (GOA)**, is a database that provides high-quality annotations of genome data [2]. The annotations are based on GO, a vocabulary that defines concepts related to gene functions and relation among them. Large part of the annotations are generated electronically by converting existing knowledge from the data to GO terms. Electronic annotations are associated with high-level ontology terms. The process of generating more specific annotations can hardly be automated with the current technologies, therefore it is done manually.

3. CRITICAL ASSESSMENT

In this section, we conduct critical assessment of the current research based on the review presented in the previous section.

Semantic Web technologies. The whole stack of semantic technologies provide ways of making the content readable by machines. The metadata that describes the content can be used not only to disregard useless information, but also for merging results to provide a more constructed answer. A major drawback of this process of giving data a semantic meaning is that it is time consuming and requires great amount of resources, thus people sometimes feel unmotivated to do it. Another point to make is that semantic annotations cannot solve the ambiguities of the real world.

Technologies for storing data and metadata. The data in relational databases is stored in a very structured way, making them a good choose for applications that relay

[3]`https://archive.ics.uci.edu/ml/`
[4]`https://www.kaggle.com/datasets`
[5]`https://github.com/EpistasisLab/penn-ml-benchmarks`
[6]`https://www.openml.org/`

on heavy data analysis. Moreover the referential integrity guarantees that transactions are processed reliably. While relational databases are a suitable choice for some applications, they have difficulties dealing with large amounts of data. On the other hand, NoSQL databases were designed primarily for big data and can be run on cluster architectures. Non-relational databases store unstructured data, with no logical schema. They are flexible, but this comes with the price of potentially inconsistent data.

Describing data and metadata. OntoDM is an ontology that describes the domain of DM, ML and KDD with a great level of detail. Because it covers a wide area, some parts would be irrelevant for our application. DMOP is ontology built with the special use case of optimizing the DM process. Nevertheless, both of them can be used for describing ML and DM datasets. DC vocabulary and PROV-O define a wide range of provenance terms, therefore both of them can be employed in the provenance metadata generation.

Repositories of machine learning datasets. The UCI repository offers a wide range of datasets, but they are not available through a uniform format or API. Although it also provides data descriptors for searching the data, a major setback is that none of the descriptors is based on any vocabulary or ontology, which certainly limits interoperability. Kaggle Datasets, KEEL, PMLB also provide similar meta annotations, but they all lack semantic interpretability. Another shortcoming of the UCI repository, KEEL and PMLB is that they don't allow uploading new datasets. All datasets stored in the OpenML repository can be downloaded in CSV or ARFF format. The annotation are based on Exposé ontology, and they can be downloaded in JSON, XML or RDF format. A major weakness of this repository is that annotations are not stored, but they are calculated on-the-fly and can not be used for semantic inference.

Frameworks for describing, storing and querying domain datasets. The NIF framework is very progressive in terms of semantic annotation, storing, and querying. Its advantages come from providing domain experts with the ability to contribute to the ontology development, by adding new terms through the use of Interlex. It has a powerful search engine, and it follows the OBDA paradigm. Heterogeneous data is stored in its original format. The user defined, keyword query is mapped to ontological terms to find synonyms, and then translated to a query relevant to the individual data store. With respect to the genomics domain, GOA database is favourable because of its high-quality annotations. Curators put extreme efforts in generating manual annotations. To speed up the query execution it uses the Solr document store. Another superiority of GOA database is that it provides advanced filtering of the annotations, for downloading customized annotation sets. The deficiency of NIF and GOA database is that they are not able to query and access the annotations in RDF format, which is an emerging standard for representing semantic information

4. PROPOSAL FOR SEMANTIC REPOSITORY OF DM/ML DATASETS

In this section, we propose three possible architecture designs of the semantic data repository for the domain of ML and DM. The proposals are based on the critical review of the approaches and technologies. Each of the proposed architectures has positive and negative sides, so there will be trade-off when choosing one.

The common part of the three designs is that DM and ML datasets will be annotated through a semantic annotation engine. The semantic query engine will receive SPARQL query as input, and it will bring back results in form of set of RDF triples. There will be SPARQL endpoint through which users can specify the query used as input in the semantic query engine. Another open possibility is to enable users to query data and metadata by simply writing keywords. Later, the system itself generates SPARQL query based on those keywords. The anotation schema used by the semantic annotation engine will be based on three different types of ontologies such as ontologies for DM and ML (e.g., OntoDT, OntoDM-core, Onto-KDD, DMOP), domain ontologies, and ontologies and schemes for describing provenance information (e.g., Dublin Core ontology, PROV-O). Part of the annotations will be generated automatically, e.g., annotations related to datatypes, while others will be semi-automatically because they require concept mapping, e.g., annotations based on domain ontologies.

We plan to build a web-based user interface that will enable users to search and query both datasets and metadata annotations. Users will be given a chance of uploading new datasets in CSV or ARFF fromat. Besides the dataset, users will be expected to specify some additional information about it such as data mining task they plan to execute on the data, domain, provenance information, descriptions of the attributes, etc. Since the whole process of semantic annotation can't be automatic, when new dataset is uploaded, it won't be immediately available on the site. First it must be curated, and only when the complete set of metadata annotations is generated, the metadata will be published online. The dataset itself will be released under clear data usage licence.

The three architectural designs differ in the way of storing the datasets. The metadata annotations will be RDF triplets and they will be stored in triplestore that optimizes physical storage. Next, we briefly explain the differences between storing the datasets and what are the effects on querying.

Proposal I. The simplest approach of storing a dataset would be to store it in RDF format in the same triplestore as the metadata. The datasets from their original format, will be converted to RDF triples. Having only one triplestore will ease querying, but it will require more storage capacity (see Figure 2).

Proposal II. The second option is to store the datasets in a relational database and the metadata in RDF triplestore. Datasets from CSV or ARFF format will be translated into a relational database. Here, querying becomes more complicated, for which we will need a federated query engine. A federated query engine allows simultaneous search on multiple data sources. A user makes a single query request, which is distributed across the management systems participating in the federation and translated to a query written in a language relevant to the individual system. We will have two data stores, one for the data itself and one for the metadata. For querying the two data stores, we will still use the same

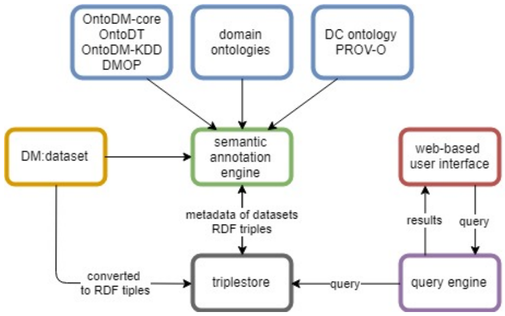

Figure 2. Architectural design I

RDF query language, SPARQL. In order to query the relational database with SPARQL, it will be mapped to virtual RDF graph (see Figure 3).

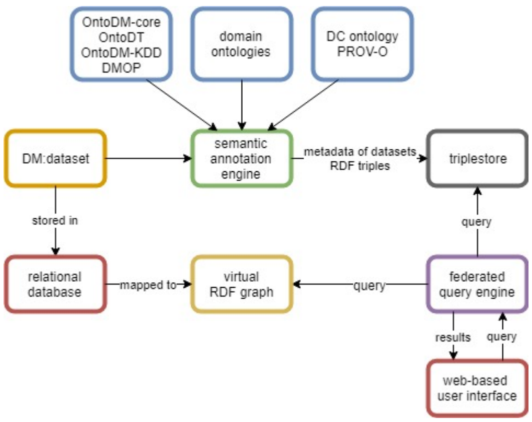

Figure 3. Architectural design II

Proposal III. Instead of mapping the relational database to virtual RDF graph, we can use the OBDA methodology and federated querying to use a combination of SQL queries and SPARQL queries. Metadata will be queried with SPARQL queries, but for the datasets, they will be mapped to SQL queries. The integrated results are brought back to the user (see Figure 4).

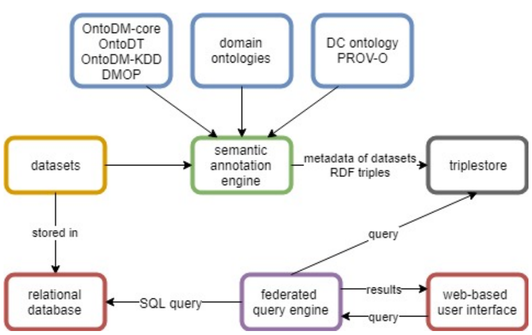

Figure 4. Architectural design III

5. CONCLUSION

We have conducted a literature overview of research being done in the field of semantic annotation, storage, and querying of ML and DM datasets. We also examined specific implementations of frameworks in the domain of neuroscience and genomics. Taking into consideration the critical assessment of the current state-of-the-art we will construct semantic data repository for ML and DM datasets. The semantic repository would be utilized for easy access of semantically rich annotated datasets and semantic inference. This, will improve the reproducibility and reusability in ML and DM research area. Moreover, annotating the datasets with domain ontologies will facilitate the process of understanding the analyzed data. As of now, we have three proposed architectural designs for the semantic data repository that differ in the way of storing the datasets. We will either store both data and metadata in a triplestore, or we will have multiple data stores which will require usage of tools and methods from the ontology based data access paradigm.

Acknowledgements

The authors would like to acknowledge the support of the Slovenian Research Agency through the projects J2-9230, N2-0056 and L2-7509 and the Public Scholarship, Development, Disability and Maintenance Fund of the Republic of Slovenia through its scholarship program.

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Towards a semantic store of data mining models and experiments

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ABSTRACT

Semantic annotation provides machine readable structure to the stored data. We can use this structure to perform semantic querying, based on explicitly and implicitly derived information. In this paper, we focus on the approaches in semantic annotation, storage and querying in the context of data mining models and experiments. Having semantically annotated data mining models and experiments with terms from domain ontologies and vocabularies will enable researchers to verify, reproduce, and reuse the produced artefacts and with that improve the current research. Here, we first provide an overview of state-of-the-art approaches in the area of semantic web, data mining domain ontologies and vocabularies, experiment databases, representation of data mining models and experiments, and annotation frameworks. Next, we critically discuss the presented state-of-the-art. Furthermore, we sketch our proposal for an ontology-based system for semantic annotation, storage, and querying of data mining models and experiments. Finally, we conclude the paper with a summary and future work.

1. INTRODUCTION

Storing big amounts of data from a specific domain comes in hand with several challenges, one of them being to semantically represent and describe the stored data. Semantic representation enables us to infer new knowledge based on the one that we assert, i.e. the description and annotation of the data. This can be done by providing semantic annotations of the data with terms originating from a vocabulary or ontology describing the domain at hand. In computer and information science, ontology is a technical term denoting an artifact that is designed for a purpose, which is to enable the modeling of knowledge about some domain, real or imagined [15]. Ontologies provide more detailed description of a domain, first by organizing the classes into a taxonomy, and further on by defining relations between classes. With semantic annotation we attach meaning to the data, we can infer new knowledge, and perform queries on the data.

Data mining and machine learning experiments are conducted with faster pace than ever before, in various settings and domains. In the usual practice of conducting data mining experiments, almost none of the settings are recorded, nor the produced models are stored. These predicaments make for a research that is hard to verify, reproduce and upgrade. This is also in line with the FAIR (Findable, Accessible, Interoperable, Reusable) data principles, introduced by Wilkinson et al. [9]. Implementing these principles for the annotation, storing, and querying of data mining models and experiments will provide a solid ground for researchers interested in reproducing and reusing the results from the previous research on which they can build and improve.

In the literature, there exist some approaches that address some of these problems. In both ontology engineering and data mining community, there are approaches that aim towards describing the data mining domain, as described in Section 2. Furthermore, Vanschoren et al. [5] developed the OpenML system, a machine learning experiment database for storing various segments of a machine learning experiment such as datasets, flows (algorithms), runs, and completed tasks.

In other domains, such as life sciences, storing annotated data about experiments and their results is a common practice. This is mostly due to the fact that the experiments are more expensive to conduct, and require specific preparations. From the perspective of annotation frameworks, there are significant advances in these domains, such as The Center for Expanded Data Annotation and Retrieval (CEDAR) workbench [8] , and the OpenTox framework [11].

This paper is organized as follows. First, we make an overview of the state-of-the-art approaches in annotating, storing, and querying of models and experiments. Next, we critically assess these approaches and sketch a proposal for a system for annotating, storing and querying data mining models and experiments. Finally, we provide a summary and discuss the possible approaches for further work.

2. BACKGROUND AND RELATED WORK

The state-of-the-art in semantic annotation of data mining models and experiments provides very diverse research, ranging from domain-specific data mining ontologies, experiment databases, to new languages for deploying annotations in unified format. Here, we provide an introduction to the state-of-the-art in semantic web, ontologies and vocabularies, representations of data mining models and experiments, experiment databases, and annotation frameworks.

Semantic technologies. The Semantic Web is defined as an extension of the current web in which information is given well-defined meaning, enabling computers and people to work in cooperation [14]. The stack of technologies consists of multiple layers, however, in this paper we will focus on the ones essential for our scope of research. Resource Description Framework (RDF) represents a metadata data model for the Semantic Web, where the core unit of information is presented as a triple. A triple describes the subject by its relationship, which is what the predicate resembles, with the object. RDF files are stored in triple store (typically organized as relational or NoSQL databases [12]), on which we can perform semantic queries, by using querying languages such as SPARQL. Finally, ontology languages, such as Resource Description Framework Schema (RDFS) and Ontology Web Language (OWL), are formal languages used to construct ontologies. RDFS provides the basis for all ontology languages, defining basic constructs and relations, while OWL is far more expressive enabling us to define classes, properties, and instances.

Ontologies & vocabularies. Currently, there are several ontologies that describe the data mining domain. These include the OntoDM ontology [16], DMOP ontology [7], Expose [4], KDDOnto [1], and KD ontology [10]. MEX [2] is an interoperable vocabulary for annotating data mining models and experiments with metadata. In addition there have been developments in formalism for representing scientific experiments in general, such as the EXPO ontology [6].

Representation of models. With the constant development of new environments for developing data mining software, it is necessary to have a unified representation of the constructed data mining models and the conducted experiments. The first open standard was the Predictive Model Markup Language (PMML). For a period of time it provided transparent and intuitive representation of data mining models and experiments. However, due to the fast growth in the development of new data mining methods, PMML was unable to follow the pace and extend its more and more complicated specification. Its successor, the Portable Format for Analytics (PFA), was developed having the PMML's drawbacks as guidelines for improvement.

Experiment and model databases. Storing already conducted experiments in a well structured and transparent manner is essential for researchers to have available, verifiable, and reproducible results. An experiment database is designed to store large number of experiments, with detailed information on their environmental setup, the datasets, algorithms and their parameter settings, evaluation procedure, and the obtained results [3]. The state-of-the-art in storing setups and results is abundant with approaches and solutions in different domains. For example, OpenML[1] is the biggest machine learning repository of data mining datasets, tasks, flows, and runs, the BioModels[2] repository stores more than 8000 experiments and models from the domains of systems biology, and ModelDB[3] is an online repository for storing computational neuroscience models.

Annotation frameworks. When it comes to frameworks for (semi) automatically or manually annotating data, there are several solutions that exist outside of the data mining domain, which provide innovative approaches and good foundation for development in the direction of creating a software to enable ontology-based semantic annotation of models and experiments, their storage and querying. The CEDAR Workbench [13] provides an intuitive interface for creating templates and metadata annotation with concepts defined in the ontologies available at BioPortal[4]. On the other hand, OpenTox [11] represents domain specific framework that provides unified representation of the predictive modelling in the domain of toxicology.

3. CRITICAL ASSESSMENT

In this section, we will critically assess the presented state-of-the-art in Section 2 in the context of semantic annotation, storage and querying of data mining models and experiments.

The state-of-the-art in *ontology design* for data mining provides well documented research with various ontologies that thoroughly describe the domain from different aspects and can be used in various applications. OntoDM provides unified framework of top level data mining entities. Building on this, it describes the domain in great detail, containing definitions for each part of the data mining process. Because of the wide reach, it lacks a particular use case scenario. On the other hand, this same property makes this ontology suitable for wide range of applications where there is a need of describing a part of the domain.

Ontologies like EXPO and Exposé have a essential meaning in the research since the first one describes a very wide and important interdisciplinary domain, while the latter uses it as a base for defining a specific sub-domain. DMOP ontology describes the process of algorithm and model selection in the context of semantic meta mining. Both the KD ontology and KDDOnto describe the knowledge discovery process in the context of constructing knowledge discovery workflows. They differ mainly in the key concepts on which they were built. At the same time, the MEX vocabulary provides a lightweight framework for automating the metadata generation. Since it is tied with Java environment, it provides a library which only uses the MEX API and can also be implemented in other programming languages.

All in all, the current state of the art in ontologies for data mining provides a good foundation for development of applications which will be based on one or several of these ontologies. Given the wide of coverage they can be easily be combined in a manner to suit the application at hand.

In the area of *descriptive languages for data mining models and experiments*, one can see the path of progress in research. PMML was the first, ground-breaking, XML-based descriptive language. However, with the expansion of the data mining domain, several weaknesses of PMML emerged. The language was not extensible, users could not create chains of models, and it was not compatible with the distributed data processing platforms. Therefore, the same community started working on a new, extensible, portable

[1] https://www.openml.org/
[2] http://www.ebi.ac.uk/biomodels/
[3] https://senselab.med.yale.edu/modeldb/
[4] https://bioportal.bioontology.org/

language. Since its inception, the PFA format was intended to fill the small gaps that PMML had. Made up of analytic primitives, implemented in Python and Scala, it provides the users with more customizable framework, where they can create custom models, model chains, and implement them in a parallelized setting.

Storing and annotating experiments is of great significance in multiple scenarios. First, in domains where conducting the experiment is not a trivial task, i.e. the physical or financial conditions challenge the process, there needs to be a database where the setup and the findings of the experiment will be saved. For example, in BioModels.net we have two groups of experiments: Manually curated with structured metadata, and experiments without structure. The main drawback with this type of storage is the need for manual curation of the metadata. It is repetitive, time consuming task for which there is a strong need to be automated.

In the domain of neuroscience, ModelDB provides an online service for storing and searching computational neuroscience models. In this database, alongside the files that constitute the models, researchers also need to upload the code that defines the complete specification of the attributes of the biological system represented in the model, together with files that describe the purpose and application of the model. Therefore, researchers can search the database for models with specific applications describing biological systems.

OpenML provides a good framework for storing and annotating data mining datasets, experimental setups and runs, as well as algorithms. One particular drawback of OpenML is that it does not store the actual models that are produced from each experimental run, and one can not query the models. Furthermore, it's founded on relational-database which can not provide execution of semantic queries.

All in all, these three examples show significant advances in storing and annotating models and experiments. However, there is also a significant room for improvement in the direction of storing the models and experiments into NoSQL databases that are better suited for this task.

Finally, in the context of annotation tools the CEDAR Workbench and the OpenTox Framework provide a good insight in annotation frameworks. CEDAR enables the user to execute the annotations in modular manner by creating templates and adding elements to them. After curating the annotations, they can export the schemas either in JSON, JSON-LD, or RDF file. OpenTox [11] is also based on ontology terms and represents a complete framework that describes the predictive process in toxicology, starting with toxicity structures and ending with the predictive modelling.

4. A PROPOSAL FOR SEMANTIC STORE OF MODELS AND EXPERIMENTS

After analysing the previous and current research, we can conclude that despite the great achievements, there is a wide area for improvement in which we will contribute in the upcoming period by developing an ontology-based framework for storage and annotation of data mining models and experiments. In order to annotate a data mining experiment, we need to have complete information about the conditions in which that experiment was conducted. Namely, we need to have an annotated dataset, annotation of the algorithm and its parameter settings for the specific run of the experiment. Since one experiment usually consists of multiple algorithm runs we annotate each run separately, as well as each of the results from each of them. For annotating the results, we use the definitions of the performance metrics formalized in the data mining ontologies. A sketched example of the proposed solution is shown in Figure 1.

The proposed system for ontology-based annotation, storage, and querying of data mining experiments and models will consist of several components. The users will interact with the system through an user interface enabling them to run experiments on a data mining software, which will export models and experiment setups to a semantic annotation engine. For example, for testing purposes we plan to use CLUS[5] software for predictive clustering and structured output prediction, which generates different types of models and addresses different data mining tasks.

In the semantic annotation engine, the data mining models and experiments will be annotated with terms from the extended OntoDM ontology and then stored in a database. Once stored, the users will be able to semantically query the models and experiments in order to infer new knowledge. This will be done through a querying engine based on the SPARQL language, accessible through a user interface.

In order to perform annotation, we will extend the existing OntoDM ontology by adding a number of new terms, linking it to other domain ontologies, such as Exposé and EXPO. Linking OntoDM to these ontologies will extend the domain of OntoDM towards connecting the data mining entities that it already covers with new entities that describe the experimental setup and principles. With this we will obtain a schema for annotation of data mining models and experiments. The schema will then be used to annotate the data mining models and experiments through a semantic annotation engine. The engine will have to read the models and experiments from a data mining software system, annotate them with terms from developed schema and produce an RDF representation of the annotated data.

Furthermore, the RDF graphs will be stored in a triple store database. Since the data mining models and experiments differ a lot in their structure, we have yet to decide on the type of database in which we will store them. The data stored in this way is set for performing semantic queries on top of it. Therefore, we will develop a SPARQL-based querying enigne so the users can perform predefined or custom semantic queries on top of the storage base.

Finally, the format of the results is another point where we need to decide whether the results will be presented as RDF graphs, or in a different format (such as JSON) that is easier to interpret. This software package along with the storage will then be added as a module to the CLUS software, developed at the Department of Knowledge Technologies.

[5] `http://sourceforge.net/projects/clus`

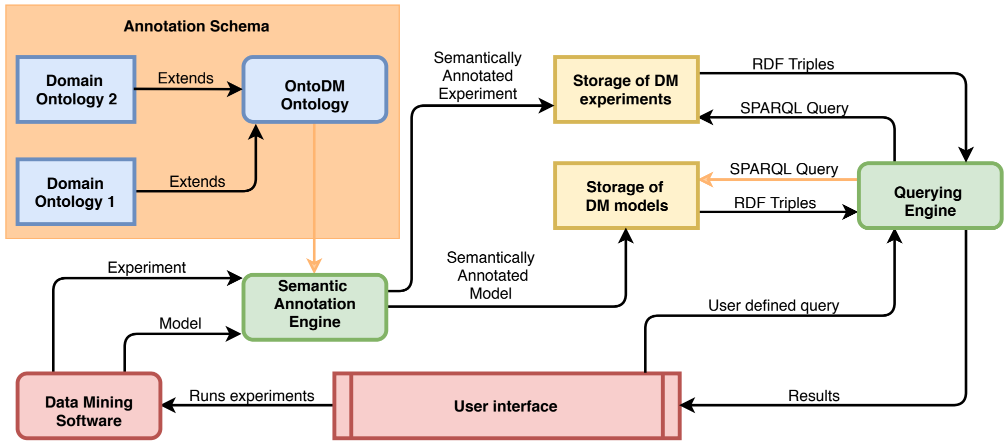

Figure 1. Schema of the proposed solution

5. CONCLUSION & FURTHER WORK

In this paper, we presented the state-of-the-art in annotation, storage and querying in the light of designing a semantic store of data mining models and experiments. We first gave an overview of semantic web technologies, such as RDF, SPARQL, RDFS, and OWL that provide a complete foundation for annotation and querying of data.

Furthermore, we critically reviewed the state-of-the-art ontologies and vocabularies for describing the domain of data mining provide detailed description of the domain of data mining and machine learning (OntoDM, Expose, KD Ontology, DMOP and KDDOnto, MEX). Next, we focused on experiment databases as repositories where the experiment datasets, setups, algorithm parameter settings, and the results are available for the performed experiments in various domains. Furthermore, we saw that annotation frameworks provide environments for (semi) automatically or manually annotating data, by discussing two frameworks from the domains of biomedicine and toxicology in order to analyze best practices present in those domains.

Finally, given the performed analysis of the state-of-the-art, we outlined our proposal for an ontology-based framework for annotation, storage, and querying of data mining models and experiments. The proposed framework consists of an annotation schema, a semantic annotation engine, and storage for data mining models and experiments with a querying engine, all of which will be controlled from an user interface. It will allow users to semantically query their data mining models and experiments in order to infer new knowledge.

In the future, we plan to adapt this framework for the needs of research groups or companies that conduct high volume of data mining experiments, enabling them to obtain a queryable knowledge base consisting of annotated metadadata for all experiments and produced models. This will enable them to reuse existing models on new data for testing purposes, infer knowledge based on past experimental results, all while saving time and computational resources.

Acknowledgements

The authors would like to acknowledge the support of the Slovenian Research Agency through the projects J2-9230, N2-0056 and L2-7509 and the Public Scholarship, Development, Disability and Maintenance Fund of the Republic of Slovenia through its scholarship program.

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A Graph-based prediction model with applications

[Extended Abstract]

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ABSTRACT
We present a new model for probabilistic forecasting using graph-based rating method. We provide a "forward-looking" type graph-based approach and apply it to predict football game outcomes by simply using the historical game results data of the investigated competition. The assumption of our model is that the rating of the teams after a game day correctly reflects the actual relative performance of them. We consider that the smaller the changing of the rating vector – contains the ratings of each team – after a certain outcome in an upcoming single game, the higher the probability of that outcome. Performing experiments on European football championships data, we can observe that the model performs well in general and outperforms some of the advanced versions of the widely-used Bradley-Terry model in many cases in terms of predictive accuracy. Although the application we present here is special, we note that our method can be applied to forecast general graph processes.

Categories and Subject Descriptors
I.6 [**Simulation and Modeling**]: Applications; I.2 [**Artificial Intelligence**]: Learning

1. INTRODUCTION
The problem of assigning scores to a set of individuals based on their pairwise comparisons appears in many areas and activities. For example in sports, players or teams are ranked according to the outcomes of games that they played; the impact of scientific publications can be measured using the relations among their citations. Web search engines rank websites based on their hyperlink structure. The centrality of individuals in social systems can also be evaluated according to their social relations. Ranking of individuals based on the underlying graph that models their bilateral relations has become the central ingredient of Google's search engine and later it appeared in many areas from social network analysis to optimization in technical networks (e.g. road and electric networks) [16].

Making predictions in general, and especially in sports as well, is a difficult task. The predictions generally appear in the form of betting odds, that, in the case of "fixed odds", provide a fairly acceptable source of expert's predictions regarding sport games outcomes [21]. Thanks to the increasing quantity of available data the statistical ranking, rating and prediction methods have become more dominant in sports in the last decade. A key question is that how accurate these evaluations are, more concretely, the outcomes of the upcoming games how accurately can be predicted based on the statistics, ratings and forecasting models in hand.

Statistics-based forecasting models are used to predict the outcome of games based on some relevant information of the competing teams and/or players of the teams. A detailed survey of the scientific literature of rating and forecasting methods in sports is beyond the scope of this paper, we refer only some important and recent results in the topic. For some papers with detailed literature overview and sport applications of the the celebrated *Bradley-Terry model* [3], see e.g. [5, 7, 24]). Other popular approach is the Poisson goal-distribution based analysis. For some references, see for instance [10, 15, 20]. In these models the goals scored by the playing teams follow a Poisson distribution with parameter that is a function of attack and defense "rate" of the respective teams. A large family of prediction models only consider the game results win, loss (and tie) and usually uses some probit regression model, for instance [11] and [13]. More recently, well-known data mining techniques, like artificial neural networks, decision trees and support vector machines have also become very popular; some references - without being exhaustive - see e.g [8, 9, 14, 18].Based on the huge literature it can be concluded that the prediction accuracy strongly depends on the investigated sport and the feature set of the machine learning algorithms used. A notable part of prediction models based on the historical data of game results use the methodology of ranking and rating. Some recent articles in the topic are e.g. [2, 6, 12, 17, 23]. Specifically highlighting [2] the authors analyzed the he predictive power of eight sports ranking methods using only win-loss and score difference data of American major sports. They found that the least squares and random walker meth-

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ods have significantly better predictive accuracy than other methods. Moreover, utilizing score-differential data are usually more predictive than those using only win-loss data.

In contrast to those techniques that use the actual respective strength of the two competing teams, we provide a graph-based and forward-looking type approach. The assumption of our model is that if a rating of the teams after a game day correctly reflects the actual relative performance, then the smaller the change in that rating after a certain result occurs (in an upcoming single game) the higher the probability of that event occur.

The structure of this paper is follows. After presenting the classical approaches ("Betting Odds" and "The Bradley-Terry Model"), our new model is introduced. Then in Sec. 3 we present our preliminary experimental results, and finally in Sec. 4 we conclude and discuss some possible research directions.

2. MODELS

Let $V = (1, \ldots, n)$ be the set of n *teams* (or players) and let R be the number of *game days* in a competition among the teams in V. A *rating* is a function $\phi^r : V \to \mathbb{R}^n$ that assigns a score to each team after each game day r ($r = 1, \ldots, R$). This is considered as the quantitative "strength" of the teams. A *ranking* $\sigma^r : V \to V$, after game day r, is an ordering of the teams that is simply obtained by sorting the teams according to the rating ϕ^r. Using the game results data set, one can define a directed multigraph (i.e. a graph where multiple links are allowed), where nodes represent teams, while links between them represent outcomes of games they played. The links are directed and each of them is going from the loser team to the winning team. If ties are also considered they can be represented by two directed links with opposite directions and half weight. An edge weighting can be naturally considered if the final scores of the games are given

2.1 Betting Odds

Bookmakers determine *betting odds* for the games according to their expectations of outcome probabilities. Here we deal with fixed odds, means that they do not vary over time depending on the betting volumes. These "fixed-odds" represent the predictions of bookmakers [21]. The meaning of the betting odds for an upcoming game is the following: Assume that the betting odds between team i and team j are odds(i) and odds(j), respectively. It means that if one bets \$1 to i's win and it comes out, he wins odds(i) dollars, while if j wins, then the bettor loses his \$1. We can calculate the probabilities of the respective events as

$$\Pr(i \text{ beats } j) = \frac{1/\text{odds}(i)}{1/\text{odds}(i) + 1/\text{odds}(j)}$$

and

$$\Pr(j \text{ beats } i) = \frac{1/\text{odds}(j)}{1/\text{odds}(i) + 1/\text{odds}(j)}.$$

We should note here that odds provided by betting agencies do not represent the true chances (as imagined by the bookmaker) that the event will or will not occur, but are the amount that the bookmaker will pay out on a winning bet. The odds include a profit margin meaning that the payout to a successful bettor is less than that represented by the true chance of the event occurring. This means mathematically that $1/\text{odds}(i) + 1/\text{odds}(j)$ is more than one. This profit expected by the agency is known as the "over-round on the book".

2.2 The Bradley-Terry Model

The *Bradley-Terry model* [3] is a widely-used method to assign probabilities to the possible outcomes when a set of n individuals are repeatedly compared with each other in pairs. For two elements i and j, the probability that i beats j defined as

$$\Pr(i \text{ beats } j) = \frac{\pi_i}{\pi_i + \pi_j},$$

where $\pi_i > 0$ is a parameter associated to each individual $i = 1, \ldots, n$, representing the overall skill, or "intrinsic strength" of it. Equivalently, π_i/π_j represents the odds in favor i beats j, therefore this is a "proportional-odds model". Suppose that i and j played N_{ij} games against each other with i winning W_{ij} of them, and all games are considered to be independent. The likelihood is given by

$$L(\pi_i, \ldots, \pi_n) = \prod_{i<j} \left[\frac{\pi_i}{\pi_i + \pi_j}\right]^{W_{ij}} \left[\frac{\pi_j}{\pi_i + \pi_j}\right]^{N_{ij} - W_{ij}}.$$

Then the log-likelihood is

$$\begin{aligned} \ell(\pi_i, \ldots, \pi_n) &= \sum_{1 \le i \ne j \le n} \left[W_{ij} \log \pi_i - W_{ij} \log(\pi_i - \pi_j)\right] \\ &= \sum_{i=1}^{n} W_{ij} \log \pi_i - \sum_{1 \le i < j \le n} N_{ij} \log(\pi_i + \pi_j) \end{aligned}$$

which need to be maximized.

One possible derivation of the model assumes team i produces an unobserved score S_i, no matter which is the opposing team, with the cumulative distribution function

$$S_i \sim F_i(s) = \exp[-e^{-(s - \log \pi_i)}].$$

It follows that distribution of the difference $S_i - S_j$ follows a logistic distribution function

$$S_i - S_j \sim F_{ij}(s) = \frac{1}{1 + e^{-(s - (\log \pi_i - \log \pi_j))}},$$

which implies that

$$\begin{aligned} \Pr(S_i > S_j) = \Pr(S_i - S_j > 0) &= 1 - \frac{1}{1 + e^{\log \pi_i - \log \pi_j}} \\ &= \frac{\pi_i}{\pi_i + \pi_j}. \end{aligned}$$

Extension with Home advantage and Tie. A natural extension of the Bradley-Terry model with "home-field advantage", according to [1], say, is to calculate the probabilities as

$$\Pr(i \text{ beats } j) = \begin{cases} \frac{\theta \pi_i}{\theta \pi_i + \pi_j}, & \text{if } i \text{ is at home} \\ \frac{\pi_i}{\pi_i + \theta \pi_j}, & \text{if } j \text{ is at home} \end{cases}$$

where $\theta > 0$ measures the strength of the home-field advantage (or disadvantage). Considering also a tie as a possible final result of a game, the following calculations, proposed in [22], can be used :

$$\Pr(i \text{ beats } j) = \frac{\pi_i}{\pi_i + \alpha\pi_j},$$

$$\Pr(i \text{ ties } j) = \frac{(\alpha^2 - 1)\pi_i\pi_j}{(\pi_i + \alpha\pi_j)(\alpha\pi_i + \pi_j)}$$

where $\alpha > 1$. Combining them is straightforward. In our experiments, we used the Matlab implementations found at `http://www.stats.ox.ac.uk/~caron/code/bayesbt/` using the *expectation maximization* algorithm, described in detail in [7].

2.3 Rating-based Model with Learning

Our new model is designed as follows. We will use the term "game day" in each case when at least one match is played on the given day. For any game day in which we make a forecast, we consider the results matrix that contains all the results of the previous $T = 40$ game days. For the 40 game days time window, the entries of the results matrix S are defined as $S_{ij} = \#\{$scores team home-i achieved against team away-j$\}$. To take into account the home-field effect, for each team i we distinguish team home-i and team away-i. Thus, we define a $2n \times 2n$ results matrix, which, in fact, describes a bipartite graph where each team appears both in the home team side and the away team side of the graph. For rating the teams, a time-dependent PageRank method is used. The PageRank scores are calculated according the time-dependent PageRank equation

$$\phi = \mathbf{\Pi} = \frac{\lambda}{N}[I - (1-\lambda)S^t_{mod}(\mathbf{1}\mathbb{1}^t)^{-1}]^{-1}\mathbb{1}, \qquad (1)$$

defined in [19]. The damping factor is $\lambda = 0.1$, while we may multiply each entry of S with the exponential function 0.98^α to consider time-dependency and obtaining S_{mod}, where α denotes the number of game days elapsed since a given result occurred (and stored in S). Note, that a home team and an away team PageRank values are calculated for each team. We would like to establish a connection between team home-i and team away-i using the assumption that home-i is not weaker than away-i. In our implementation we assumed that home-i had a win $2:1$ against away-i to give a positive bias for home-i at the beginning. In our experiments this setup performed well, but it was not optimized precisely.

Using the above-defined results matrix S and the PageRank rating vector ϕ, we assign probabilities to the outcomes {home team win, tie, away team win} of an upcoming game in game day r between home-i and away-j as follows. Before the game day in which we make the forecast, let the calculated PageRank rating vector be $\phi_{40}^{r-1}(V)$. We use δ^r_{xy} to measure how the rating vector of the teams changes if the result of an upcoming game between teams i and j is $x : y$, where $x, y = 0, 1, \ldots$ are the scores achieved by team i and team j, respectively[1]. We define δ^r_{xy} as the Euclidean distance between $\phi_{40}^{r-1}(V)$ and $\phi_{40}^{r}(V)$ that is the rating vector for the new results matrix obtained by adding x to S_{ij} and y to $S_{n+j,i}$. In the results graph interpretation this simply means that an edge from node away-j to node home-i with weight x and an edge from node home-i to node away-j with weight y are added to the graph, respectively. Our assumption is that if an outcome $x : y$ has a high probability and it occurs, then it causes a small change in the PageRank vector; hence δ_{xy} will be small. To simplify the notations let $\{\delta_1, \ldots, \delta_m\}$ be the distance values obtained by considering different results $\{E_1, \ldots, E_m\}$ of the upcoming game between i and j. The goal now is to calculate the probability that a certain result occurs if $\{\delta_1, \ldots, \delta_m\}$ is given. To do this, we use the following simple statistics-based machine learning method. Let $f^+()$ be the probability density function of δ_i random variable where the event (game result) E_i occurred. In our implementation $E_i \in \{0:0, 1:0, 1:1, \ldots, 5:5\}$, assuming that the probability of other results equals 0. Similarly, let $f^-()$ be the probability density function of δ_i random variable in which case the event (game result) E_i did not occur. To approximate the $f^+()$ and $f^-()$ functions, for each game we use the training data set contains all results and related δ_i $(i = 1, \ldots, m)$ values of the preceding $T = 40$ game days of the considered game. In our experiments, the gamma distribution (and its density function) turned out to be a fairly good approximate for $f^+(\delta)$ and $f^-(\delta)$.

Assuming that $\delta_1, \ldots, \delta_m$ are independent, using the Bayes theorem and the law of total probability, we can calculate that

$$\Pr(E_i|\{\delta_1, \ldots, \delta_m\}) = \frac{f^+(\delta_i)\prod_{k\neq i} f^-(\delta_k)}{\sum_\ell f^+(\delta_\ell)\prod_{k\neq l} f^-(\delta_\ell)}.$$

We should note here that in this way we assign probabilities to concrete game final results, which is another novelty of our model. Then, for the upcoming game between i and j, the outcome probability of the event "i beats j" is calculated as

$$\Pr(i \text{ beats } j) = \sum_{\substack{k:\ E_k \text{ encodes a result} \\ \text{of team-i win}}} \Pr(E_k|\{\delta_1, \ldots, \delta_m\}),$$

where we sum over those E_k results for which i beats j (i.e. 1:0, 2:0, 2:1, 3:0, 3:1, etc.). The probabilities $\Pr(i \text{ ties } j)$ and $\Pr(j \text{ beats } i)$ can be calculated in a similar way.

3. EXPERIMENTAL RESULTS

To measure the accuracy of the forecasting we calculate the mean squared error, which is often called *Brier scoring rule* in the forecasting literature [4]. The Brier score measures the mean squared difference between the predicted probability assigned to the possible outcomes for event E and the actual outcome o_E. Suppose that for a single game g, between i and j, the forecast is $\mathbf{p}^g = (p^g_w, p^g_t, p^g_l)$ contains the probabilities of i wins, the game is a tie and i loses, respectively. Let the actual outcome of the game be $\mathbf{o}^g = (o^g_w, o^g_t, o^g_l)$, where exactly one element is 1, the other two are 0. Noting that the number of games played (and predicted) is N, BS is defined as

$$BS = \frac{1}{N}\sum_{g=1}^{N} ||\mathbf{p}^g - \mathbf{o}^g||_2^2$$
$$= \frac{1}{N}\sum_{g=1}^{N}[(p^g_w - o^g_w)^2 + (p^g_t - o^g_t)^2 + (p^g_l - o^g_l)^2].$$

[1] We should note here that if the result is $0:0$, then $x = y = 1/2$ is used.

The best score achievable is 0. In the case of three possible outcomes (win, lost, tie) we can easily see that the forecast $\mathbf{p}^g = (1/3, 1/3, 1/3)$ (for each game g and any N) gives accuracy $BS = 2/3 = 0.666$. We consider this value as a worst-case benchmark. One question of our investigation is that how better BS values can be achieved using our method, and how close we can get to the betting agencies' fairly good predictions.

The data set we used contained all final results of given seasons of some football leagues, listed in the first two column of Table 1. We tested our method as it was described in Sec. 2.3. We start predicting games starting from the 41th game day; for each single game predictions are made using the results of the previous 40 game day before that game. The Brier scores were calculated using all predictions we made. Our initial results are summarized in Table 1. To calculate the betting odds probabilities we used the betting odds provided by bet365 bookmaker available at `http://www.football-data.co.uk/`. We could see that these predictions gave the best accuracy score (BS) in each case. We highlighted the values where the difference between the Bradley-Terry method and the PageRank method was higher than 0.01. Although we can see that slightly more than half of the cases the Bradley-Terry model gives a better accuracy, the results are still promising considering the fact that the parameters of our method and the implementation are far from being optimized.

4. CONCLUSIONS

We presented a new model for probabilistic forecasting in sports, based on rating methods, that simply use the historical game results data of the given sport competition. We provided a forward-looking type graph based approach. The assumption of our model is that the rating of the teams after a game day is correctly reflects their current relative performance. We consider that the smaller the changing in the rating vector after a certain result occurs in an upcoming single game, the higher the probability that this event will occur. Performing experiments on results data sets of European football championships, we observed that this model performed well in general in terms of predictive accuracy. However, we should note here, that parameter fine tuning and optimizing certain parts of our implementation are tasks of future work.

We emphasize, that our methodology can be also useful to compare different rating methods by measuring that which one reflects better the actual strength (rating) of the teams according to our interpretation. Finally we should add that the model is general and may be used to investigate such graph processes where the number of nodes is fixed and edges are changing over time; moreover it also has a potential to link prediction.

5. ACKNOWLEDGMENTS

This work was partially supported by the National Research, Development and Innovation Office - NKFIH, SNN117879.

Miklós Krész acknowledges the European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program.

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Table 1: Accuracy results on football data sets. The values where the difference between the Bradley-Terry method and the PageRank method was higher than 0.01 are shown in bold.

League	Season	Betting odds error	Bradley-Terry error	PageRank method error
Premier League	2011/12	0.58934	0.60864	**0.59653**
	2012/13	0.56461	0.59744	**0.58166**
	2013/14	0.54191	**0.55572**	0.59406
	2014/15	0.55740	0.60126	0.60966
Bundesliga	2011/12	0.58945	0.59994	**0.59097**
	2012/13	0.57448	0.59794	**0.58622**
	2013/14	0.55724	**0.57803**	0.60125
	2014/15	0.57268	0.60349	0.60604
La Liga	2011/12	0.54598	**0.57837**	0.58736
	2012/13	0.56417	**0.58916**	0.60205
	2013/14	0.57908	**0.58016**	0.60473
	2014/15	0.52317	0.55888	0.56172

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Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek D

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume D

Mednarodna konferenca o visokozmogljivi optimizaciji v industriji, HPOI 2018
International Conference on High-Performance Optimization in Industry, HPOI 2018

Uredila / Edited by

Bogdan Filipič, Thomas Bartz-Beielstein

http://is.ijs.si

8. oktober 2018 / 8 October 2018
Ljubljana, Slovenia

PREDGOVOR

Z optimizacijskimi problemi se v realnem svetu, zlasti pa v industriji, srečujemo vsakodnevno. Visokozmogljiva optimizacija temelji na združevanju računske moči in naprednih optimizacijskih algoritmov in se je pojavila kot odgovor na izzive, ki jih predstavljajo zahtevni optimizacijski problemi, ki so lahko visokodimenzionalni, multimodalni, šumni, dinamični, večkriterijski ali pa njihovo reševanje vključuje časovno zahtevne simulacije.

Mednarodna konferenca o visokozmogljivi optimizaciji v industriji (*High-Performance Optimization in Industry*, HPOI 2018) je mišljena kot forum za predstavitev primerov uporabe in izmenjavo izkušenj med akademskimi in industrijskimi partnerji o uvajanju visokozmogljive optimizacije. Poleg tega spodbuja nadaljnje širjenje metodologije in neposredno sodelovanje med akademskimi ustanovami in industrijo.

Konferenca je aktivnost projekta *Synergy for Smart Multiobjective Optimization* (SYNERGY, http://synergy-twinning.eu) iz programa Twinning v Obzorju 2020. Eden od ciljev tega projekta je prenesti znanje, ki so ga pridobili partnerji v konzorciju, na druge raziskovalne ustanove in v industrijo, zlasti podjetja, ki sodelujejo v Slovenski strategiji pametne specializacije (S4). Pri doseganju tega cilja so člani projekta že predstavili svoje dosežke v visokozmogljivi optimizaciji na specializirani delavnici na Gospodarski zbornici Slovenije, nekatere pa predstavljajo tudi na tej konferenci.

Program konference obsega 11 predstavitev, vsi prispevki pa so objavljeni v konferenčnem zborniku. Prispevalo jih je 21 (so)avtorjev, od katerih je večina sodelavcev projekta SYNERGY. Obravnavane teme vključujejo optimizacijsko metodologijo, pristope k premoščanju vrzeli med akademskimi ustanovami in industrijo ter študije primerov s področij transporta, avtomobilske industrije, inženirstva in proizvodnje.

Zahvaljujemo se avtorjem za oddajo in predstavitve njihovih del, članom programskega odbora za ocenjevanje prispevkov, Institutu »Jožef Stefan« kot gostitelju srečanja in organizatorjem 21. Mednarodne multikonference Informacijska družba (IS 2018), katere del je tudi HPOI 2018, za organizacijsko podporo.

Bogdan Filipič, Thomas Bartz-Beielstein

FOREWORD

Optimization problems are met in the real world, and particularly in industry, on a daily basis. High-performance optimization (HPO) is founded on the coupling of high computing power and advanced optimization algorithms, and has emerged in response to the challenges posed by hard optimization problems that can be high-dimensional, multimodal, noisy, dynamic, multiobjective or involve time-consuming simulations in order to be solved.

The International Conference on High-Performance Optimization in Industry (HPOI 2018) is meant as a forum for presenting use cases and exchanging experience among academic and industrial partners on deploying HPO. Apart from that, it stimulates further proliferation of the methodology and direct collaboration between academia and industry.

The conference is an activity of the Horizon 2020 Twinning project "Synergy for Smart Multiobjective Optimization" (SYNERGY, http://synergy-twinning.eu). One of the objectives of this project is to spread the knowledge gained by the consortium partners to other research institutions and the industry, in particular to the companies participating in the Slovenian Smart Specialization Strategy (S4). Pursuing this goal, the project members have already presented their achievements in HPO at a specialized workshop at the Chamber of Commerce and Industry of Slovenia, and some of them are also being presented at this conference.

The conference program consists of 11 presentations and the related papers are published in the proceedings. They were contributed by 21 (co)authors, most of them being the SYNERGY project members. The topics discussed include the optimization methodology, approaches to bridging the gap between academia and industry, and case studies from the domains of transportation, automotive industry, engineering, and manufacturing.

We are grateful to the authors for submitting and presenting their work, the program committee members for reviewing the papers, the Jožef Stefan Institute for hosting the event, and the staff of the 21st International Multiconference on Information Society (IS 2018) that HPOI 2018 is part of for organizational support.

Bogdan Filipič, Thomas Bartz-Beielstein

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This event has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692286.

On Using Real-World Problems for Benchmarking Multiobjective Optimization Algorithms

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ABSTRACT
Although the motivation to study multiobjective optimization algorithms comes from practice, there are only a few challenging real-world problems freely available to the research community. Because of this, algorithm benchmarking is performed primarily on artificial test problems. The most popular artificial test problems have characteristics that are not well-represented in real-world problems. This and the predominant inadequate performance assessment methodology widen the gap between theory and practice in the field of multiobjective optimization. The paper suggests to instead compare the algorithms with the anytime performance benchmarking approach of COCO (the Comparing Continuous Optimizers platform) on more realistic artificial problem suites as well as suites with diverse real-world problems. By listing the benefits of sharing the real-world problems with the community, the paper hopes to encourage domain experts to embrace this practice.

Keywords
multiobjective optimization, real-world problems, algorithm benchmarking

1. INTRODUCTION
Most real-world optimization problems found in science and engineering are inherently multiobjective. For example, the task of many engineering design problems is to find solutions of high quality and low cost. Such problems seldom have a single solution (called the ideal solution) that would optimize all objective simultaneously. Rather, they have (possibly infinitely) many Pareto-optimal solutions that represent different trade-offs among the objectives. These solutions form the so-called Pareto set in the decision space and Pareto front in the objective space.

Evolutionary Multiobjective Optimization (EMO) [4] is one of the most active research areas that deal with multiobjective problems. It studies algorithms that make no assumptions on the properties of the optimization problems, such as linearity, continuity and unimodality, and are therefore applicable to a variety of problems, including black-box optimization ones. EMO algorithms have successfully solved numerous challenging real-world optimization problems [3].

Nevertheless, there is a large gap between theory and practice in the EMO field (stemming from the one in Evolutionary Computation [18]), which is widened by the dominating (inadequate) paradigm of algorithm performance assessment. The artificial test problems that are being consistently used for benchmarking EMO algorithms have characteristics that are not representative of real-world problems. They also fail to incorporate the peculiarities of real-world problems, which means that the algorithms need additional adjustments before they can be applied to real-world problems [8]. Furthermore, most studies do not investigate the influence of the problem dimension on the performance of the algorithms and the performance assessment is often done only at a predefined number of evaluations. This makes it hard to predict which algorithm will perform best on a particular real-world problem when less evaluations are allowed than the (high) numbers usually used in the studies.

The COCO platform [2, 10] resolves many of these issues by providing an alternative to the overused test suites and a more rigorous approach to algorithm benchmarking. However, in order to bridge the gap between theory and practice, multiobjective optimization algorithms should be studied and compared not only on well-understood and easy-to-compute artificial functions, but also on real-world problems with various characteristics. Currently, only a small number of challenging real-world problems are freely available to the EMO community, which hinders the development of algorithms that could be used ‘off the shelf’.

The purpose of this paper is to show the advantages of benchmarking algorithms on real-world problems and to encourage domain experts to share their hardest problems with the researchers to their mutual benefit.

In the remainder of the paper, we first recall the purpose of algorithm benchmarking (Section 2). Then, we review the existing practice of benchmarking multiobjective optimization algorithms on artificial test problems and remind of an available alternative in the form of the COCO platform (Section 3). Next, we mention some real-world problems that have been made publicly available, discuss the benefits of sharing real-world problems and give recommendations for proposing new real-world problems and performing benchmarking with them (Section 4). We conclude with some closing remarks (Section 5).

2. THE PURPOSE OF ALGORITHM BENCHMARKING
The no free lunch theorem implies that no optimization algorithm performs best for *all* possible problems [22]. The observed differences in performance are due to the (more/less)

successful adaptation of the algorithms to the problem landscapes [12]. It is therefore crucial that the test problems used in comparison studies have characteristics that are representative of real-world problems.

Algorithm benchmarking, either when comparing variants of the same algorithm or a novel algorithm to an established one, can be used to gain an understanding of the algorithms at hand. However, the ultimate purpose of algorithm benchmarking is to find the algorithm that is expected to perform best for a specific target problem—a real-world problem of interest. This entails that we have

(a) some knowledge about the characteristics of the target problem,
(b) information on the performance of a number of algorithms on test problems with similar characteristics as those of the target problem, and
(c) an understanding of what *best* is, i.e., we can define and measure the desired algorithm performance.

Then, machine learning methods can be used to select the most appropriate algorithm for the given target problem [16].

3. USING ARTIFICIAL PROBLEMS FOR ALGORITHM BENCHMARKING

Benchmarking multiobjective algorithms on artificial optimization problems has several advantages. The evaluations are cheap (computed instantaneously), the characteristics of the problems can be controlled, and the problems can be implemented in any programming language. If constructed with care, the artificial problems can be scaled in the number of decision variables, constraints and objectives, and the Pareto sets and fronts can be known, which considerably facilitates performance assessment.

The main question when using artificial test problems for benchmarking algorithms is whether they are good representatives of real-world problems.

3.1 Issues with the Prevailing Benchmarking Methodology

Since the introduction of the DTLZ [6] and WFG [13] test suites in 2001 and 2006, respectively, the vast majority of studies in EMO have been comparing algorithms on one or both of these two suites. In fact, they have been overused to such a degree that we can speculate on overfitting of optimization algorithms to these problems. This is especially concerning because they have some properties that are beneficial when designing test suites, but are not likely to be found in real-world problems. For example, in order have a known Pareto set and a controllable shape of the Pareto front, the problems are parameterized by two sorts of variables: distance variables, which indicate the distance of a solution from the Pareto front, and position variables, which indicate the position of a solution along the Pareto front. The resulting Pareto sets and fronts are much easier to work with than the irregularly shaped real-world ones.

Many real-world problems have additional difficulties, such as constraints or a mixed-integer decision space. While there are some multiobjective test suites with constraints, for example the C-DTLZ test suite [15], there is no established test suite containing mixed-integer problems with multiple objectives.

Furthermore, although the problems from the mentioned suites are scalable in the number of variables (the problem dimension) and the number of objectives, performance studies rarely investigate the scaling of the algorithms with the problem dimension. This is usually simply fixed to a value (often 30), while the number of objectives is being changed. Such an approach to performance assessment is problematic as it disregards one of the most defining characteristics of a problem—its dimension.

Finally, most studies compare the performance of the algorithms only at a specific point in time, determined by the number of function evaluations. Because they provide no data on the performance of the algorithms prior to that moment, the findings of such studies cannot be used to infer algorithm performance when less evaluations are available, making them effectively useless for the main purpose of benchmarking mentioned earlier.

3.2 Benchmarking with the COCO Platform

COCO (Comparing Continuous Optimizers) [2, 10] is an open-source platform for benchmarking black-box optimization algorithms. It implements different test problem suites and provides an anytime performance assessment methodology that is in line with the purpose of benchmarking as described in Section 2. Furthermore, COCO incorporates the results of various optimization algorithms on its tests suites that are regularly being collected at BBOB (Black-Box Optimization Benchmarking) workshops [1] and can be readily used for comparisons with new algorithms.

In addition to singleobjective test suites, such as the established `bbob` suite [11], COCO currently provides two test suites with biobjective problems, `bbob-biobj` with 55 functions and its extended version `bbob-biobj-ext` with 92 functions [21], each instantiated in six dimensions ($n \in \{2, 3, 5, 10, 20, 40\}$) and ten instances (small alterations of the function, such as shifts, etc.). Every biobjective function is constructed using two separate `bbob` functions—one for each objective. This approach is motivated by the nature of real-world multiobjective problems, where each objective corresponds to a separate singleobjective function. It is therefore closer to real-world conditions than the constructions with distance and position variables used by the DTLZ and WFG test suites. However, this approach results in unknown Pareto sets and fronts, which is not convenient for performance assessment purposes. In order to alleviate this issue, COCO provides approximations of the Pareto fronts for all problems, collected during several runs of various EMO algorithms. These can be used in plots to showcase the characteristics of the Pareto fronts and to compute the best known hypervolume [23] values for these problems.

The anytime performance assessment approach from COCO is based on the notion of runtime, i.e., the number of function evaluations needed to achieve a target hypervolume (see [9] and [21] for more details). This makes it possible to study the results for each problem separately as well as aggregate them over all problems in a suite. For example, the plot

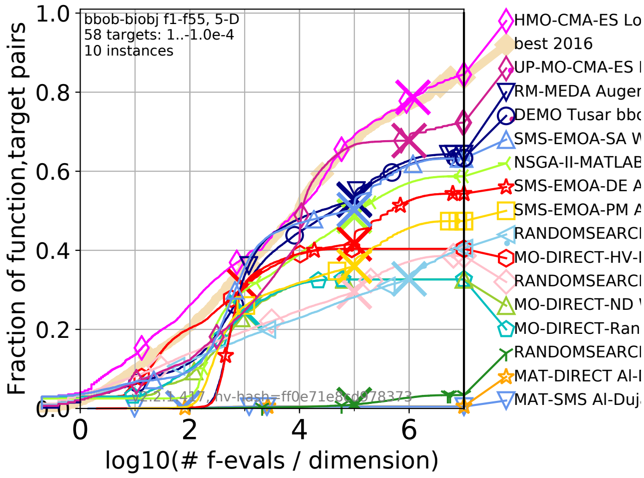

Figure 1: Bootstrapped empirical cumulative distribution of the number of objective function evaluations divided by dimension for 58 targets with target precision in $\{10^0, 10^{-0.1}, \ldots, 10^{-4.9}, 10^{-5}, 0, -10^{-5}, -10^{-4.8}, \ldots, -10^{-4.2}, -10^{-4}\}$ for 16 algorithms on all 5-D functions of the `bbob-biobj` test suite.

in Figure 1 shows the proportion of targets (on the y axis) that an algorithm is expected to achieve given the number of function evaluations (divided by the problem dimension, on the x axis). The plot presents the results aggregated over all instances of the 5-D functions of the `bbob-biobj` suite. Note that such plots allow to compare the performance of algorithms that were run using a different budget of function evaluations (up to the minimal common budget).

The COCO platform could similarly be used to benchmark real-world problems.

4. USING REAL-WORLD PROBLEMS FOR ALGORITHM BENCHMARKING

4.1 Availability of Real-World Problems

Real-world problems can be separated into those whose objectives and constraints can be given in an analytic form and others that are truly black-box problems, for example those that require complex computations or simulations to evaluate the functions and constraints of the problem. Note that as soon as one function or constraint behaves like a black box, the entire problem is considered to be a black box.

There are quite a few multiobjective real-world problems of the first type, i.e., with a known analytic form. See for example the problems from [5], [7] and [20]. Similarly to the artificial problems, they can be evaluated quickly and implemented in any programming language. However, as recently shown in [20], many such problems are not challenging enough to distinguish between algorithms and can therefore be useful for benchmarking purposes only in test suites containing other, harder problems.

On the other hand, there are also many black-box real-world problems from various domains, but only a few of them are freely available to EMO researchers. Here, we briefly mention three that are of different nature, but are very demanding and therefore suitable for algorithm benchmarking:

- The Radar Waveform problem has an integer decision space that can be scaled from four to 12 decision variables, and nine objectives [14].
- The HBV Benchmark Problem consists of calibrating the HBV rainfall–runoff model [19]. It has 14 real-valued decision variables and four objectives.
- The recently proposed Mazda Benchmark Problem [17] is a car structure design optimization problem with 222 integer decision variables, two objectives and 54 constraint functions that make it hard to find a feasible solution.

There are multiple reasons why only a few black-box real-world problems are being publicly shared. Sometimes, the companies that have such problems hide them to protect their trade secrets. Other times, the reasons are of an implementation nature, for example because some proprietary software is needed to perform the evaluations. It is also possible that people do not make their problems public simply because they see no benefit in doing so.

Most of these issues can be amended. If the domain experts wish to keep the details of the problem hidden, this can be achieved by sharing an executable program without the source code. If the companies fear that their competitors could retrieve useful information already from how the problem is defined, a simple linear transformation can be used to transform a box-constrained continuous decision space to $[0, 1]^n$ without affecting the nature of the problem landscape (an integer or mixed-integer decision space can be handled in a similar way). Although the least noteworthy, some implementation issues can be hardest to bypass. The best way might be to use freely available software instead of the proprietary one (this, of course, might not always be possible). If conceivable, time-consuming evaluations using specialized software can be replaced by surrogate models as was done, for example, in [17].

4.2 Benefits of Sharing Real-World Problems

Suppose a real-world problem is interfaced with the COCO platform and used in the BBOB workshops to benchmark multiobjective algorithms. This means that the researchers not only run their algorithms on the problem, but also submit their results to COCO for use in future comparisons. The first and most obvious benefit of such a setting is that the interested EMO community would most likely find better solutions to the problem in question than a single team of researchers. Next, if the problem has some characteristics that are not well-represented in artificial test problems, such as a mixed-integer decision space, sharing such a problem will motivate the researchers to adapt their algorithms to its characteristics. This means that in time, there will be more versatile algorithms for these kinds of problems to choose from. Finally, it is likely that in the future, the same experts who shared this problem, will face another problem of similar nature. Then, the algorithms that performed best on the original problem might be readily used on the future alternative versions of this problem.

4.3 Recommendations

When proposing real-world benchmark problems, domain experts should try to make them as flexible as possible. Ideally, it should be possible to instantiate them in a few different dimensions and also to create some instances of the same problem (minor modifications that do not change the nature of the problems). In addition to providing better grounds for performance assessment, this might also help to better understand the problems in question.

When benchmarking EMO algorithms, artificial test suites with properties reflective of the real-world problems should be used in order to gain understanding about the algorithms. In addition, the algorithms should also be tested on real-world problems to show their applicability in practice. Since real-world problems come from various domains and might have particular characteristics, the algorithms should be run on suites of real-world problems from different domains.

5. CONCLUSIONS

This paper reviewed the many drawbacks of the existing practice of benchmarking multiobjective algorithms with the over-used DTLZ and WFG test suites. Using the COCO platform most can be amended, but the performance assessment is still being done solely on artificial problem functions. The paper proposes to benchmark algorithms using COCO's anytime performance assessment on suites of real-world algorithms in addition to the artificial ones. Some benefits of sharing real-world problems with the EMO community are presented in hope to encourage greater exchange of knowledge between academia and industry.

6. ACKNOWLEDGMENTS

The author acknowledges the financial support from the Slovenian Research Agency (project No. Z2-8177).

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Bridging Theory and Practice Through Modular Graphical User Interfaces

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ABSTRACT

State-of-the-art evolutionary algorithms and related search heuristics are well suited to solve problems from industry. Unfortunately, easy to use graphical user interfaces (GUI) are not available for many algorithms. We claim that the availability of well-designed GUIs might increase the acceptance of these algorithms in the real-world domain. The spotGUI R-package, which is introduced in this paper, provides a GUI for the already well-established SPOT package. It includes state-of-the-art algorithms and modeling techniques that can be used without the requirement of optimization or programming knowledge. Using the spotGUI in industry, as well as education, delivered first promising results.

Keywords

SPOT, Graphical User Interface, Real-World Applications

1. INTRODUCTION

Industrial problems are highly complex and challenging for even the most advanced state-of-the-art algorithms. However, the difficulty in solving such problems is often not their high complexity, but rather the challenge for a non-expert user to apply a suitable algorithm. For a significant subset of the existing optimization problems in industry, suitable state-of-the-art algorithms already exist. Yet, they are often still not applied because they are

a) not known to the field specialist or
b) no simple implementation is available.

This paper presents a simple to use GUI that bridges the gap between existing algorithms and real-world problems. The core of the new package relies on the Sequential Parameter Optimization Toolbox (SPOT) [1]. SPOT provides a modular structure for combining sampling methods, modeling techniques and optimizers for an all-in-one Surrogate Model-Based Optimization (SMBO) toolbox. In SMBO, a data-driven surrogate model is fitted to the data of an expensive to evaluate objective function, e.g., a complex simulation or a real-world experiment. Under the assumption that the surrogate is cheap to evaluate, an extensive search on the model becomes feasible. The predicted candidate solution, which best fulfills some user-specified infill criterion (e.g. best model function value) is evaluated on the expensive objective function and further used to update the model. The process is repeated in an iterative fashion. A more in-depth explanation of SMBO and its applications can be found in [5] and [2].

SPOT has been further improved and developed for many years. Today the package provides a vast set of different models, optimizers, and sampling schemes, each of which can be configured to user specific requirements. The system was initially targeted to parameter optimization tasks, but is well suited to any costly to evaluate optimization problem. The availability of these methods together with their respective documentation in the R-package is a first step towards an easy to use modular optimization tool. However, SPOT remains a high-level toolbox, which requires user experience and some R programming skills. Furthermore, since R is rarely used by engineers in industry, this again leads to problems (a) and (b) as previously discussed. The presented spotGUI tries to address these problems by making the tools included in SPOT accessible to everyone through an easy to use graphical interface.

The rest of this paper is structured as follows: Section 2 gives an overview of the basic functionality and some conceptual ideas of the spotGUI. In Section3 two practical example applications for the spotGUI applied in industry are presented. One of which is the Electrostatic Precipitator (ESP) Problem, a current, costly-to-evaluate, discrete optimization problem from industry. Lastly, the software, future opportunities, and room for improvements are discussed in Section 4.

2. WORKFLOW

2.1 Availability

The spotGUI package shall give more users easy access to SPOT. All stable versions are available on CRAN. Development versions are published on GitHub. One of the primary goals of the spotGUI is to allow non-R-users and even non-programmers to use SPOTs model-based optimization techniques. Additionally, it can benefit experienced SPOT users by enabling a faster setup and even code generation which will be covered in more detail in Section 2.5. The spotGUI is developed in the R extension Shiny [4]. It is divided into

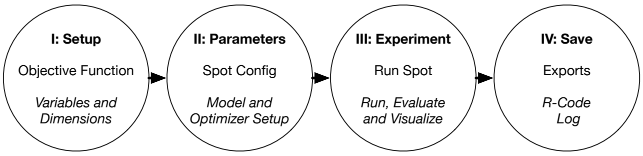

Figure 1: Typical optimization workflow for SMBO in the spotGUI

four separate tabs, arranged in a typical workflow order as presented in Figure 1 and Algorithm 2.1. Each of the tabs is explained in more detail in the following.

Algorithm 2.1: Surrogate Model-based Optimization

```
step I: setup
select and parametrize objective function
begin
    step II: parameters
    select and parametrize surrogate model
    select and parametrize experimental design
    step III: experiment
    generate design points
    evaluate design points with objective function
    build initial surrogate model
    while not termination-condition do
        search for optimum on surrogate model
        evaluate new point on the objective function
        update surrogate model
    end
    step IV: save
end
```

2.2 Setup

The objective function is specified and parametrized on the first setup tab. A screenshot of the configuration window is shown in Figure 2. Additionally to having an option to insert any function through the R-Environment and supporting manual result input, the spotGUI provides a broad set of preconfigured test functions.

The set of provided test functions is loaded from the 'smoof' R-package [3], which provides an interface to many single- and also multi-objective test functions. Of these, the spotGUI only includes the current set of single-objective functions, totaling in 76 test functions. Each of these functions is loaded with its respective bounds as well as dimensionality. Scalable functions are loaded as 2-dimensional functions and can then be adapted by the user to any desired dimensionality. The 'smoof' package also allows the user to filter the functions by specific tags such as "separable", "differentiable" or "weak-global-structure". This makes it possible to test a given optimizer on a particular type of test function that should behave somewhat similar to a real-world problem that shall be solved. Different settings for SPOT and its tools can quickly be tested by using the spotGUI with the given set of test functions.

The possibility to manually input evaluation results enables non-programmers to use the spotGUI without any requirements for an objective function definition in code. Thus for example making it possible to use SPOT to optimize

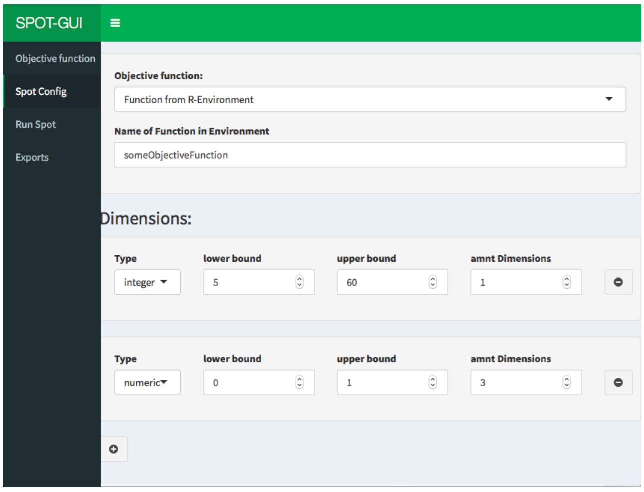

Figure 2: Screenshot illustrating the objective function setup in the spotGUI. The user has to define the function as well as it's dimensionality and variable types.

some real-world experiments by entering / importing the experiment results back into the spotGUI. The only configuration required in this scenario is to insert information on the problem dimensions. Each dimension is configured with a type (numeric/integer/factorial), as well as upper and lower bounds. If there are multiple dimensions with the same upper and lower bounds, the convenience option "amntDimensions" can be used to specify that the same bounds are required multiple times.

2.3 Parameters

One of the main benefits of the spotGUI becomes evident during the setup of SPOT itself. As previously mentioned SPOT features a wide variety of different models and optimizers, each of which again provides a variety of configuration options. In the spotGUI, these are conveniently selectable from drop-down menus. Showing each available option together with simple explanations through tooltips, tackles the requirement of any documentation reading for the user. The settings are arranged in four categories covering a general setup, modeling setup, optimizer setup and lastly design setup. Skipping the 'Spot Config' tab altogether results in a robust default setup for SPOT.

2.4 Experiment

The previously configured processes are executed in the "Run Spot" tab. The available options include creating a DOE, fitting a model, running a model-based optimization, and more. In the following, these methodologies will be briefly explained. In many expensive real-world applications, an initial screening for variable importance and interaction is desired. The spotGUI provides the option to do so with a configured sampling method to build a design of experiments. Depending on the objective function configuration, the generated experiments can be evaluated automatically or manually, e.g. a real-world experiment. Such manual results can either be imported into the spotGUI or directly entered into the result table. A surrogate-model is fitted to the given data making interactive 3D-visualizations available.

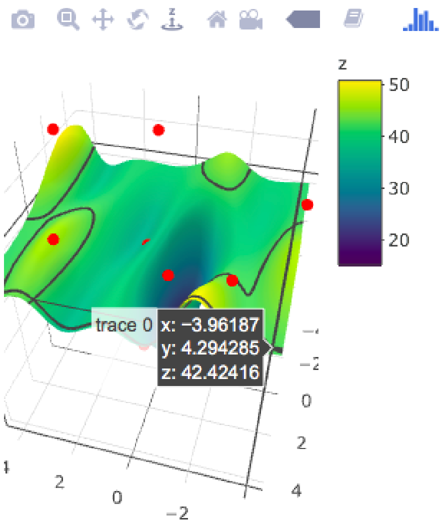

Figure 3: Auto generated plot showing the fitted surrogate model. Red dots indicate evaluated candidate solutions. Hovering the mouse over the plot results in the black info box showing more detailed information for the given plot location. The toolbar above the plots provides features for easy plot exports.

The graphics are generated through plotly, an R-library for creating web-based graphs [7]. The availability of interactive 3D plots enables the user to learn more about the landscape of their objective function intuitively and gives a deeper insight into variable behavior. After a model fit, it is easily possible to run an optimizer on the model to propose a single next candidate solution, thus enabling SMBO even to a manual user / non-programmer.

Further options are again aimed at enhancing the automatic evaluation and optimization of a configured objective function. As sometimes even just a few objective function evaluations might take a long time, the spotGUI execution can be interrupted and restarted from the last completed function evaluation. For users who only want to use the spotGUI as a quick setup tool for their code, another option exists. By entering the 'Log Only' mode, all computations that would usually be applied to the objective function are skipped. Instead, the actions are only written to the code log. From there they can be exported and used in any R-Script, enabling an extra fast setup for new SPOT projects.

2.5 Save

Each action that is executed in the spotGUI is written into an exportable R-Code log. The log is accessible on the 'Export' tab of the GUI, it can easily be exported or copied to the clipboard through the provided button. The resulting R-Code can be run standalone (given the spotGUI library is installed) and generates the same results as previously shown in the experimentation tab. This also ensures reproducibility of any work that was done with the help of spotGUI.

3. EXAMPLE APPLICATIONS

3.1 Applying the Manual Mode

The spotGUI offers a couple of functionalities to be easily usable and applicable to problems where real-world experiments are required. We can imagine the following example where the user is not too affine with software programming: A machine engineer who needs to set up a new metal hardening machine to deliver good performance.

Through the machine's interface, he is allowed to control two temperature parameters which define a temperature curve that the machine runs through in the hardening process. Additionally, he can change two time parameters which define the duration of the heating as well as the cooling phase in the hardening process. He is looking for the set of optimized parameters which result in the hardest end product. However, each test requires to run the hardening machine for a few hours and involves material costs. In this scenario, the *manual mode* of the spotGUI could help the engineer in this parameter optimization problem. First of all, by using the spotGUI in the manual mode, no coded fitness function is used. Instead, parameter settings are proposed by SPOT, manually evaluated on the hardening machine and inserted into the results table by the engineer.

The detailed workflow is as follows: After an initial setup in the spotGUI, defining the bounds and types of the input parameters, a DOE (Design of Experiments) is built. This is quickly done via the 'createDOE' button in the 'runMode' tab. A model can be fitted, and a visualization of it is available. With the now to him available information, the engineer could continue in a few different ways. He could straightforward accept the best solution found in the DOE. However, this should not be done if resources for more machine tests exist. Continuing with a more in-depth DOE, he could increase the DOE budget and optionally shrink the parameter bounds to an area that is considered as promising by the fitted model. The second option to spend the remaining test budget is to run an optimizer on the fitted model via the 'propose new point' functionality. This additional point is the model optimum for some configured infill-criterion. This criterion might be the best-predicted point, but depending on the model, it could for example also be the point with the highest expected improvement as utilized in EGO [6]. After evaluating the proposed point on the machine, the model can be refitted to include the new data point. After that, the 'propose new point' functionality is usable again. Therefore, by using this feature, surrogate model-based optimization is available in a manual use case, making a well-known and powerful optimization technique available to a broader audience. Lastly, the configuration of the spotGUI can easily be changed during the optimization process, allowing for a more interactive optimization approach.

3.2 The Electrostatic Precipitator Problem

Electrostatic precipitators (ESP)s are large scale electrical filtering/separation devices. They are used to remove solid particles from gas streams, such as from the exhaust gases of coal-burning power plants. An overview of the structure of an ESP can be seen in Figure 4. The illustrated separator has three central separation zones in which the

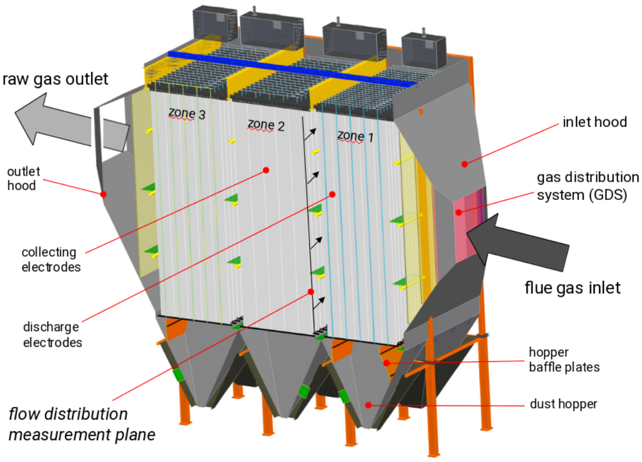

Figure 4: Electrostatic precipitator with 3 separation zones. This figure was kindly provided by Steinmüller Babcock Environment GmbH.

particles are separated from the gas flow by the precipitator. Gas streams in from piping through the inlet hood and exits through an outlet hood. The entrance and exit piping of the separator has a much smaller cross-section and therefore a higher gas velocity than desired in the separator. Without additional measures the fast gas stream would rush through the center of the precipitator, resulting in very low separation efficiency. The primary optimization target is the so-called gas distribution system (GDS). The GDS is mounted directly behind the flue gas inlet of the precipitator. It is used to distribute the gas flow from the small inlet cross-section to the much larger cross-section of the precipitation zones. The GDS in the given application consists of 49 configurable slots. Each of these slots can be filled with different types of metal plates, porous plates, angled plates, or be left completely empty. Increasing the separators efficiency by achieving a more evenly distributed gas flow allows a smaller overall separator. A reduced separator size, together with lowered operating costs would accumulate to multiple millions of euro in cost reduction.

Two central factors reveal a complex to solve optimization problem:

a) The amount of configurable slots together with the amount of available configurations per slot leads to $\approx 10^{41}$ possible configurations for the overall system
b) Each objective function evaluation requires a costly CFD-simulation in order to judge the gas flow through the system

The ESP optimization was approached with a combination of a parallelized model-based evolutionary algorithm that was equipped with newly created task-specific mutation and recombination operators. Tuning these operators was required in order to be able to reduce the overall runtime of each optimization to fit into standard project run times. In this industry project, the spotGUI was successfully applied to set up parameter tuning for the evolutionary algorithm and its operators.

4. SUMMARY

The SPOT package has been available for many years. It has been continuously updated and grew to a very large and useful platform. However, through the growing amount of possible configurations and use cases it simultaneously became more complex to dig through all settings and find the best ones for each problem. The here introduced spotGUI package reduces the configuration complexity back down to a level where any beginner can use the package. It was successfully applied to industry use cases as well as in student courses. Thus, demonstrating its ease of use and capability to provide easy to access visual information. The playful style with which different optimization methods can be applied makes the software a useful tool in education.

One of the most significant drawbacks of the current version of the spotGUI is its dependency on R. Till now, the spotGUI can only be published as a web application available through a browser or started directly in R. Future work on the spotGUI will, therefore, concentrate on making the software available as a standalone executable without the requirement of starting it through R. Additionally, more features are planned or even already are under construction, including: Parallelization support for SPOT, more DOE and analysis functionality, additional exports, and report generation.

5. ACKNOWLEDGEMENT

Parts of this work were supported by the "Ministerium für Kultur und Wissenschaft des Landes Nordrhein-Westfalen" (FKZ: 005-1703-0011).

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Expensive Optimisation Exemplified by ECG Simulator Parameter Tuning

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ABSTRACT
This article describes the tuning of an Electrocardiogram (ECG) simulator as a benchmark problem to show the application of surrogate modelling in complex global optimisation. After presenting the background on ECG, its simulation and the optimisation task, the main concepts and methods of surrogate modelling and Efficient Global Optimisation (EGO) are presented. Here, next to the standard techniques regularly involved in the algorithm, alternative approaches are discussed briefly. Finally, first results applying the depicted algorithm on the ECG simulator optimisation problem are presented.

Keywords
ECG, evolutionary algorithms, surrogate assisted optimisation

1. INTRODUCTION
The heart muscle pumps blood in a specific rhythm throughout the entire body. In order to do this, the heart muscle requires an electrical impulse to contract. This electrical impulse acts as a natural pacemaker. The electric current is then transmitted via specific pathways throughout the heart, enabling regular contraction and relaxation. ECG is the result of recording this electrical activity of the heart over a period of time using electrodes placed on the skin. It provides information about the heart's rhythm and rate. The normal ECG shape and some typical defects are well known, but the transfer function that maps the ECG measured on the skin to individual cells of the middle layer of the heart wall is unknown. Gathering additional knowledge on the transfer function would help to improve ECG-based diagnostics and enable better prediction of health condition, based on the ECG reading. Simulation models may help, but the simulation of a human ECG signal is a complex optimisation problem.

2. THE ECG SIMULATOR
The ECG simulator[1] considered within the SYNERGY[2] project is a tool which tries to mimic the activity of the left ventricle of the heart, by producing ECG waveforms for a given set of Action Potential (AP) parameters. The heart model is constructed using a three-dimensional grid [5, 6]. For the simulation, the APs are described mathematically and represent voltage as a function of time for an individual cell. The function AP(t) is parameterised with nine parameters and is approximated by a combination of exponential functions [20]. Out of nine AP function parameters, two have predefined values, while the remaining seven are subject to optimisation. As three layers of heart muscle cells are considered in the model, the total number of optimisation variables is 21. The optimisation goal is to find the best set of parameters to produce properly shaped APs and approximate simulated ECG waveforms to a measured ECG waveform by perfecting the shape of the APs.

Pearson's correlation coefficient (PC) is the covariance of the two variables divided by the product of their standard deviations. The coefficient PC_1 between the measured ECG waveforms and the simulator output builds the objective function, which is required to be maximized to obtain a good match between the two waveforms.

[1]https://github.com/synergytwinning/ekgsim
[2]http://synergy-twinning.eu/

3. THE EGO APPROACH
As each run of the ECG simulator takes around 15 minutes, finding the best solution is a time consuming process that can take days or weeks. One way of relieving the burden of expensive simulation runs is by constructing approximation models that mimic the behavior of the simulator as closely as possible while being computationally cheaper to evaluate. The basic idea of using surrogate models in optimisation can be quite simple. First, the surrogate models for the objective function with sufficient accuracy are built; second, the optimum is found by an optimizer, with the objective function evaluated by surrogate models, rather than by the expensive simulation runs. Since prediction with the surrogate models is much more efficient than that by the expensive simulation runs, the optimisation efficiency can be largely improved.

Although the framework of the surrogate-based optimisation is very intuitive and simple, questions may arise, e.g.: Is the surrogate model accurate enough and has the true optimum been reached? The solution gained by the surrogate model is only an approximation to the true optimum. One has to refine the surrogate models by adding new sample points, which are observed by running the ECG simulator. The flowchart of the surrogate-based optimisation is sketched in Figure 1.

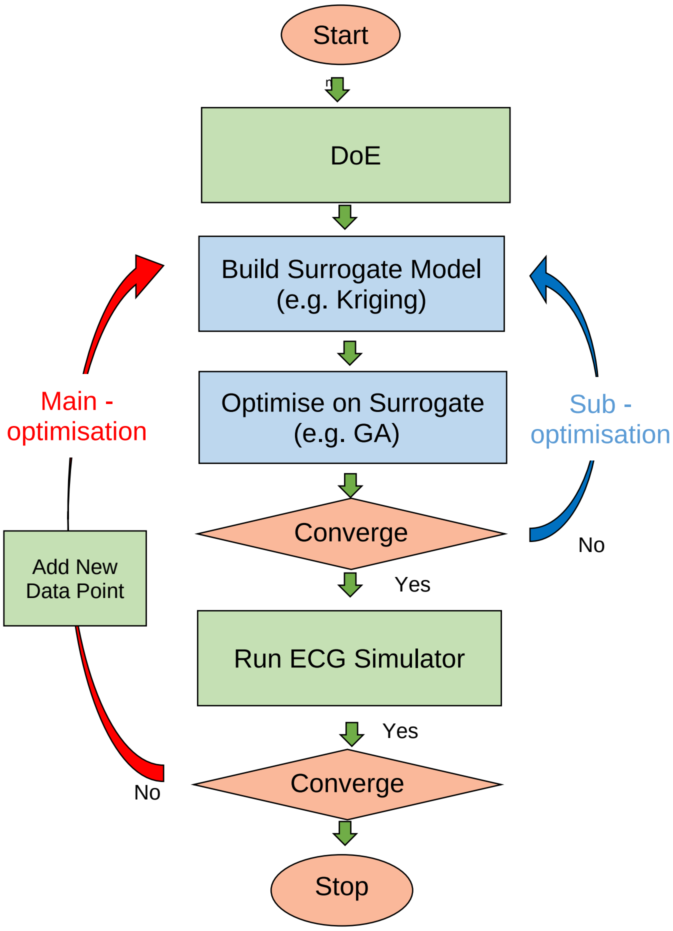

Figure 1: Flowchart of the surrogate-based optimisation

The steps from the figure like Design of Experiments (DoE), building the surrogate model, optimising on the surrogate etc. selection are explained in a bit more detail in the following. Here, we mention common techniques next to prominent alternatives. A focus is put on the techniques that are used for addressing the ECG simulator optimisation problem.

3.1 Single-objective Surrogate Modelling

In single-objective surrogate-assisted optimisation, there exists only one objective function, which is the fitted surrogate model using the acquired data points. The most straightforward approach is to find the global optimum of this model. The major problem is that the search may stall at a local optimum. Solving this problem implies that the search needs to combine exploration and exploitation; i.e., the search explores the total experimental area and zooms in on the local area with the apparent global optimum.

Efficient Global Optimisation [11, 10] is a popular search heuristic that tries to realize this exploration and exploitation. Many alternatives exist, one is the pre-selection approach described in [9]. EGO is a widely used surrogate-based optimisation algorithm for expensive single-objective optimisation specialised on utilising Kriging modelling and the Expected Improvement (EI, cf. [11]) infill criterion. EI not only considers the objective function provided by the model but also the model quality to suggest new points for time-consuming evaluations.

EGO starts by building an initial Kriging model using some initial design points which are often produced by an experiment design method. Then, in each iteration, the point with the highest EI value is selected by using a traditional optimisation algorithm. The selected point is evaluated using the real expensive objective function and used to update the Kriging model. In such a way, the EI criterion guides the search toward the optimum of the real problem.

3.2 Design of Experiments

The first mandatory step in surrogate modelling is the collection of data to set up an initial model. This is normally done by a DoE approach [2], which results in an initial sampling plan. By choosing an initial sampling plan the challenge is to limit the number of samples but nevertheless get a good and suitable design. There are various sampling techniques available such as Uniform Random Sampling, Latin Hypercube Sampling, and Orthogonal Array Sampling. A common choice is Latin Hypercube Sampling (LHS, [16]) a statistical method for generating a near-random sample of parameter values from a multidimensional distribution.

3.3 Modelling Approaches

An important issue is the huge number of surrogate models available in the literature. Here we limit our discussion to three popular techniques that are shortly described below.

3.3.1 Kriging

Kriging is a popular choice of surrogate models. It understands observations as realisations of a Gaussian process. The popularity of this technique is due to the fact that it not only produces accurate predictions, but also provides an estimate of the prediction uncertainty [14, 18].

3.3.2 Random Forests

Random Forests [3] are ensembles of prediction trees such that each tree depends on the values of a random vector sampled independently and with the same distribution for all trees in the forest. The generalisation error of a forest of tree classifiers depends on the strength of individual trees in the forest and the correlation between them. Internal estimates monitor the error, strength, and correlation, and these are used to show the response to increasing the number of features. Internal estimates are also used to measure variable importance [3].

3.3.3 Support Vector Regression

SVR is a modelling technique based on the theory of support vector machines [7, 19]. SVR models produce a pretty accurate estimate of the objective function, provided that a suitable kernel is selected and parameters are appropriately tuned. This tuning process is expensive, especially for models with higher dimensions and a high amount of sample points [12].

3.4 Optimisers

Choosing a suitable search strategy which can perform effective global optimisation is the most difficult part in surrogate-assisted optimisation. In our work we use two well-known optimisers, namely an Evolutionary Algorithm and Simulated Annealing.

3.4.1 Evolutionary Algorithms (EAs)

EAs are metaheuristics inspired by the process of natural selection that belong to the larger class of evolutionary algorithms. They are commonly used to generate high-quality solutions to optimisation and search problems by relying on bioinspired operators such as mutation, crossover and selection [4, 8]. A subclass of EAs are Genetic algorithms (GAs).

3.4.2 Simulated Annealing (SA)

SA is a method to solve complex optimisation problems [13]. This method models the physical process of heating a material and then slowly lowering the temperature to decrease defects, thus minimizing the system energy. At each iteration of the simulated annealing algorithm, a new point is randomly generated. The distance of the new point from the current point, or the extent of the search, is based on a probability distribution with a scale proportional to the temperature. The algorithm accepts all new points that improve the objective value, but also, with a certain probability, points that worsen the objective value. By accepting points that raise the objective, the algorithm avoids being trapped in local optima in early iterations and is able to explore better solutions globally.

3.5 Model Selection and Validation

K-fold cross-validation is an improved scheme which allows us to use most of the data for constructing the surrogates. In general, the final quality of the surrogate model is judged using the mean and the standard deviation of the root-mean-square error (RMSE) for each cross-validation set [17].

4. RESULTS

The purpose of this article is to summarize approaches to surrogate modelling which are applicable to the ECG simulator. The various surrogate models selected were Kriging, SVR, RF and a convex combination ensemble of the former three models.

The ensemble model performed best in K-fold cross-validation tests, while SVR performed worst. This provided an insight of how the models would actually perform during the optimisation process as shown in Figure 2. Single-objective optimisation was carried out to investigate the performance of the surrogates in a practical scenario. The single-objective surrogate-assisted optimisation yielded some pretty interesting facts about the behavior of the ECG simulator. Firstly, the maximum value that is achieved for the objective function is 0.31. The EGO algorithm based on Kriging (Expected Improvement) using simulated annealing performed superiorly relative to other strategies when comparing the mean and standard deviation of the best obtained values as shown in Figure 3 [15].

The optimisation of the weight vector for building the ensemble model revealed that the SVR model did perform

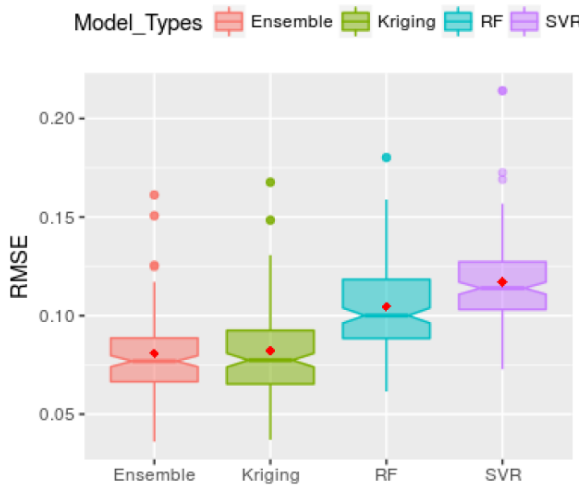

Figure 2: Box-plot of RMSE obtained for cross-validation of PC_1

worst (as its weight was optimized to a value of zero).

5. CONCLUSIONS AND OUTLOOK

The efficient global optimisation approach is presented. Next to standard settings from the methods involved in the algorithm, some alternatives were discussed briefly. The resulting algorithm is applied to the ECG simulator optimisation problem and first results are presented.

However, the parameters used for optimisation (i.e., models invoked, evolutionary algorithm, simulated annealing etc.) were not tuned for the best performance. Parameter tuning of optimisers might further enhance the surrogate-assisted optimisation process. Here, SPOT [1] might be invoked, which provides a set of tools for model-based optimisation and tuning of algorithms. It also includes surrogate models, optimisers and design of experiment approaches.

The simulator provides two simulated ECG signals at different positions on the body surface. A second coefficient PC_2 could be used for multi-objective optimisation, also known as multi-criteria optimisation or Pareto optimisation. It is a special case of solving optimisation problems with more than one objective function to be optimised simultaneously. The final result is a set of solutions known as Pareto optimal solutions. The Pareto front is a set of non-dominated solutions, being chosen as optimal, if no objective can be improved without sacrificing at least one other objective.

6. ACKNOWLEDGMENTS

This work is funded by the European Commission's H2020 programme, through the Twinning project SYNERGY under Grant Agreement No. 692286 as well as through the UTOPIAE Marie Curie Innovative Training Network, H2020-MSCA-ITN-2016, Grant Agreement No. 722734.

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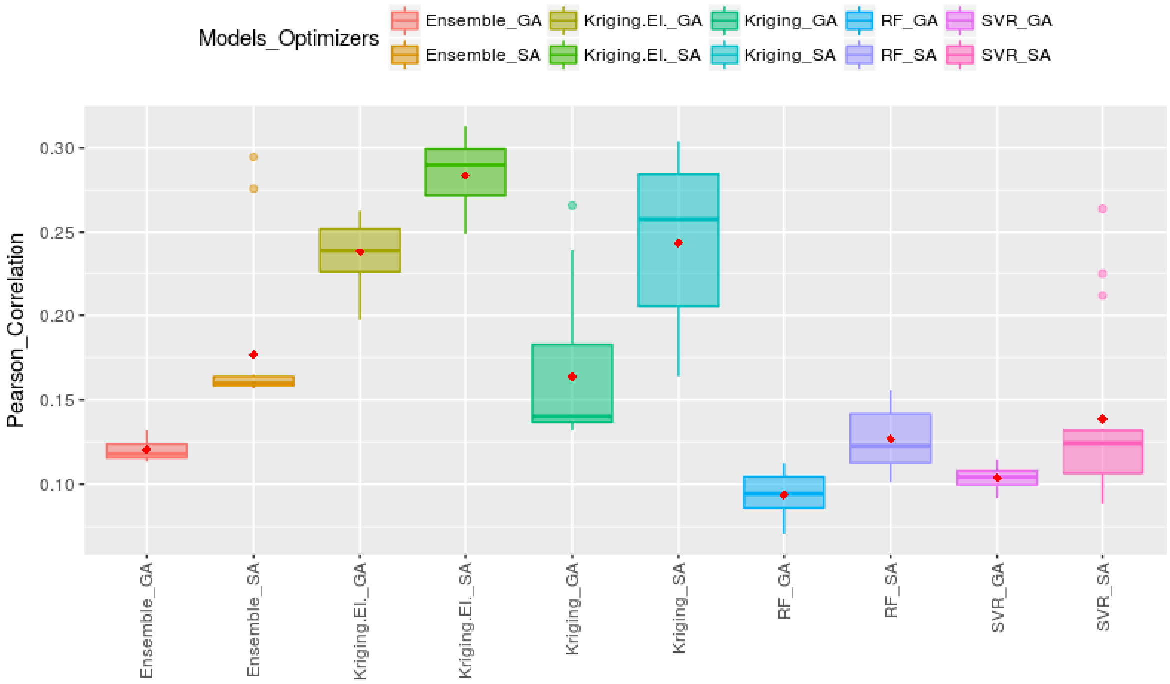

Figure 3: B-plot of best observed values for optimisation of PC_1

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A Hybrid Optimization Strategy with Low Resource Usage for Large Scale Multi-objective Problems

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ABSTRACT
The use of multi-objective approaches to solve problems in industry grew in the last years. Nevertheless, these strategies are still unused in many fields where their performance is suboptimal or when they are too complex to be implemented or even are simply unknown. One example is in the poultry industry with its particularly complex chain. In this paper, we will discuss a hybrid multi-objective approach with low computational resource usage intended for this scenario as well as other similar ones.

Keywords
multi-objective, optimization, many variables, low resource usage.

1. INTRODUCTION
In corporate environments, the use of simpler tools in some situations might be favored against other tools that would generate better results. This business decision might be caused due to the lack of technical understanding of these tools or due to cost and performance reasons. One practical example shown in a previous work of the author [7] is the Production Plan algorithm used by one of the largest meat companies in the world, specifically its poultry business line.

By definition, the supply chain in industry is a complex set of operations and resources that must be extremely optimized in order to achieve its maximum potential which does include the management of upstream and downstream relationships in order to achieve an outcome which is more profitable to all the parties in the chain [2]. One of its parts is the Production Plan, which defines what should one or more plants build considering a myriad of variables—i.e. market demand, production line capacity, logistics and stock limits, suppliers constraints, raw material limits, etc. Therefore, an accurate Production Plan is a key component to maximize the potential profits.

In the meat industry the challenges are greater. Since it is livestock, at the same time the supply chain is very large and very tight [3]. The former because its production involves genetics, feeding, breeding, growth control from the current animal up to its grandparents and the latter because there are very strict sanitary (including, but not limited to the health, safety and environment) controls with the ration, water, effluents, temperature and vaccination, for example. Also, the whole animal must be pushed to the market—in the case of the chicken, for instance, even though the market might be more interested to purchase the thighs or other cuts, all the other parts must also be processed and sold somehow.

As a result, the production plan is by itself a problem composed of a large number of variables (at least 2000) [7]. This plan is usually executed as a single-objective problem (the objective being the overall profits) since it is currently able to provide results within the same day. However, it is well known that these profits differ from the real values since the reliability of the plants vary. By *reliability* impacts we mean both internal (e.g. different production costs between the plants, worker strikes, unscheduled maintenance, stock issues) or external (suppliers, weather) causes that are responsible to reduce the projected profits. Therefore, the company could benefit if the reliability of the production plans was known beforehand—if it was converted to a multi-objective problem (MOP) with the objectives being the expected profits and the reliability of said plans, depending on the case the analyst could choose a production plan that has less expected profits, but higher reliability rates. On the other hand, he or she could also be more aggressive and attempt higher profits, but also with higher chances of not achieving the expected value.

The work presented in [7] proved it was possible to convert the production plan of the company into a multi-objective problem. However, two problems were found: *1)* there was an issue with the input data (the reliability rates of each plant), which resulted in very similar grades for all the plants and *2)* the multi-objective optimization algorithm took too long (more than 24 hours in an i7 desktop with 16 GB RAM) to generate the production plans. Nevertheless, before its implementation can be greenlit by the company, additional work on both sides is required. As such, while the data issue was corrected by the plants themselves so that it can be usable, the multi-objective optimization algorithm needed to be greatly improved in order to be executed faster and with lower resource usage so that it could be used by an off-the-shelf corporate laptop and able to generate a Pareto front approximation in under one hour.

Considering this background, the proposal is to generate a multi-objective optimization (MOO) algorithm intended for problems with a large number of variables (more than 2000 since the original problem is expected to grow in complexity). As such, the main objective here is to have an algorithm that balances both the performance (i.e. low computational resource usage) and the scalability (i.e. capable of processing problems with thousands or tens of thousands of variables). On that end, a test set with similar characteristics of the real-world problem will be used to evaluate the algorithm.

The remainder of this document is structured as follows. The second section explains the background of the test problems that will be used as well as their rationale. The third section shows the proposal to modify and test the presented case into a MOP. Then, the following section specifically shows the technical details of the created MOP as well as its results after optimization. The fifth section presents the conclusions and the future work to be done from this document.

2. BACKGROUND

Currently, in the meat industry some optimization solutions are both single-objective and using specialized algorithms built from scratch with the profitability in mind such as Otimix™. However, said algorithms might not enable the industries to use two or more objectives or provide greater parameter tuning possibilities. Since such algorithms are targeted towards only one objective, the problem designer usually has only one solution as the result of the minimization/maximization, eliminating the possibility to analyze the tradeoffs between different production plans considering two or more objectives. As a result, the production planners are required to empirically consider the differences between the plants from a reliability standpoint, leaving no possibility to compare the solutions based on this factor.

The scenario that originated this algorithm had two objectives: profitability and reliability [7]. 2032 variables were employed from which all were integers—however, this scenario was known to be a test—therefore, more variables were expected. As such, considering these characteristics and the other business requirements, the new algorithm had to meet the following objectives:

- Be a multi-objective optimization algorithm;
- Be able to resolve problems with many variables (more than 1000, ideally with more than 15000), all integers;
- Low computer resource usage (preferably less than 1 GB RAM per 5000 variables);
- Be able to generate a Pareto front approximation (even if there is still room for improvements) in less than one hour.

Since the original data needed additional work from the teams responsible for it, the alternative was to choose easily configurable and reliable mathematical problems. The choice was the test problems in [1]—nine large-scale, multi-objective problems were considered to evaluate the proposed algorithm, each configured with 1000, 5000, 15000, 30000 and 50000 variables. All the variables are integers similar to the production plan problem—all of the problems were set to have 2 objectives, analogous to the production plan problem. These test problems are henceforth named LSMOPn, where n is the problem number ranging from 1 to 9 and forming a different problem. All the tests use a combination of six basic single-objective functions. These functions are the sphere function, the Schwefel's function, the Rosenbrock's function, the Rastrigin's function, the Griewank's function and the Ackley's function and, as shown in [1], implements features such as a chaos-based pseudo random number generator (to address the nonuniform grouping), a correlation matrix to keep track of the correlations between variable groups and the objective groups, different basic fitness landscape functions (to achieve the mixed separability) and also making use of a linkage function to define the variable linkages.

3. PROPOSAL

As mentioned in the Section 2, this article proposes to implement an algorithm capable of resolving multi-objective problems with many variables with low resource usage. For this reason, the approach chosen was a hybrid multi-objective genetic algorithm. By hybrid, as shown in [4], it is considered to be an algorithm (in this case a genetic algorithm) enhanced with an additional local search step shortly after the selection of the individuals. The algorithm, shown in the Algorithm 1 and implemented in MATLAB©, heavily focuses on the parallelization for performance purposes. On the other hand, it attempts to overuse large matrices in order to reduce the memory footprint.

Algorithm 1: The proposed algorithm

```
Data: design space, objective vector
Result: the Pareto front approximation
generate n random solutions;
rank the solutions by a dominance filter;
for each generation until it reaches the stopping criteria do
    store previous solutions and their objective values;
    generate offspring by tournament, recombination and
      mutation;
    join the offspring to the other solutions;
    partially rank all solutions with a dominance filter;
    locally improve the best solutions;
    replace the best solutions with locally improved
      solutions;
    rank all the joined solutions with a dominance filter;
    prune some solutions by their crowding distances.
end
```

The local improvement algorithm (shown in Algorithm 2) has a new, optional parameter named *number of random neighbors for the local search* (*NumberRandomNeighbors*). It is used to improve the performance in scenarios where there are too many variables and this algorithm would take too long to process all of the variables.

For example, if a solution has 1000 variables and this parameter is not used, this algorithm will create 1000 new solutions based on the original solution where the first solution assigned a new random value for the first variable while keeping all the other variables intact; the second solution assigned a new random value for the second variable while keeping all the other variables intact and so on. If 100 solutions are involved in the local search, at least 100 thousand new solutions would be created as a result. On the other hand, if a solution had 15000 variables, considering the same 100 solutions as a result 1.5 million new solutions would be created. Considering the local search would happen more than once during the algorithm execution, this method—based on the *exhaustive neighborhood exploration* [5] would take too long. This results in greater performance gains between the different generations.

Algorithm 2: Local improvement

Data: a solution
Result: *Neighbors*
initialize the list of neighbors *Neighbors*;
if *NumberRandomNeighbors was given* **then**
  select *NumberRandomNeighbors* random variables;
else
  select all the variables;
end
foreach *one of the variables selected* **do**
  copy the original solution;
  randomly modify its value according to its bounds;
  evaluate the new solution;
  add it to *Neighbors*;
end
replace *Neighbors* with only its anchors.

4. TEST

The new, proposed algorithm and the other algorithms were tested on an i7 desktop equipped with 16 GB RAM and a dedicated video card running Windows 10 Pro running MATLAB© R2015a. This desktop ran all the tests over the course of three weeks with one weekly system restart. In MATLAB©, the start and end time of each algorithm were tracked (therefore storing the time taken for each execution) as well as the Pareto front approximation found for each execution, each limited to 300 seconds. Outside MATLAB©, the Windows Performance Monitor (perfmon.exe, a known, built-in performance monitor tool in Windows) was used to track performance and memory usage in MATLAB©. As such, it was able to properly track resource usage by each algorithm. The new algorithm was tested against MATLAB©'s own *gamultiobj*, a built-in, optimized algorithm based on NSGA-II and a Multi-objective Differential Evolution with Spherical Pruning algorithm (sp-MODE II) [8].

4.1 Evaluation Methods

With the aforementioned tools both the hypervolume found for each algorithm considering the best Pareto front approximations found for them and the memory and processor usage for each algorithm were measured.

For each of the nine LSMOP problems and number of variables (1000, 5000, 15000, 30000 and 50000 variables), 51 runs were executed for each one of the three algorithm. *NumberRandomNeighbors* was set to *50* in the new algorithm and the initial number of random solutions set to *20* for all algorithms, limited to *200 * number of generations* and a maximum of *5* generations without improvement (where an improvement is determined when the utopia had improved in at least 0.0001% for at least one objective) per run.

4.2 Findings

The values shown in Table 1 represent the median values for each one of the runs for each algorithm and for each problem based on the implementation in [6]. From the hypervolume in itself the new algorithm proved incrementally better performance when the problem has more variables—in fact, starting with 15000 variables the other algorithms are unable to run these problems due to out of memory errors (as shown by their lack of median values depending on the case).

Problem	NVar	gamultiobj	sp-Mode II	new algorithm
LSMOP1	1000	**0.998933**	0.916951	0.966355
LSMOP2	1000	**0.531942**	0.472204	0.497616
LSMOP3	1000	**0.999881**	0.916340	0.960246
LSMOP4	1000	**0.562390**	0.494451	0.521077
LSMOP5	1000	**0.997482**	0.427428	0.628847
LSMOP6	1000	**0.999599**	0.626870	0.916751
LSMOP7	1000	**0.999644**	0.615992	0.947478
LSMOP8	1000	**0.995152**	0.508990	0.686416
LSMOP9	1000	**0.991079**	0.483426	0.695966
LSMOP1	5000	**0.990506**	0.931265	0.958904
LSMOP2	5000	**0.512829**	0.470381	0.488354
LSMOP3	5000	**0.996004**	0.925004	0.954693
LSMOP4	5000	**0.545665**	0.496839	0.516004
LSMOP5	5000	**0.995279**	0.561639	0.609145
LSMOP6	5000	**0.947114**	0.575706	0.677455
LSMOP7	5000	**0.999411**	0.752861	0.882027
LSMOP8	5000	**0.993857**	0.599694	0.609580
LSMOP9	5000	**0.958439**	0.507450	0.593416
LSMOP1	15000	**0.979783**	-	0.945874
LSMOP2	15000	**0.513371**	-	0.484434
LSMOP3	15000	**0.998651**	-	0.941039
LSMOP4	15000	**0.535847**	-	0.510049
LSMOP5	15000	**0.974157**	-	0.688771
LSMOP6	15000	**0.771705**	-	0.585666
LSMOP7	15000	**0.999059**	-	0.845907
LSMOP8	15000	**0.989229**	-	0.680188
LSMOP9	15000	**0.990760**	-	0.540451
LSMOP1	30000	-	-	**0.840306**
LSMOP2	30000	-	-	**0.466373**
LSMOP3	30000	-	-	**0.885842**
LSMOP4	30000	-	-	**0.486888**
LSMOP5	30000	-	-	**0.192226**
LSMOP6	30000	-	-	**0.604263**
LSMOP7	30000	-	-	**0.223234**
LSMOP8	30000	-	-	**0.184088**
LSMOP9	30000	-	-	**0.668866**
LSMOP1	50000	-	-	**0.831989**
LSMOP2	50000	-	-	**0.476713**
LSMOP3	50000	-	-	**0.887729**
LSMOP4	50000	-	-	**0.485269**
LSMOP5	50000	-	-	**0.220266**
LSMOP6	50000	-	-	**0.573581**
LSMOP7	50000	-	-	**0.081000**
LSMOP8	50000	-	-	**0.208853**
LSMOP9	50000	-	-	**0.669033**

Table 1: Median hypervolume values found for each algorithm and problem. The values are relative to the utopia and nadir determined from all solutions in the Pareto front approximations found for all runs and all algorithms. The best values are in bold.

On the performance side, the memory allocation behavior was similar for the problems with the same size for all the three algorithms. The Figure 1 represents the memory usage for all the runs with 5000 variables for a given problem. First, from 11:34:49 PM to around 03:48:00 AM all the 51 runs for the new algorithm took place, followed by the 51 runs of the gamultiobj from that time to around 7:00:00 AM and later by the 51 runs of sp-MODE II. The new algorithm, as specially shown in Figure 1, used a little more than 1 GB in memory in order to achieve the results. The processor usage registered the same pattern with around 15% in overall usage for the new algorithm.

Furthermore, the memory usage grew considerably when changing the problem size to 15000 variables, as seen in an attempt recorded in the Figure 2. While the new algorithm, with its runs recorded between 11:28:23 PM to around 3:30:00 AM kept the memory usage around 1 GB in

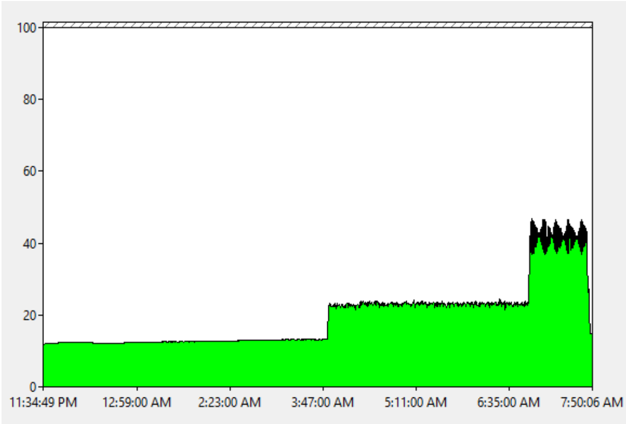

Figure 1: Results for the memory usage for three algorithms with 5000 variables. The y-axis represent the memory usage in hundreds of megabytes.

memory, gamultiobj (executed from that time up to around 8:00:00 AM) registered around 10 GB in usage. sp-MODE II, on the other hand, attempted to allocate more than 16 GB (as registered by the last spike to the right), culminating in an out-of-memory error. This behavior happened again with 30000 and 50000 variables, but with gamultiobj as well. The processor usage also showed the same behavior from an usage standpoint. With 15000 variables the new algorithm used around 25% from the processor, peaking in around 35% with 50000 variables, depending on the problem.

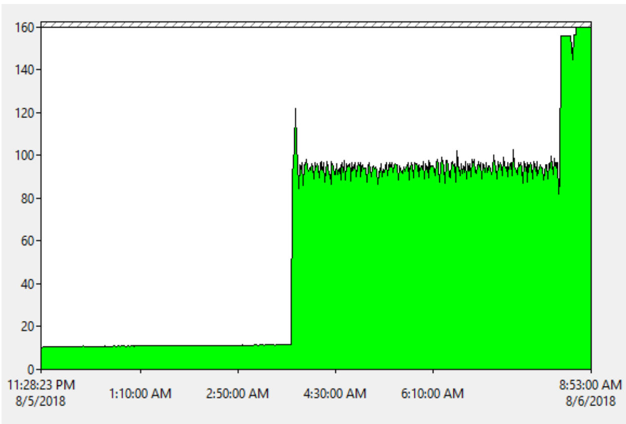

Figure 2: Results for the memory usage for three algorithms with 15000 variables. The y-axis represent the memory usage in hundreds of megabytes.

5. CONCLUSIONS

The proposed algorithm showed that it is better suited for problems with a large number of variables. As of the time of writing this paper the company still could not make a new, real-world case available for tests. On the other hand, the new algorithm can also be implemented in other complex scenarios where, for example, the objectives are both the maximum profits for a given distributed production plan and the energy and steam consumption reduction in the plants. The energy and steam consumption variables would result in an estimated multi-objective problem with around 40000

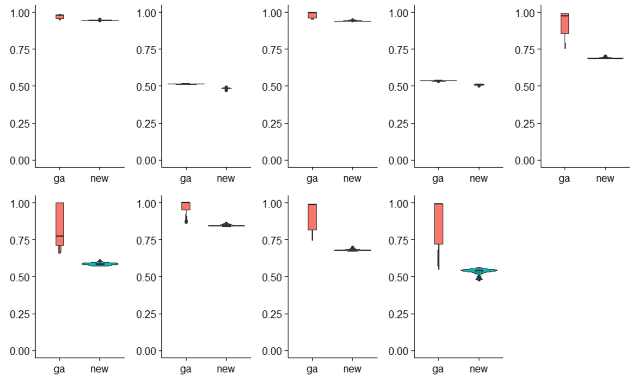

Figure 3: Hypervolume distribution for all the problems for 15000 variables. The *y*-axis represents the hypervolume values, where *ga* represents the runs with gamultiobj and *new* with the new algorithm.

variables since each industrial boiler, production line and work shift could also be accounted.

6. ACKNOWLEDGMENTS

The authors would like to thank the Pontifical Catholic University of Paraná for supporting the research. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 and the PQ2|304066/2016-8 grant.

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Electric Vehicle Routing Problem: State of the Art

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ABSTRACT
Electric vehicles (EVs) represent a clean alternative but have some limitations especially in terms of autonomy. Therefore, efficient routing of EVs is crucial to encourage their use. This article surveys the existing research related to electric vehicle routing problems (EVRP) and their variants. It examines EVRP in terms of their definitions, their objectives, and algorithms proposed for solving them.

Keywords
optimization, electric vehicles, routing problem

1. INTRODUCTION
Although, electric vehicles face several challenges such as: the low energy density of batteries compared to the fuel of combustion engined vehicles, the long recharge times compared to the relatively fast process of refueling a tank and the scarcity of public charging stations, they contribute to a sustainable and environmental friendly freight transportation by reducing the air pollution.

Electric vehicle routing problem and variants are considered as optimization problems and, more specifically, they belong to the combinatorial optimization problem that can be solved by two types of solution methods: exact methods and approximate ones.

This paper presents an overview of different problems related to the electric vehicle routing, different variants and solution methods found in the scientific literature. The rest of the paper is structured as follows. First, Section 2 gives the main characteristics of EVRP. Then Section 3 enumerates the electric vehicles drawbacks. Section 4 describes the variants of EVRP presented in the literature. Finally, Section 5 reports on different solution methods for EVRP.

2. CHARACTERISTICS OF EVRP
The electric vehicle routing problem aims at routing a fleet of EVs on a given network, or a subset of a network, to serve a set of customers under specified constraints in order to optimize one or several fixed objective(s). So, an EV routing problem can be defined in terms of the following components:

- **Network:** The network can be represented as a graph composed of nodes referring to cities, customers and depots and arcs standing for connections. Sometimes, we assign to each arc the cost considering that the distance is known and given for each arc. Time windows associated with nodes or arcs may also be defined in some problems.
- **Demand:** The demands are either given for each node and are known in advance in the case of deterministic problem or given by probabilistic formulas.
- **Fleet:** The fleet refers to a set or a group of EVs. In fact, it is associated to the electric vehicles available to the routing problem, hence we can either have a homogeneous or a heterogeneous fleet.
- **Electric vehicles recharging technologies:** Unlike the combustible vehicles, the electric vehicles are charged by plugging the car to the electric grid. There are four main technologies:
  - Household charging: EVs can be charged by a conventional household plug using a cable and a connector in the vehicle. This technology is slow.
  - Fast charging: This technology is a conductive charging method. It's faster than the previous one.
  - Wireless charging systems: also known as inductive charging is an emerging technology that allows EV recharging without the use of a cabled connection.
  - Battery swap: It's a a high-speed method.
- **Cost:** The cost is a term that depends on different parameters. It depends on the distance traveled, the energy consumed and the time of the travel. In addition, in the case of the time window variant, there are some penalties that could be added if the window isn't respected. Moreover, the cost changes from one recharging technology to another.
- **Objectives:** It could be a single-objective problem or a multi-objective problem according to the number of objectives considered. The objectives are very diversified because the EVRP has a lot of components in its definition, for instance, minimizing the total travelling distance, the delay time and the waiting time, the total cost, etc.

3. ELECTRIC VEHICLES CHALLENGES

To combat environmental and energy challenges, electric vehicles may provide a clean and safe alternative to the internal combustion engine vehicles. However, electric vehicles are still facing several weaknesses:

3.1 Autonomy Limitations

The vehicles have a much smaller driving range due to the limited battery capacity. The range of an electric vehicle depends on the number and type of batteries used but generally the driving range varies between 80 and 130 km for light duty EVs according to [13].

3.2 Long Charging Times

EVs often have long recharge times compared to the relatively fast process of refueling a tank which takes just a couple of minutes. Its charging time ranges between 0.5 and 12 hours as mentioned in [12]. Hence, the user must think about refueling at night for example.

3.3 Scarce Charging Infrastructure

The number of electric recharging stations is still very small compared with that of conventional fuel stations as the electric fuelling points are still in the development stages. So, the driver must do a research about the plug-in stations localisation to know where and when he will have the opportunity the recharge his EV.

4. EVRP AND VARIANTS

Several versions and extensions of the basic electric vehicle routing problem have been presented in the literature.

4.1 Green Vehicle Routing Problem (GVRP)

Erdoğan and Miller-Hooks [3] are the first to introduce the Green VRP which consists of alternative fuel-powered vehicle fleets with limited driving range and limited refueling infrastructure. The objective is to minimize the total distance traveled by the vehicles while allowing them to visit stations when necessary.

In [10], Koç et al. proposed the same problem as Erdoğan and Miller-Hooks with the motivation of saving the ecosystem and the health of humans while serving and executing the transportation and good distribution process.

More recently, J. Andelmin et al. [8] also studied the green vehicle routing problems taking into account the several particularities of autonomy and charging process of this type of vehicles. Hence, the refueling stops are allowed. Their model aims to find optimal routes while minimizing the total distance and by using a homogeneous fleet of vehicles. Contrary to Erdoğan and Miller-Hooks, they didn't put the restriction on the number of vehicles that must be used.

4.2 The Green Vehicle Routing Problem With Multiple Technologies And Partial Recharges

Felipe et al. [4] presents a variant in which different charging technologies are considered and partial EV charging is allowed in recharging stations when needed in order to ensure the continuity of the route.

4.3 Electric Vehicle Routing Problem

Lin et al. [7] presents a general Electric Vehicle Routing Problem (EVRP) that seeks to optimize the routing problem while minimizing the total cost related to the distance as well as to the energy consumption by the battery. The proposed EVRP finds the optimal routing strategy in which the total cost is minimized such that each customer is visited exactly once by one vehicle on its route, the total demand of the customers served on a route does not exceed the vehicle capacity.

4.4 Electric Vehicle Routing Problem with Non-Linear Charging Functions (EVRP-NL)

Montoya [12] extended current EVRP models to consider partial charging and non-linear charging functions which is more realistic for the charging process. In EVRP-NL, the task consists of minimizing the total traveling distance as well as the charging time since it does not depend on the total tour distance.

4.5 Electric Vehicle Routing Problem with Time Windows (EVRP-TW)

This variant seeks to satisfy the order of customers within certain time window. Many researches have been interested in studying this variant. Some of works found in the literature are outlined below.

4.5.1 EVRP-TW with recharging stations

In fact the time window variant of EVRP was first introduced by Schneider et al. [14]. They studied the electric vehicle routing problem with time windows and recharging stations (E-VRPTW) which incorporates the possibility of recharging at any of the available stations considering that the required recharging time depends on the state of the charge. Hence, electric vehicles, which have a restricted capacity, must reach cutomers whithin a time window while minimizing the number of vehicles used and the total travel distance.

4.5.2 Electric vehicle routing problems with time windows

Desaulniers et al. [2] tackled the routing problem in which route planning has to take into account the limited driving range of EVs and the customer time window. The authors studied four variants of this problem. The first one allows a single recharge per route knowing that batteries must depart fully recharged from the station, the second one permits multiple recharges but only full rechargement are allowed unlike the next one where partial battery recharges are allowed but just one time and the last one with partial but multiple recharges permitted.

4.5.3 The electric fleet size and mix vehicle routing problem with time windows and recharging stations

Hiermann et al. [6] aim to optimize the fleet and the vehicle routes including the choice of recharging times and recharging stations as the refuelling operation is assumed necessary for EVs because of the limited capacity storage of electricity by batteries. They considered that the fleet is heterogeneous which adds complexity to the problem. Furthermore, they incorporate the time windows constraint where customers have to be reached within a specified time interval.

4.5.4 The recharging vehicle routing problem with time window

Conrad and Figliozzi [1] introduced the recharging vehicle routing problem wherein vehicles with a limited range must service a set of customers, but may recharge at certain customer locations instead of using only dedicated recharging stations while operating whithin customer time window. In other words, the battery of a vehicle can be recharged while servicing the customer if needed. Also, the authors showed the impact of the customer time windows on the tour distance taking into account that the driving range is limited and the recharging time is long.

4.5.5 Electric vehicle routing problem with time windows and mixed fleet

Goeke et al. [5] proposed to study a mixed fleet of electric vehicles and internal combustion vehicles. They consider that the energy consumption function isn't linear and follows a realistic model depending on multiple parameters like the speed of the vehicle and the load distribution. Hence, EVs can recharge anytime en route to enhance the driving range.

4.5.6 Partial recharge strategies for the electric vehicle routing problem with time windows

In their work, M. Keskin et al. [9] relax the full recharge restriction and allow partial recharging in order to minimize time. Therefore, shorter recharging durations are allowed especially when the customer time window is set. The objective of the model proposed is to minimize the total distance while respecting the time constraints. Concerning the partial recharge scheme, the charging process is identified by a continuous decision variable.

4.5.7 Heterogenous electric vehicle routing problem with time dependent charging costs and a mixed fleet

Sassi et al. [13] studied a new real-life routing problem in which they consider a number of realistic features such as: different charging technologies, coupling constraints between vehicles and charging technologies, charging station availability time windows, and charging costs depending on the time of the day. Also, partial charging is allowed and the cost of vehicles as well as the total travel and charging costs.

5. SOLUTION APPROACHES TO EVRP FROM LITERATURE

In the literature, many studies work on finding sophisticated and efficient solution methods that can be applied to EVRP.

5.1 MCWS and DBCA

Two heuristics were proposed by Erdoğan and Miller-Hooks [3] with the goal of finding a set of routes that represents the feasible solution of the green vehicle routing problem knowing that the authors have formulated it as a mixed-integer linear program (MILP). Actually the first one is the modified Clarke and Wright savings (MCWS) heuristic as the original Clarke and Wright algorithm was developed to tackle the classical vehicle routing problem and its variants, thus it was modified to take into consideration the need to visit stations that have to be inserted in the routes while avoiding redundant. Meanwhile, the second heuristic is the density-based clustering algorithm (DBCA) that consists of forming clusters in a clustering step dedicated for that and then the MCWS algorithm is applied for each single cluster.

5.2 Exact Algorithms

Desaulniers et al. [2] decided to solve the different variants of EVRP-TW presented in their paper using exact methods. They used the exact branch-price-and-cut algorithms adapted to each variant. Hence, for each variant a set of routes is generated and for that monodirectional and bidirectional labeling algorithms are presented.

Branch-and-price is a metaheuristic that was used by Hiermann et al. [6] to solve the E-FSMFTW which is formulated as a mixed-integer linear program (MILP). In fact, the algorithm has to insert the charging constraints in its procedure.

Exact methods were also used by J. Andelmin et al. [8] to solve set partitioning (SP) formulation of the green vehicle routing problem where each variable corresponds to a simple circuit of a route, thus each SP contains a limited subset of routes. The authors proposed an exact method composed from two phases: Phase I computes the lower and upper bounds, while Phase II executes the set partitioning heuristic and the dynamic programming algorithm.

Koç & Karaoglan [10] implemented the B & C (branch and cut) algorithm for the exact solution of the GVRP where the initial solution is generated using the classical simulated annealing. In addition, the authors adapted the simulated annealing to the problems related to the electric vehicle routing problem by adding the GVRP constraints to improve the results. At each step of the method the new solution is compared with the current one so that the best solutions is accepted.

5.3 Local Search Heuristics

In [4], some constructive and local search heuristics have been proposed by Felipe et al. to find feasible routes while considering the recharge constraints as well as the real-world size problems. In addition, the authors used the 48A algorithm in which they consider 48 combinations of improving algorithms with different neighborhood structures.

In their study, Sassi et al. [13] formulated the Heterogenous Electric Vehicle Routing Problem with Time Dependent Charging Costs and a Mixed Fleet (HEVRP-TDMF) using a Mixed Integer Programming Model. And to solve it, they worked with a Charging Routing Heuristic (CRH) in order to find feasible routes. This algorithm is based on two main steps: the first one manages the charging of EVs in depot and the second one solves the problem starting from the depart of EVs from the depot. Moreover, a Local Search Heuristic based on the Inject-Eject routine with three different insertion strategies has been introduced.

5.4 Hybrid Heuristics

5.4.1 Hybrid VNS/TS heuristic

To solve the E-VRPTW, Schneider et al. [14] used a combination of Variable Neighbourhood Search (VNS) and Tabu Search (TS) heuristics in order to make use of the diversification of the search provided by the VNS algorithm and the efficiency of TS as many combinatorial problems have proved that this last heuristic is very strong. This combination has the aim to find feasible solutions while respecting all the constraints.

5.4.2 Multi-space sampling heuristic + Hybrid metaheuristic

Montoya [12] adapted the multi-space sampling heuristic (MSH) used before to tackle the VRP with stochastic demand [11] to the green vehicle routing problem by designing a tailored route extraction procedure. MSH is a heuristic that consists of two main phases: the sampling phase and the assembling phase. Furthermore, a hybrid metaheuristc is proposed to tackle the EVRP with non linear charging function. The metaheuristic combines two heuristics: the iterated local search and heuristic concentration.

5.5 Adaptive Large Neighborhood Search Algorithm

The ALNS algorithm was also used by Hiermann et al. [6]. In order to optimize the location of the refueling stations during the routing process, a hybrid heuristic has been proposed. This heuristic is a combination of the Adaptive Large Neighbourhood Search (ALNS) and an embedded local search procedure that uses different neighbourhoods. Indeed, the local search was used to itensify and strengthen the search operation guided by the ALNS.

Moreover, like Hiermann et al., Goeke et al. [5] developed the Adaptive Large Neighborhood Search algorithm to address the Electric Vehicle Routing Problem with Time Windows and Mixed Fleet. They also enhanced the algorithm by a local search for intensification.

Also, the ALNS algorithm was proposed by M. Keskin et al. [9] to solve the EVRP with time window. The authors formulated the problem as a mixed integer linear program.

6. CONCLUSIONS

Over the last several years, the green vehicle routing problem has been widely studied. This survey lists the main works that exist in the scientific literature since its appearance in 2011 by Erdoğan and Miller-Hooks.

Based on this paper, the models that have been proposed are single-objective. Yet, most of real problems in industry are multi-objective by nature, so a multi-objective variant of EVRP must be proposed.

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Optimization of End-to-End Deep Learning for Obtaining Human-Like Driving Models

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ABSTRACT
Modeling human driving with human-like driving models can help companies in the evaluation of human drivers. While a human-like driving model can be tested in various scenarios, this is not feasible for driver evaluation due to time constraints. During the evaluation, only a small set of driving data can be typically collected for each driver, which represents an issue for advanced modeling approaches such as deep learning. To overcome this issue, an optimization approach is proposed, which tunes deep learning when a small learning dataset is available.

Keywords
optimization, deep learning, human-like driving models

1. INTRODUCTION
Human-like driving models have been learned with several methods, such as ARX models [8], Gaussian processes [11], Gaussian mixture models [1], artificial neural networks [15], support vector regression [13], etc. Recently, Deep Neural Networks (DNN) are being effectively used in learning tasks from various application fields. For example, when driving a vehicle, DNN can be used to recognize the road, other vehicles, pedestrians, etc. from video data [7]. Moreover, DNN has been also applied to directly learn the control actions from video data without firstly reconstructing the scene. This approach is called end-to-end learning and its examples aim to learn steering, throttle and braking control actions, etc. [5, 6, 14].

Unfortunately, deep learning has a significant drawback: it requires a lot of learning data. Existing driving datasets used for training DNN models vary from about 10 hours to up to 10,000 hours [14]. However, in some cases such a large set of driving data is not available. For example, the deep learning approach can be used to assess a driver, e.g., if he/she drives safely, is able to avoid critical situations, etc. [12]. This can be done by building a human-like driver model, i.e., a clone of the driver, and test it in a large number of driving situations. A similar approach has been applied in related domains where the goal was to learn human behavior [10]. This procedure requires only a small set of driving data, i.e., driving data of only a small subset of driving situations. Consequently, the time to collect the driving data is reduced, while the driver or more precisely his/her clone is still evaluated in a large number of situations.

Existing work has demonstrated that end-to-end approach for learning to drive is appropriate when large sets of learning data are available [5, 6, 14]. On the other hand, the problems with small sets of learning data have not been addressed appropriately. This paper aims at tackling this issue by enhancing end-to-end deep learning approach with optimization in order to obtain human-like driving models from small sets of learning data.

The paper is further organized as follows. Section 2 presents the optimization approach for end-to-end deep learning. Experiments and results are described in Section 3. Finally, Section 4 concludes the paper with ideas for future work.

2. OPTIMIZATION OF END-TO-END DEEP LEARNING
End-to-end deep learning approach applies deep neural networks to learn the transformation between the input and the output data. The main property of this approach is that a single model is used to obtain this transformation. There exist also other approaches that decompose the problem and apply specific models for each subproblem. For example, one model can be used to recognize the objects, while another model can be used for higher-level reasoning [7]. The end-to-end approach aims at solving all the subproblems at once with a single model [5].

Existing work in the field of end-to-end deep learning for obtaining human-like driving models has shown that the selection of deep learning model and its parameter values is not straightforward [9]. In addition, the data need to be augmented to learn how to recover from poor positions or orientations [3]. We propose to automate the selection of appropriate parameter values and data augmentation functions with an evolutionary algorithm. Evolutionary algorithms are search and optimization algorithms inspired by the principles of biological evolution. They work with a set

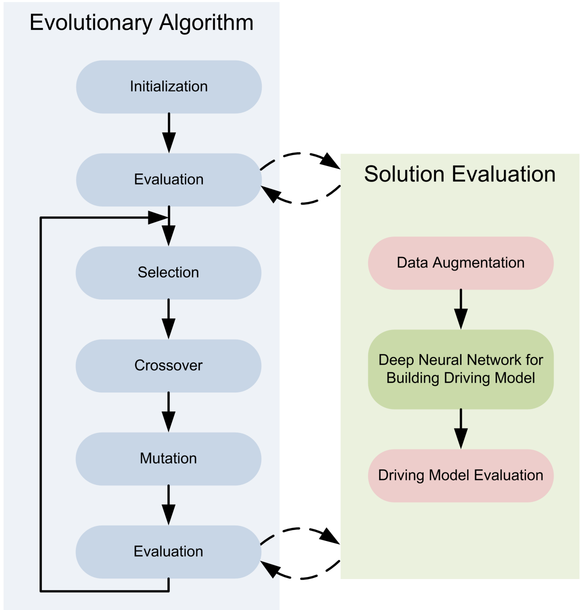

Figure 1: Overview of the algorithm for obtaining human-like driving models.

of solutions that are improved through several generations by applying genetic operators, i.e., selection, crossover and mutation [4].

We propose to discover human-like driving models in two steps. In the initial step, driving models that are able to drive the vehicle along a route are built, while in the final step, these models are enhanced to imitate human driving. The approach presented in this paper focuses on the initial step by applying an evolutionary algorithm to maximize the length of the route that has been traveled by the driving model during the simulation. Each solution (consisting of parameters of model construction) is evaluated by applying the following steps:

1. The learning data are augmented to enable recovery from poor situations or orientations.
2. The deep learning algorithm is used to learn a human driving model.
3. The driving model is evaluated on a route to measure the route length of feasible driving.

The driving simulation stops if the driving becomes infeasible (e.g., the vehicle goes offroad) or when the entire route is traveled. The evolutionary algorithm applies tournament selection (tournament size = 2), two-point crossover (probability = 0.9) and uniform mutation (probability = 0.1) to improve the solutions over generations. An overview of the developed algorithm and its steps, i.e., evolutionary algorithm steps (selection, crossover and mutation) and solution evaluation steps (data augmentation, model building and model evaluation), is shown in Figure 1.

The evolutionary algorithm optimizes the following deep learning and data augmentation parameters:

- *Batch size*: Parameter of the deep learning algorithm. Defines the number of training examples utilized in one learning iteration.
- *Number of epochs*: Parameter of the deep learning algorithm. Defines the number of passes through the training dataset during learning.
- *Image multiplier*: Data augmentation parameter. Defines how many times an image is multiplied. If it is multiplied, it is divided into overlapping subimages. For example, if the image is multiplied by 3, three images are created containing: 1) left 80 % of the original image; 2) central 80 % of the original image; 3) right 80 % of the original image. The control actions are also appropriately adapted. For the left images steering is added to simulate turning right, while for the right images steering is subtracted to simulate turning left.
- *Noise added to output*: Data augmentation parameter. Defines the amount of noise a_n to be added to the control actions. The amount of noise is randomly selected at each time step with a uniform distribution $\mathcal{U}(-a_n, a_n)$.
- *Flip image*: Data augmentation parameter. Defines whether randomly selected images should be vertically flipped. If the image is flipped, the control action is also appropriately adapted.
- *Activation function*: Parameter of the neural network model. Defines the activation function of the neural network layers.
- *Kernel regularizer*: Parameter of the neural network model. Defines the regularization of the neural network layers, which applies penalties on layer weights. The penalties try to keep the weights small, which reduces the possibility of overweighting a small subset of layer's input data and prevents overfitting.

3. EXPERIMENTS AND RESULTS

The developed approach was tested on two scenarios. Both scenarios did not contain traffic vehicles or pedestrians. For both scenarios, the same architecture of the neural network was used. This architecture is shown in Figure 2 and is based on the architecture presented in [2]. It contains five convolutional layers and three fully connected layers. The convolutional layers extract features, from simple features such as lines to complex features such as road contour. The fully connected layers implement the vehicle controller, which calculates the control action based on the extracted features.

3.1 First scenario

The first scenario consisted of a circular route of around 2 km, which is shown in Figure 3a. An example of a route image as input to the neural network is shown in Figure 4a. The learning data were obtained from one driving along the route.

The proposed approach was evaluated by tuning only a subset of the parameters listed in Section 2, which already enabled us to obtain models that drove along the entire route for this scenario and consequently no additional parameters

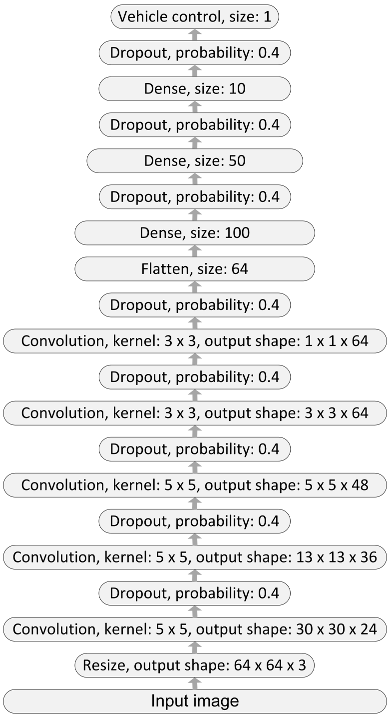

Figure 2: Architecture of the neural network.

(a) (b)

Figure 3: Maps of the testing routes: (a) first scenario, (b) second scenario.

needed to be tuned. The values of tuned and not tuned parameters are shown in Table 1.

The feasible solutions, i.e., those solutions that drove the entire route, are shown in Table 2. These results show that feasible solutions multiply the images by 3 or 5 and flip images, while the noise added to output does not influence the results. In addition, the results also show that a lower number of epochs is needed if the images are multiplied more times.

3.2 Second scenario

The second scenario was related to a city whose map is shown in Figure 3b. Figure 4b shows an example of the city image, which was given as input to the neural network. The learning data were obtained from one driving through several crossroads. In contrast to the first scenario, the second scenario does not predefine the route. Nevertheless, the simulation stops if a distance of more than 2 km has been

(a) (b)

Figure 4: Examples of the input images: (a) first scenario, (b) second scenario.

Table 1: Parameter values for the first scenario

Parameter	Values
image multiplier	$\{1, 3, 5\}$
noise added to output	$\{0, 0.1\}$
flip image	$\{true, false\}$
batch size	40 (not tuned)
number of epochs	100 (not tuned)
activation function	*elu* (not tuned)
kernel regulizer	*none* (not tuned)

driven.

The proposed approach was evaluated with the parameter values shown in Table 3. The results show that the built models were able to drive only short routes (see Figure 5). However, it should be noted that due to high time complexity of deep learning, only a small number of generations were executed. More precisely, it took more than 17 days to execute 30 generations on a 3.6 GHz desktop computer with 16 GB RAM. The analysis of the results also shows that the activation function had the most significant effect on the results. It turned out that the majority of models that were able to drive more than 450 m, contained the *relu* activation function. In addition, the models were able to drive on straight segments, but had issues with crossroads. This is probably due to the relatively simple architecture of neural network. For example, images of the first route (see Figure 4a) are significantly less complex in comparison to the images of the second route (see Figure 4b), since they do not contain any buildings, sidewalks, crossroads, etc. Consequently, more complex architectures of the neural network are needed for the city roads. These can be obtained by optimizing also the topology of the neural network.

4. CONCLUSIONS

This paper presented an optimization approach for tuning end-to-end deep learning that builds human-like driving mod-

Table 2: Tuned parameter values of feasible solutions for the first scenario

Noise added to output	Image multiplier	Flip image	Epochs to feasible solution
0	3	*true*	30
0.1	3	*true*	30
0	5	*true*	18
0.1	5	*true*	16

Table 3: Parameter values for the second scenario

Parameter	Values
batch size	$\{20, 40, ..., 200\}$
number of epochs	$\{10, 20, ..., 50\}$
image multiplier	$\{1, 3, 5, 7\}$
noise added to output	$\{0, 0.05, ..., 0.20\}$
flip image	$\{true, false\}$
activation function	$\{linear, elu, relu\}$
kernel regulizer	$\{none, l2(0.001)\}$

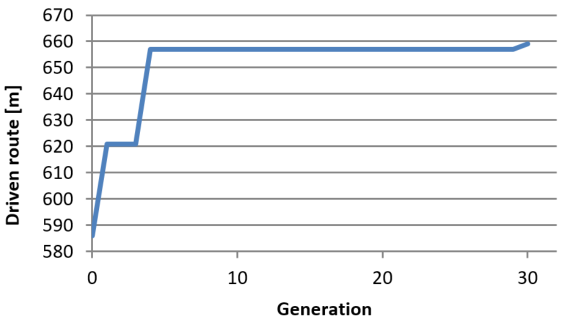

Figure 5: Length of the feasible route through generations for the second scenario.

els. This approach aims at learning good driving models when a low quantity of learning data is available. It was evaluated with one neural network architecture on two routes: a circular route and a city route. The results show that this approach was able to find driving models for the circular route, but did not manage to find driving models for handling crossroads inside the city.

Future work will focus on determining the most appropriate neural network architecture for urban environments. In addition, the efficiency of the evolutionary process needs to be increased by, for example, introducing parallelism in the model learning. Furthermore, the behavior of the obtained driving models will be compared to human driving behavior to determine how well the models reproduce human driving. In case of unacceptable reproduction, these models with be enhanced to obtain driving models that are able to imitate human driving.

5. ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0209, and research project “Multiobjective discovery of driving strategies for autonomous vehicles”, funding No. Z2-7581). This work was also partially funded by NERVteh, raziskave in razvoj, d.o.o., and is part of a project that has received funding from the *European Union’s Horizon 2020 research and innovation programme* under grant agreement no. 692286.

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A Bi-Objective Maintenance-Routing Problem: Service Level Consideration

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ABSTRACT
We study a joint maintenance and routing problem and investigate the impact of service level on the optimization of the total expected cost. We propose a new bi-objective mathematical model to determine an optimized maintenance-routing policy, simultaneously. In this model, the first objective function minimizes the total costs due to traveling and a delay in start time of a Preventive Maintenance (PM)/Corrective Maintenance (CM) operation. The second objective function considers the service level which is measured based on waiting times before beginning of the CM operations. In the proposed model, we consider time windows in repairing the machines and skill-based technician assignment in performing PM/CM operations. The proposed framework is modelled as a mixed-integer linear program and is solved by using the software GAMS.

Keywords
preventive and unforeseen maintenance, vehicle routing problem, scheduling, service level, multi-objective mathematical model

1. INTRODUCTION
Regularly planned and scheduled maintenance is a critical requirement to reduce the occurrence of an unforeseen failure and keeping the equipment running at peak efficiency. Maintenance scheduling becomes complex when the machines are geographically distributed. In this case, in addition to assigning the maintenance operations to technicians, it is needed to find the best set of routes for technicians' visits. In fact, it is necessary to study the maintenance and the routing scheduling decisions simultaneously. Such a joint decision problem is known as the maintenance-routing problems.

In the literature there are various studies which investigate combination of maintenance and routing problem [1]–[5]. In the most of these studies, authors have two initial assumptions:

- The replacement would be done immediately, if an unforeseen failure occurs for the machines. In fact the authors do not consider waiting time for performing a CM operations. While considering the waiting time is important especially where the machines are geographically distributed and the number of technicians and machines are limited.

- The scheduling is predefined and authors try to assign the technicians to machines considering skill of technician, time windows and etc. An unforeseen failure causes changes of the maintenance scheduling. In this case, maintenance scheduling and routing should be done simultaneously.

To the best of our knowledge, few studies attempted to investigate the simultaneous maintenance scheduling and vehicle routing problem and consider two described assumptions. López-Santana et al. [6] combine maintenance and routing problems to schedule maintenance operations for a set of geographically distributed machines and plan to assign a set of technicians to perform preventive maintenance at the customer sites. The authors use a distribution function for taking into account failures of machines as an uncertain parameter. In this study, they use two-step iterative approach to solve the model which causes minimizing the total maintenance and routing cost, waiting time at each customer and failure probability.

In this study, we propose a new framework to model and to establish the trade-off between the service level (measured based on waiting times before beginning of the CM operations) and different maintenance costs by taking into account the presented issues.

2. PROBLEM DESCRIPTION
In this section, a bi-objective mathematical model is proposed to determine optimized routing-maintenance policy. In this model, first objective function minimizes the total costs due to traveling, delay in start time of a Preventive Maintenance (PM)/Corrective Maintenance (CM) operation at customer while second objective function attempts to minimize the waiting times before beginning of the CM operations.

In this study, we consider a system with geographically distributed customers, where each customer has one machine that should be visited and repaired by technician in different cycles. The PM operations are scheduled with a certain frequency to reduce the occurrence of unforeseen failure in the long term. Regarding the previous experiences, the time of unforeseen failure occurrence is known for each machine at each customer, but its repairing can be postponed until defined period. The time interval between occurrence of unforeseen failure and its repairing named waiting time. The set of technicians, who need to visit the set of machines to perform the PM/CM operations to prevent the system failure. The technician are different in duration time of doing a PM/CM operation which causes different in salary. A central depot is concerned as the point of departure and final destination. Since each technician should travel to perform PM/CM operation at the customer location, the distance between each two customer is defined. The main aim of this study consist of determining a joint routing-maintenance policy for all machines taking into account making a balance between the waiting time and total cost of system. The optimized maintenance policy determines in which periods the PM and CM operations should be performed at each customer. The optimized routing policy determines that which technician is assigned to which customers and in which sequence should visit and perform PM and CM operations at each period.

The detailed conditions of system are summarized as follows:

- The time required to perform a maintenance operation depends on the skill of the assigned technician.
- More skilled technicians receive more salary.
- All technicians are able to perform any PM/CM operation.
- The technicians start in the central depot in the beginning of each period and should return to the central depot by the end of the period.
- Each machine should be repaired by only one technician at each period. It means if the machine should be repaired in the specific period, only one technician should be assigned to the machine.
- The PM operation should be performed on all the machines at the first period.
- If no unforeseen failure occurs on the machine at planning horizon, the PM operations will be performed regarding the defined frequency. The frequency is defined regarding planning horizon and the duration of the interval between two consecutive PM operations.
- In the case of unforeseen failure occurrence on the machine, no predictive maintenance can be scheduled and performed before performing CM operation. In this case, CM operation should be scheduled to assign a technician on the machine until maximum L period. Moreover, next PM operation will be scheduled and performed after λ period.
- After performing a CM operation, the machine returns to the good condition and no unforeseen failure occurs until the next repairing that will be a PM operation in λ period. It means two unforeseen failure cannot occur consequently.
- The time required to perform a CM operation is longer than the time required to perform a PM operation on each machine.
- The CM cost is larger than the PM cost.
- The machines impose time windows on the system which means the technician should start maintenance operation before the latest possible start time. In cases where this time windows is not respected, a delay penalty applies if the technician starts after the latest allowed time.
- The travel time between two customers depends on the speed of the vehicle in the rout at each period.

2.1 Mathematical Formulation

The following notations are used in the proposed model.

Sets	
M	set of customers, index for customers (1,2,…, m)
M'	set of customers and central depot, (0,1,2,…, m+1)
K	index for technicians (1,2,…, k)
t, t', t''	index for period (1,2,…, T)
Parameters	
c_k	one unit time cost of a PM/CM operation by technician *k*
pm_k	time required to perform a PM operation by technician *k*
cm_k	time required to perform a CM operation by technician *k*
λ	duration of the interval between two consecutive PM operations
L	allowed duration to repair occurred unforeseen failure
z_{it}	a binary parameter which determines occurrence of unforeseen failure in customer i at period t
t_{ij}	traveling time between customer *i* and *j*
r	transportation cost per unit time
$[a_i, b_i]$	earliest and latest possible start time of a PM/CM operation at customer *i*
p_i	penalty cost of one unit time delay due to start time of a PM/CM operation at customer *i* after latest possible arrival time
G	a large value number
Variables	
x_{ijkt}	1 if customer *j* is visited exactly after customer *i* by technician *k* at period *t*, otherwise 0
y_{it}	1 if PM operation is planned in customer *i* at period *t*, otherwise 0
$u_{it't}$	1 if a CM operation is planned in customer *i* at period *t* for the an occurred unforeseen failure at period *t'*, otherwise 0
$\beta_{itt'}$	1 if delay occurred in visiting customer *i* at period *t,* otherwise 0
μ_{ikt}	1 if customer *i* is visited by technician *k* at period *t* to perform a PM operation, otherwise 0
π_{ikt}	1 if customer *i* is visited by technician *k* at period *t* to perform a CM operation, otherwise 0
T_{ikt}	start time of an operation by technician *k* in customer *I*, period *t*
d_{it}	delay in start time of a PM/CM operation in customer *i* at period *t*

The mathematical model associated with the presented framework is provided in this section. Each equation in this model is detailed below.

$$Min \quad f_1 = \sum_{i,j,k,t} x_{ijkt}.t_{ij}.r + \sum_{i,t} d_{it}.p_i + \sum_{i,k,t} \mu_{ikt}.c_k.pm_k + \sum_{i,k,t} \pi_{ikt}.c_k.cm_k \tag{1}$$

$$Min \quad f_2 = \sum\nolimits_{i,t,t'} \beta_{itt'} \tag{2}$$

S. t.

$$\sum\nolimits_t y_{it} \le \left(\frac{|T|-1}{\lambda} \right) + 1 \qquad \forall i \in M \tag{3}$$

$$y_{it} \le 1 - z_{it} \qquad \forall i \in M, t \qquad (4)$$

$$y_{i1} = 1 \qquad \forall i \in M \qquad (5)$$

$$\sum_{t'=t+1}^{t+\lambda-1} y_{it'} \le 1 - (y_{it} + u_{it''t}) \qquad \forall i \in M, t, t'' \qquad (6)$$

$$y_{it} \le y_{i(t+\lambda)} + \sum_{t'=t}^{t+\lambda} z_{it'} \qquad \forall i \in M, t \qquad (7)$$

$$u_{it't} \le y_{i(t+\lambda)} + \sum_{t'=t+1}^{t+\lambda} z_{it'} \qquad \forall i \in M, t \qquad (8)$$

$$\sum_{t=t'}^{t'+L} u_{it't} = z_{it'} \qquad \forall i \in M, t' \qquad (9)$$

$$\beta_{itt'} = (t' - t).u_{itt'} \qquad \forall i \in M, t, t' \qquad (10)$$

$$\sum_{t} u_{itt'} \le 1 \qquad \forall i \in M, t' \qquad (11)$$

$$y_{it} + u_{it't} \le 1 \qquad \forall i \in M, t, t' \qquad (12)$$

$$\sum_{k} \mu_{ikt} = y_{it} \qquad \forall i \in M, t \qquad (13)$$

$$\sum_{k} \pi_{ikt} = \sum_{t'} u_{it't} \qquad \forall i \in M, t \qquad (14)$$

$$\sum_{i \in M',\, i=0}^{|M'|-1} x_{ijkt} = \mu_{jkt} + \pi_{jkt} \qquad \forall j \in M, j \ne i, k, t \qquad (15)$$

$$\sum_{j \in M,\, j=1}^{|M|+1} x_{0jkt} \le 1 \qquad \forall j \in M', k, t \qquad (16)$$

$$\sum_{i \in M',\, i=0}^{|M'|-1} x_{ijkt} - \sum_{i \in M',\, i=2}^{|M'|} x_{jikt} = 0 \qquad \forall j \in M, k, t \qquad (17)$$

$$\begin{aligned} &T_{ikt} + \mu_{ikt}.pm_k + \pi_{ikt}.cm_k + t_{ij} && \forall i, j \in M' \\ &\le T_{jkt} + G.(1 - x_{ijkt}) && \forall k, t \end{aligned} \qquad (18)$$

$$a_i . \sum_{j \in M',\, j=0}^{|M'|-1} x_{jikt} \le T_{ikt} \le b_i . \sum_{j \in M',\, j=0}^{|M'|-1} x_{jikt} + d_{it} \qquad \forall i \in M', \forall k, t \qquad (19)$$

$$x_{ijkt}, y_{it}, u_{it't}, \beta_{it't}, \mu_{ikt}, \pi_{ikt} \in \{0,1\} \qquad \forall i, j \in M', k, t \qquad (20)$$

$$T_{ikt}, d_{it} \ge 0 \qquad \forall i \in M', k, t \qquad (21)$$

The first objective function (1) minimizes the total cost which consist of traveling cost between customers, penalty cost due to start time out of time windows and the wages of technicians for PM/CM operations. The second objective function (2) optimizes the customer satisfaction level by minimizing the waiting times until performing a CM operation in the case where an unforeseen failure occurs.

Constraint (3) checks number of PM operations on the machine of each customer should not be exceeded. Constraint (4) guarantees that if the unforeseen failure occurred, then the PM cannot be scheduled and performed for the same period. Equation (5) determines that at the first period, PM operation should be performed on the all the machines. Equation (6) guarantees that performing a CM operation return the machine to as good as new condition again and no PM operation is needed until next λ periods. Constraint (7) ensures that when a PM operation is performed at the period t and no unforeseen failure occurs on the machine until the next λ periods, then a PM operation should be scheduled and performed at the period of t+λ. Constraint (8) checks that when a CM operation is performed, then a PM operation can be scheduled at the interval of λ periods or an unforeseen failure can be occurred until next λ periods. Equation (9) determines in which period a CM operation should be scheduled and performed to repair the occurred unforeseen maintenance. Moreover, this equation checks that CM operation should be scheduled in a way to assign a technician on the machine until maximum L period after the failure. Equation (10) calculates the waiting time until performing a CM operation in the case where an unforeseen failure occurs. Equation (11) ensures in case of unforeseen failure occurrence, the CM operation should be performed once. Constraint (12) guarantees that CM operation and PM operation cannot be scheduled and performed for the same period, simultaneously. Equations (13) and (14) determine that visiting the customer is related to a PM operation or a CM operation.

Equation (15) makes a connection between routing and maintenance variables. This equation checks when a PM/CM should be performed on the machine, a technician should be assigned to the machine.

Constraint (16) guarantees that only one technician should be assigned on the each machine at each period. Constraint (17) ensures that technician leave the current customer to the next one, after finish the PM/CM operation. Equation (18) determines the start time on the machine, which is calculated as the start time of the immediate previous customer, increased by the PM/CM operation time and the traveling time between the two customers. Equation (19) checks the time windows constraint and calculates the delay. Finally, (20) and (21) impose bounds on the variables.

3. RESOLUTION METHOD

In this section we firstly introduce the instance generation method and solution procedure, briefly. Then, a numerical analysis is presented which derives managerial results.

Problem instances have been generated by a random generator. In this way, parameters of the problem are generated using random numbers by a discrete uniform distribution. Then, to solve the problem, we use the weighted sum method [7]. Under this method, the problem is solved by considering each objective function separately in both the maximization and the minimization for finding extreme points of each objective function. Then, a new single objective is considered that aims to minimize the weighted sum over the normalized and non-dimensional objective function.

In order to show the feasibility and applicability of proposed model, a small size problem is generated and it is solved based on generated instance problem. It is assumed that there are 6 customers (m=6) where 3 periods are defined as duration of the interval between two consecutive PM operations (λ=3) and 2 periods are considered as allowed duration to repair occurred unforeseen failure (L=2) by using 3 types of technicians (k=3) during 10 periods. To solve this problem, the "GAMS v22.2" optimization software using solver CPLEX v10.1 is used.

At the beginning, the problem is solved without considering the second objective. In this case the total cost is optimised. The results show that minimum value of total cost is 402 while waiting time in this situation is 14. In the next step, the first objective function is relaxed and model is solved by minimizing the second objective function. The obtained results shows when the minimum value of waiting time (second objective function) is 6, the value of total cost is 1,053. Table 1, shows the minimum and maximum value of objective functions.

Table 1: Min. and Max. value of objective functions

	Minimum value	Maximum Value
First objective	402	1,053
Second objective	6	14

The bi-objective model can be converted to a MILP model with one objective function using the equation (22).

$$f = \alpha \frac{f_1 - f_1^{\min}}{f_1^{\max} - f_1^{\min}} + (1-\alpha)\frac{f_2 - f_2^{\min}}{f_2^{\max} - f_2^{\min}} \qquad (22)$$

In this equation, α presents the importance degree of each objective function and varies between 0 and 1.

Furthermore, the Objective Functions Value (OFV) by changing α value is introduced in Table 2.

Table 2: OFV against α

	α				
	0	0.3	0.5	0.7	1
First OFV	1,053	886	689	602	402
Second OFV	6	8	9	12	14
Run time (second)	157	166	147	133	158

According Table 2, the total cost from 1,053 to 402 causes increasing 57% in waiting time (from 6 to 14). It means the best value of waiting time can be reached by increasing 62% in total cost.

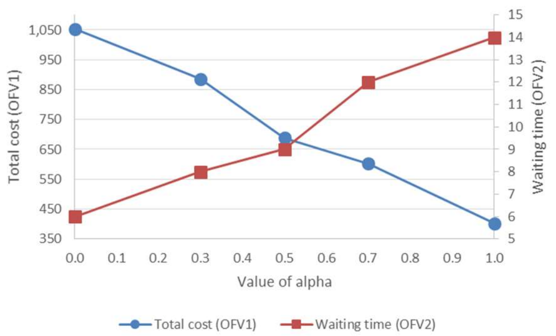

Figure 1: Variation of total cost against waiting time by changing value of α

The variation of objective functions value by changing of α value is presented in Figure 1. In this figure, X-axe shows value of total cost and waiting time while Y-axe presents different value of α. By this figure changes of total costs and waiting time is visualized against variation of α.

4. CONCLUSION

In this paper the integration of maintenance and routing problem is investigated by taking into account waiting time for performing a CM operation when unforeseen failure occurs. For this Purpose, a bi-objective mathematical model is proposed to find the optimized policy of maintenance and routing problems and make a trade-off between maintenance costs and service level which is measured by waiting time for performing a CM operation. In the proposed model the time windows is considered for starting maintenance operation on the machine by technicians. Moreover, the technician's skill regarding required time to perform a maintenance operation is considered. Our results for a small size instance show that to decrease by 57% of the waiting time, we have to increase the costs by 62%.

Our future research in this area includes the consideration of stochastic parameters and proposing an efficient solution approach.

5. ACKNOWLEDGMENTS

This project is supported by The ELSAT2020 project which is co-financed by the European Union with the European Regional Development Fund, the French state and the Hauts de France Region Council.

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Study on Reducing Turn-Around Time of Multi-Objective Evolutionary Algorithm on an Industrial Problem

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ABSTRACT

Multi-objective evolutionary algorithms (MOEAs) are population based global optimization algorithms and it is said that the performance of the MOEAs depends on the population size. Considering that the recent trends of computer development is in large-scale many-core architectures, and massive parallel computation is getting feasible in more companies and laboratories, the available population size is increasing and the efficiency of MOEA with large population size should be enhanced. This study examines the effect of the population size on MOEAs' performance on a real-world-derived benchmarking optimization problem, with large population size. In this paper, three mate selection schemes with different degree of elitist strategy are adapted to NSGA-II-M2M. The experimental results show that the elitist strategy can efficiently make use of the effect of the large population size, therefore can reduce the turn-around time.

Keywords

multi-objective optimization, large population size, mate selection, real-world problem

1. INTRODUCTION

Many of industrial design problems involve multiple objectives and constraints and they are so-called constrained multi-objective optimization problems. Considering that creating high value-added products in industries is getting more and more important along with the increase of the sophistication and diversity of social needs, it is very important to catch up to the changes in customer demands and so short development time of each product is highly appreciated.

For multi-objective optimization problems, multi-objective evolutionary algorithms (MOEAs) have been regarded as a promising approach. With respect to the application of MOEAs to industrial design problems, the development time of the products corresponds to the turn-around time for MOEAs. The turn-around time of MOEAs corresponds to the number of generations in MOEA, supposing that the runtime for MOEA itself is negligible compared with the runtime for solution evaluations. Here the turn-around time is the time from the beginning of the optimization to the end of the optimization when a desired quality of solution set is obtained.

One of the recent trends of computer development is in large-scale many-core architectures [2] and the computational algorithms, say MOEAs, should utilize the large-scale computational resources efficiently. One of the simple yet effective ways of MOEAs for utilizing the large-scale computational resources would be to increase the number of concurrent solution evaluations, i.e., the population size. Note that the increased number of objectives of multi-objective optimization problems also gives a reason to increase the population size: the necessary number of solutions to cover the entire Pareto front exponentially increases as the number of objectives increases [9, 18]. Therefore, the increase in the population size would be the right direction for recent MOEAs.

This study aims to reduce the turn-around time of MOEAs when large population size is used. This paper demonstrates the population size effect on the performance of an MOEA on a real-world-derived benchmarking problem and the reduction of the turn-around time by making use of the population size effect is attempted. This paper is organized as follows. In Section 2, the experimental settings are explained first, and the results demonstrating the impact of the population size on the performance of the MOEAs is presented. Then the method to reduce the turn-around time is described and the experimental results are provided. Section 3 concludes this paper.

2. REDUCTION OF TURN-AROUND TIME

2.1 Experimental setting

- Problem: The Mazda CdMOBP problem [11]. This problem has two objectives, 54 constraints, and 222 variables. The problem originates from an actual design optimization of car models and the constraints comprise the requirements for crashworthiness, body torsional stiffness, and low frequency vibration modes. These constraints are evaluated by finite element simulations on a supercomputer in actual design process, however, in the benchmark problem these simulation results are modeled with radial basis functions so as to shorten the evaluation time while retaining the nonlinearity as much as possible. The details are presented in [11] and the problem is available from the website [12].

- MOEA: NSGA-II-M2M [15] with the subproblem size of 10. The probability that the parents are chosen from the corresponding subproblem δ is set to 0.9.

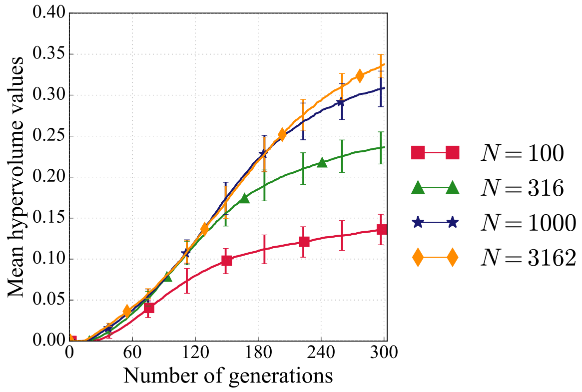
- Constraint handling technic: Multiple constraint ranking (MCR) [5], which generally performs well on constrained optimization benchmarking problems [7]. The constraint handling technic is incorporated into NSGA-II-M2M with the MOEA-CHT incorporation framework [7].
- Mate selection schemes: Random selection, binary tournament (BT) [1], or Elitist BT (EBT, explained in next subsection) [8]. The random selection scheme is the default mate selection scheme for NSGA-II-M2M [15] and its modified version of Jain et al. [10] is employed so as to handle constraints.
- Reproduction operators: The crossover and mutation operators with the same control parameter values as in [14, 15].
- Direction vector generation method: Das and Dennis's systematic approach [4].
- Stopping criterion: The number of generations of 300. The number of fitness evaluations differs according to the population size at a given generation, but the focus is in this study is on the reduction of the required generations, and so the differences in the number of fitness evaluations is not considered in this study.
- Independent runs: Each case run for 31 times independently.
- The population size N: N is set to be the numbers in a geometric progression with a scale factor of 100, and a common ratio of $\sqrt{10}$ is used to see the population size effect. Specifically, the population sizes of 100, 316, 1000, and 3162 are used, especially for drawing Figure 3.

2.2 Performance Metric

The hypervolume (HV) indicator [20] is used as the performance indicator. In this study, the solution set used for the calculation of the HV value is the solutions not only in the final population but also in the external unbounded archive [13], considering that the designers in actual industries use MOEAs as design support tools for decision making and so use of the unbounded external archive is more practical than use of the solutions obtained only at the final generation. For calculating the HV value for a generation, non-dominated solutions are extracted from all the feasible solutions obtained by the generation and are used to calculate the HV value. For the details of the formulation for the HV calculation, please refer to [11]. The larger the HV value, the better the approximation to the Pareto front.

2.3 Impact of the population size on the performance

Figure 1 presents the convergence history of the mean HV values with various population sizes for NSGA-II-M2M with random selection. It is observed that the cases with higher population size show generally higher mean and smaller standard deviation values. This result supports the motivation for increasing the population size, however, the effect of the increased population size is not clearly observed until around the number of generations of 200, between the cases with the population size of 1000 and 3162.



(a) Random selection

Figure 1: Convergence history of the HV values with various population sizes for the case with random selection. The mean and the standard deviation values are plotted.

2.4 Reduction of turn-around time by enhancing the population size effect

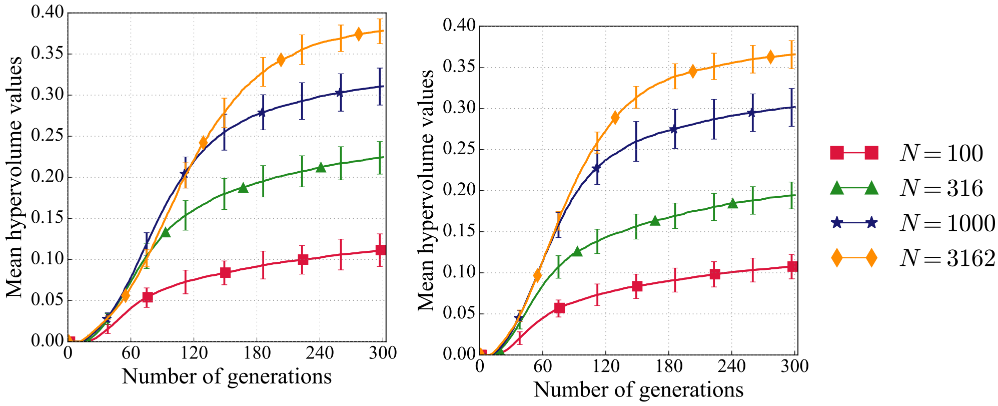
The population size affects the diversity of the solutions and the convergence speed, and now it is commonly accepted that the population size should be large enough to guarantee the diversity of the solutions while the large population size makes the convergence slow [16, 3, 17, 19].

Considering that the phenomenon of the population size effect can be explained by a term “selection pressure” [19], we attempt to mitigate the slow convergence with large population by somehow strengthening the selection pressure. In this study, a standard and popular mate selection of BT and a recently proposed mate selection scheme with a strong elitist strategy named EBT [8], both of which have stronger selection pressure than the random selection, are employed. In EBT, i) the usual BT selection is conducted at first for all the solutions in each subproblem then the indices of the selected solutions are sorted according the number of times the each index is selected. Apart from that, ii) the indices of the solutions are also sorted according the solutions' fitness. Finally, every sorted indices i) is replaced by the index in ii) with the same rank order with i), so that the solution with higher rank is selected more. For further details of EBT, please refer to [8].

The most elitist is EBT, followed in order by BT and random selection.

It must be noted that the strong elitist strategy tends to deteriorate the diversity of the solutions, and the negative effect of the strong elitist strategy should be compensated by using some diversity-enhancing method. In this study, we enhance the MOEAs' capability of keeping diversity by employing M2M, and this is the reason why the base algorithm in this study is not NSGA-II [6] but NSGA-II-M2M.

Figure 2 shows the convergence history of the mean HV values with various population sizes for NSGA-II-M2M with



(a) BT

(b) EBT

Figure 2: Convergence history of the HV values with various population sizes for the cases with BT and EBT selection. The mean and the standard deviation values are plotted.

BT and EBT. Comparing Figure 1 and 2, it can be observed that the strong elitist mate selection enhances the large population size effect and the differences in the mean HV values can be observed more clearly and from earlier generations.

With regard to the reduction of the turn-around time, Figure 3 shows the generation that is required to attain a HV value against the population size. For example, in Figure 3, the HV value of 0.2 can be attained with the number of generations of approximately 300 with the population size of approximately 300, and with the number of generations of approximately 160 with the population size of approximately 1000. The subfigures in Figure 3 show that the required generation to attain a certain HV value is reduced with stronger mate selection scheme.

Compared with the case with BT, the results for EBT shows relatively poor performance with small population sizes, and so further development of more robust and more efficient algorithm for reducing the turn-around time will be required.

3. CONCLUSIONS

This paper demonstrates the population size effect on the performance of an MOEA on a real-world-derived benchmarking problem (Mazda CdMOBP) and the reduction of the turn-around time by making use of the population size effect is attempted.

By the demonstration of the population size effect, it is shown that the large population size can improve the performance of an MOEA, and it is also shown that the population size effect is not clearly shown until late stage of the evolution with random mate selection scheme.

The late-appearing population size effect is then improved by employing two techniques: a strong mate selection scheme and its complementary scheme of M2M. The results show that the case with stronger elitist strategy exhibits relatively faster large population size effect and the aim of reducing turn-around time is achieved in some degree. Future work will include further improvement of the population size effect, even with much smaller population size.

Acknowledgment

This research is supported by the HPCI System Research Project "Research and development of multi-objective design exploration and high-performance computing technologies for design innovation".
(Project ID: hp160203 and hp170238)

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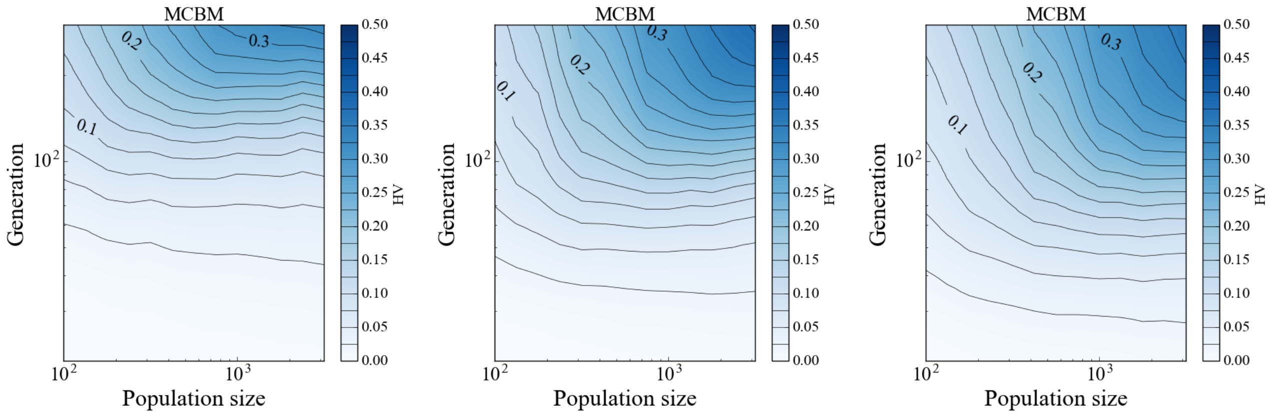

(a) Random selection (b) BT (c) EBT

Figure 3: Plot for the generation that is required to attain a HV value against population size.

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Evolution of Electric Motor Design Approaches: The Domel Case

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ABSTRACT
The paper presents the evolution of geometry design approaches in the optimisation of an electric motor, more specifically its rotor and stator. It starts with the initial manual approach, which was replaced with the automatic approach that introduced evolutionary algorithms to allow the intelligent search in collaboration with evaluation tools. Next, the new platform for remote optimisation was recently introduced that allows remote optimisation with various algorithmic approaches, including multi-objective optimisation. At the end we propose further solutions that will improve high performance of the design process.

Keywords
electric motor, design, evolution, high-performance

1. INTRODUCTION
Many widely-used home appliances (e.g., mixers, vacuum cleaners, drills, etc.) use electric motors. These small motors are required to have high power and provide high starting and running torques, despite their small sizes. While having sufficient output power they should be energy efficient and inexpensive to manufacture [12].

There is a number of past works addressing the geometry optimisation design of rotor and stator parts [6], [10], [12], electric motor casing [7] and impeller [4]. These works, performed on various products of Domel company [1], introduced various artificial intelligence methods to implement automatic search of an optimal design. The reported optimisation approaches were mostly single objective. Still, there were some initial steps identified towards multi-objective handling of the design process.

This paper focuses on the approaches for automatic optimisation of the electric motor geometry. The main parts of the electric motor, i.e., stator and rotor, are presented in Figure 1.

While improving the applicability of the multi-objective optimisation, supported by parallelisation and surrogate modelling through the support of the Horizon 2020 Twinning project SYNERGY - Synergy for smart multi-objective optimisation [3], we implemented a platform for an efficient optimisation with different methods and approaches. The platform is briefly presented in this paper. In line with Slovenian smart specialisation strategy [2], it is planned to transfer this solution into Slovenian industry.

The rest of the paper is organized as follows: Section 2 briefly describes the geometry elements of an electric motor and the optimisation goal; Section 3 presents the conventional manual approach to the motor design; in Section 4 the use of evalutionary algorithms in electric motor design is outlined; Section 5 introduces the new developed platform for remote optimisation; and Section 6 draws conclusions and proposes possible future work.

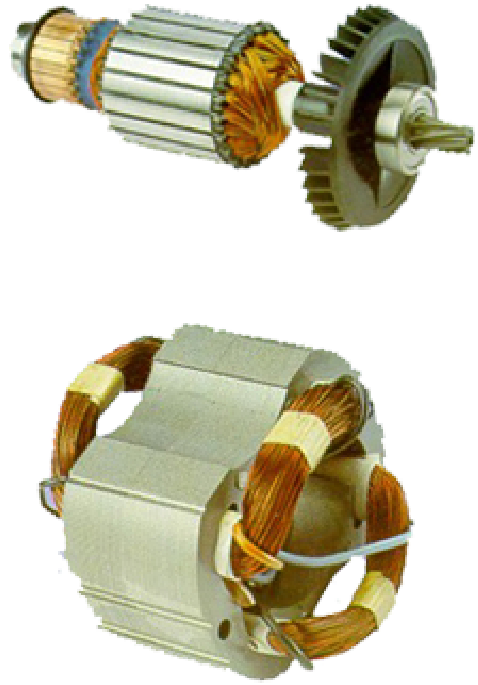

Figure 1: Rotor and stator of an electric motor [10].

2. PROBLEM DESCRIPTION
The rotor and the stator of an electric motor are constructed by stacking the iron laminations. The shape of these (rotor and stator) laminations is described by several geometry parameters that define the rotor and stator in two dimensions (2D).

The whole set of geometry parameters consists of invariable and variable ones. Invariable parameters are fixed, as they cannot be altered, either for technical reasons (e.g., the air gap) or because of the physical constraints on the motor (e.g., the radius of the rotor's shaft). Variable parameters, on the other side, do not have predefined optimal values. Among these parameters, some are dependent (upon others variables), while some variable parameters are mutually independent and without any constraints. The mutually independent set of variable parameters of the rotor and stator geometry (see details in Figure 2) can be subject to optimisation:

- rotor yoke thickness (ryt),
- rotor external radius (rer),
- rotor pole width (rpw).
- stator width (sw),
- stator yoke horizontal thickness (syh),
- stator yoke vertical thickness (syv),
- stator middle part length (sml),
- stator internal edge radius (sie),
- stator teeth radius (str),
- stator slot radius (ssr).

One of the optimisation tasks is to find the values of geometry parameters that would generate the rotor and stator geometry with minimum power losses.

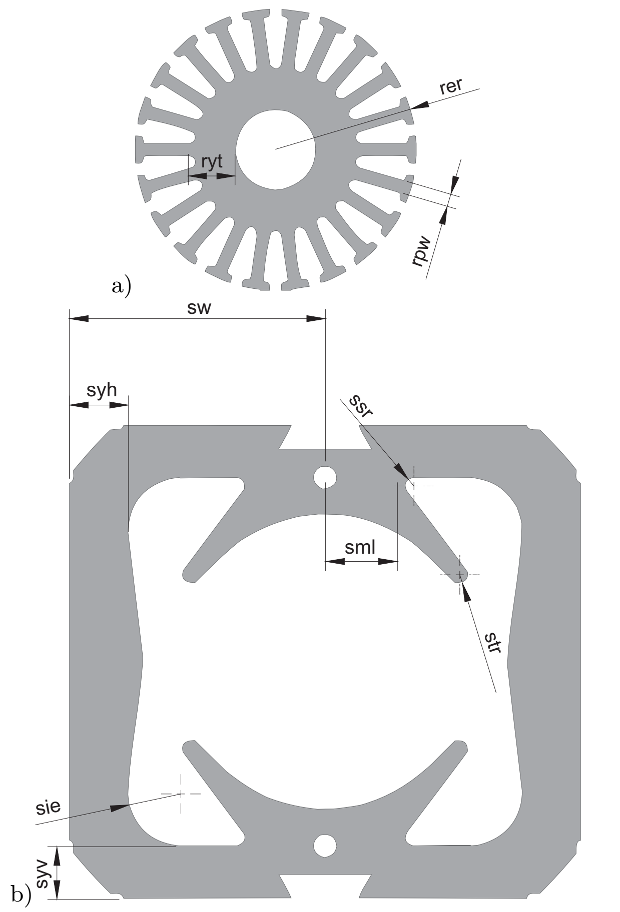

Figure 2: Geometry parameters of a) rotor and b) stator [12].

2.1 Mathematical formulation of the problem

The efficiency of an electric motor is defined as the ratio of the output power to the input power. It depends on various power losses (see details in [9]), which include:

- Copper losses: the joule losses in the windings of the stator and the rotor.
- Iron losses: including the hysteresis losses and the eddy-current losses, which are primarily in the armature core and in the saturated parts of the stator core.
- Other losses: brush losses, ventilation losses and friction losses.

The overall copper losses (in all stator and rotor slots) are as follows:

$$P_{Cu} = \sum_i (J^2 A \rho l_{turn})_i \quad (1)$$

where i stands for each slot, J is the current density, A is the slot area, ρ is the copper's specific resistance and l_{turn} is the length of the winding turn.

Due of the non-linear magnetic characteristic, the calculation of the iron losses is less exact; they are separated into two components: the eddy-current losses and the hysteresis losses:

$$P_{Fe} = k_e B^2 f_{rot}^2 m_{rot} + k_e B^2 f_{stat}^2 m_{stat} + k_h B^2 f_{stat}^2 m_{stat} \quad (2)$$

where k_e is an eddy-current material constant of 50 Hz, k_h is a hysteresis material constant of 50 Hz, B is the maximum magnetic flux density, f is the frequency, and m is the mass.

Three additional types of losses also occur, i.e., brush losses P_{Brush}, ventilation losses P_{Vent}, and friction losses P_{Frict}.

The output power P_2 of the motor is a product of the electromagnetic torque T, and the angular velocity ω,

$$P_2 = T\omega \quad (3)$$

where ω is set by the motor's speed, and T is a vector product of the distance from the origin r, and the electromagnetic force F.

The overall efficiency of an electric motor is defined as:

$$\eta = \frac{P_2}{P_2 + P_{Cu} + P_{Fe} + P_{Brush} + P_{Vent} + P_{Frict}} \quad (4)$$

2.2 Fitness evaluation

Each solution candidate of the population was decoded into a set of the rotor and stator parameters. The fitness was estimated by performing a finite-element numerical simulation to calculate the iron and the copper power losses (using the above mentioned equations). The sum of power loses corresponds to the solution's fitness.

For multi-objective version we can also introduce additional objective like material costs, making it a typical price/ performance optimisation. The cost is calculated by taking into account the amount of materials (i.e., iron and copper), that are used to produce the electric motor, and their corresponding prices.

3. MANUAL OPTIMISATION

A manual design procedure of an electric motor consists of the geometry estimation of the rotor and the stator of an electric motor by an experienced engineer. The suitability of the proposed geometry is usually analyzed by means of numerical simulation (e.g., FEM with an automatic finite-element-mesh generation) of the electromagnetic field of each proposed solution separately.

The manual procedure can be repeated until the satisfied evaluation results is obtained. Similarly, the conventional approach in most new designs starts with manual design, as there exist no prior design.

The advantage of the manual approach is that the engineers can significantly influence the progress of the design process with their experiences and react intelligently to any noticeable electromagnetic response with proper geometry redesign.

The drawback of this approach is that an experienced engineer and a large amount of time (that is mostly spent on computation) are needed.

4. AUTOMATIC OPTIMISATION

The above-described manual design approach can be upgraded with one of the stochastic optimisation techniques which, in connection with reliable numerical simulators, allow for highly automated design process where the need for an experienced engineer to navigate the process is significantly reduced.

So far, several evolutionary approaches have already been proven to be efficient in the process of the electric motor geometry optimisation; e.g., electromagnetism-like algorithm [5], multi-level ant-stigmergy algorithm [6], adaptive evolutionary search algorithm [8], genetic algorithm [9], particle swarm optimization, and differential evolution [12].

The automatic approach with the use of an evolutionary algorithm can be summarized into the following steps:

1. The initial set of solutions is defined according to an initial electric motor.
2. It provides a set of problem solutions (i.e., different configurations of the mutually independent geometrical parameters of the rotor and the stator).
3. For evaluation of each solution (i.e., their fitness) each geometrical configuration is analyzed using some FEM program (e.g., ANSYS). This step requires a decoding of the encoded parameters into a set of geometrical parameters that define the rotor and the stator.
4. After the fitness calculation, the reproduction of the individual solutions is performed and the application of various recombination operators to a new population are done.
5. The evolutionary algorithm repeats the above procedure until some predefined number of iterations have been accomplished or some other stopping criteria is met.

Some evident advantages of this approach are:

- There is no need for an experienced engineer to be present during the whole process. He is required only at the beginning to decide on the initial design.
- There is no need to know the mechanical and physical details of the problem. The problem can be solved, by the use of optimisation algorithm, irrespective of any knowledge about the problem.

Some possible drawbacks of this approach can appear:

- The improper use of recombination operators leads to slow search progress.
- An initial solution set that is not divergent enough, can lead to a longer convergence time.

5. REMOTE OPTIMISATION PLATFORM

The multi-objective optimisation is a natural approach to solve difficult real-world problems. As the presented electric motor geometry design can have several contradictory constraints, it is useful to introduce the multi-objective algorithms (e.g., NSGA-II, IBEA) into this process [11].

Within the project SYNERGY, we developed and implemented a platform for an efficient optimisation with different methods and approaches. Its main role is to allow comparison and testing of an effective optimisation methods for the optimisation of electric motor geometry. The platform allows comparison of single objective as well as multi-objective algorthms.

The platform is based on web-based services to allow remote work of different experts, while keeping some important, secret features and characteristics hidden. The remote tool also allows for parallel processing, which allows for fast calculations, without any intervention from the expert.

Remote access enables experts to use the evaluation of the proposed solution regardless of his location. The platform allows remote access towards any simulation tools (e.g., FEM analysis). Furthermore, all evaluations are being stored in database and in case the same solution is being put to evaluation, the result is immediately returned without the need to wait for it to be actually evaluated again, which furthers speed up the evaluation process.

Since actual parameter values are not relevant for optimisation process and to ensure that no secrets about the problem are being shared, the platform hides the important properties of the solutions. Meaning all parameter values and evaluation results are being normalised within the interval $[0.0, 1.0]$. This way, the problem can be tackled by any optimisation expert without acquiring any relevant knowledge (e.g., actual dimensions, problem specifications) about the problem.

Parallelisation within the platform is considered on the level of solution evaluation. Any other parallelisation on the level of optimisation algorithm is left to the optimisation expert.

6. CONCLUSION

This paper presented the evolution of approaches to the optimisation of the geometry design of the electric motor. From the initial manual approach, through the automatic approach that uses some evolutionary algorithm combined with evaluation tools, towards the platform that allows remote optimisation with various algorithms. The latter allows simple comparison and study of different methodologies and algorithms.

In the future version of the optimisation platform we plan to introduce some surrogate models as well as some multi-level approaches, which would allow for additional speed up of the evaluation process, since most of the real-world problems have time-complex evaluations.

7. ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0098). This work is also part of a project SYNERGY that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 692286.

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Model-Based Multiobjective Optimization of Elevator Group Control

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ABSTRACT

Finding a suitable control strategy for the elevator group controller (EGC) is a complex optimization problem with several objectives. We utilize the sequential-ring (S-Ring) model of EGC systems and propose a biobjective formulation of the EGC optimization problem. Unlike the previous work, we use true multiobjective optimizers in solving this problem. Their results on three real-world elevator systems reveal the possible trade-offs between the objectives and offer a valuable insight into the problem.

Keywords

elevator group control, S-Ring, perceptron, multiobjective optimization, NSGA-II, DEMO

1. INTRODUCTION

With larger number of people living in urban areas and modern barrier-free building design, elevator systems are becoming more and more important. Modern multi-car elevator systems are controlled by elevator group controllers (EGC) that assign elevator cars to their destinations based on the customer service calls. The control strategy strongly affects the desired service quality, customer satisfaction, energy consumption, and material attrition. Thus, finding an adequate control strategy depicts a complex optimization problem with several objectives, which is further dependent on the building structure and the passenger traffic situation. Optimization of EGC imposes challenges, such as being nonlinear and multimodal, as well as highly dynamic and stochastic due to the stochasticity of customer arrivals. This renders classic gradient-based optimizers as not applicable to these problems [1]. Moreover, EGC simulators are computationally expensive and limit the number of control strategy evaluations.

While EGC optimization problems are widely discussed and known for involving conflicting objectives, they are seldom solved with true multiobjective optimization. Hakonen et al. [3] utilize a set of objectives, such as the customer waiting time, the ride time, and the total number of elevator stops, but combine them linearly into a single objective. Tyni and Ylinen [7] use a weighted aggregation method to optimize the landing call waiting time and energy consumption with an evolutionary algorithm in a real-time environment. In Sahin et al. [6], a real-time monitoring system is installed to reduce the number of redundant stops, and improve passenger comfort and energy consumption. In [1], an approximation model for EGC systems, the so-called *sequential ring* (S-Ring) [4], is used to benchmark single-objective heuristics. Using the S-Ring model, it is possible to retain a high level of complexity and optimize an EGC control strategy using modern heuristics with a high number of strategy evaluations, while keeping a feasible computational load.

In this paper, we utilize the S-Ring model of EGC systems and propose a biobjective formulation of the EGC optimization problem. In this formulation, the objectives are normalized to allow for comparison of results for elevator systems of various configurations. As opposed to previous work, we apply true multiobjective optimizers capable of finding approximations for Pareto-optimal solutions that represent trade-offs between the objectives. Specifically, we use two multiobjective evolutionary algorithms (MOEAs) and demonstrate their performance in optimizing EGC for three real-world elevator systems.

The paper is further organized as follows. Section 2 introduces the S-Ring model, explains its elements and illustrates it with an example. Section 3 provides the optimization problem formulation. In Section 4, numerical experiments on the three test elevator systems and the results are presented. Section 5 concludes the paper by summarizing the study and planning future work.

2. S-RING MODEL OF ELEVATOR GROUP CONTROL

The S-Ring is a discrete, nontrivial event system to optimize and benchmark control strategies without the need to use expensive EGC simulators [4]. It focuses on modeling the operation of an elevator system, i.e., handling the passenger traffic and serving passengers in the fastest and most comfortable way. We adapted the S-Ring model to feature two service quality related objectives as described in Section 3.

In general, the S-Ring consists of three key elements:

- The deterministic state-space representation of the elevator control inputs for the customers c_i and elevator cars s_i, $i = \{1, ..., N_s\}$, where $N_s = 2n - 2$ is the number of states, while n is the number of floors. Figure 1 shows an example of this state-space representation. The size of the S-Ring depends on the number of floors n, and the number of active elevator states is equal to the number of elevator cars m. The number of currently active customer states is influenced by the probability of a new arriving customer, p.

- The state transition table, which is explained in detail by Markon [4], defines fixed and dynamic rules for a transition in the current position of the S-Ring. If no fixed rule is triggered, the dynamic rules decide how the state transition is performed. They are established by a control policy.
- The control policy π can be realized by a lookup table, but as its size grows exponentially with n, it is maintained by a perceptron with a weight vector of length $|\mathbf{w}| = 2N_s$. The perceptron represents the most elementary implementation of neural network (NN). For a given setup of n, m and p the objectives are only influenced by the weight vector $\mathbf{w}$ of the NN controller and the number of state transition steps, N_t. At each state, it is first checked whether a new customer arrived. Next, if the current state is an active elevator state, the controller determines whether the elevator car stops or continues to the next state. Finally, the indication of the customer active state is updated depending on whether or not the customers were served.

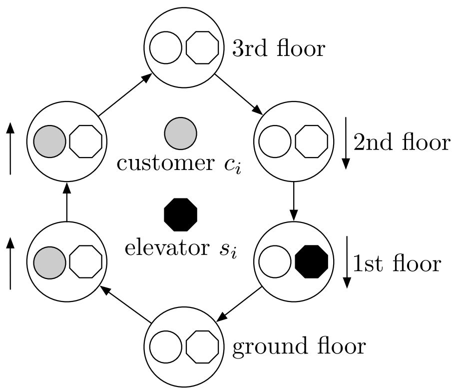

Figure 1: S-Ring: No waiting customer at the ground and floor ("0"), two customers who want to go up on the first and second floor ("1,1"), and no customers who want to go down on the third, second and first floor ("0,0,0"). By combining these information we obtain the following state vector for waiting customers: (0,1,1,0,0,0). The state vector for the elevator is obtained in a similar manner.

Due to its low computational costs, the S-Ring can quickly evaluate a broad variety of EGC instances as benchmarks for the proposed multiobjective optimization approach.

3. OPTIMIZATION PROBLEM FORMULATION

In this work, we deal with two EGC objectives that are often studied in the literature and both need to be minimized: i) the average number of states with waiting customers, and ii) the total number of elevator stops [3, 6, 7]. In contrast to previous publications, we do not combine the objectives into a single function, but adopt the multiobjective perspective. Moreover, to make it possible to compare the performance of elevator systems of various configurations (determined by the number of floors n and the number of elevator cars m), we consider normalized objective function values.

The first objective (h_1) is the proportion of states with waiting customers. It is expressed as the average number of states with waiting customers, M_w, divided by the number of all states, N_s:

$$h_1 = \frac{M_w}{N_s}. \tag{1}$$

The second objective (h_2) is the proportion of elevator stops. It is equal to the total number of elevator stops, M_t, divided by the maximum possible number of elevator stops. The latter can be calculated as the number of elevator cars m multiplied by the number of EGC simulation cycles, which is in turn equal to the number of state transition steps, N_t, divided by the number of states, N_s, therefore

$$h_2 = \frac{M_t}{mN_t/N_s}. \tag{2}$$

Intuitively, the customers' discomfort with long waiting times and long riding times due to many elevator stops does not increase linearly with time, but more drastically. To model this effect, we have additionally modified the original objectives as

$$f_1 = h_1^\alpha \quad \text{and} \quad f_2 = h_2^\beta, \tag{3}$$

where $\alpha, \beta \in [1, 2]$ are the objective function coefficients. The choice of their values is subjective, but the idea is to reflect the elevator system characteristics and the custumer preferences.

The control policy π is represented by a perceptron as $\pi(\mathbf{x}) = \theta(\mathbf{w}^{\mathrm{T}}\mathbf{x})$, where $\mathbf{x}$ is a binary input vector, i.e., a concatenation of the waiting customer and the elevator car state vectors of total length equal to $2(2n-2) = 4(n-1)$, θ is the Heaviside function, and $\mathbf{w}$ a vector of perceptron weights from $W = [-1, 1]^{4(n-1)}$. In this framework, the policy π is defined by the weight vector w only. Therefore, the decision space of the EGC optimization problem as defined here is equal to W.

4. EXPERIMENTS AND RESULTS

The multiobjective optimization of EGC was experimentally evaluated on three test problems reflecting the characteristics of real-world elevator systems operating in various buildings in Ljubljana, Slovenia. They are as follows.

- S1: This system operates in a parking building ("Parking garage Šentpeter") situated in the city center. Intensive passenger traffic can be observed in the building on workdays.
- S2: This is an elevator system installed in a typical residential building in the densely populated neighborhood ("Nove Fužine") in the eastern part of Ljubljana. Here the traffic intensity alternates between high (e.g., early in the morning) and low (e.g., at midday).

- S3: This is the elevator system in the "Crystal Palace", a skyscraper situated in the north-western area of the city. With its 89 meters it is currently the tallest building in Slovenia. As an office building it has low passenger traffic.

The characteristics of these elevator systems are summarized in Table 1.

Table 1: Characteristics of the test elevator systems: number of floors n, number of elevator cars m, probability of new arriving customer p, objective function coefficients α and β, number of states in the S-Ring representation N_s.

System	n	m	p	α	β	N_s
S1	7	2	0.6	1.0	1.5	12
S2	13	2	0.3	1.4	1.8	24
S3	21	4	0.2	1.5	1.5	40

Based on the multiobjective formulation of the EGC optimization problem, the experimental evaluation aimed at finding sets of trade-off solutions representing approximations for Pareto fronts. For this purpose we used two well-known MOEAs: Nondominated Sorting Genetic Algorithm II (NSGA-II) [2] and Differential Evolution for Multiobjective Optimization (DEMO) [5]. The algorithms were assessed from the point of view of both effectiveness (quality of results) and efficiency (spent computational resources).

The experimental setup was defined in the following way. Both algorithms were run with populations of 100 solutions for 100 generations. Specifically, in NSGA-II, the crossover probability was set to 0.7 and the mutation probability to 0.2, while DEMO was run using the SPEA selection procedure, the crossover probability of 0.3 and the scaling factor of 0.5. On each test problem every MOEA was run 30 times, each time with a new randomly initialized population.

Population members were the perceptron weight vectors of length $2N_s = 4(n-1)$. Each solution was evaluated through a computer simulation of the perceptron EGC during which the values of objectives f_1 and f_2 were calculated. The simulation was performed for a predefined number of simulation cycles which was 100.000 for all test problems. As a consequence, the number of state transition steps was equal to $N_t = 100.000N_s$.

The quality of results of an algorithm run was measured with the hypervolume of the Pareto front approximation found in that run. Given $f_1, f_2 \in [0, 1]$, the reference point for hypervolume calculations was set to $(1.1, 1.1)^{\mathrm{T}}$. As the computational efficiency measure the execution time of algorithm runs was recorded. The experiments were run on a 3.50 GHz Intel(R) Xeon(R) E5-2637V4 CPU with 64 GB RAM.

The hypervolume and execution time results are shown in Table 2, both averaged over 30 runs of every MOEA on each test problem. From these results it is evident that regardless of the elevator system, the hypervolumes obtained with NSGA-II and DEMO are very similar. Standard deviations for both optimizers are small (less than 10^{-3}), indicating robust and repeatable algorithm behavior on all three elevator systems. Similarly, small deviations are present for execution times no matter which MOEA is used to produce approximations for Pareto fronts.

Figures 2 and 3 show Pareto front approximations for the test elevator systems resulting from typical runs of NSGA-II and DEMO, respectively (there were negligible differences between the results of different runs). As we can see, both MOEAs obtain well-distributed and very similar sets of solutions. The best solutions with respect to both objectives were found for system S3. This was expected since S3 has more elevator cars and a lower probability of new customer arrivals than S1 and S2.

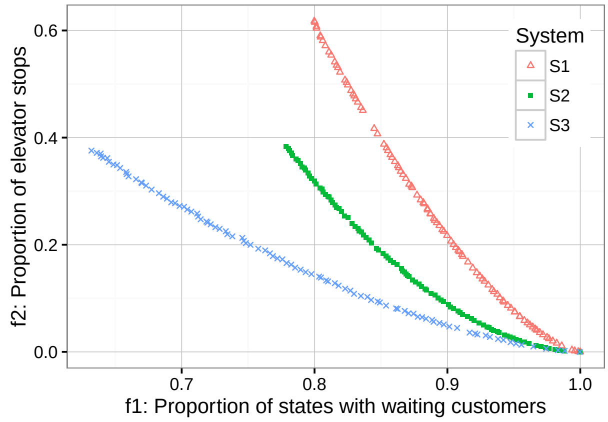

Figure 2: Pareto front approximations for the test elevator systems produced by NSGA-II.

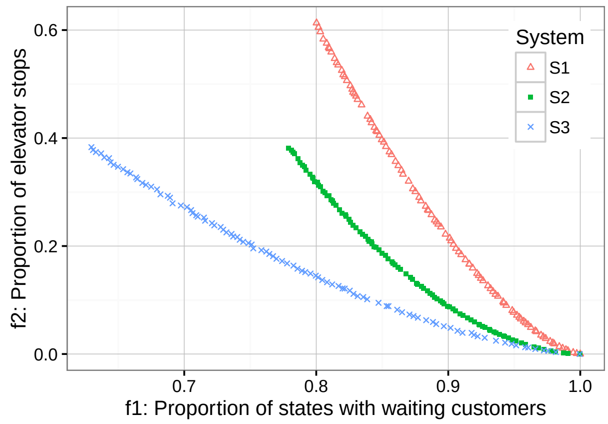

Figure 3: Pareto front approximations for the test elevator systems produced by DEMO.

An additional experiment was devoted to the analysis of hypothetical variants of system S3 with various numbers of elevator cars. While S3 has its fixed configuration, such a study is relevant for designing elevator systems for new buildings and assessing potential configurations.

Pareto front approximations obtained with NSGA-II for variants of S3 with 2, 3, 4, 5 and 6 elevator cars are presented in Figure 4. The figure clearly shows how the number of

Table 2: Average hypervolume and average execution time for both optimizers on the test elevator systems.

Elevator system	NSGA-II		DEMO	
	Hypervolume	Time [min]	Hypervolume	Time [min]
S1	0.28066 ± 0.00005	38 ± 1	0.28069 ± 0.00005	28 ± 1
S2	0.32455 ± 0.00016	147 ± 1	0.32450 ± 0.00014	128 ± 1
S3	0.46506 ± 0.00081	398 ± 2	0.46543 ± 0.00037	401 ± 2

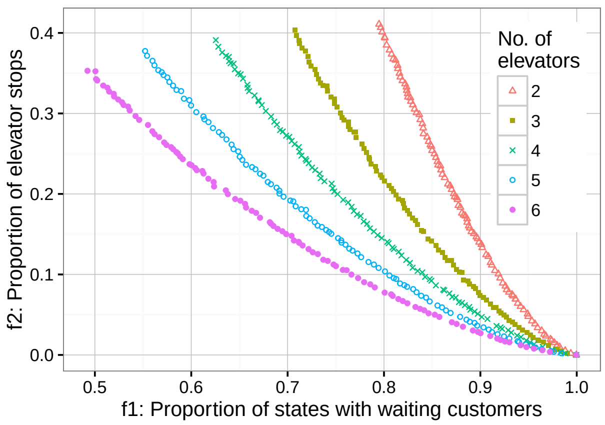

Figure 4: Pareto front approximations for variants of S3 with different numbers of elevator cars (2, 3, 4, 5, 6) found by NSGA-II.

cars affects the trade-off EGC policies. Higher number of cars implies policies that can reduce the proportion of states with waiting customers and the proportion of elevator stops simultaneously. For example, in the case of only 2 elevator cars the lowest value of objective f_1 is about 0.8, while with 6 elevator cars it can be reduced to 0.5. However, one should be careful in comparing the results with respect to f_2, since the maximum possible number of elevator stops increases with the number of elevator cars. Nevertheless, these results allow for better problem understanding and are insightful to various stakeholders involved in deciding on elevator system configurations, ranging from EGC designers to investors.

5. CONCLUSIONS

We studied the optimization of EGC needed in the design and operation of multi-car elevator systems. Utilizing the S-Ring model of EGC systems, we proposed a biobjective formulation of the EGC optimization problem that takes into account the proportion of states with waiting customers and the proportion of elevator stops, both subject to minimization. In this formulation, the objectives are normalized to support comparative empirical studies on elevator systems with various numbers of floors and elevator cars.

As opposed to previous work, we applied true multiobjective optimizers capable of finding approximations of Pareto-optimal solutions. The results of two MOEAs for three real-world elevator systems were comparable regarding both the quality and execution time. They revealed the nondominated sets of trade-off control policies for the considered elevator systems. Moreover, we demonstrated how the approach can be used to support the elevator system configuring at the design stage.

In the future we plan to further assess the resulting elevator control policies through a comparisson with the results of single-objective optimization and investigate the scalability of the applied optimization methodology. We will also analyze the produced trade-off solutions in the design space, and deal with alternative, potentially more transparent policy implementations.

6. ACKNOWLEDGMENTS

This work is part of a project that has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement no. 692286. We acknowledge financial support from the Slovenian Research Agency (young researcher programme and research core funding no. P2-0209).

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From a Production Scheduling Simulation to a Digital Twin

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ABSTRACT

Digital twins are becoming ever more important in smart specialisation of factories of the future. Transition from using current state in industry to using digital twins is a big step. We propose an initial step to upgrade simulations to digital twins to enhance the productivity even further. The multi-objective optimisation approach is important in achieving high efficiency of production scheduling. The goal of the optimisation is to find a production schedule that satisfies different, contradictory production constraints. We take a simulation tool that was used by a memetic version of the Indicator-Based Evolutionary Algorithm with customized reproduction operators and local search procedures to find a set of feasible, non-dominated solutions and analyse the required steps to achieve a digital twin. We show that with a multi-objective approach that is able to find high-quality solutions and flexibility of many "equal" solutions, the digital twin becomes a powerful tool for a decision maker.

Keywords

multi objective, scheduling, optimisation, real world, digital twin

1. INTRODUCTION

Since production scheduling is important for smart specialisation goals in factories of the future, we decided to take relevant results from [4], and apply them to see the impact of digital twins. A digital twin is a digital copy of physical world (physical twin) in form of processes and systems. It provides both, the elements and dynamics of the real-word, so one can simulate and predict the future events with an up-to-date model, which is relevant for a decision maker.

In [4] we applied the multi-objective approach that uses specific local search procedures to the problem of production scheduling. As the basic algorithm we used the Indicator-Based Evolutionary Algorithm (IBEA) [8]. We decided to use the IBEA because it was shown that it can substantially outperform results generated by other multi-objective algorithms, such as the improved Strength Pareto Evolutionary Algorithm [9] and NSGA-II [2], in terms of different performance measures [8]. Due to the addition of local search procedures, we called our approach the Memetic Indicator-Based Evolutionary Algorithm (M-IBEA). As such it represents a synergy of the multi-objective evolutionary approach with separate, individual, learning or local improvement procedures (local searches).

If the approach would be left as is, it would be considered only as multi-objective approach using a simulation tool to find an approximation set of non-dominated solutions. But since it can be introduced into the actual production, meaning that the current information of the state of production, with regard to standing orders and orders which have already been processed so far, we can consider such an enhanced simulation model to be a digital twin of the production. With it, we could not only simulate theoretical future capacities, but also include actual production and its daily specifics to predict future events with higher accuracy.

The rest of the paper is organized as follows: in Section 2, we briefly describe the production scheduling problem; in Section 3, we introduce required changes to create a digital twin; in Section 4, we present the main idea of Memetic IBEA; in Section 5, we present the experimental environment and the results of the evaluation with the real-world data; in Section 6, we present the usability study; and in Section 7, we draw conclusions and propose possible future work.

2. PRODUCTION SCHEDULING PROBLEM

The scheduling problem was introduced for a company that produces components for domestic appliances, including hot plates, thermostats and heating elements. The fabrication process for components used in different types of plates is similar, but due to clients' demands the models differ in size (height, diameter), connector type, and power characteristics (wattage). For logistic reasons, the clients group different models of plates within the same order, implying the same due-dates for different products. As a consequence, their production must be scheduled very carefully to fulfil all the demands (quantities and due-dates), to maintain the specified amounts of different models in stock, to optimally occupy their workers, and to make efficient use of all the production lines. The assignment of due-dates is usually performed separately and before the production scheduling, but since there are strong interactions between the two tasks, using the proposed digital twin can allow for more accurate arrangement of due-dates. For each order, the completion time should be as close as possible to the due-date in order to reduce the waiting time and costs [7]. Furthermore, not all the production lines are equal, since each of them can produce only a few different models. A detailed formulation of the production scheduling problem is presented in [5].

The required inputs to such a problem are:

- Production norms that specify which products are being produced on each line and what is the changeover time from one product to another for each specific line.
- Amount of stock for each product.
- Orders that need to be processed and their deadlines.
- Number of planned shifts.
- Number of lines.

Looking from the perspective of a simulation tool that is able to take into account all this inputs and evaluate the expected time of production for every order, it is a simple simulation tool. But such a tool alone lacks the dynamics of the real world, so it is not able to react “instantly” to the changes in the production environment.

3. DIGITAL TWIN

For a simulation tool to become a digital twin, some capabilities need to be added. Mainly, the interaction between what is happening in the real world and the description of the problem instance. First of all, the relevant information, which defines the problem instance, can be gathered from the company's information system. This allows receiving up-to-date information about new orders, the current stock, and amount of products that were produced so far in the day. With the way production companies are working, usually this needs to be done only once a day, since production plans do not change for the current day (actually they are fixed for up to several days in advance), due to the requirements of having the required materials for producing orders at hand. The main reason for this is that an additional requirement is also to have the stock of materials at the factory as small as possible. We must be aware that any unnecessary stock is actually an expense that every company would like to reduce or even remove.

The simulation tool only takes into account the technical data provided by the company with regard to the above mentioned required inputs. Though any changes in production can be “detected” by the simulator through changes in inputs (e.g., how many products were actually produced), this does not provide a good baseline for predicting future production with inclusion of predicting maintenance. For prediction maintenance to be included in the digital twin a machine learning techniques should be used to estimate/model any informalities that happen, but are not included in production norms (e.g., failures on lines). All this is based on previous experiences and requires to gather lots of data, so the machine learning algorithm is able to be trained to detect abnormal, correlated patterns in production, which will lead to better predicting future production and provide insight into preventing maintenance, which will lead to further reducing of delays on production lines due to failures by applying maintenance before a defect happens.

4. MEMETIC IBEA

The IBEA is a multi-objective version of a genetic algorithm, where the selection process is based on quality indicators. An indicator function assigns each Pareto-set approximation a real value that reflects its quality. The optimisation goal becomes the identification of a Pareto-set approximation that minimizes an indicator function. The main advantage of the indicator concept is that no additional diversity-preservation mechanisms are required [1].

The detailed description of the memetic IBEA can be found in [4], but the main idea is presented as a pseudo code in Algorithm 1. In our implementation of the basic version, the IBEA is used to guide the local search procedures. Since we are dealing with a combinatorial problem, we implemented problem-specific versions of the crossover and mutation operators. Additionally, we added different local search procedures to enhance the efficiency of the algorithm.

Algorithm 1 Memetic IBEA

SetInitialPopulation(P)
Evaluate(P)
while not EndingCondition() **do**
  $P' =$ MatingSelection(P)
  Crossover(P', p_c)
  Mutation(P', p_m)
  Evaluate(P')
  LocalSearch(P')
  $P =$ CalculateFitness($P \cup P'$)
  $P =$ RemoveWorse(P)
end while

Compared to the basic version of the algorithm, the main difference is in the procedure LocalSearch(P'). Here, not only one but many problem specific local search procedures are applied [4].

Such a version of the algorithm is suitable for running a simulation based approach, but it lacks the required dynamicity to actively adapt to changes in the production environment. Two things need to change, first, the changes in the production environment should be transferred to the algorithm solution space, and second, the algorithm should be able to detect and adapt to such changes. Since the production is not a living system that changes every second and requires immediate changes (as mentioned above, the production is fixed for several days in advance) this is not a crucial aspect, since this changes could be applied to the algorithm on a daily basis. But from the point of view of acquiring new orders and providing potential deadlines to the customers, this is another matter. By providing a more dynamic system, a product sales person could easily insert a new potential order and determine what would be the most efficient and safe deadline to be offered to the customer. And if a customer requires an earlier deadline, which could force other orders to be put in jeopardy of missing the deadline, it allows a product sales person to better estimate the required higher price for covering the costs ocured from delays of other orders. The use of machine learning would also cover the irregularities that happen in production.

5. CASE STUDY

5.1 Test cases

The algorithm was tested on two real order lists from the production company. Task 1 consisted of $n = 470$ orders

Table 1: Comparison of the BF (12 threads) and M-IBEA approach (1 thread).

	Evaluations		Time		Pareto
n	BF	M-IBEA	BF	M-IBEA	matching
7	$3.94 \cdot 10^8$	$3.5 \cdot 10^4$	22 s	17 s	4/4
8	$1.58 \cdot 10^{10}$	$5 \cdot 10^5$	15 min	33 s	5/5
9	$7.09 \cdot 10^{11}$	$5 \cdot 10^6$	11 h	5 min	15/15

for 189 different products and Task 2 consisted of $n = 393$ orders for 175 different products. The number of orders n represents the problem dimension, with $m = 5$ representing the number of available production lines.

To mimic the digital twin which is being updated with information once a day (after the end of the daily production) we ran a task overnight and looked at the results. In this time, the algorithm made about 300 million evaluations, so this was set as our stopping criterion for future tests. A lexicographic evaluation [6] was used for presenting multi-objective solutions. In the simulation evaluation, the number of delayed orders (n_{orders}) was set as the most important objective, followed by the required number of workers (n_{workers}), the sum of delayed days for all the delayed orders (n_{days}), and the sum of the change-over downtime in minutes (t_{change}). This order was set according to the most common objective hierarchy.

5.2 Evaluating the approach

To make sure that our proposed M-IBEA was working well, we ran a brute-force (BF) approach where all the possible solutions were evaluated for $n < 10$ orders and the optimal Pareto front was constructed for each of them. Table 1 shows a comparison of the number of problem evaluations, the execution time, and the matching of the Pareto front obtained for $n = 7, 8, 9$. We did not include smaller n values, since in all cases a sub-one-second time was needed with perfect Pareto matching. From the obtained results it is clear that with more than nine orders, the complexity increases well beyond an acceptable time (approximately two months) to calculate all the solutions. Also, in all cases we were able to acquire the same Pareto front using the BF and M-IBEA approaches. When considering times, one must take into consideration that the BF was ran multithreaded with 12 threads fully utilized, while the M-IBEA approach was single threaded. The perfect Pareto-front matching is unsurprising, since the IBEA already proved to be one of the best algorithms for solving multi-objective problems with more than three objectives [3], which was also the main reason that we selected the IBEA as our base algorithm.

5.3 Results

In [5], we optimized only according to the number of orders. To show that the multi-objective approach presented in [4] is a better alternative, we compared the results with regard to the best result from the single-objective to the multi-objective approach. The results showed that the single-objective solution primarily concentrated on the number of orders, while it neglected other objectives. But this is not a surprise, as multi-objective solutions were able to find equally good solutions with regard to the number of orders and significantly better for other objectives, compared to single-objective solution. Though we used the same number of evaluations, this single-objective solution does not stand out with respect to any objective – quite the opposite is the case. This can also be observed from Table 2, where the single-objective solution returns an average quality solution on all the objectives except n_{orders}. The results are summarised in Tables 2 and 3, where the width of the Pareto approximation front is denoted with "Pareto min" and "Pareto max".

Table 2: Results of optimisation for Task 1.

Statistics	n_{orders}	n_{workers}	t_{change}	n_{days}
Pareto min	18	631	353	127
Pareto max	88	823	867	681
Single-objective	18	767	714	156

Table 3: Results of optimisation for Task 2.

Statistics	n_{orders}	n_{workers}	t_{change}	n_{days}
Pareto min	16	538	355	59
Pareto max	50	778	433	330
Single-objective	15	702	443	155

From the results we can conclude that using the Pareto-front approach gives us an expected greater versatility in choosing a good solution, while at the same time we are not sacrificing one, likely the most important, objective. The only important drawback is that multi-objective approaches need many more evaluations than single-objective approaches. So, if we do not have time to carry out enough evaluations, then the single-objective approach is the only way.

6. USABILITY OF MULTI-OBJECTIVE SOLUTIONS

The multi-objective approach provides a set of feasible solutions, offering the possibility to select the final schedule based on the specific decision maker needs. Since none of the given solutions dominates the other solutions, all of them are acceptable. Based on the current conditions, and according to the proposed set of solutions, a decision maker can give more weight to some of the decision criteria. For this an intuitive representation of the resulting solutions inside the GUI of the Planer application was provided, which is presented in Figure 1.

After the M-IBEA algorithm found the set of non-dominated solutions, they are presented in the Planer application. In the upper-right section there is a list of all the non-dominated solutions. In general, there might be up to several hundred possible solutions.

However, some of the criteria can be set tighter according to the resulting range of each criterion, and according to the current business conditions. In the specific example shown in Figure 1, the initial set consisted of 518 solutions. The decision maker put the first objective into the range from 16 to 17 out of 50, which in consequence moved the sliders of the second objective from 697 to 738, the third objective from 405 to 415, and the fourth objective from 60 to 111. So irregardless of which slider is moved, the ranges move accord-

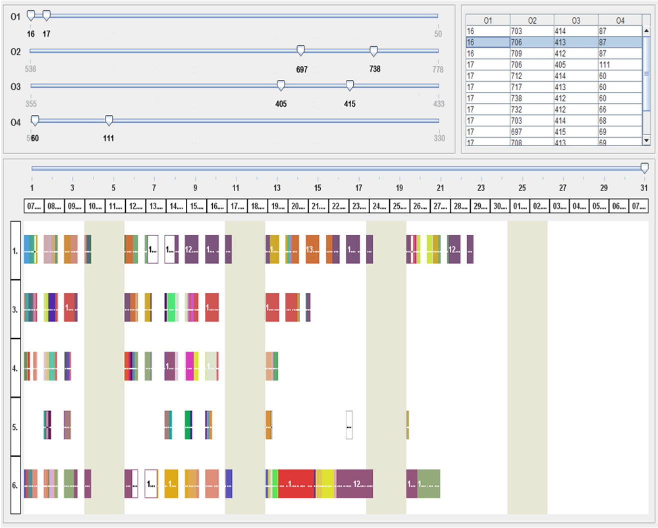

Figure 1: The graphical user interface.

ingly to the possible solutions of other objectives. Simultaneously, the list of possible solutions is updated to reflect the current setting of the objectives' ranges. In the above example, the list narrowed down to 14 solutions. From them, the decision maker can select one solution which best fulfils the current demands. The visual representation consists of all the relevant data, i.e., the production lines' load, the order types' distribution, and change-over downtime lengths, which are necessary to make the final decision. If the visual representation of the solution is accepted, it becomes the production schedule. By determining (using sliders), which objective is the most important in the current situation and to what extent, we automatically determine which part of Pareto front is important and at the same time disregard all the solutions from the Pareto front, which do not fulfil the selected conditions. This way we are able to freely move the useful part of the Pareto front by moving sliders.

7. CONCLUSION AND FUTURE WORK

We presented what steps would be needed to make a memetic, multi-objective approach that used a simulation tool to asses some real-world test cases of a production scheduling problem a more dynamic system by upgrading a simulation tool to a digital twin. From the perspective of the algorithm not many changes would be required, since with a restart procedure being already implemented any changes in the problem description could be "inserted" into the problem solving part.

On the other hand, more substantial changes are required within the simulation tool. Primarily, how required inputs are being automatised (gathering data directly from the company's system). Additionally, an inclusion of some machine learning algorithm, that would be able to detect and predict failures on production lines, is foreseen for better longterm estimation of production.

For future work, we are planning to implement the proposed changes, which will enable for more real-life scenarios (including uncertainties-based worst-case scenarios), while currently only "ideal" solutions are provided, which are often not realistic.

8. ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0098). This work has also received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No 692286 (project SYNERGY) and No 722734 (under the Marie Skłodowska-Curie action project UTOPIAE).

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Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek E

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume E

Delavnica AS-IT-IC
AS-IT-IC Workshop

Uredila / Edited by

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http://is.ijs.si

12. oktober 2018 / 12 October 2018
Ljubljana, Slovenia

PREDGOVOR

Delavnica AS-IT-IC omogoča predstavitev primerov uporabe ter izmenjavo izkušenj med znanstveniki in drugimi deležniki na področju pametnega turizma, ki ga omogočajo inteligentna orodja in storitve, podprte z informacijsko-komunikacijskimi tehnologijami (IKT), predvsem umetno inteligenco (UI). Delavnica omogoča krepitev vezi in sodelovanja med izvajalci praktičnih turističnih storitev in znanstveno-raziskovalno sfero in spodbuja uporabo naprednih rešitev v turizmu. Delavnica je ena izmed aktivnosti projekta *Avstrijsko-Slovenski Turistično-Informacijski Center* (AS-IT-IC), ki je bil sprejet na Programu sodelovanja Interreg V-A Slovenija-Avstrija 2014-2020. Glavni cilj projekta je operativni center, kjer ponudniki turističnih informacij in virtualni asistenti sodelujejo pri odgovarjanju na turistično orientirana vprašanja turistov in jim pomagajo pri načrtovanju izletov na Slovensko-Avstrijskem čezmejnem območju.

Sprejeti prispevki opisujejo stanje projekta AS-IT-IC eno leto pred zaključkom projekta. Prispevek *Avstrijsko-Slovenski Inteligentni Turistično-Informacijski Center: Poročilo o napredku projekta* povzame napredek glede na projektne in programske kazalnike, med tem ko se ostali prispevki osredotočajo na posamezne komponente končnih projektnih rezultatov. V *Pregledu IKT orodij v turizmu* so predstavljene različne IKT rešitve za pomoč turistom in ponudnikom turističnih infomacij. V *Podatkovnih zbirkah AS-IT-IC* so predstavljeni podatki ter podatkovni servisi, ki so na voljo na platformi AS-IT-IC. V prispevku *API za podatke*, je predstavljen sistem za pridobivanje ter dostop do podatkov. V e-Turist2.0 je predstavljena nadgrajena verzija sistema za načrtovanje in priporočanje izletov. V prispevku *Testiranje varnosti pogovornih asistentov z uporabo planiranja* avtorji opisujejo napredni sistem za ugotavljanje varnostnih pomanjkljivosti pogovornih asistentov.

INTRODUCTION

The AS-IT-IC Workshop is a forum for presenting the use cases and exchanging experience among academic and service industry partners on deploying intelligent information communication technology, in particular artificial intelligence, supported tools and services for enabling smarter tourism, as well as stimulating further adoption of such solutions through promotional activities and establishing direct collaboration between academia and industry.

The workshop is an activity of the Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020 project Austrian-Slovenian Intelligent Tourist-Information Center (AS-IT-IC project). The main project output will be the operational center with human and virtual assistants enabling automatic answering to the tourism-oriented questions in natural language and performing services to enable trip planning in the Slovenian-Austrian cross-border region.

Accepted papers describe the AS-IT-IC project state one year before the project conclusion. *Austrian-Slovenian Intelligent Tourist-Information Center: Project Progress Report* summarizes the project progress with respect to project and programme indicators, while other contributions focus on specific modules of the final project results. In *Tourism Related ICT Tools: a Review* different ICT solutions with the aim to help tourist and tourist information providers are presented. In *AS-IT-IC Databases* the data and data services made available through the AS-IT-IC Platform are described. In the *Content API* paper the system for retrieving and serving the data is presented. In *e-Tourist2.0* authors write about the upgraded trip planning and recommendation solution. Finally, the smart security testing for security leaks for common attack scenarios is presented in *Planning-based Security Testing for Chatbots* paper.

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Austrian-Slovenian Intelligent Tourist Information Center: Project Progress Report 2018

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ABSTRACT

Austrian-Slovenian Intelligent Tourist Information Center (AS-IT-IC) is a project that was accepted in the Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020 call. The project goal is to create a joint Austrian-Slovenian center – an information and communication technology (ICT) supported network of service providers and tourist offices, municipalities, tourists and citizens to enhance continuous cooperation between them. The main project output will be the AS-IT-IC operational center with humans involved, having support of the ICT tools for communication, automatic question answering in natural language, information provision, trip recommendation and trip planning. This paper overviews the current state of the project progress.

Keywords

virtual assistants; chatbots; chat platforms; tourism; natural language understanding; AS-IT-IC project

1. INTRODUCTION

According to [1] a tourist cannot get the desired information in an integrated way from both humans and Web services, and much less the joint Austrian-Slovenian services. Typically, Slovenian or Austrian tourist office will provide only predefined national tours and not user-centric cross-border tours. As a consequence, tourists may miss locations they might be interested in visiting and tourist locations get less visits. The goal of the project is to create a joint Austrian-Slovenian center – an ICT supported network of service providers and tourist offices, municipalities, tourists and citizens to enhance continuous cooperation between them. Thus, cross-border tourist exchange, collaboration and expertise transfer between providers will largely increase with respect to the current state. The main project output will be an operational center having support of the following tools: Virtual assistant (providing automatic answering in natural language to the questions and performing services according to demands from tourists), Communication service (ICT solution that will enable conversation between the tourists, virtual assistants, tourist information workers and local communities), Information sources (inclusion of existing information sources), Recommender system for tour planning, Network of tourist services and services from local communities.

The system will help tourists better plan their cross-border visits, discover less popular sites that would otherwise be missed, stay longer and better satisfy their needs. Local communities will easily offer local services and information to visitors, e.g. a tour might include visiting a specialized craftsman and boost the selling of local products. Tourist officers will get better access to tourists. AS-IT-IC project (Table 1) provides the integration of virtual and human services from Austria and Slovenia with the uniform functionality – to provide most relevant information, attract tourists, and prolong their stay.

Table 1: Project information card

Title	Austrian-Slovenian Intelligent Tourist Information Center
Partners	1. Institut "Jožef Stefan" (lead partner) 2. Technische Universität Graz, Institut fűr Softwaretechnologie 3. Javni zavod za turizem, šport, mladinske in socialne programe SPOTUR Slovenj Gradec 4. Združenje občin Slovenije 5. Graz Tourismus und Stadtmarketing GmbH
Duration	From 1. 7. 2016 to 30. 6. 2019

The rest of the paper goes as follows. In Section 2 we describe the state of deliverables and project workpackages, in Section 3 we describe the project idea, while Section 4 overviews the state of the prototypes and provides information on what has been accomplished by now. Sections 5 and 6 describe the project dissemination activities and project impact, respectively, so far. Section 7 concludes the paper.

2. PROJECT PROGRESS

The project has entered the last year of implementation (Figure 1). While the majority of the technical details (Table 2) have been resolved, the project results are still under active implementation and testing. Additionally, the dissemination strategy and sustainability plan will be addressed in more details in the coming months.

3. PROJECT IDEA

The AS-IT-IC project tries to combine several solutions that already provide partial solutions for smarter tourism: attraction discovery, trip planning [2], and communication

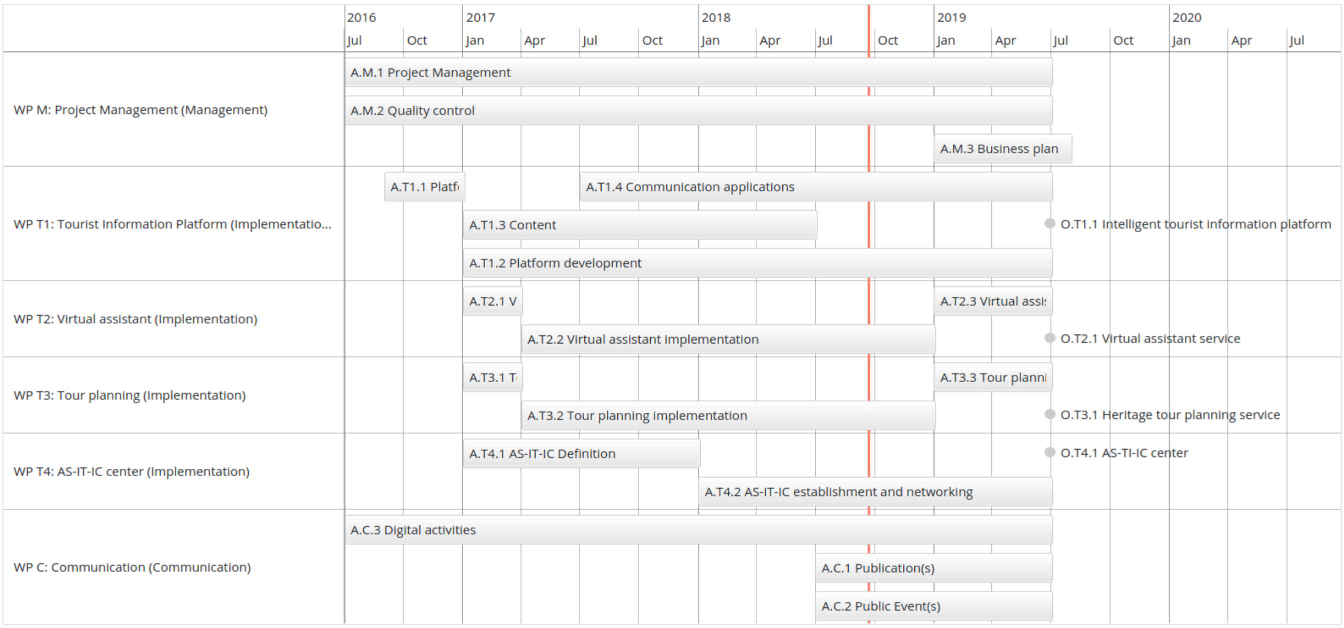

Figure 1: Project Gantt chart

Table 2: Project deliverables status

Management	Project reports	3/6
Communication	Dissemination and promotion report	not started
	Promotion material	✓
	Publications	2/4
	Scientific publications	7/1
	Workshops on AS-IT-IC	4/3
	Participation in tourist related events	0/3
	Project website	✓
Tourist information platform	System requirements and specification	✓
	Tourist information platform	in progress
	Content items	✓
	Content creation guidelines	✓
	Communication applications	in progress
Virtual assistant	Virtual assistant requirements	✓
	Virtual assistant service prototype	in progress
	Virtual assistant service	not started
Tour planning	Tour planning requirements	✓
	Tour planning service prototype	in progress
	Tour planning service	not started
AS-IT-IC Center	AS-IT-IC Deliverable	✓
	AS-IT-IC Center	in progress

with human and virtual assistants [3, 4]. In order to provide the state-of-the art platform that enables smarter tourism several open source technologies, data sources and internal tools and services were examined, upgraded and are in the process of integration into one tourism platform – the AS-IT-IC platform. Using the open source software enables us to start with a solid working solution and provide necessary modifications as required by the project. A simplified reference architecture is presented in Figure 2.

3.1 Communication platform

The communication platform enables the users to communicate with each other (tourist – tourist, tourist – tourist information provider, tourist – virtual assistant) over the chat based interface. Increased popularity of chat applications (Facebook messenger[1], WhatsApp[2]) prove that this is a valid communication option used for exchanging and obtaining information. The main benefit being the option to upgrade the communication by integrating various virtual assistant services.

3.2 Virtual assistants

Virtual assistants (also chatbots or conversational robots [3]) are computer programs that can process input in natural language and provide a reply. The input can either be voice or text and the answer is usually a combination of a response in natural language and an action that was carried out by taking into account the user input. An example would be as follows. User asks ”What are some cultural heritage sights I could visit near me?”. The virtual assistant would then first identify the intent (the user would like to execute a search) and the arguments (location: near the user, type of sight: cultural heritage). Then it would acquire user location and user preferences from the system and issue a request to the system database in order to obtain relevant attractions. The

[1] `https://www.messenger.com/`
[2] `https://www.whatsapp.com/`

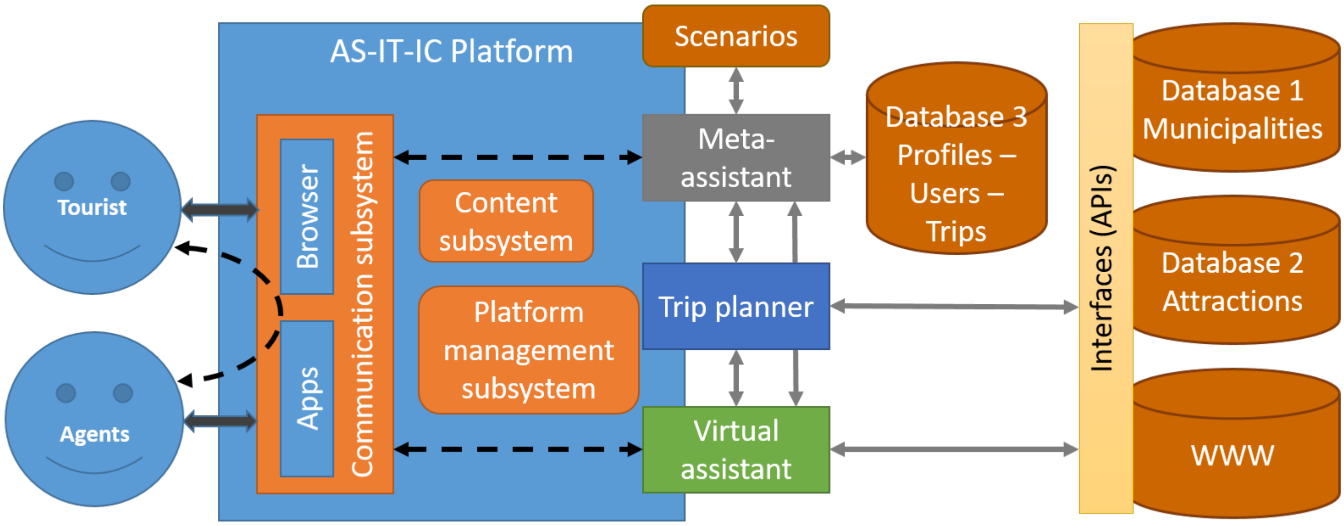

Figure 2: Simplified architecture corresponding to the project idea

results would then be properly formatted and presented to the user: "I have found the following attractions that match your search: Ljubljana castle, Cankar memorial house and Manor pavilions. Would you like to learn more about a specific attraction?".

3.3 Trip planner

Trip planners [2] help the user in planning the trip by keeping track of the places the user intents to visit, recommending attractions and points of interest relevant for the user, and automatically arranging the itinerary in order to optimize the travel between the items on the itinerary. Trip planners usually also enable the user a visual overview of the whole trip and sometimes even enable the navigation.

3.4 Databases

At the heart of the platform are the databases that provide all the information required by the AS-IT-IC services. The databases provide structured data that can be used by several services for further processing. The databases consist of: the information about the attractions and other points-of-interest (castles, caves, restaurants, etc.); the information about the geographical entities (places, regions, rivers, municipalities, etc.); and information scraped from the useful webpages (municipality information, opening hours, etc.).

Beside the "Content" databases the system also requires databases for user management and storing of the system states and user generated content (conversation, saved trip itineraries, etc.).

4. PROTOTYPES

The AS-IT-IC platform will consists of services deployed either using Docker[3] virtualization technologies or Flynn[4] – a self-hosted platform-as-a-service.

4.1 Communication platform

As a base an open source team communication software Rocket.Chat[5] was chosen. In order to meet the project requirements, several additions were developed: a custom home dashboard; a message modification for improved user experience; a custom information tab with information about the trip; notification modifications for better operation of mobile communication application; custom application programming interface for automatic message processing and posting. Screenshot of the conversation user interface is presented in Figure 3.

4.2 Virtual assistants

The virtual assistant used in the AS-IT-IC platform comprises several modules. Two approaches were used when designing the assistant modules: rule-based approach (which is an upgrade of virtual assistants deployed at Jožef Stefan Institute and the majority of Slovenian municipalities [3]); and natural language based approach [4]. The rule based models are more stable and easier to debug and understand, however, they have the issue of rule design, since every rule has to be designed by hand, which is why they take a long time to implement. The natural language based modules, however, enables one to produce a virtual assistant that transforms the natural language input into a structured format that can be further used by computer programs. The main disadvantage of such systems is the need of a language model (which is an active area of research, especially for smaller languages such as Slovenian) and the need for a large set of training data.

Within the AS-IT-IC Platform the rule-based approach is used for the virtual assistant action that results from the user interaction with the uniquely identifiable objects present in the user interface (for instance buttons) and for common text input provided by the user. The natural language based approach is used for intelligent search capabilities and in cases where the rule-based approach fails to work. Two backends are currently used for parsing the user input and

[3]https://www.docker.com
[4]https://flynn.io/
[5]https://rocket.chat/

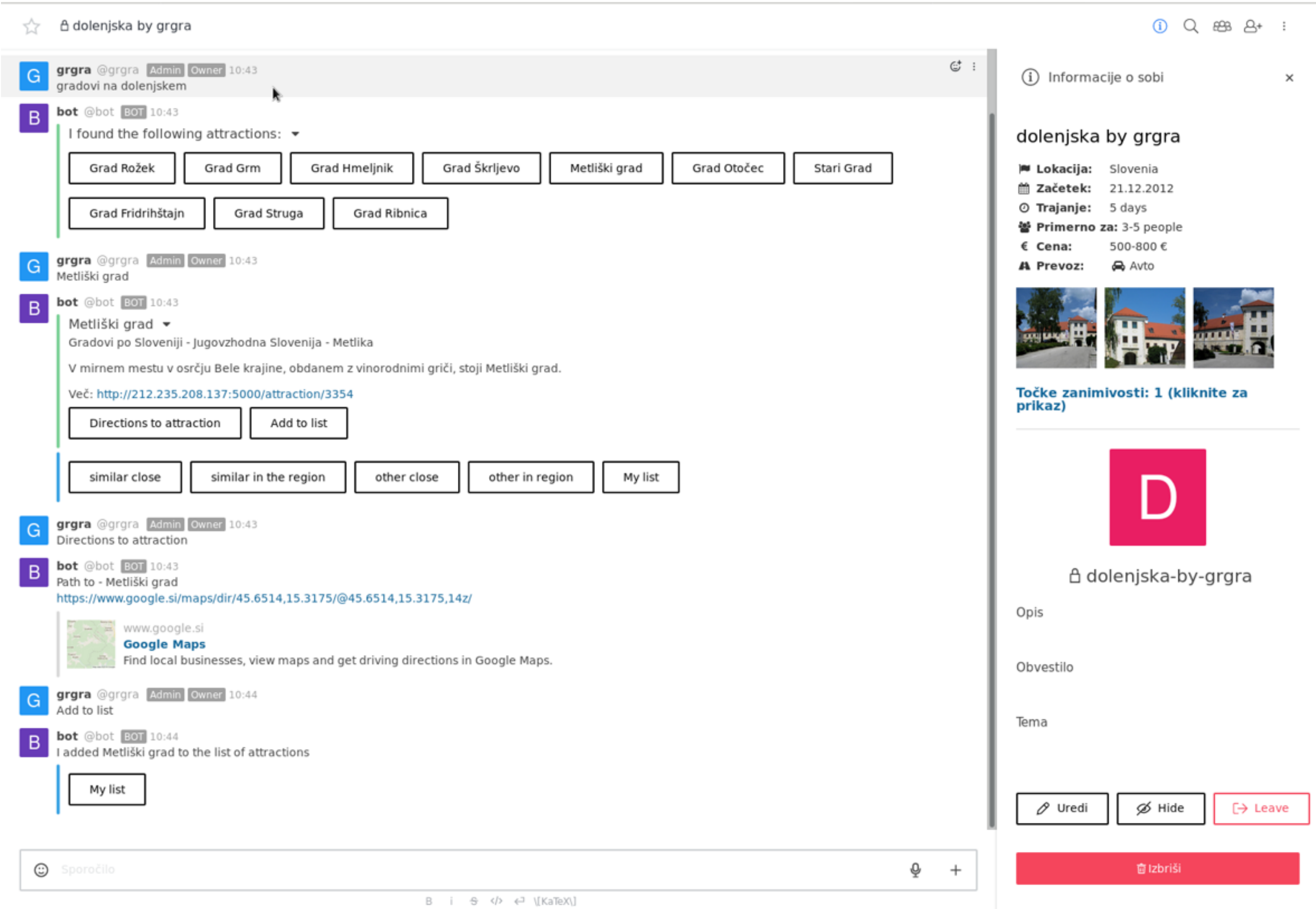

Figure 3: Conversation user interface

translating it into structured text – Dialogflow[6] and Rasa[7]. Additionally, in some cases we take the advantage of the full-text search capability of the PostgreSQL[8] database – we have made the required adjustments for the full-text search to work in all three project languages: Slovenian, English and German.

Adapters were developed that enable the interaction between the communication system and the virtual assistant services: reading the user input, processing the text, performing required actions and returning a response to the user.

4.3 Trip planner

A basis for the trip planner used in the AS-IT-IC platform was the e-Tourist application [2]. In order to meet the project requirements heavy modifications were made to the e-Tourist codebase: the databases were extended to support additional attraction and geographical data; the routing was adjusted so that the trip planner can be used by third party applications; user management was upgraded to enable AS-IT-IC platform users to automatically log-in into the system; several functions that were previously coded by hand were moved to the database, which significantly reduced the project size; and all the modules used by the application were upgraded to the latest versions, therefore increasing the application security.

[6]https://dialogflow.com/
[7]https://rasa.com/
[8]https://www.postgresql.org/

4.4 Databases

Webpages and datasources that contain relevant tourism-oriented information and enable the use of the content for non-commercial purpose were reviewed and gathered. While there are many datasources with relevant information (Slovenia.info[9], DEDI[10], OPSI[11], Geoportal ARSO[12], e-Geodetski podatki[13], eVode[14], register kulturne dediščine[15]) there was additional work needed to unify the data formats, remove the data that was not of sufficient quality and integrate all

[9]https://www.slovenia.info/en
[10]http://www.dedi.si/
[11]https://podatki.gov.si/
[12]https://gis.arso.gov.si
[13]https://egp.gu.gov.si/egp/
[14]http://www.evode.gov.si/sl/vodni-kataster/zbirka-vode/zbirka-podatkov-o-povrsinskih-vodah/hidrografija/
[15]http://www.mk.gov.si/si/storitve/razvidi_evidence_in_registri/register_nepremicne_kulturne_dediscine/

the data into one database.

5. DISSEMINATION

Project partners have been active in disseminating the project results, producing scientific papers at conferences and international journals, producing publications for general public, maintaining the project website, hanging project posters at partner sites, and organizing workshops.

Scientific papers and publications for general public introduced the project to the wider audience by presenting the project idea, describing the need for such a project, and presenting tools, services and prototypes, developed within the project. Project partners have so far contributed to 7 scientific papers and 2 publications for general audience.

Project website[16] was deployed in the first half year of the project. It presents all relevant information about the project and project partners, together with the project news. Additionally it enables the visitors of the website to contact the project partners.

Project posters were designed according to the Cooperation Programme Slovenia-Austria rules and posted at partner sites (Jožef Stefan Institute, GUT Institute for Software technologies, and Association of municipalities of Slovenia).

Workshops are one of the main dissemination channels, where partners invite general audience to attend or the partners present the project and project results to the general audience. Several workshops were organized, where AS-IT-IC project was presented: "AS-IT-IC Workshop" within the Information society 2017 Multiconference, "Presentation of tourism applications" workshop on behalf of the invitation in Nazarje, "Artificial Intelligent into every municipality" workshop organized at Jožef Stefan Institute, and a "Site visit" workshop organized at Jožef Stefan Institute, where Jožef Stefan Institute employees were invited.

6. PROJECT IMPACT

The AS-IT-IC project enables the project partners to greatly increase the cooperation in the cross border area. The partners have organized five cross-border meetings, which resulted in the exchange of information, data, examples of good practice in the field of tourism and also in additional project application. The partners also cooperated in the organization of workshops, which enabled the project partners to reach several third party stakeholders: 7/50 (7 reached out of 50 promised) representatives from local public authorities – entities were reached so far (ministries and municipalities); 10/30 representatives from interest groups including non-governmental organizations (development centers, tourist organizations); 7/5 small and medium sized companies; and 89/3000 interested individuals.

The main communication goals of the project are:

1. Integrated tourist communication service: to raise awareness of the AS-IT-IC platform. AS-IT-IC was mentioned five times in press and web page news.
2. Tourist workers networking: to change behaviour and increase the cooperation of tourist workers and providers of ICT tools for tourism. Nine meetings and workshops were organized to promote AS-IT-IC and enable such networking.
3. eHeritage: to raise the awareness of the need to make the description of heritage sights and attractions available on the Internet in a way that enables easy search and the inclusion of such attractions into the tourists' itineraries. So far cca. 1000 heritage attractions were inserted into the AS-IT-IC content database.

[16] https://as-it-ic.ijs.si

7. CONCLUSION

In the paper we presented the AS-IT-IC project, its goals and the issues it addresses. Project partners from the Slovenian-Austrian cross-border area came together in order to enable smarter tourism by integrating several tools and services into one platform. The project has entered its last year of implementation and so far the development has gone according to the plan. The prototypes for communication platform, virtual assistant, and trip planners are under development and will soon be ready for integration into the AS-IT-IC platform and ready for testing by end users.

The majority of the future work will be on disseminating the project results and attracting a larger user base. To this end the tourist partners are in contact with the major tourist organizations (such as Slovenian tourist board), which will enable us to reach a wider target audience and receive useful user feedback.

Additionally, the partners will look into sustainable options for transferring the AS-IT-IC Platform management to interested organizations. This will enable additional growth of the AS-IT-IC Center, while the partners will maintain the functionality of the AS-IT-IC platform as developed for the purpose of the project.

8. ACKNOWLEDGMENTS

The work was co-funded by Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020, project AS-IT-IC.

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Tourism Related ICT Tools: a Review

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ABSTRACT
In the paper we review the existing information and communication technology (ICT) based tools and services that empower tourists and tourist information providers in obtaining and providing information needed for trip planning. We define four tourism-related service categories: search with booking, trip planners, chatbots, and forums. We summarize the good practices identified in the reviewed tools and expose the issues stemming from the fragmentation of the tools and data. In order to overcome the identified problems we propose the AS-IT-IC Platform – a project result of the Austrian-Slovenian Intelligent Tourist Information Center (AS-IT-IC) project, accepted in the Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020 call. The AS-IT-IC project aims to integrate several functionalities usually offered by distinct services, unifying the databases, and providing free access to tools and services for tourists and tourist information providers.

Keywords
virtual assistants; chatbots; tourism; trip planning; search; review; AS-IT-IC project

1. INTRODUCTION
Due to the increase in the Internet usage it has become paramount that organizations and their tools are accessible through the Internet. In the last few years a steep increase in the mobile usage has additionally fueled the development of mobile applications and mobile friendly web applications, several of those in the domain of tourism.

In this paper we present the tools provided by organizations that operate on a global scale. We categorize the tools into four categories:

1. Search with booking
2. Trip planners
3. Chatbots – conversational robots
4. Forums

Each category is unique: in the ways it helps the user in the process of trip planning; in the type of data it uses; and in the target users. This, however, leads to the fragmentation of data and the need for: tourists to check several web sites and applications, when searching for the trip-related information; tourists to call or go to local tourist information offices for additional info; tourist information providers to keep their information available in several systems all over the internet and structured in different – often incompatible ways; tourist information providers to pay for the presence on tourism-tools and services. There is clearly room for improvement [3] and the first step would be the establishment of an online platform that would in one place integrate several services and tools and enable the users to gather and provide all necessary information related to trip planning. One such platform is being developed within the Austrian-Slovenian Intelligent Tourist Information Center (AS-IT-IC) project.

The rest of the papers continues with the description of four categories of tools and services in Sections 2, 3, 4 and 5. Good practices are summarized in Section 6 and the need for an integrated solution is addressed in Section 7. Section 8 concludes the paper.

2. SEARCH WITH BOOKING
The group offering the least functionality is the one of search engines for hotels, plane flights, restaurants and such. The user is mostly required to input a predetermined set of parameters, and is then referred to a list of matching options they can choose from. This list can sometimes be further filtered and/or sorted based on additional criteria. After deciding on what suits them best, the user is relegated to booking, which is how the site makes money.

Of course most if not all hotels, airlines, tourist agencies and other tourist providers have their own websites, which allow a prospective user to directly book their services. The examples below are of search engines that accumulate data from many such sites, or get it directly from the end providers and try to make it more convenient for a prospective tourist to find what they are looking for.

- Sabre – `https://en.eu.sabretravelnetwork.com/home/page/book_flights_hotels`
- Expedia – `https://www.expedia.com`
- TripAdvisor – `https://www.tripadvisor.com`
- Priceline – `https://www.priceline.com`
- Yelp – `https://www.yelp.com`

- OpenTable – https://www.opentable.com/start/home
- Booking.com – https://www.booking.com
- Skyscanner – https://www.skyscanner.com

3. TRIP PLANNERS

A slightly more interesting group is the group of trip planners. They also require the user to input a set of predetermined parameters, but unlike in the previous group where the parameters are mostly the same on all websites, here they vary quite a lot from service to service. What is different is also that these services mostly output a single trip plan which can later be modified. After a user decides on their final trip plan, they are offered accommodation and transportation booking necessary for the trip's realization. The booking stage on some of the websites utilizes services from the first category. Some interesting examples of such services are provided below.

- Roadtrippers – https://roadtrippers.com
- Mapquest – https://www.mapquest.com/routeplanner
- Triphobo Tripplanner – https://www.triphobo.com/tripplanner
- Inspirock – https://www.inspirock.com
- Sygic Travel – https://travel.sygic.com
- routeperfect – https://www.routeperfect.com/trip-planner
- wanderapp – https://www.wanderapp.me
- Go Real Europe – https://www.gorealeurope.com

4. CHATBOTS

With the emergence of natural language processing tools like dialogflow[1], wit[2] and rasa[3] that make it quite easy for developers to implement chat based interfaces in a growing number of languages, there has been an explosion in the number of applications and websites that offer a chat based interface. There are even companies like Botflux[4] that offer their customers custom made chatbots.

Facing the consumer, chatbots offer a more dynamic (request values for different parameters based on the user's input so far) and interactive approach to defining the user's requirements than classical forms and menus. They also offer a completely new experience when using a voice interface through a smartphone or a specialized device such as Amazon's Echo or Google Home. A good resource for finding interesting chatbots based on the messaging platform, where one can converse with them, and their area of expertise is botlist.co[5].

[1]https://console.dialogflow.com
[2]https://wit.ai
[3]https://rasa.com
[4]https://www.botflux.com/tourism
[5]https://botlist.co/

4.1 Customer service chatbots

One of the trends in using chatbots is to automate customer service on a company's website. Things like providing answers to frequently asked questions, or finding relevant information on the website without having to manually search for it can easily be automated by chatbots. The aim of these bots is to reduce the load on human customer service staff and to provide a better customer experience by making it easier and faster to get answers from data on the website. In this context a chatbot is an addition to an existing website, often appearing as a chat window in one of the corners.

Examples of such chatbots are:

- Ana – https://connectmiles.copaair.com/en/web/guest/ask-ana
- Julie – https://www.amtrak.com/about-julie-amtrak-virtual-travel-assistant

4.2 Instant messaging chatbots

With rising popularity of instant messaging platforms like Facebook's messenger[6] and Telegram[7] that expose APIs for bots to converse with users, many bots now exploit this channel for access to users. By responding to messages in group chats (possible on Facebook's messenger for instance), chatbots are a new way for making a product more discoverable and for making the user's trip from wish to purchase shorter.

In many cases chatbots present on an instant messaging platform are just a different interface to an existing service. Examples of such bots are:

- Expedia – https://viewfinder.expedia.com/features/introducing-expedia-bot-facebook-messenger
- Skyscanner – https://www.skyscanner.net/news/tools/skyscanner-facebook-messenger-bot
- Cheapflights – https://www.cheapflights.co.uk/news/cheapflights-chat-awards
- Hello Hipmunk – https://www.hipmunk.com/hello

There are a number of chatbots that act as aggregators over different services. They provide a conversational interface for searching offers from many sources and providing the user with the result that most closely matches their requirements. An example of such a bot is Assist[8], a chatbot that aggregates several services for making hotel reservations, ride hailing, making table reservations and online shopping. It is the only product of a start up with the same name and can be used through messenger, Telegram, SMS, Twitter, Google Assistant and Slack.

According to statista[9], business travel in 2016 amounted to 1.3 trillion USD and represented about 10% of all travel

[6]https://www.messenger.com/
[7]https://telegram.org/
[8]http://www.assi.st/
[9]https://www.statista.com/topics/2439/global-business-travel-industry

spending in 2015. Thus it makes sense that a number of travel chatbots are specifically targeting business travellers:

- Carla – `https://www.cwtcarla.com/CarlaWeb`
- Pana – `https://pana.com`
- MEZI – `https://mezi.com`

A different kind of application is a so called virtual concierge. Its main goal is to assist in communication between hotel staff and their guests by providing an interface for checking into a hotel, ordering room service, and requesting information about the hotel. They have automatic translation integrated into the service, so customers can interact with the staff in their native language. These applications are in this category because they mainly function through a conversational interface and use instant messaging technology. Also some of their functions are fully automated so they are bots and not just messaging apps with translations. An example of such a virtual concierge is The Besty[10], a phone app to help people communicate with their hotel's staff as well as find and book tours, restaurants and activities at the "lowest" prices. They also offer tour guides and live chat with local tour experts. The MEZI chatbot, mentioned earlier also offers a virtual concierge service of this kind as part of its capabilities. Another example of this kind of chatbot is Hi Jiffy[11]. It is available on messenger, and allows searching for hotels and making reservations in addition to its customer care functionality. It employs a model where queries that cannot be answered automatically are forwarded to hotel staff. The query and the provided answer are then included in the bot's training set so that it can answer automatically when a similar query is input by a user. According to its website 77% of its answers are provided automatically at the time of this writing.

5. FORUMS

When people want opinions, recommendations or advice, they turn to the forums, where they can ask questions related to their planned excursions and get answers from travellers who have been there before. On some of the forums, travel agents seem to be quite involved as well, answering questions by prospective tourists while advertising their services. All of the forums we came across cover travelling to the whole world, but usually have a different section for each continent which is then further divided by country.

Most forums also have a section dedicated to posting longer accounts of travellers who believe they have experienced something worth sharing. An interesting website that collects longer posts by travellers as well as photos is Travelblog[12]. In addition to their forum for discussing travel plans and asking for advice, they also have a blog section, where anyone can write about their experiences or post a photo they think is particularly eye catching, and the rest of the users will vote on the best blog and photo of the week.

[10]`https://thebesty.com/`
[11]`http://hijiffy.com/`
[12]`https://www.travelblog.org`

In most cases travel related forums appear as part of a bigger travel related website. The popular TripAdvisor website also includes a typical travel forum[13] of this kind. Questions and responses are checked for destinations and attractions TripAdvisor knows and if any are found, they are displayed in a card, below the user's post, showing their name, a picture and their ranking. Clicking on the card will show the site for that attraction.

Another example of a website that also includes a forum is Lonely Planet[14]. According to Wikipedia[15] they are the largest travel guide publisher in the world. They also provide a website that would fall into the search with booking category, coupled with their newsletter and of course selling travel guides. This rather expansive website also includes a forum for exchanging "travel advice, hints and tips" as they put it. The forum is not limited to country based discussions but also has (among others) sections about equipment, travel health and vaccinations, searching for travelling companions, house sitting and swapping as well as people selling and buying stuff through the forum.

According to the quick analysis of posts, Fodor's Travel Talks Forum[16] seems to be the most popular. They also sell guidebooks and have a very extensive website that also offers hotel bookings.

As we are living in the age of social media, it would be remiss not to mention the `#travel` tag on Twitter[17], used to post about travel experiences, as well as the existence of quite a number of twitter accounts that are dedicated solely to travel news[18].

6. GOOD PRACTICES

By reviewing the existing ICT solutions available on the internet, the following commonalities and good practices were observed.

1. Since almost 53% of all internet traffic in 2017 was produced through mobile devices[19], having a mobile application or a different way of making the application work on a mobile phone (like through messenger, or a mobile-first web application) is a must.
2. When possible it is a good idea to integrate with applications users are already using in their everyday life, like calendars. This allows to get user data without needing the user to type everything, as well as enables the user to use the results of an application more conveniently.
3. Integrating multiple data sources into a single view is very helpful for users as they get more complete

[13]`https://www.tripadvisor.com/ForumHome`
[14]`https://www.lonelyplanet.com/thorntree/welcome`
[15]`https://en.wikipedia.org/wiki/Lonely_Planet`
[16]`https://www.fodors.com/community`
[17]`https://twitter.com/`
[18]`http://mashable.com/2012/08/04/travel-twitter/#KtwUdPjm_Gqw`
[19]`http://www.trendreports.com/article/technology-in-tourism`

information about a destination and do not have to check multiple sources on their own.

4. Many popular applications scrape provider websites for information and special offers. Others rely on providers to manually enter all information.

5. Sites that cover a wider geographical area are more useful, since they provide a one-stop shop for the whole trip as opposed to having to visit several websites to get informed on each destination individually.

6. Availability through multiple channels. Having a website is fine, but also being available through other channels, especially instant messaging platforms really helps with discoverability.

7. Until the invention of general AI, machines will be limited in what they can do, so to minimize customer frustration, keeping humans in the loop on the provider side can be very helpful.

8. Making customization of automatically generated trip plans and other suggestions as easy and complete as possible, or the users will only use the tool to get the suggestions then they will use more low level tools to actualize the parts they liked. This lowers the conversion rate of the tool and makes customers less happy.

9. Allowing users to filter and sort displayed information based on their interests. A good example is how Roadtrippers allows users to set what kinds of points of interest they want to see on the map.

7. RELATION TO AS-IT-IC

The AS-IT-IC project tries to combine several partial solutions already implemented by the ICT tools mentioned in this paper: attraction discovery, trip planning [1], and communication with human and virtual assistants [2, 4]. In order to provide the state-of-the art platform that enables smarter tourism several open source technologies and data sources were utilized and integrated into one tourism platform – AS-IT-IC platform.

AS-IT-IC project empowers tourists by: helping in obtaining all the required information related to trip planning in one place; and enabling discovery of local and less known but still relevant attractions. Further, it empowers tourist information providers by: providing an integrated way of exposing the tourism content in his or her area to the Internet; and enabling the access to the tourists in an asynchronous, modern chat-based style.

The reviewed tools, together with traditional communication methods, indeed already offer the same or at least very similar functionality as is planned for the AS-IT-IC platform. However, even disregarding the obvious benefit of the functionality integration into one platform, there are still advantages of the AS-IT-IC project results, for the time being mainly for the Slovenian-Austrian cross-border area:

1. Larger database of attractions.

2. Inclusion of path-based attractions – for instance wine roads, or walking trips and geographical information.

3. Cooperation of several local tourist information centers with vast knowledge on the touristic offers in their area.

4. Free access for tourists and tourist information providers.

5. Open access to data and data services.

The AS-IT-IC Platform, however, does have one big disadvantage compared to the rest of the services – it is a publicly founded project with reserved funds for the development and initial activities to raise the project awareness and disseminate results. After the end of the project, no resources have been granted yet to further promote project results. While the partners have committed to maintain the project results for another 5 years after the end of the project, the issue of getting sustainable funds to enable further promotion and dissemination is yet to be solved.

8. CONCLUSION

In this paper the ICT tools provided in order to empower smarter tourism are presented. Providers from around the world were taken into account. The tools were classified into categories in order to provide a sense of what is available for tourists and tourist service providers. Additionally, the tools were critically assessed and good practices were identified. Further, the AS-IT-IC Platform was compared to existing tools and main similarities and differences were pointed out.

The review provides a basis for anyone interested in the deployment of tourism-oriented services. One has to take into account, however, that not every problem in tourism has a technological solution. One of the main components of the AS-IT-IC project is the networking one, where the goal is to connect several stakeholders that provide technology solutions to the users in need of such solutions.

9. ACKNOWLEDGMENTS

The work was co-funded by Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020, project AS-IT-IC.

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AS-IT-IC Databases

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ABSTRACT
Austrian-Slovenian Intelligent Tourist Information Center (AS-IT-IC) is a project that was accepted in the Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020 call and has two main goals: one is to build information and communication technnology (ICT) tools to support the tourist when he or she creates personalized itinerary for the visit of Slovenian-Austrian cross-border area; and the second is to create a sustainable community that will support the use of the tools. In this paper we describe the provision, cleaning, integration and deployment of data and data services needed by the ICT tools in tourism. Data and data services form one of the main pillars that enables the AS-IT-IC platform to provide tools and services, which could serve tourism-related information to end users – tourists and tourist information providers.

Keywords
web spider; data; tourism; databases; web services; AS-IT-IC project

1. INTRODUCTION
There is an increasing number of services and applications available for tourists and tourist information providers across the Internet. The services could be roughly categorized into the following categories: *Search with booking*; *Trip planners*; *Virtual assistants*; and *Forums*.

Search with booking enables the user to search for a type of accommodation, transport or adventure, specifying the time interval of using the services and in some cases even buying the service or reserving it. Examples are Expedia[1] and OpenTable[2].

Trip planners enable the user to view attractions in certain area, obtain additional attractions by clicking on them and forming a customized trip. Examples of such services are Roadtrippers[3] and Triphobo Tripplanner[4].

Virtual assistant enables the user to obtain tourism-related information using a rich-text based interface, similar to the ones provided by Facebook Messenger[5] . Examples include Hello Hipmunk[6] and MEZI[7].

Forums provide a place where usually users but sometimes also professionals provide descriptions of their trips, express their opinions about attractions and places to visit, and provide helpful advice to fellow travellers. Examples include Fodor's Travel Talks Forum[8] and Lonely Planet[9].

In order to provide such services developers need data. The data can be obtained in several ways:

1. The information about attractions and other points of interest can be obtained in advance (as is the case with some trip planners and virtual assistants).
2. By making an application programming interface (API) call to an external service (search with booking).
3. By relying on users to provide the content when the application is already live (forums).

The ICT tools that will be used directly by the users and are developed within the AS-IT-IC project integrate several services that belong to the before-mentioned categories: communication platform that enables communication of tourists with tourist information providers and virtual assistants; virtual assistant, which provides useful information 24/7;

[1]https://www.expedia.com
[2]https://www.opentable.com/start/home
[3]https://roadtrippers.com
[4]https://www.triphobo.com/tripplanner
[5]https://www.messenger.com/
[6]https://www.hipmunk.com/hello
[7]https://mezi.com
[8]https://www.fodors.com/community
[9]https://www.lonelyplanet.com/thorntree/welcome

and tour planning for the automatic creation of a trip. In order to provide useful tourist information services, we had to combine several data procurement options, also used by other systems that usually cover only a part of the AS-IT-IC functionality.

Additional difficulty in obtaining the data was the fact that AS-IT-IC covers the Slovenian-Austrian cross-border area, for which little structured information is available. This is especially true for natural and cultural heritage attractions, which are the focus of the Interreg Slovenia-Austria Programme. We reviewed several data sources that are available for non-commercial use and tried to include the most relevant and quality ones.

According to the review, the following types of data was identified as useful: attraction data and tourism-related points-of-interest (natural and cultural heritage, sights, activities, accommodation, places to eat etc.); geographical data (structured representation of geographical entities such as rivers, lakes, municipalities, cities etc.); and services related to getting from place A to place B, so called routing services.

In the rest of the paper we review available data sources in Section 2. Further, we describe the data related to attractions in Section 3, the geographical data in Section 4, and the chosen routing system in Section 5. Section 6 provides a brief description of how the data will be used within the AS-IT-IC Platform and Section 7 concludes the paper.

2. DATABASES AND DATA SOURCES

The following data sources were identified as the most relevant:

1. Slovenia.info website[10] (Figure 1). The data source comprises 8798 tourist attractions and is still growing, due to the fact that the tourist information providers are constantly uploading and updating new attraction descriptions.

2. Dedi.si website[11]. The data provided by this website comprises only natural and cultural heritage, therefore being very suitable for the purpose of the project. However, due to the incompatible data formats, the inclusion of the Dedi.si data is postponed for the time being.

3. Europeana website[12]. This data source stores the data about artworks, artifacts, books, films and music from European museums, galleries, libraries and archives from around the world. The number of all entries is around 58 millions. However, due to the automatic data collection the information is very often wrong. We have decided to not include the Europeana data.

4. Open data portal of Slovenia[13]. The portal provides the information, tools, and useful resources, which can be used in web and mobile applications. There are fourteen data categories on the web site: Population and Society, Justice, the legal system and public safety, Public Sector, Education, Culture and Sport, Social and employment, Health, Environment and Spatial Planning, Transport and infrastructure, Agriculture, fisheries, Forestry and nutrition, Finance and Taxes, Economy, Energy, Science and Technology and International Affairs. Some of the datasets available on the portal are of interest also for the tourism domain, for instance a computer readable map of bodies of water, where bathing is possible.

5. Slovenian Cultural heritage register[14]. This is an official database of cultural heritage on the territory of the Republic of Slovenia, provided by the Ministry of Culture of Republic of Slovenia. The registry contains 30.095 entries of several types. The big disadvantage of this database, however, is that the use of the database is prohibited for online applications, which is a big drawback in the information age – especially since the data is of public interest.

6. Graz Tourism database. The data of this website comprises the tourism sights, attractions and offers of the city of Graz and its neighbouring regions. The data is available via a back-end using a REST-JSON API. The data is maintained by Graz Tourism and the tourism partners to provide detailed and high-quality data.

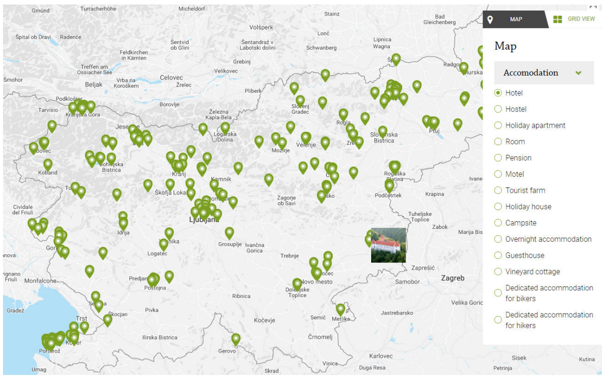

Figure 1: Tourist attractions from Slovenia.info

3. ATTRACTIONS DATA

This sections describes all the attributes used to represent an attraction datum. Data was structured in an appropriate way that will enable the AS-IT-IC services to provide different kind of functionality.

The data was imported into the PostgreSQL[15] database, where each datum insert is represented as follows (the data structure is based on the already developed e-Tourist systems [1]):

- title (sl, en, de, it): the title of attraction stored in four languages – Slovenian, English, German, Italian. For example "Gostišče Kimovec"

[10]`https://www.slovenia.info/en/map`
[11]`http://www.dedi.si/`
[12]`https://www.europeana.eu/portal/en`
[13]`https://podatki.gov.si/`

[14]`http://www.mk.gov.si/si/storitve/razvidi_evidence_in_registri/register_nepremicne_kulturne_dediscine/`
[15]`https://www.postgresql.org/`

- description (sl, en, de, it): description of tourist attraction in four languages
- category (sl, en, de, it): for example "Adrenaline sports"
- subcategory (sl, en, de, it): for example "Paragliding"
- location: GPS coordinates of tourist attraction, for example "(45.94,13.71"
- figure: image that represents the tourist attraction (web path)
- trip advisor: attraction rating retrieved from TripAdvisor[16] web site
- address: "Zgornji Hotič 15, 1270 Litija"
- recommended viewing duration time: "1:30:00"
- price range: how much does it cost to visit the attraction "1-5"
- expert evaluation: what is the expert opinion in the quality of the attraction "1-5"
- parking: parking options
- campers: availability of camper parking
- web page: "www.gostisce-kimovec.com"
- phone: "05 458 654"
- working hours: "mo-fr: 8:00-18:00"
- working hours comment: "Always opened"
- accessibility: how can one visit the attraction "(car, walk, bike, boat, bus)"
- keywords: few keywords that relate most to the attraction

According to the data analysis, the data categories are presented in Table 1.

Table 1: Category counts for the attraction data

Category	Count
Accommodation	2040
Adrenaline sports	63
Casinos	59
Cities	649
Culture	2337
Cycling and biking	326
Food and wine	1857
Hiking	142
Nature	703
Spas and health resorts	287
Sports	72
Water activities	208
Winter sports	55

There are additional 103 subcategories that further classify each attraction datum or point-of-interest, however, they are not listed here due to the space reasons.

4. GEOGRAPHICAL DATA

The database of Geographical data is composed of two parts; geographical data and statistical regions. Geographical data contains geographical data for Slovenia such as lakes, rivers, caves etc. The data related to the water bodies was obtained from the "eVode portal"[17] (eng. eWaters), while the data regarding other natural bodies was retrieved from the ARSO Geoportal[18].

Water bodies data contains the information in the GeoJSON format[19]:

1. 48 bathing areas.
2. The Slovenian coast.
3. 20 lakes and larger bodies of water.
4. 165 rivers.

Additional data on natural heritage also contained the data in the GeoJSON format:

1. 17 protected areas not included into Natura 2000.
2. 307 areas of ecologic importance.
3. 10.730 caves with descriptions added.
4. 357 Natura 2000 areas.
5. 2.657 items from the registry of natural heritage.
6. 517 additional protected areas.

The geographic information data on statistical regions and settlements has been acquired from GURS (Slovenian Geodetic administration) portal e-Surveying data[20]. All the data was obtained in the GeoJSON format and it included: Boundaries of *12 statistical regions*; Boundaries of *6037 settlements.*

5. ROUTING SERVICE

There are several routing services available on the Internet, the most popular being the Google maps[21]. While being practical the subscription services are not cost effective and not in line with the project goals. We have therefore looked into open source solutions available. The most popular open source solution identified was the Open Street Routing Machine [2] (OSRM).

We have downloaded the map data[22] and combined the Austrian and Slovenian maps into one file using the recommended `osmconvert`[23] tool. Then we processed the data according to the official OSRM instructions[24]. The authors of the OSRM tool also provide a Docker[25] image that can be used for the processing of the maps data and for serving the routing back-end. We have utilized the OSRM docker image in order to process and deploy three distinct routing services: for walking, cycling and car riding. This enables the service to recommend routes to the user based on his or her preferred way of traveling.

Services are currently available through the API calls, for instance, when the service requires a route from point A to point B, it issues an API call to:

```
http://docker-e9.ijs.si:5007/route/v1/driving/LON-A,
LAT-A;LON-B,LAT-B?steps=false
```

[16] https://www.tripadvisor.com/
[17] http://www.evode.gov.si/sl/vodni-kataster/zbirka-vode/zbirka-podatkov-o-povrsinskih-vodah/hidrografija/
[18] https://gis.arso.gov.si/geoportal/catalog/main/home.page
[19] https://tools.ietf.org/html/rfc7946
[20] https://egp.gu.gov.si/egp/
[21] https://cloud.google.com/maps-platform/
[22] http://download.geofabrik.de/europe.html
[23] https://wiki.openstreetmap.org/wiki/Osmconvert
[24] https://github.com/Project-OSRM/osrm-backend/wiki/Docker-Recipes
[25] https://www.docker.com/

The service returns a JSON response with the most important objects: route specifications in the form of an encoded polyline; route distance in meters; and route travel time in seconds. Additional information about the API can be obtained on the official OSRM website[26].

6. DATA SERVICES IN AS-IT-IC

The described data and data services will enable the AS-IT-IC services to provide the functionality as required by the project.

Th attractions database enables: the virtual assistant to search for points-of-interest that best match the users query, recognize points-of-interest entities, and fetch information about the attraction; the tour planning service to take into account the attractions locations and provide recommendations to the user based on the attraction category, subcategory, location and similarity to other attractions based on the attraction description; the communication platform to present the data about attractions through the familiar user interface.

The geographical data enables: the virtual assistant to recognized geographical entities, search using the geographical position qualifiers (e.g. “cultural heritage in the Ljubljana city”); the tour planning service to enable recommendation based on the exact location and geographical area boundaries.

The routing service enables: the virtual assistant to take into account the tourist travel options (e.g. “show me natural heritage sites that I can reach in one hour by a bicycle”); the tour planning service to calculate optimal travel plan (since it takes into account the geographical position of the attractions on the itinerary and the transport option chosen by the tourist) and to provide a preview of the trip on a map.

7. CONCLUSION

In the paper we described the data sources, procurement, structure and types of data made available for the AS-IT-IC platform. Additionally we provided a short description of services, which are possible due to the data availability.

The main problem with the tourism-related data procurement is the unavailability of data in a structured, easily accessible format. The portal “Odprti Podatki Slovenije”[27] (eng. Slovenian Open Data) for instance is a good start, however, there are still problems with the discoverability, data formats and data availability. Several good data sources were identified only after weeks of searching for relevant data over the Internet. In order to obtain relevant information users with non-commercial intent can still use web-scrapping in order to obtain the desired data, add the authorship notice and link to the original data source, however, this leads to fragmentation of data structures, additional stress on Internet bandwidth and non-optimal solutions to keep the data updated. Additional problem is the unavailability of data for the use in public interest. This is the case with the registry of cultural heritage.

In the future we plan to integrate additional data sources into the AS-IT-IC databases – by performing data-fusion procedures we will merge the data into a single, richer database. Additionally, we will try to provide the data services to third party developers that now have to go through the same procedure as we did, in order to obtain similar data. Open data and services was one of the main project goals from the start, since we want to improve the tourist experience not only directly but also indirectly by providing services that will enable third party developers to come up with their own innovative solutions.

8. ACKNOWLEDGMENTS

The work was co-funded by Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020, project AS-IT-IC.

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[26] `https://github.com/Project-OSRM/osrm-backend/blob/master/docs/http.md`

[27] `https://podatki.gov.si/`

Content API - A Cloud-based Data Source for the AS-IT-IC Platform

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ABSTRACT

This paper introduces the design and implementation of an element of a microservice application for supporting a modern application for tourist information. Therefore, we introduce the Content Application Pogramming Interface (API) system, a microservice, which collects tourism relevant data from multiple sources and provides it to serveral services within the Austrian-Slovenian Intelligent Turist Information Center (AS-IT-IC) plattform in turn. Content API is built using modern technologies and frameworks, like Docker[1], Spring [2] or Vaadin [3].

Categories and Subject Descriptors

H.2 [**Database Management**]: Systems; I.2 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent agents*; K.6 [**Management of Computing and Information Systems**]: Software Management—*Software development*

General Terms

Database

Keywords

User interface, data aquisition, REST API

1. INTRODUCTION

The AS-IT-IC platform[4] was introduced in order to enable tourists and tourism information provider to interact and collaborate with each other. Several data sources exist from which the AS-IT-IC partners can retrieve information of sights, natural heritage as well as other events and tourism offers in the program area. The information from these databases is not stored in an unified format, so in order to integrate this information into the AS-IT-IC platform it is nesseary to integrate those data into a fitting format. The content subsystem, called Content API, integrates this data and provides it to the AS-IT-IC ecosystem. The system collects information from other web sources in order to combine and complete the information for a specific offering.

The core items of these databases are:

1. Sights
2. Tourism companies (e.g. hotels, restaurants,...)
3. Natural Heritage (e.g. rivers, mountains,...)
4. Events
5. Cultural heritage

The goal of the content subsystem is to integrate various information sources about tourism offers into a single database. This database is meant to be updateable from these sources, like Google or other tourim websites. The integrated user interface also allows human-computer interaction in order to update and review the integrated data. This allows a collaborative approach that enables users to add new information pieces to our database and helps to keep the database up-to-date as well.

The remainer of the paper is organised as follows: In the next section, we present the chosen design of the system. In Section 3, we get into details of the architecture. Afterwards, Section 4 provides an overview about the implementation and the deployment of the system. Finally, we show some related research and conclude the paper.

2. DESIGN & ARCHITECTURE

To fit the domain specific data requirements, we figured out a data structure that allows to represent the data needed in our platform, as shown in Figure 2.

The Core Service Layer contains the main functionalities of the web service. The layer hosts the data storage logic, the data aquisition along with the merger functionalities. They are encapsulated to ensure easy extensibility for new data sources to be included. We call these modules within the initial startup sequence as well as on demand.

The possiblity to merge data from different sources together is crucial in order to present a good and up-to-date data quality. This functionality is contained within the Core Service Layer.

It is also possible to integrate new data sources in order to add new information aspects into the database.

The system is integrated into the architecture of the AS-IT-IC platform as discussed in [1].

[1] see `docker.com`
[2] see `spring.io`
[3] see `vaadin.com`
[4] see `as-it-ic.ijs.si`

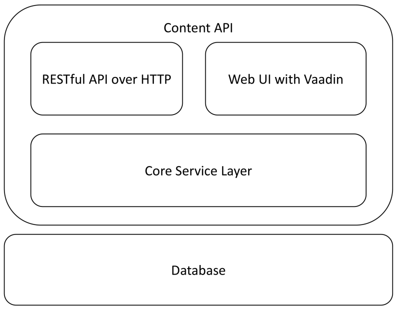

Figure 1: Layer of the Content API

2.1 Update Process

The update process collects several web data sources and integrates it into the database in an automated manner. Every data source needs a specific update routine that is implemented to integrate the collectable data. These routines compare the recently collected data with the stored data stored and update the information in case that there is any change provided by the external source. The process can be scheduled automatically or triggered manually.

2.2 User Interface

The web-based user interface (UI) allows the community to contribute information to the platform. It is possible to add new information items, such as sights or tourism offers, to the database. Reviewing existing items and updating them represents also a very important opportunities for the user community in order to allow a wiki-like contribution model.

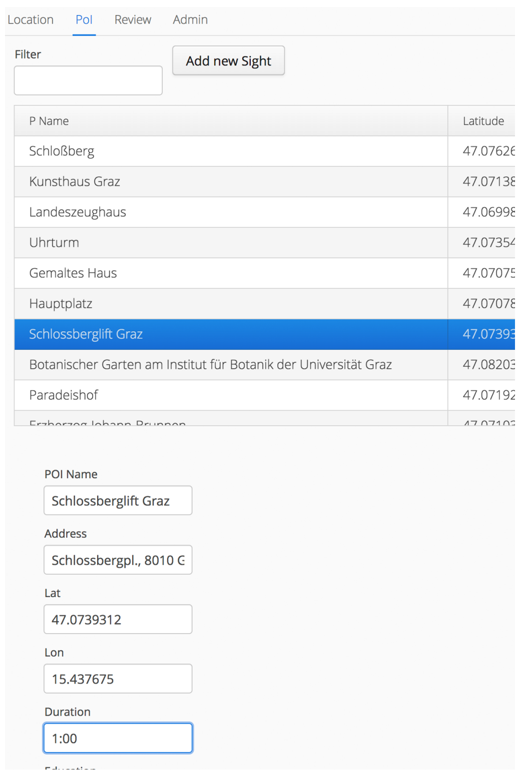

Figure 2: Screenshot of the web-based UI

In Figure 2, we show the Vaadin based UI containing several subforms to interact with the different entries from the database.

2.3 REST Interface

The Representational State Transfer (REST) interface can be used to implement operations like create, read, update and delete (CRUD) the information of the content subsystem.

There exist endpoints that represent the information in the database and allow to access them via JSON objects, i.e.:

- Location
- Points of interest (POI)
- Equipment
- Transportation

We use these endpoints in order to access and modify the data in the system via HTTP-JSON calls.

3. IMPLEMENTATION & DEPLOYMENT

We use Docker within the implementation and the deployment step. Docker Compose is a tool for defining and running multi-container Docker applications. In this project, Docker Compose is used on the developer machine to set up a testing environment, which configurations corresponds to the productive pendant.

4. CONCLUSION

In this paper, we presented the Content API, the content microservice and database of the AS-IT-IC platform. Here we focussed on the architecture and design of the system, as well as the implementation and the deployment. We also highlighted the use of the web-based user interface and the REST API as interaction possiblies. Finally we described the automated deployment using an application container technology as well as continous integration and deployment tools.

5. ACKNOWLEDGMENTS

Research presented in this paper was carried out as part of the AS-IT-IC project that is co-financed by the Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020, European Union, European Regional Development Fund.

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e-Tourist 2.0: an Adaptation of the e-Tourist for the AS-IT-IC Project

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ABSTRACT

This article presents a new version of the `e-Tourist` system called `e-Tourist2.0`. The `e-Tourist2.0` system is developed within the Austrian-Slovenian Intelligent Tourist-Information Center (AS-IT-IC) project, accepted in the Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020 call. The new `e-Tourist2.0` system brings a number of additional features with respect to the `e-Tourist`, such as location aware search, an implicit recommendation engine and a more interactive interface for trip planning. In the paper we briefly explain the need for a new system, and present the architecture and functionality of the `e-Tourist2.0`.

Keywords

trip planner; AS-IT-IC project; tourism; attractions; tourism database; recommendation engine; location aware search

1. INTRODUCTION

Trip planners are applications that require a user to input a number of predetermined parameters and then respond by offering the user a trip plan that can later be modified. The Austrian-Slovenian Intelligent Tourist-Information Center (AS-IT-IC) platform provides a trip planner with a chat based user interface. It is built from three major components, each contributing to the final user experience. They are:

1. the front-end provided by a slightly modified version of `Rocket.Chat`[1]
2. `e-Tourist2.0` that fulfils the role of the back-end
3. a conversational program (a bot) that takes user inputs, be they free form text input or button clicks, from `Rocket.Chat` and generates responses, using data acquired from `e-Tourist2.0` when necessary

In its function as the back-end for the AS-IT-IC platform, `e-Tourist2.0` needs to support an assortment of queries over textual and geographical data (i.e. the ability to provide an answer to questions like "Which 5 points of interest are most similar to the Bled castle based on their descriptions?" or "List all castles in the Gorenjska region"), a recommendation engine, that uses implicit data about user interest, as well as trip planning functionality. It also needs to provide the pieces of the user interface that are missing from `Rocket.Chat`.

Initially we believed that this role could be filled by the existing `e-Tourist` after some light modifications. However, a more thorough inspection of its capabilities and architecture convinced us that extensive adjustments to the code base are required. Additionally some of the functionality originally implemented in the application code is now supported by the database itself which would lead to the deletion of several lines of code. The resulting conclusion was to write a new system using the latest tools and design patterns, while reusing the old code as much as possible.

This rest of this article describes the need for a new system in Section 2, followed by a presentation of the new system Section 3, where we present the features available through the application programming interface (API) of `e-Tourist2.0`. In section 4 we present the system architecture and 5 concludes the paper.

2. WHY A NEW SYSTEM

The required back-end functionality includes:

1. Trip planning
2. Location aware search
3. Recommendation system

Initially `e-Tourist` was designed to plan trips visiting the coastal region of Slovenia.It was provided with a relatively small list of tourist attractions in both regions and is capable of planning a trip to either of them. The user can specify a number of constraints like the exact start of their trip, and whether they want to eat along the way and the `e-Tourist` produces a nice trip recommendation. Based on how well this works, we were convinced that all that needed doing was to add additional data with points for other regions of Slovenia and Austria, spruce up the API so the bot would be able to use the system from outside, and we would have our back end. This was presented in [1].

We are porting some of the trip planning capabilities of `e-Tourist` to `e-Tourist2.0`, and in this respect `e-Tourist` mostly meets our requirements, except for not being RESTful, that is calls to the API needed session specific state with

[1] `https://rocket.chat/`

them in order for it to return the correct result. Figure 1 shows what the original user interface for trip planning looks like. It shows the trip on a map and adds controls to add or remove points from it.

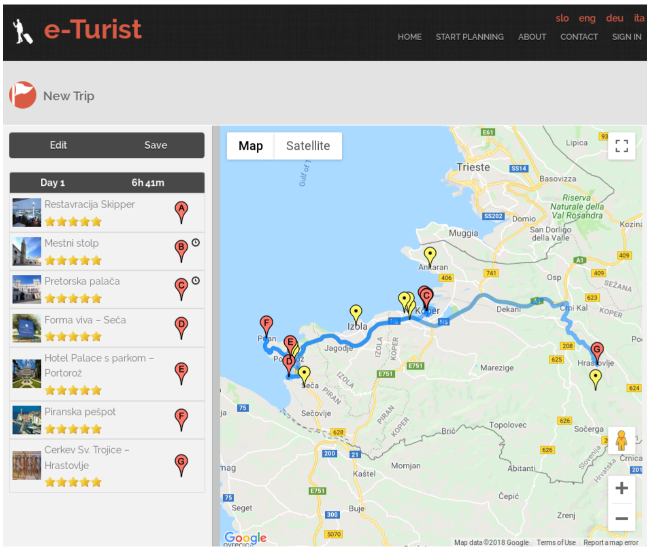

Figure 1: `e-Tourist` trip planning interface

As it turns out, the `e-Tourist` database stores each point of interest in a tree-based data structure, based on its location – a point-of interest belongs to (or is a child in a tree-based structure of) a settlement that in turn belongs to a region. This proves to be a very brittle way for storing larger amounts of points where some of the settlements have the same names and some areas of interest belong to multiple settlements and even regions. Also the `e-Tourist` does not make it possible to ask queries based on actual distance, like "Which restaurants are within 1km of lake Bohinj?". Therefore, a rewrite of the location aware search aspects of the application would be required.

In terms of the recommendation system `e-Tourist` requires users to rate the points of interest on a 1 to 5 scale or to input a lot of data about themselves like their education, age, gender so forth. It also requires data about points of interest that would be hard to acquire in an automated way, like which age groups a point of interest is most appealing to or the level of education of the people who most enjoy their visit to the point of interest. Since the implementation of the `e-Tourist` several modules have been developed that implement various recommendation algorithms and were released as open source software[2]. For reasons of stability, security and ease of maintenance we opted for one of those instead of using our own recommendation engine implementation.

According to the code analysis we reached the following conclusions:

1. A recommendation system needs to be rewritten to also include implicit information about user interaction with the system.
2. Location aware search needs to be included.
3. Proper database migrations have to be implemented.
4. Database architecture needs to be reworked.
5. The way travel time was computed was very storage and time intensive.
6. `e-Tourist` is not REST-ful.
7. We need a more stateless way of user authentication.
8. Code base has to be updated to the newest framework versions.

Besides the tree based structure mentioned in the introduction, that becomes unnecessary when storing geographic data correctly, the database schema of `e-Tourist` also failed to make use of several data structures offered by the PostgreSQL database engine that would make some queries simpler and more performant. The main problem with the database however was the lack of an initial migration that would create the relations required in the application. The authors assumed that future developers would use a copy of a pre created database for that, an approach that made creating a new development environment as well as deployment an unnecessarily complicated task.

Because `e-Tourist` does not comply with REST best practices, it is quite hard to use programmatically, which is essential for us since most of it is going to be used by the `Rocket.Chat` bot, a program. The latter also means that session cookies are not a viable way for us to check user credentials and a different way of authenticating calls to the API is needed.

Finally the code used some features of an older version of the framework that were discarded in the newer ones. In order to be able to guarantee long term support for the project we decided that a newer framework version with longer support was required.

Tallying up all of the above we figured it would take more work to make the necessary changes to the old system then writing a new one from scratch with an eye out for code reuse whenever possible.

3. FEATURES

In addition to the features already mentioned at the start of the Section 2, the new `e-Tourist2.0` supports:

1. Finding similar points of interest
2. A user interface that allows quickly adding points to a trip plan and deleting them from it by using a map
3. Exporting trips to Google Maps
4. Full text search for points of interest based on their descriptions, and limited by their location
5. A recommendation engine that uses implicit data about user's interaction with the system to find points that might interest a particular user based on the user's history

[2] `https://github.com/benfred/implicit/`, `http://surpriselib.com/`

We will continue with a discussion of the features, what they do and why we need them.

3.1 Trip planning

Trip planning means that given a list points of interest a potential tourist wants to visit, the system can plan a route on a map that visits all the points listed by the tourist. The new `e-Tourist2.0` does this by using the `open source routing machine` [2] which uses open street map[3]data to plan the route. In addition to being able to plan the route, `e-Tourist2.0` is also capable of exporting that route to a Google Maps link, so that users may conveniently follow along using the Google Maps app on their devices. The trip planning user interface will also display potentially interesting attractions near the route already chosen so that a tourist may quickly add them to their trip plan.

3.2 Recommendation

Recommendations are a way to present the users with more of the relevant content based on their interests as shown through their history of using the system. This will also allow a registered user to simply ask the system "What is interesting in Koroška?", as well as provide additional suggestions along the planned path.

Another use of a recommendation system is to compare attractions based on user behaviour. This allows us to *find similar attractions* to the one picked by the user. Another way to find similar attractions is by comparing their descriptions and `e-Tourist2.0` uses both of them. This feature enables the users to quickly narrow in on what they want to see or to just explore their options more conveniently.

3.3 Full text search

Full text search is a way to quickly search a large database of documents for the ones containing given words or phrases. In `e-Tourist2.0` this is coupled with some sentence analysis that attempts to produce more relevant results. It searches through attraction descriptions in German, English and Slovenian.

All attractions and geographical features in `e-Tourist2.0` carry complete information about their location. Complete in the sense that regions and settlements are saved as polygons describing their borders, rivers are saved as lines describing their entire flow and so on. This enables all sorts of *location based search* queries, as well as constraining other queries to certain locations. Examples of such queries are "List all museums in Slovenj Gradec" and "Find all attractions similar to the Bled castle near Klagenfurt".

The most important feature from the standpoint of the tourist providers is the *administration interface*, which will allow them to add new points of interest to the system and make corrections to the data on those already there. To request administration access, a tourism provider should fill in a form available on the `e-Tourist2.0` website[4].

[3]`https://www.openstreetmap.org/`
[4]`https://e-turist.docker-e9.ijs.si/tourism-provider/request-admin`

4. `e-Tourist2.0` ARCHITECTURE

In order to make it easier to port code from `e-Tourist` to `e-Tourist2.0` we chose to implement `e-Tourist2.0` in the same framework as `e-Tourist`, *Django*[5]. Besides allowing us to more easily port code from the old project it also comes with a built in administration interface that made implementing the user interface for tourist information providers a lot easier, since we just had to customise the one provided with the framework.

Our data storage is provided by the *PostgreSQL*[6] database. By using the *Postgis*[7] extension we were able to save geographical data and use it for several spatial queries. It also supports full text search. In order to enable support for the Slovenian language we provided some language specific configuration and files, while the German and English languages are supported out-of-the-box.

5. CONCLUSIONS

We have presented a short description of the new `e-Tourist2.0`, describing the need for a new trip planner implementation, its features and its architecture. While some of the `e-Tourist` code base was reused, the new `e-Tourist2.0` is mostly a new program. Most of the features presented here are already fully functional, however, the program is not yet entirely complete and changes to existing features, or additional features are possible in the future.

6. ACKNOWLEDGMENTS

We thank students Tadej Petrič, Aljaž Glavač and Martin Češnovar, who contributed to `e-Tourist2.0` development. The work was co-funded by Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020, project AS-IT-IC.

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[5]`https://www.djangoproject.com/`
[6]`https://www.postgresql.org/`
[7]`https://postgis.net/`

Planning-based Security Testing for Chatbots

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ABSTRACT

Chatbots are of increasing importance in modern day communication between users and industrial applications. For example, providers of financial and medical institutions make use of intelligent agents in order to provide accessibility on a 24/7 basis. The human-like communication, often realized in an entertaining way, represents one of these advantages that chatbots offer. Eventually, chatbots make use of artificial intelligence methods in order to learn from past communication interactions, to provide better and more personalized responses. Often chatbots are deployed as part of web applications. As a consequence, this makes them vulnerable to typical security attacks on websites. Planning-based techniques can help to identify security leaks for common attack scenarios in a smart way. In this paper, we present such an approach that relies on artificial intelligence planning for security testing of chatbots that are accessible using web applications.

Categories and Subject Descriptors

C.2 [**Computer-Communication Networks**]: General—*Security and protection*; D.2 [**Software Engineering**]: Testing and Debugging; I.2 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Intelligent agents*

General Terms

Theory, Security

Keywords

Planning, security testing, chatbots

1. INTRODUCTION

ELIZA [21] is first known computer program that communicated in a natural language with a person, which was developed in 1966. Over the years, further improvements have been added to such similar applications, called chatbots [9, 20]. Chatbots are deployed in a stand-alone or online fashion, i.e., as part of websites in form of virtual assistants. Such programs offer the advantage of human-like communication and as well an almost unlimited accessibility. Deploying chatbots offer financial advantages for service providers as well. They can be used in order to respond to customers' inquiries, e.g., provide information about certain goods or services without the need of human intervention.

In contrast to the initial versions of chatbots, where the programs usually responded to an inquiry according to stored natural language patterns, intelligent agents can be trained to learn from the communication with clients by relying on machine learning. In the long term, these smart chatbots refine their responses and provide better answers over time. Advanced chatbots offer the client the possibility to authenticate herself or himself, thus personalizing the connection between machine and person. Here the chatbot stores potentially sensible data from the user. In this case, the chatbot must guarantee user authenticity and data integrity. The failure to fulfill such promises might result in personal and financial consequences for the user.

This requirement and the fact that chatbots can be deployed as part of web applications leads to security issues, since web applications are known to be vulnerable to several hacking attacks. Vulnerabilities like SQL injections (SQLI) and cross-site scripting (XSS) are still very common [4], despite security measures and new security testing approaches. It is interesting to know that the security issue in the context of chatbots have almost not been considered before.

Automated planning and scheduling, or simply planning, is a branch of artificial intelligence that was initially used in robotics and intelligent agents [17]. There planning is used for guiding an agent by responding to encountered conditions. Some approaches have applied planning to security testing in specific domains as well [14, 16]. In order to contribute to the mentioned security issues, we introduce an automated planning-based security testing approach for chatbots in this paper.

The paper is organized as follows. Section 2 introduces planning to security testing of chatbots. Then, Section 3 gives an overview about a test execution framework. Finally, Section 4 concludes the work and discusses potential goals for the future.

2. PLANNING FOR CHATBOTS

Planning has been already used in security testing to a small degree. The authors of this paper have applied planning for testing of web applications (e.g. [7]) and the TLS protocol [6]. However, the application to chatbots is novel in this sense. The main motivation behind using planning for testing is the fact that attacks against applications can be depicted in form of a sequence of steps that could be applied against every program. Actually, a plan acts as a blueprint for an attack. In this paper, we applied the planning specification from our previous work [5] but use it for identifying vulnerabilities in the case of chatbots.

In general, the planning problem was initially given in [11] and can be defined as follows.

Definition 1. *A planning problem is defined by the tuple* (I, G, A). *A state is defined by a set of first order logic predicates.* I *represents the initial state, the goal state is* G *and the set of actions is given by* A. *Every action* $a \in A$ *comprises a precondition and an effect. The functions* $pre(a)$ *and* $eff(a)$ *connect the individual preconditions and effects, respectively.*

If the precondition $pre(a)$ of an action a is satisfied the current state S, then this action will be selected for the solution of the planning problem. The execution of this action will lead to a new state S', namely $S \xrightarrow{a} S'$. This procedure will continue until the execution reaches the goal state G, i.e. fulfills its preconditions. The program that reads the planning specification and searches for a solution according to a planning algorithm is called a planner.

Definition 2. *The solution for the planning problem* (I, G, A) *is returned in form of a plan, which is given by a sequence of actions* $\langle a_1, \ldots, a_n \rangle$ *such that* $I \xrightarrow{a_1} S_1 \xrightarrow{a_2} \ldots \xrightarrow{a_{n-1}} S_{n-1} \xrightarrow{a_n} G$.

The planning problem is implemented in the Planning Domain Definition Language (PDDL) [15]. Here, two specifications have to be provided:

- Domain definition: Data that is present for every problem definition.
- Problem definition: Data that defines one specific problem.

PDDL supports a type-object hierarchy of data and uses it in conjunction with first-order logic predicates. Every object correspondents to a specific type, which relates to variables and classes in object-oriented programming, respectively. The individual action definitions are built from parameters and pre- and postconditions, which are defined with one or more predicates. For example, an excerpt from the the domain definition for chatbot testing is depicted below.

```
(define (domain chatdomain)
 (:requirements
    :strips :typing :equality :fluents
    :adl)
 (:types
    status address server status-si
    status-se type expect result username
    password action method integer sqli
    xssi response script)
 (:constants
    init - status two - status-si sqli
    xss - type get post head - method
    username - username
    password - password)
 (:predicates
    (inInitial ?x)
    (inAddressed ?x)
    (inSentReq ?x)
    (inRecReq ?x)
    (inSQLI ?x)
    (inXSS ?x)
    (inAttackedSQL ?x)
    (inAttackedXSS ?x)
    (inFound ?x)
    (Empty ?url)
    (FoundScript ?script - script ?resp -
        response))
 (:action Start
    :parameters(
      ?x - status
      ?url - address)
    :precondition (and
      (inInitial ?x)
      (not (Empty ?url)))
    :effect (and
      (inAddressed ?x)
      (not (inInitial ?x))))
 (:action SendReq
    :parameters(
      ?x - status
      ?se - status-se
      ?si - status-si)
    :precondition (inAddressed ?x)
    :effect (and
      (inSentReq ?x)
      (not (inAddressed ?x))
      (assign (sent ?se) 1)
      (statusinit two)))
 (:action ParseRespXSSCheck
    :parameters(
      ?x - status
      ?script - script
      ?resp - response)
    :precondition (and
      (inRecRespRXSS ?x)
      (not(FoundScript ?script ?resp)))
    :effect (and
      (FoundScript ?script ?resp)
      (inFound ?x)
      (not(inRecRespRXSS ?x)))))
```

Domain description in PDDL

As can be seen, the PDDL definition encompasses, among others, types, predicates and actions. Again, the individual action definitions make use of the predicates and apply parameters in order to check if the predicate is valid. The specification uses the parameter x to denote the current state of execution. As mentioned, the above domain, due to space reasons, does not include our entire specification. On the other hand, the problem definition is defined as follows.

```
(define (problem chatproblem)
 (:domain chatdomain)
 (:objects
    x - status
    s - server
    url - address
    m - method
    exp - expect
    script - script
    resp - response)
(:init
   (inInitial x)
   (not (Empty url))
   (Method post)
   (Response resp)
   (not (FoundScript script resp))
(:goal
   (inFinal x)))
```

Problem description in PDDL

The problem definition comprehends the definition of objects and, most important, the initial state. This state represents the starting point from which the planner will start the search. Modification of the initial state will result in the generation of a different plan. If no plan can be generated, then the planner returns an error. A generated plan looks as follows:

```
0: START X URL
1: SENDREQ X SE SI
2: RECREQ X SI
3: PARSE X M USERNAME PASSWORD TYPE
4: CHOOSEXSS X TYPE
5: ATTACKXSS X XSSI M UN PW
6: PARSERESPXSS X SCRIPT RESP
7: PARSERESPXSSCHECK X SCRIPT RESP
8: FINISH X
```

Generated plan for XSS

As mentioned before, the plan is represented by a sequence of actions and corresponding parameters picked from the domain definition. In our case, we used the planner `Metric-FF` [3]. Now, this sequence of steps acts as an abstract test case that will be executed by an executioner against the system under test (SUT). The purpose of the plan is to guide the test execution process that, in the best case, will lead to the detection of a vulnerability. The main idea here is to apply this plan against every chatbot that corresponds to the scenario as described in the next section.

3. SECURITY TESTING OF CHATBOTS

Security plays a major role for every software system. Failure to fulfill security requirements might lead to severe private, financial and reputation consequences. For this reason, programs have to be tested during the development lifecycle and after release of the software. Until now, many manual and automated approaches have been introduced in order to test for vulnerabilities. For example, model-based approaches usually rely on a model of the SUT [19, 18], whereas fuzzing and combinatorial testing put emphasis on test case generation from a pentesting aspect [10, 13].

SQLI and XSS represent two common vulnerabilities for many years and need further addressing for this reason. Detailed information about these two vulnerabilities can be found in [8] and [12], respectively. Chatbots, as already mentioned, when deployed as part of a web application, inherit the vulnerabilities as well. A scenario that depicts the entire planning-based security testing system is depicted in Figure 1.

Attack vectors are malicious input strings that an attacker or tester submits against an application. For XSS, the list of attack vectors consists of JavaScript code, whereas malicious SQL statements are used for SQLI. As already mentioned in Section 2, a generated plan is used as an abstract test case. The reason for this is the fact that PDDL is limited with regard to setting of concrete values for parameters. For this reason, we define a test execution framework, that encompasses, among others, an executioner. This framework is implemented in Java and contains concrete Java methods that correspond to the individual actions from PDDL. More information about this mechanism can be found in [5].

The executioner reads the abstract plan and searches for the concrete counterpart of the individual actions. Then, HTTP requests are created with the help of `HttpClient` [1] and instantiated with an attack vector. Then, the attack is carried out in form of the HTTP request. The SUT is a deployed chatbot that encompasses a database. The chatbot has a user input field, e.g. an HTML element for textual inputs, that represents the target for the executioner. The test oracles specify what test output is expected and provide the final test verdict. We rely on our previously implemented oracles from [7] for this purpose. After an attack, a parser reads the response from the SUT. It searches the HTML structure for critical vulnerability indicators, as specified in the oracles. In this scenario, we rely on `jsoup` [2]. The testing process continues as long as the plan has been executed for every attack vector.

4. CONCLUSION

In this paper, we introduced a security testing approach for chatbots that relies on planning. After manually defining the specification and generating the plan, a test execution implementation executes the plan in an automated manner. The approach is meant for testing of chatbots against two common web vulnerabilities, namely XSS and SQLI. Under the assumption that chatbots will play a major role in the future, it remains important to address this issue. In the future, the proposed security testing approach will be evaluated against real-world applications and compared to other testing techniques.

Acknowledgments

The research presented in the paper has been funded in part by the Cooperation Programme Interreg V-A Slovenia-Austria under the project AS-IT-IC (Austrian-Slovene Intelligent Tourist Information Center).

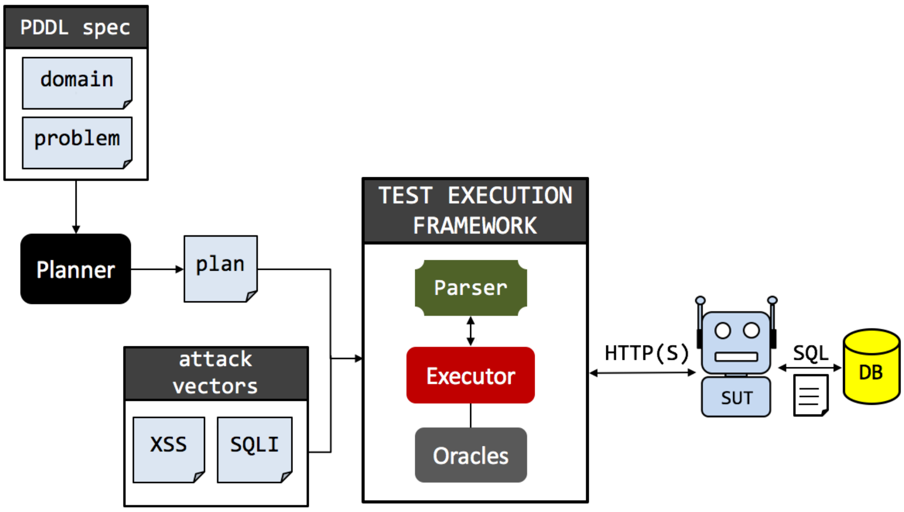

Figure 1: Planning-based Chatbot Security Testing

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Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek F

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume F

Soočanje z demografskimi izzivi
Facing Demographic Challenges

Uredila / Edited by

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http://is.ijs.si

4. maj 2018 / 4 May 2018
Ljubljana, Slovenia

FOREWORD
»FACING DEMOGRAPHIC CHALLENGES«

It is the 11th annual conference “Facing demographic challenges” and it represents a milestone in our endeavor in several ways. Firstly, we managed to organize the conference in coordination with the meeting in the National Council of the Republic of Slovenia. The event had a major media effect with several conflicting viewpoints. Unfortunately, some scientific arguments were shadowed by non-scientific discussions, probably bringing this event to an undesired halt. Our motivation to help preserve European and Slovenian civilization, culture and position in the world was not accepted well by everybody.

There were a couple of major demographic shifts in recent years in Slovenia: First, a decade ago the Slovenian birth rate was close to 1.2. Second, in recent years it has risen to around 1.6 and stalled there. Third, these events caused major discussion about the core scientific observations, presented also at the conference:

a) The world is getting overpopulated and we need to bring the global birthrate towards the longterm ideal 2.1. While most of the world has stabilized its demographic growth, several parts like Africa are out of these terms.
b) Europe and Slovenia with average birthrate around 1.6 will turn the current situation towards stagnation and degradation.
c) It is important to incorporate mechanisms for decreasing birthrates in those countries with excessive birthrate, and for increasing birthrates in the developed world.
d) It is important to understand that the exponential nature of demographics will hit hard unless treated in time. The ignorance might turn costly even to the extent of stagnation and degradation of world, European and Slovenian democracy.
e) The influx of refugees has to be systematically taken care of by preventing mass exodus and continuing with a relatively small immigration.
f) The question why demographic scientific revelations were being threatened as if having political or ideological orientations, remains unanswered. However, the impression is that the scientific knowledge is not as welcome as, for example, a decade ago. It seems that in recent times ideology is taking over science and interests of citizens.

At the conference, we constantly emphasized that among often misunderstood issues is the effect of the European “demographic winter”. Governments, public opinions and media often fail to understand the importance of population in the domains of economics, politics and other components of societal and individual standard of living. Studies show that the demographic challenges are directly linked to education, work and employment, health care, financial problems, retirement and other important topics of everyday life. In plain words: with fertility rates around 1.6, the quality of life in Slovenia is significantly lowered compared to safe, say 1.8. Imagine just two statistical data: nearly 20% of Slovenian women do not experience maternity, while today’s men have 50% less sperm than 50 years ago, thus being severely hampered in their ability. Other problems included overload due to too many elderly, which is in itself a major civilization achievement; decreasing active work span, exodus of young educated generation (8,000 yearly in recent years, around 1,000 of the smartest 2,000 in the generation).

The "Facing Demographic Challenges" final conference deals with all questions related to the demography and population development, in particular:

- fertility
- mortality/health care
- migrations
- population ageing
- family
- solidarity between generations
- gender relations
- moral/ideological influences
- (rural) planning in new demographical conditions
- economic aspects
- anthropological aspects
- sociological aspects
- historical aspects
- population projections
- mathematical/computational models
- demography of national minorities
- theological aspects
- reforms

We present our analyses and hypotheses in the top academic environment, openly presenting the worrisome future trends. Not only that, based on national, European and global studies, we also discuss various potential solutions and propose them to our leading politicians and political institutions.

It is not that demographic science has solutions to all dilemmas, in particular in measures to raise the too-low fertility rate in the developed countries. New scientific studies in particular in relation to artificial intelligence indicate that there might be some rather simple and inexpensive solutions to solve the abovementioned problems.

We continue to pursue an ambitious goal – to enlighten Slovenian and European leaders with demographic problems and knowledge to enable them to govern the society better. Now more than ever it is becoming clear that the voices of the demographic science should be carefully studied.

Janez Malačič and Matjaž Gams

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Koliko nas manjka?

Zakaj Vlada skriva obseg primanjkljaja ljudi v delovni starosti?

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POVZETEK

Avtor s pomočjo statističnih podatkov o številu rojstev in odseljevanju državljanov RS poskuša prikazati razsežnosti primanjkljaja ljudi v delovni starosti in poskuša pokazati, da je primanjkljaj večji, če želimo ohraniti razmerje med zavarovanci in upokojenci. Z analizo novejših vladnih dokumentov ugotavlja, da vlada pregled nad primanjkljajem ima, vendar njegove razsežnosti skriva. Vlada bi morala objaviti razsežnosti primanjkljaja, njegove srednjeročne projekcije, oceniti gospodarske in družbene posledice, časovno in finančno konkretizirati svoje ukrepe na tem področju in oceniti njihov domet.

Ključne besede

Demografija, rodnost, obnavljanje prebivalstva, primanjkljaj rojstev, selitveni prirast, delovna starost, število zavarovancev, število upokojencev, Bela knjiga o pokojninah, Strategija dolgožive družbe, Strategija razvoja Slovenije 2030, vladni ukrepi.

1. UVOD

Podnaslov vsebuje trditev, ki jo bom v nadaljevanju dokazal. Poglejmo, koliko več bi nas moralo biti v delovni starosti, da bi ne bila ogrožena gospodarstvo in blaginja, ter kaj o tem pravita, in česa ne povesta, vlada in ministrstva.

2. PRIMANJKLJAJ

Primanjkljaj po mnenju avtorja izvira iz prenizkega števila rojstev pred desetletji in iz odseljevanja v zadnjih nekaj letih; če vzamemo za kriterij ohranitev razmerja med zavarovanci in upokojenci, pa tudi povečevanje števila upokojencev.

2.1 Zaradi prenizkega števila rojstev

Leta 1980 smo v Sloveniji ob rodnosti 2.11 otrok na žensko zadnjič imeli dovolj rojstev za dolgoročno enostavno obnavljanje prebivalstva. Letni primanjkljaj rojstev - to je razlika med številom, potrebnim za enostavno obnavljanje in dejanskim številom - je potem naraščal, dosegel številko 13 tisoč letno, zadnja leta pa znaša okrog sedem tisoč letno. Če seštejemo letne primanjkljaje do leta 2016 [1] dobimo seštevek 331 tisoč otrok, ki bi leta 2016 dopolnili od 0 do 35 let, kar predstavlja 37% od 889 tisoč zavarovancev decembra 2016.

Letni primanjkljaj je v letih 2011 - 2016 znašal 7 do 8 tisoč otrok, kar bi lahko pomenilo, da lahko ob nespremenjenih pogojih brez dodatnih ukrepov za zvišanje rodnosti, tolikšen letni primanjkljaj pričakujemo tudi v prihodnjih letih. Vendar bo ob odsotnosti pozitivnih ukrepov zadeva verjetno slabša in se bo število rojstev zmanjšalo, saj demografi opozarjajo na »*padec števila žensk v starosti 25-34 let do leta 2030, in sicer v primerjavi z letom 2010 kar za tretjino, zaradi česar se bo zmanjšalo tudi število živorojenih otrok..... Do leta 2030 bo tako število rojstev upadalo.*« [2, str. 16]

Ustavimo se pri skupini mlajših od 25 let, ki se postopoma zaposluje. V letih 1991 do 2015 se nam je rodilo 264 tisoč otrok premalo za enostavno obnavljanje prebivalstva. Ti otroci bi bili konec leta 2015 stari od 0 do 25 let. Z meddržavnimi priselitvami (V letih 1991 – 2016 je bil meddržavni selitveni prirast skupno 84 090 oseb.) je prišlo tudi nekaj otrok, ki so bili rojeni od začetka leta 1991 do konca leta 2015. Na osnovi starostne porazdelitve teh priseljencev, lahko pa pridemo do dokaj zanesljive ocene, da jih je bilo okrog 18 tisoč. Primanjkljaj mlajših od 25 let je torej leta 2016 znašal 246 tisoč, kar je povprečno skoraj **deset tisoč letno**, in predstavlja 28% od števila zavarovancev decembra 2016.

2.2 Zaradi odseljevanja državljanov RS

Leta 2012 so odselitve za 5 450 oseb presegle priselitve. Negativna bilanca se je do leta 2016 povečevala in leta 2016 dosegla številko 5955; v letih 2012-2016 se je odselilo 28 437 slovenskih državljanov več kot se jih je priselilo, torej povprečno 5 687 letno. Ob enakih gospodarskih pogojih brez pozitivnih ukrepov je torej v prihodnjih letih pričakovati dodatni primanjkljaj državljanov RS na ravni **6 tisoč oseb letno**.

2.3 Za ohranitev razmerja med zavarovanci in upokojenci

Po podatkih ZPIZ je bilo število zavarovancev konec leta 1916 enako 889 tisoč. Število uživalcev pokojnin se je od leta 2007 do januarja 2017 povečalo od 519 na 617 tisoč, torej letno za povprečno skoraj 11 tisoč, in se bo še povečevalo, *» saj naj bi se v obdobju od leta 2013 do 2060 življenjsko pričakovanje ob rojstvu za ženske povišalo za 5,6 let, za moške pa za 7,2 let*.« [2] Če bo letna rast števila upokojencev ostala enaka 11 tisoč, bo za ohranitev razmerja med številom zavarovancev in upokojencev, da bi se torej ohranilo finančno zdravje javnih blagajn in obstoječa raven blaginje, potrebno vsako leto **dodatnih 15 tisoč zavarovancev**.

3. KAJ PRAVI VLADA? O ČEM MOLČI IN KAJ SKRIVA?

Ker se letni primanjkljaji seštevajo v ogromne zneske in presegajo letno število rojstev, ki je bilo v obdobju 1990 - 2 000 med 18 in 23 tisoč, bi pričakovali, da bo ta demografska luknja, ki se od četrtine veča na preko tretjine števila zavarovancev, osrednja tema vladnih razvojnih dokumentov, vsaj tistih iz zadnjih dveh let, ko so vsi trije zapisani primanjkljaji dobro znani. Pričakovali bi, da bodo zato podali konkretne, finančno ovrednotene ukrepe in ocene, kaj od ukrepov lahko pričakujemo, ter kaj nas čaka, če ne bodo uspešni. Poglejmo si tri vladne dokumente iz let 2016 in 2017.

3.1 Bela knjiga

Daje delne nižje podatke in napačne izračune. Na strani 12 preberemo: »*Vsaka generacija mladih, ki sedaj vstopa na trg dela, je torej za okrog 20% oziroma 5 tisoč oseb manjša, kot bi bila sicer – in to vsako leto! Zato bomo imeli iz tega naslova v prihodnjih desetletjih za okrog 25 krat po 5 tisoč, torej skupaj okrog 75 tisoč manj oseb v delovni starosti, kot bi jih imeli sicer.*« Dokument se izogne navajanju visokih številk tako da: ne poda ocene celotnega primanjkljaja rojstev , ampak le tisti del, ki ga pripisuje odlaganju rojstev; celó iz vprašljivo ocenjenega letnega primanjkljaja 5 tisoč oseb izračuna 25 letni primanjkljaj v višini 75 tisoč in ne 125 tisoč.

3.2 Strategija dolgožive družbe

Vlada je leta 2017 sprejela Strategijo dolgožive družbe [3], v kateri na strani 11 ugotavlja padanje deleža prebivalstva v starosti 20–64 let ter potrebo po spodbujanju » *priseljevanja delovne sile*« in »*aktivnosti v vseh življenjskih obdobjih*«. Zapiše, da to spodbujanje tudi ob neto priseljevanju 4 000 oseb letno ne bo dovolj za zaustavitev padanja razmerja med aktivnim in neaktivnim prebivalstvom, in da bo to padanje postalo omejitveni dejavnik za gospodarsko rast. Pove torej, da bo 4 tisoč premalo, ne pa, koliko bi bilo dovolj. Iz Slike 3 na strani 16 se z grafa da odčitati, da se bo starostna skupina 20-64 let od leta 2015 do 2040 zmanjšala za 280 tisoč, kar je primerljivo našim izračunom, vendar je to podano le slikovno; bralec se mora potruditi, da se dokoplje do številčne ocene.

Med ukrepi v poglavju *Zagotavljanje delovne sile* (str. 39) najdemo tudi *prizadevanje za povečanje priseljevanja, zmanjšanje odseljevanja državljanov , spodbujanje vračanja izseljenih državljanov, zagotavljanje možnosti za integracijo tujcev* … Vendar manjka konkretizacija in ovrednotenje cene ter učinkov ukrepov. Trditev, da bo to »omejevalo možnosti za zagotavljanje in povečevanje blaginje prebivalstva«, zavaja v razumevanje, da sedanja raven blaginje ne bo ogrožena. Bralec ne dobi občutka ogromnosti in usodnosti prihajajočih sprememb in nujnosti ukrepanja.

3.3 Strategija razvoja Slovenije 2030

Vlada jo sprejela 7. 12. 2017, z osrednjim ciljem *kakovostno življenje za vse* [4]. Od petih strateških usmeritev (*vključujoča, zdrava, varna in odgovorna družba;učenje za in skozi vse življenje; visoko produktivno gospodarstvo, ki ustvarja dodano vrednost za vse; ohranjeno zdravo naravno okolje; visoka stopnja sodelovanja, usposobljenosti in učinkovitosti upravljanja*) nobena določno ne naslavlja pomanjkanja ljudi v delovni starosti. Iz nobenega od dvanajstih razvojnih ciljev, niti iz množice 30 številčnih ciljnih kazalnikov, ki naj bi pomagali slediti njihovo uresničevanje, ni videti zavedanja ogromnosti prebivalstvenega primanjkljaja, oziroma je razvidno zamolčevanje tega problema; izjema je kazalnik stopnje aktivnosti prebivalstva, ki naj bi se povečala od sedanje 70 na več kot 75, in posredno naslavlja problem premajhnega števila zavarovancev. Med kazalniki vsekakor manjkajo totalna mera rodnosti, obseg odseljevanja državljanov Slovenije, obseg priseljevanja tujcev, razmerje med zavarovanci in upokojenci. Celo pri cilju 5 *Gospodarska stabilnost* (str. 32) je problematika primanjkljaja ljudi v delovni starosti popolnoma odsotna. Kot bi do podrobnosti načrtovali lesno podjetje, pa bi niti ne omenili, koliko lesa potrebujemo in od kje ga bomo dobili. Strategija kot » *krovni okvir razvoja države*« (str. 49) bi morala naslavljati poglavitne naloge in izzive.

Zavedanje problema na splošni deklarativni ravni sicer ni popolnoma odsotno, saj na strani 10 beremo, da »*Nadaljnje razvojne možnosti tako omejujejo nizka produktivnost, neprilagojenost demografskim spremembam, ...)*«, na strani 12, pa, da »*Demografske spremembe torej vodijo v relativno hitro zmanjševanje zmogljivosti aktivnega prebivalstva, kar zaradi pomanjkanja ustrezne delovne sile lahko tudi pomembno zmanjša sposobnost za hitrejši gospodarski napredek, ki je pogoj za nadaljnje izboljšanje življenjskega standarda prebivalstva.*« Vendar je še to zapisano olepševalno, kot ovira za večje izboljšanje in hitrejši razvoj, ne pa kot huda grožnja sedanji ravni blaginje.

Mediji so leto pred volitvami nehali objavljati svarila EU o najslabši starostni sestavi Slovenije med vsemi članicami EU. Namesto načrtov, kako se lotiti primanjkljaja, ki nam že letos pije kri, še bolj pa jo bo v naslednjih letih, poslušamo vladno predvolilno zgodbo o uspehu, višji rasti, proračunskem presežku, povečanju pokojnin, novih dela prostih dnevih, in poročila o drugih predvolilnih golažih koalicije. Kot tisti, ki je padal iz 100 nadstropnega nebotičnika in se je pri petdesetem nadstropju hvalil, da mu gre za zdaj zelo dobro.

4. SKLEP

Vlada torej navaja probleme in področja ukrepov, ne pa velikosti problemov in njihovih posledic, niti cene in pričakovanega učinka ukrepov. Kjer navaja ocene primanjkljaja ljudi v delovni starosti in priseljevanja, navaja mnogo prenizke in pove, da ne zadoščajo; ne pove pa, koliko bi zadoščalo. Namesto, da bi številčno prikazala svojo zapuščino, pred volitvami prodaja zgodbo o uspehu.

Omenjeni graf v *Strategiji* je moč narisati le iz številčnih podatkov. Če vlada zapiše, da nekaj ni dovolj, ve, koliko je dovolj. Vlada torej ve več, kot pove. Kakšen bolj realen podatek tudi uide. Tako je ministrica Anja Kopač Mrak povedala « *Po ocenah UMAR se bo delež aktivnega prebivalstva do leta 2020 v povprečju zmanjšal za osem tisoč ljudi na leto.*« [6]

Vlada torej ima ocene primanjkljaja in s tem povezanega priseljevanja, ne le po obsegu, ampak verjetno tudi po državah izvora. Ve namreč, da se države izvora dosedanjega priseljevanja praznijo: na strani 12 *Bele knjige* namreč preberemo: »*Zadnje projekcije Eurostat-a predpostavljajo neto migracije od 4000 do 6000 prebivalcev letno več do leta 2060. Ob upadanju neto migracij od leta 2010 dalje se postavlja vprašljivost te predpostavke.*«

Pravočasna dosegljivost ključnih demografskih parametrov je nujna za gospodarski razvoj. Če parlamentarne stranke vladi dopuščajo, da jih omalovažuje ali morebiti celo prikraja, morebiti Državni svet lahko doseže ali vsaj pripomore, da vlada brez uporabe kake inovativne poštevanke takoj objavi **primanjkljaj ljudi v delovni starosti** v naslednjem mandatu (in v naslednjih 10, 15, 20, 25 letih) za ohranitev razmerja med številom zavarovancev in številom upokojencev, pri sedanji starostni sestavi prebivalstva, napovedanem podaljševanju življenjske dobe, sedanji ravni odseljevanja državljanov ter sedanji pokojninski in drugi zakonodaji;tudi projekcije upokojevanja po letih. Oceni naj **gospodarske in družbene posledice** tega primanjkljaja za obseg gospodarstva, prihodke proračuna, pokojnine, zdravstvo, šolstvo, …. Ukrepe za zmanjševanje primanjkljaja naj konkretizira, oceni njihovo ceno, doseg in učinek; pove naj, kolikšen obseg primanjkljaja namerava reševati s priseljevanjem, ter kako in iz katerih držav izvora bo uresničila tak obseg priseljevanja. Razkrije naj načrte za dvig sedanje prenizke rodnosti, katere posledice bomo čutili v gospodarstvu čez 25 let - ukrepe za vzpodbujanje odločanja za življenje v mladih družinah.

Do teh podatkov imamo pravico državljani, politične stranke, ki preko parlamenta in vlade usmerjajo razvoj, in vsi drugi tudi v Državnem svetu zastopani dejavniki.

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Demografski trendi v svetu in Sloveniji

Kako preprečiti izumiranje slovenskega naroda?

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POVZETEK

V prispevku so analizirani osnovni demografski trendi doma in po svetu s poudarkom na izumiranju slovenskega naroda in na relacije, ki najmočneje vplivajo na to. Predlagani so tudi potencialni ukrepi kot način debate v pomoč pri reševanju problematike. Ključnega pomena pa je, da se slovenska javnost in politika zavesta problemov, preden bo prepozno.

ABSTRACT

We analyze basic demographic trends worldwide and in Slovenia. The emphasis is on the forthcoming extinction of the Slovenian nation. Several relations, reasons, and possible improvements are identified. The key factor is that the media and governing acknowledge the trends and the final outcome unless major changes are introduced.

Keywords

Artificial intelligence, demography, economy, world, Slovenia

Ključne besede:

Umetna inteligenca, demografija, ekonomija, svet, Slovenija

1. UVOD

Demografski pojavi so razen v primeru vojn, katastrof ali epidemij običajno dolgotrajni in zato pogosto nepomembni za javnost ter tudi politike, ki najpogosteje razmišljajo le o postopkih izvolitve, kar pomeni časovni razpon nekaj let. Posledica tega je, da so dolgoročne demografske napovedi v javnosti sprejete z nezainteresiranostjo in tudi skepso.

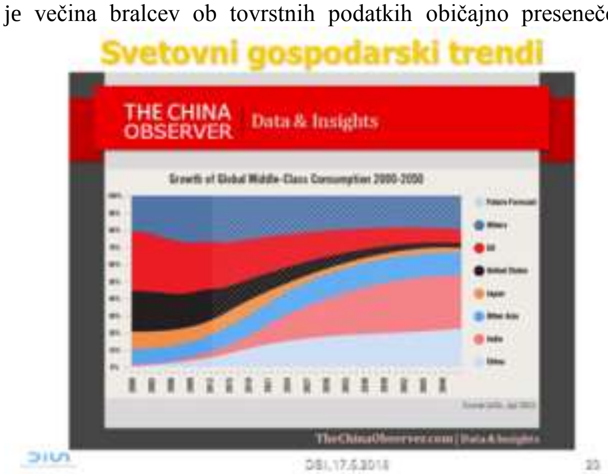
Poglejmo sliko 1, ki kaže pričakovane spremembe v deležu svetovne populacija po celinah. Leta 1950, tj. po drugi svetovni

Slika 1: Deleži populacije kontinentov v svetu.

vojni, je bilo Evropejcev skoraj 22 odstotkov. Leta 2015 jih je bilo le še 10%, leta 2100 jih bo le še 6%. Leta 1950 je bilo 2,6 milijarde ljudi na svetu, 2015 7,4 milijarde in leta 2100 jih bo predvidoma 11,2 (EUROSTAT). Delež Slovencev v svetu se zmanjšuje z 0,6 promila leta 1950 na 0,2 promila leta 2015 in po projekcijah na 0,09 promila leta 2100. Od druge svetovne vojne do 2100 se bo torej delež Slovencev v svetu zmanjšal za 6-krat.

Pomemben je še en pojav, opazen s slike 1. Medtem ko je leta 2015 skoraj 60% vse svetovne populacije prebivalo v Aziji in ko je bilo leta 1950 le 9,1% Afričanov, bo leta 2100 44% Azijcev in 39% Afričanov. V času od druge svetovne vojne do 2100 se bo delež Afričanov povečal za več kot štirikrat, medem ko se bo delež Evropejcev zmanjšal za skoraj štirikrat (EUROSTAT).

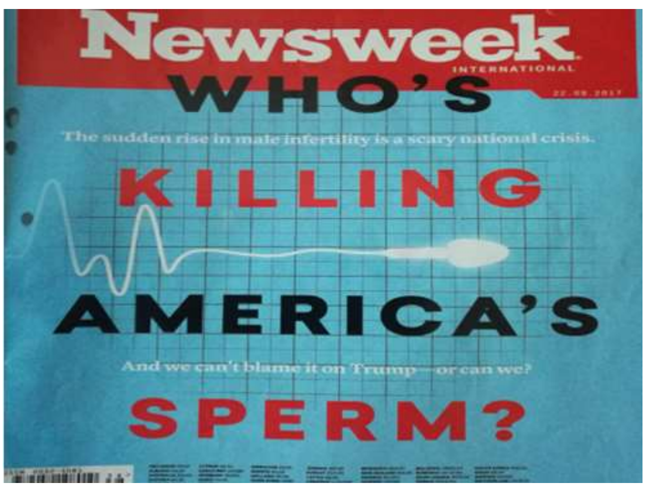
Posledice demografskih premikov so očitne tudi v ekonomskem in drugih pogledih. Čeprav zahodna civilizacija preko svojega NATO pakta ostaja dominantna vojaška sila, se ekonomsko gledano Kitajska prebija na mesto svetovno najpomembnejše ekonomije, še značilnejše pa so projekcije srednjega razreda. Slika 2 kaže izrazito zmanjševanje srednjega razreda v ekonomskem globalnem deležu. V resnici absolutno število srednjega razreda v zahodni civilizaciji rahlo upada, medtem ko se bo npr. na Kitajskem povečal na 700 milijonov leta 2030. Ko pa številčnost srednjega razreda pomnožimo z ekonomskimi učinki, dobimo sliko 2. Trenutno po tem kriteriju prevladuje Evropa, ki pa jo dohiteva Kitajska, medtem ko projekcije kažejo, da bo leta 2030 Indija po tem kriteriju prehitela vse druge države. Slika 2 nazorno kaže, kako slabo nas o teh pojavih obveščajo svetovni mediji, saj je večina bralcev ob tovrstnih podatkih običajno presenečena.



Slika 2: Delež svetovne potrošnje srednjega razreda.

Pomembno se je tudi zavedati, da je srednji razred nosilec kvalitete življenja: zgornji razred preveč obremenjuje okolje, spodnji razred pa nima dovolj kvalitetnega življenja. Premajhna rodnost vpliva na poslabševanje kvalitete življenja v ekonomskem in drugih ozirih (Lee .. Sambt 2014).

Iz svetovnih analiz je očitno, da se dogajajo izjemne demografske spremembe v relativno mirnem obdobju človeške zgodovine, kjer ni svetovnih vojn ali življenjsko nevarnih epidemij. Po spletu se pojavlja vrsta teorij, kaj se dogaja. Nekateri celo trdijo, da gre za genetsko propadanje bele rase, kar se včasih povezuje z raznimi »izmi« - rasizmi, šovinizmi, feminizmi, političnimi in drugimi ideologijami, in pozivanju k nasilju. Znanost mora zato skrbno paziti, da ne prekorači meje objektivnosti. Drugi celo trdijo, da gre za namerno uničevanje bele rase, kar se vidi npr. v zmanjševanju količine sperme pri mladih moških (Slika 3). Dodaten »dokaz« naj bi bilo sistematično izigravanje tovrstnih informacij v medijih. To sicer ne bi bilo nič novega, saj so v javnosti mediji pogosto sistematično zatirali znanstvena in strokovna spoznanja (npr. nevarnost kajenja, globalno segrevanje, politični oporečniki itd.). Kljub temu se zdi povsem neverjetno, da bi lahko nekdo obvladoval medije v toliko državah in toliko različnih političnih usmeritvah. Kakorkoli, vsaj desetletje so posamezne objave kazale na alarmanten trend zmanjševanja spermijev pri mladih moških, pri čemer so predlagale različne vzroke za to, npr. pretesne spodnjice. Širša skupnost in predvsem mediji pa so se tem raziskavam bolj ali manj posmehovali. Poglavitni znanstveni pomislek je bil, da so bile študije narejene na malem številu primerov in tipično v eni državi. Šele leta 2017 je vrsto raziskav združil dr. Levine, vodja Environmental Health Track pri Hebrew University-Hadassah skupaj z dr. Shanna H. Swanovo, profesorico v New Yorku in s tem prodrl v javnost (Levine 2016). Slika 3 opisuje pojav pretežno v Ameriki, vendar je značilen za ves razviti svet (Evropa, Amerika), medtem ko ne velja za manj razvite kraje, recimo Afriko. Študija sama ne poda razlage, kaj je vzrok za tako radikalno zmanjševanje, ki bi v nekaj generacijah lahko pripeljala do radikalnega zmanjšanja reprodukcijske sposobnosti oz. kot pravi avtor: »sedaj je le kanarček v rudniku«. Najverjetnejša se zdi razlaga, da to povzročajo snovi, tj. onesnaževalci.



Slika 3: Količina spermijev se je v generaciji moških zmanjšala za polovico.

Kaj je torej razlog za velike demografske spremembe? Poglavitna raziskovalna teza tega prispevka je, da se človeška populacija približuje trajnostni zmogljivosti tega planeta in da je potrebno ustaviti človeško demografsko rast.

2. SMO DOSEGLI KAPACITETE PLANETA?

Meje rasti, angleško »https://en.wikipedia.org/wiki/File:Club_of_Rome_Logo.svgThe Limits to Growth« je najbolj odmevno predstavil Rimski klub leta 1972 (Meadows 1972), ponovno izdano 26. novembra 2017. Računalniške predikcije, temelječe na eksponentnih rasteh (še starejši vir: Malthus; novejše EUROSTAT), so leta 1972 predstavili na konferencah v Moskvi in Riu de Janeiru. Izdanih je bilo preko 30 milijonov knjig. Leta 2004 je izšla nova verzija: »The Limits to Growth: The 30-Year Update« (EUROSTAT). Čeprav so bile prve napovedi o skorajšnjem pomanjkanju nafte in drugih naravnih resursov pretirane, saj se npr. v Ameriki po dolgoletnem zmanjševanju proizvodnje zadnja leta z drobljenjem skrilavcev hitro povečuje, je očitno, da so na vsakem omejenem prostoru meje eksponentne rasti slej ko prej dosežene. Zaradi narave eksponentne rasti, ki je našim možganom relativno tuja, saj je v naravnem okolju skorajda ni, pa ljudje brez strokovnih študij tega ne uspemo dojeti. .

Najpomembnejša zaključka novih študij sta dva:
- Če se bo rast ljudi in industrije nadaljevala, bo pripeljala do strmega »vrha« okoli leta 2070 in pripeljala do propada, tj. velikega padca populacije in gospodarstva
– z ustreznimi mehanizmi, predvsem zmanjševanjem demografske rasti, bo možno preiti v trajnostno stanje.

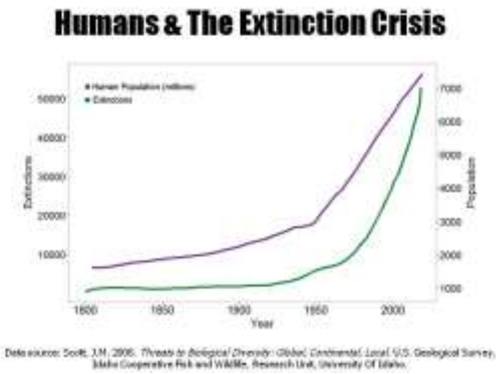
Glede na razne študije ljudje že sedaj vsako leto porabimo precej več virov, kot jih zemlja letno proizvede. To velja zlasti za fosilne vire, ki so nastajali nekaj sto milijonov let, smo jih pa skoraj polovico že potrošili. Podobno smo preoblikovali že polovico svetovnega površja, s tem da smo uničili 5% površine. Tudi v Sloveniji nismo bistveno na boljšem glede normalnega odnosa do narave. Medtem ko imamo med največ kilometri avtocest na prebivalca in kvadratnimi metri veletrgovin na prebivalca, smo glede preskrbe padli na mizerni nivo: medtem ko pride na Slovenca 800 m2 obdelovalnih površin, bi jih potrebovali 2000, zato smo na dnu Evrope po tem kriteriju. Ne glede na to pospešeno gradimo tako ceste kot nove tovarne na najbolj kvalitetnih površinah. Medtem ko se pred 40 leti nisi mogel poleti peljati na morje, ne da se ne bi vsaj enkrat ustavil in umil šipo, se sedaj lahko voziš cel teden. Študij in objav o tem ni, morda nekaj malega o izginjanju čebel, pri čemer nihče točno ne ve, podobno kot pri zmanjševanju sperme, kaj to povzroča. Še en »kanarček v rudniku«?

Še bolj neprijeten je neposreden vpliv na okolje in živa bitja. Slika 4 kaže sovpadanje rasti človeškega prebivalstva z upadanjem / izumiranjem živalstva. Študije kažejo, da je
- izumiranje vrst 100x hitreje kot normalno (de Vos 2014)
- v 40 letih 50% živali manj na svetu
- v 27 letih v Nemčiji 75% manj letečih žuželk.

Strokovnjaki govorijo o šestem velikem izumiranju na našem planetu (Kolbert 2016).

Če torej dosegamo meje rasti človeške populacije, ali se rast človeške populacija ustavlja in zakaj? Odgovor je nenavaden, saj število ljudi hitro raste (http://www.worldometers.info/world-population/), kljub temu pa se svetovna rast prebivalstva ustavlja. Število otrok zadnjih 10 let je precej konstantno. Svetovno prebivalstvo se v seštevku povečuje predvsem zaradi rasti na določenih geografskih lokacijah in zaradi povečevanje življenjske dobe. Rast pa se je globalno skoraj ustavila (Pearce 2008).

race (also Caucasoid or Europid)https://en.wikipedia.org/wiki/Caucasian_race - cite_note-2« (EUROSTAT)).



Slika 4: Eksponentna rast prebivalstva zadnje stoletje sovpada z uničevanjem živalstva in okolja.

V letih 1950-55 je bila rodnost (število otrok na žensko) 5. V letih 2005-2010 je bila rodnost 2,5 in je sedaj padla na 2,4. Z rodnostjo 2,5 bi v 10 generacijah svetovna populacija narasla na 40 milijard, v 13 generacijah pa na skoraj 80 milijonov. Z rodnostjo 5 pa bi v 10 generacijah prišli na 40.000 milijard, v 13 generacijah bi prišel en prebivalec na 1 m2 površine, v 40 generacijah pa 1 na kg Zemlje. Število Slovencev bi v 10 generacijah ob sedanjih trendih padlo na 3.5% prebivalstva v Sloveniji – brez povečane emigracije.

3. IZUMIRANJE SKUPIN LJUDI

Izumiranje oz. praktično izumiranje določenih skupin ljudi je znano iz nedavne človeške zgodovine. Če pa gremo nekoliko dlje, je Neandertalec živel v Evropi od 230.000 do 30.000 let nazaj. Bil je zelo podoben nam, sodobnim ljudem, in še danes ima večina svetovne populacije razen Afričanov 1-2% neandertalskih genov. Še dalj je živel Homo floresiensis v Indoneziji (Zimmernan 2010), pradavna verzija malega človeka (hobit), ki je izumrl pred cca 10.000 leti.

Leta 1492 je Krištof Kolumb odkril obe Ameriki, poseljeni z Indijanci. Ocena populacije se giblje nad 50 milijoni. V 150 letih pa je bila smrtnost skoraj 90% in sedaj je Indijancev manj kot 2 milijona v deželi s skoraj 330 milijoni, tretji najštevilčnejši državi sveta. Precejšen del Indijancev v Severni Ameriki je v rezervatih, ki so verjetno preprečili popolno izumrtje.

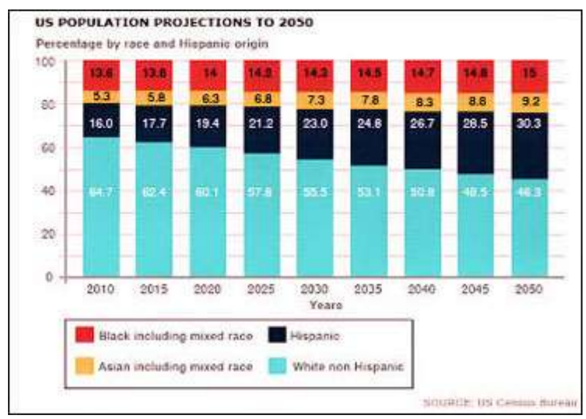
Podobno se je zgodilo avstralskim aboriginom – pred kolonizacijo jih je bilo okoli 1,25 milijona, leta 1930 le še 50.000. Otok Mavricijus so po letu 1500 odkrili Evropejci in se nekaj časa borili med seboj za prevlado. Danes je Hindujcev / Indijcev 40%, Kreolov (Afro, Afro-Indijcev) 22%, indijskih muslimanov 16%, Tamilcev (južnih Indijcev) 4,5%, drugih Kreolov 3%, Kitajcev 2%, belih Francozov 1%, belih Južnoafričanov 1,5%.

Za primere evropskega dogajanja ni treba iti daleč. Pred nekaj desetletji je bila večina ljudi na ulicah Londona evropskega izvora, danes pa jih je le približno polovica. Matere brez matičnega državljanstva v evropskih državah rodijo od 10% do 30% otrok, ta delež pa je v zadnjih 10 letih zrasel za nekaj odstotkov. Kljub temu je večinsko prebivalstvo od 70-90% v večini razvitih zahodno usmerjenih držav (ZDA, Evropa, Avstralija) evropskega izvora. Svetovno gledano je rodnost 2,4, medtem ko je rodnost belcev 1,5. (Opomba: v svetovni strokovni literaturi in v medijih se namesto izraza »belec« pogosteje uporabljajo drugi izrazi, npr. »evropskega izvora« ali »Caucasian race (also Caucasoid or Europid)https://en.wikipedia.org/wiki/Caucasian_race - cite_note-2« (EUROSTAT)).

Slika 5: Razmerje med prebivalci bele in črne polti Vir: National policy institute.

Slika 5 kaže glede na sliko 1 pričakovano spreminjanje razmerja med prebivalci bele in črne polti. Slika 6 kaže razmerja med populacijskimi skupinami v Ameriki – leta 2040 bo manj kot polovica belcev in do 2100 manj kot 20%, če se bo sedanji trend nadaljeval.

Morda bi kdo dejal, da se zgodovina aboriginov in Indijancev ponavlja, ampak potrebno se je zavedati drugačnih okoliščin: v prvih dveh primerih je šlo za nasilno kolonizacijo civilizacijsko bolj napredne skupine ljudi, v sedanjem primeru izumiranja belcev pa gre za mirni proces s podobnimi posledicami. Nepreverjena hipoteza tega prispevka je, da se belci »zavedajo« preobremenjenosti planeta, da je potrebno ustaviti svetovno rast prebivalstva, in da imajo zato manj otrok.



Slika 6: Populacijske skupine v ZDA. Belcev bo manj kot 50% leta 2040, če se razmerja ne spremenijo. Čeprav gre za objektivne strokovne analize, se je potrebno ograditi od rasizma in podobnih nezaželenih pojavov, zato je obzirnost pri tolmačenju številk nujna.

Ameriška dogajanja so zanimiva, ker so podrobneje analizirana – EU sestoji iz več nacionalnih držav, vsaka s svojimi študijami, Amerika pa je enotna. V letu 2016 je bilo vsega 60,2 rojstev na vsakih 1000 žensk v starosti od 14 do 44 in rodilo se je 3,85 milijonov otrok, 2% manj kot leta 2016. Pri tem se je proporcionalno rodilo 50% več otrok v družinah z manj kot $10.000 v primerjavi s tistimi z $200.000 in več. Strokovnjaki ugotavljajo, da srednjeročno in dolgoročno tako stanje kulturno in ekonomsko ni vzdržno. Predsednik Trump je sicer povečal davčne olajšave za otroka s $1.000 na $2.000, trenutno še brez učinka na povečano rodnost. Mimogrede – študije avtorja ugotavljajo, da finance niso ključna komponenta za večjo rodnost.

Razmere v Evropi so daleč slabše, saj je rodnost na naši celini 1,56 (približno kot slovenska), medtem ko je ameriška 1,76. Pri tem pa je treba upoštevati tako veliko imigracijo kot tudi bistveno večjo rodnost pri prišlekih. Pri tem ameriški demografi bijejo plat zvona in opozarjajo, da jih mediji ignorirajo. Vseeno občasno pridejo na prvo stran poglavitnih medijev, kar se v Sloveniji še ni zgodilo (Fox news 2018). Še slabša so razmerja pri voditeljih. Voditelji 8 ključnih evropskih inštitucij (komisija EU, VB, Nemčija, Francija, Italija, Belgija, Luksemburg, Nizozemska) imajo skupno 2 otroka, leta 1951 pa so imeli ti voditelji 32 otrok. To ni nedolžno, kot morebiti izgleda na prvi pogled. Taki voditelji pač ne skrbijo ne za otroke in ne za primerne družinske razmere, hkrati pa ljudje volivci volijo take politike, kar kaže na prevladujočo miselnost. Demografi ugotavljajo, da je to posledica načina življenja in vrednot – zasledovanje kariere in užitkov namesto dolgoročnih ciljev in naravnosti. Pojav je opisan že leta 1994 (Postman 1994) in se samo še potencira.

4. SLOVENSKA POPULACIJA

Slovenska demografska gibanja smo analizirali v vrsti lastnih programov in smo jih primerjali s programi EU in EUROSTAT (Gams 2007, 20012). Izkazalo se je, da so predikcije zelo podobne, kar pomeni, da je ob sedanjih predpostavkah prihodnost dobro predvidljiva. Seveda pa lahko pride do spremembe razmer, kar vpliva na nadaljnje spremembe. Analize so objavljene v prejšnjih referatih konference »Soočanje z demografskimi izzivi«, ki je z dobrim desetletjem strokovnih analiz vodilno slovensko srečanje na tem področju.

Projekcije kažejo, da bo okoli leta 2100 v Slovenji le še pol Slovencev po narodnosti. Podrobnejše analize so dokaj decidivno odgovorile, kaj so ključni vzroki za upadanje rojstev in s kakšnimi ukrepi bi lahko povečali število slovenskih rojstev oz. preprečili izumrtje Slovencev.

Če na kratko povzamemo:

- S Slovenci se dogaja podobno kot z belci in Evropejci: z rodnostjo okoli 1,5 nam sledi demografsko nazadovanje in s tem povezano ekonomsko, marginalizacija, degradacija obstoječe kvalitete življenja in delovanja, nazadovanje slovenske kulture in civilizacije. Spremembe ne bodo hipne, so pa že dokaj opazne.
- Ključen je sistem vrednot in vpliv neoliberalno-globalističnih medijev, ki vsiljujejo manjšo rodnost, kar je dobrodošlo na svetovnem nivoju za krotitev preštevilčne populacije, za Slovenijo in Evropo pa predstavlja čedalje večji problem.
- Slovenski mediji, javnost, politika sledijo vzoru neoliberalnih medijev, ignorirajo opozarjanja in forsirajo take vrste družbo in vrednot in ukrepov politike, da zmanjšuje slovensko rodnost.

Že sedaj pa je po podatkih statističnega urada SURS (http://www.stat.si/StatWeb/Field/Index/17/104) 15% mladih od 0 do 14 let, 19,4% starejših od 65 let in 5,9% tujih državljanov.

5. DISKUSIJA

Hipoteza tega prispevka je, da so se ljudje nezavedno odločili, da je potrebno ustaviti rast prebivalstva, na kar vrsto let opozarja tudi stroka. Podobno se je odločila Kitajska, kjer je partijsko vodstvo najprej zapovedalo 1,5 otroka in sedaj 2 otroka na žensko. V razvitem svetu ni možno zapovedati števila rojstev na tak, ekspliciten način, zato pa mediji, sistem vrednot, sistem delovanja družbe avtomatsko vodijo v zmanjševanje prebivalstva, ki je sedaj za belo raso v razvitem svetu izrazito z 1.5 otroka na žensko.

Ostali deli sveta, predvsem Afrika, tem smernicam ne sledijo, ampak vztrajajo pri visoko rodnosti. Posledično prihaja in bo še bolj prihajalo do demografskega emigracijskega pritiska, ki bo vršilo silovit pritisk predvsem na Evropo, ki je geografsko povezana z Azijo in Afriko (Gams 2015). Ob prepuščanju demografskim množicam bosta tako evropska kot slovenska civilizacija relativno kmalu izginili oz. se transformirali, genetsko pa se bo evropsko prebivalstvo korenito spremenilo.

Politiki in javnost gledajo na tovrstna vprašanja ideološko, politično, medtem ko je pogled v tem prispevku predvsem strokovno demografski, skozi število ljudi in zakonitosti, ki jih prinašajo množice. Te demografske analize so dokaj nesporne, saj so številke dokaj nesporne – en človek je pač en človek – in omogočajo dokaj zanesljive analize vzrokov in napovedi.

Zanimivo je primerjati analize, ki smo jih naredili z metodami umetne inteligence, z drugimi strokovnimi analizami in potezami slovenske politike. Napovedi domačih in tujih strokovnjakov so v vseh primerih dokaj podobne in kažejo, da bo ob nespremenjenih pogojih najverjetneje prišlo do napovedanega scenarija. Seveda pa se razmere lahko spremenijo in recimo na primeru migracije v Evropo je težko napovedati, kako se bo Evropa odločila – povsem odprla meje, jih priprla ali celo hermetično zaprla. Oba ekstrema najbrž nista dobrodošla.

Pri analizi slovenske politike in delovanja ministrstev opazimo večje razlike glede na naše in tudi druge strokovne analize. Na papirju vsi skrbijo za idealno rodnost 2.1, v praksi pa sprejemajo zakone, ki negativno vplivajo na rodnost (Gams 2007, 2008, 2011, 2012, 2013, 2017). Med njimi so:

- Preobremenjenost žensk. Sodobna ženska ima težko otroke, ker potem nima časa hoditi v službo in delati kariero. Če pa je nezaposlena, pa nima sredstev za kvalitetno življenje. Nima tudi varnega okolja, ker jo lahko moški kadarkoli brez posledic zapusti. Zato so predvsem mlade ženske pri iskanju varnega materinstva najbolj diskriminirana skupina, vsaj po mnenju avtorja.
- Zmanjševanje pomena usmeritev, ki nagovarjajo k večjemu številu rojstev.
- Zmanjševanje pomena in vloge družine, padanje ugodnosti in posledično deleža porok, ukinjanje tradicionalnih vlog v družini, forsiranje liberalnega in hedonističnega pogleda na svet, promoviranje feminizma in raznih alternativnih oblik družine (Gams 2013) brez varnosti za otroke in mame, forsiranje egoističnega potrošništva in ukinjanje skupnosti, ukinjanje stabilnih in kvalitetnih okolij za ženske – mame.
- Sprejemanje ukrepov v smislu neoliberalnega globalizma in pretiranega potrošništva tudi na področju medčloveških odnosov, predvsem uničevanju vseh skupnosti od družin do držav.
- Ignoriranje pomena premajhne rodnosti, odhajanja najboljših mladih v tujino in drugih demografskih problemov.

Vsako leto iz Slovenije odide nekaj tisoč najsposobnejših v populaciji, ki ima manj kot 20.000 otrok (Dnevnik 2016). Pa se glede tega le malo razburjamo, veliko pa je govora o tem, da je potrebno biti odprt v svet, da ne smemo ljudi nasilno zadrževati in podobno. Recimo v nedavni debati v Državnem svetu so mi uradni predstavniki zatrjevali, da odhajanje v tujino ni nič slabega, saj vse nadomestimo z migranti. Ampak, če gre pomemben del najsposobnejših mladih v tujino, to vsakemu normalnemu posamezniku pomeni siromašenje bazena mladih prodornih in pametnih, polnih energije in poleta. Globalizem ne pomeni samo koncentracijo kapitala, ampak tudi kadrov, posledično pa siromašenje vseh na obrobju. Finančne posledice so precej hujše kot samo vlaganje v šolanje, ki znaša okoli 300.000 v posameznika. Problem je v tem, da se le malokdo vrne v Slovenijo. Če bi se vračali, bi bilo to zelo dobrodošlo po več kriterijih.

V zaključku: Hvalevredno je, da se rast človeške populacije ustavlja. Pritisk na Evropejce, belce in planet pa ostaja oz. se povečuje, to pa je zaskrbljujoče. Zlasti je ta pritisk velik na Slovenijo, ki zaradi svoje majhnosti ne zmore dalj časa zdržati tega trenda, ne da bi prišlo do marginalizacije slovenske populacije, civilizacije, kulture, jezika.

Zakaj slovenski politiki, mediji, množice ne začnejo biti plat zvona zaradi migracije, premalo rojstev, grozeče marginalizacije Slovencev kot narodnosti in državljanstva (Gams 2017)? Jasnega odgovora avtor po desetletju raziskav še vedno nima. Zdi se, da so ljudske mase in politiki tako pod vplivom neoliberalnih globalističnih pogledov svetovnih elit, da niso sposobni razumeti, kaj je za Slovenijo in Slovence, tako državljane in državljanke kot po narodnosti (slovenski, hrvaški, italijanski, srbski itd.) dobro in kaj ne.

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KOMUNICIRANJE S SPLOŠNO JAVNOSTJO O ZDRAVJU IN ZDRAVILIH: Razumevanje besedil z vidika starejših oseb

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POVZETEK

Zdravje je ena največjih vrednost. Informacije o zdravju in zdravilih nas spremljajo na vsakem koraku; nekatere informacije načrtno iščemo, druge pa nas dosežejo, ne da bi posebej poizvedovali za njimi. Poleg ustreznih sporočil o zdravju in zdravilih je razpoložljivih veliko informacij, ki niso ustrezne, ali so celo zavajajoče. Dobro razumevanje informacij o zdravju in zdravilih je bistvenega pomena za vedenje oseb, ki zagotavlja učinkovito in varno zdravljenje.

Starejše osebe se pogosto soočajo s težavami pri pridobivanju informacij o zdravju in zdravilih, velikokrat zaradi zdravstvenih razlogov. Pojavljajo se lahko tudi težave z razumevanjem pisnih sporočil o zdravju in zdravilih. Poleg besedil z opisom zdravil, ki se predpisujejo na recept, je pomembno tudi ustrezno razumevanje besedil, ki opisujejo zdravila brez recepta. Določitev berljivosti besedil, analiza apelov v besedilih in pripisovanje pomembnosti specifičnim atributom so del raziskovanja besedil o zdravju in zdravilih. Rezultati raziskovalnih dosežkov lahko vodijo v ukrepe za izboljšanje razumevanja informacij. Poseben poudarek mora biti namenjen ranljivim skupinam, vključno s starejšimi osebami.

Staranje prebivalstva je pomemben del demografskih sprememb in predstavlja tudi izziv za sistem javnega zdravja. Ustrezno razumevanje informacij o zdravju in zdravilih prispeva k učinkovitemu ohranjanju zdravja in zdravljenju.

Ključne besede

Zdravje, informacije o zdravju in zdravilih, učinkovito in varno zdravljenje, demografske spremembe, starejše osebe, berljivost, apeli, zaznana pomembnost atributov.

ABSTRACT

Health is one of the most important values. We are accompanied by health and medicines information at every step; some information is intentionally searched for and other information reaches us without a demand. Besides appropriate health and medicines messages, a lot of inappropriate information or even misleading information is available. Good comprehension of health and medicines information is essential for patients' behavior which is in accordance with efficient and safe treatment.

Older persons are often confronted with the difficulties in obtaining health and medicines information, many times due to the health issues. Also the difficulties with comprehension of written health and medicines messages may appear. Besides the texts, describing the prescribed medicines, also a proper comprehension of texts, describing OTC medicines is important. Determining readability of texts, analyzing appeals in the texts and assigning of importance to specific attributes is a part of researching health and medicine texts. The results of the research achievements may lead to the measures for improving comprehension of information. Special emphasis must be dedicated to the vulnerable groups, including older persons.

Population ageing is an important part of demographic changes and also represents a challenge for the public health system. Appropriate comprehension of health and medicines information contributes to an efficient maintaining of health and treatment.

Keywords

Health, Health and medicines information, Efficient and safe treatment, Demographic changes, Older persons, Readability, Appeals, Perceived importance of attributes.

1. UVOD

V sedanjosti se vsakodnevno soočamo z velikim številom informacij, vključno z informacijami o zdravju in zdravilih. Za nekaterimi izmed informacij načrtno poizvedujemo, veliko informacij pa ne iščemo, niti jih ne potrebujemo, pa nas vseeno dosežejo. Pomembno je izbrati informacije, ki so zanesljive, uporabne in bodo imele pozitiven vpliv na naše zdravje. Kar pa ni vedno enostavno.

Informacijam o zdravju in zdravilih pripisujemo velik pomen. Zdravje je opredeljeno kot ena največjih vrednost. Rezultati raziskave (1) kažejo, da je ovrednotenje zdravja v skupini mladih žensk z leti naraščalo; ženske srednjih let pa so zdravju pripisale večjo vrednost kot moški srednjih let. Tudi v slovenski raziskavi (2) je zdravje opredeljeno kot najpomembnejša vrednota mladih.

Na eni strani se srečujemo s sporočili, ki so ustrezna in se jim pripisuje pozitiven vpliv na zdravje, pa tudi s sporočili, ki so neuporabna, ali celo zavajajoča. Posebej internet je neobvladljiv vir informacij, ki ga velik del prebivalstva, predvsem pa mlade osebe, uporablja za sporazumevanje. Poleg informacij, ki pozitivno vplivajo na naše življenje in zdravje, je nemalo takih, ki imajo negativen, lahko celo škodljiv in ogrožajoč vpliv. Raziskava (3) kaže, da kakovost spletnih informacij o zdravju vpliva na usklajeno komunikacijo med zdravnikom in pacientom; iz te ugotovitve izhaja pomen zdravnikovega usmerjanja pacientov k pomembnim virom informacij o zdravju.

Tudi bolj tradicionalni viri informacij o zdravju in zdravilih, kot so na primer pisni, tiskani viri, so kljub zakonodajnim zahtevam (4) nadzorovani le v omejenem obsegu.

Razumevanje sporočil o zdravju in zdravilih se zdi samoumevno. Uvedle so se izboljšane vsebine določenih uradnih virov o zdravilih, kot so na primer navodila za uporabo zdravil. Vendar iz različnih virov izhaja veliko vsebin, ki so zasičene z medicinsko terminologijo, se lahko interpretirajo na zelo različen način, ali pa so celo zavajajoče. Izkušnje kažejo, da strokovnjaki pri dajanju pojasnil o zdravljenju z zdravili brez recepta menijo, da je pacient nasvet prejel od drugega strokovnjaka, ali pa se zanašajo, da je natančno prebral navodila za uporabo. Obseg svetovanja je odvisen tudi od razpoložljivega časa, zavedanja pomena informacij o zdravju in zdravilih ter od drugih dejavnikov.

V raziskavah so med merila kakovosti informacij zajeli natančnost, popolnost, berljivost, oblikovanje, jasnost informacij in vključenost referenc. Raziskovalci (5) so pri pregledu zbirk podatkov o člankih ugotovili, da avtorji kar v 70 % člankov ugotavljajo, da kakovost informacij o zdravju ni ustrezna, zaključki 22 % raziskav kažejo nevtralne rezultate, le iz 9 % raziskav pa izhaja pozitivna ocena kakovosti informacij.

Razumevanje informacij se povezuje z odločitvami, namerami in vplivom na vedenje. Težave nastopijo, ko je vedenje neustrezno do te mere, da se poslabša zdravje. Neustrezno jemanje oziroma ravnanje z zdravili brez recepta lahko vodi v slabšo učinkovitost zdravil in/ali povečano tveganje zaradi pojava neželenih učinkov ali medsebojnih učinkovanj med zdravili.

Glede na demografske spremembe, katerih pomembni del je staranje prebivalstva, se potrebujejo strategije in ukrepi za poučevanje starejših oseb o informacijah o zdravju in zdravilih, vključno z usmerjanjem k zanesljivim virom informacij. Starejše osebe pogosto jemljejo več zdravil hkrati, različne bolezni pa jim onemogočajo primerno razumevanje informacij Na osnovi raziskovanja bi bilo koristno ustvarjati gradiva, ki bodo z večjo razumljivostjo pripomogla k učinkovitejšemu in varnejšemu zdravljenju.

2. RAZISKOVANJE INFORMACIJ O VIRIH INFORMACIJ O ZDRAVJU IN ZDRAVILIH

2.1 Izhodišča za raziskovanje sporočil v gradivih o zdravilih brez recepta

Zdravila brez recepta so opremljena z navodili, ki jih pregledajo strokovnjaki iz pooblaščene uradne ustanove. Iz navodil za uporabo zdravil brez recepta lahko razberemo podatke o učinkovitosti, jemanju zdravil, indikacijah, možnih neželenih učinkih, kontraindikacijah, medsebojnem učinkovanju z drugimi zdravili in druge pomembne podatke. Zdravila brez recepta lahko medsebojno učinkujejo tudi z zdravili na recept. Vsebina promocijskih gradiv o lastnostih zdravil brez recepta pa se le delno nadzoruje s strani uradnih ustanov; to velja za tiskana gradiva, še v večji meri pa za spletne informacije.

Izhajali smo tudi iz opažanja, da izdajo zdravil brez recepta večinoma spremlja manj pojasnil kot izdajo zdravil, ki se predpisujejo na recept. Deloma pacienti prejmejo nasvete o zdravljenju z zdravili brez recepta v lekarni. Čeprav bi morali navodila za uporabo prebrati, vsi pacienti tega napotila ne upoštevajo.

Poleg tega je izdaja zdravil brez recepta obsežna. Skladno s podatki za leto 2016 je bila vrednost trga zdravil na recept v Sloveniji 201,0 milijona evrov, vrednost trga zdravil brez recepta pa 27,9 milijonov evrov, se pravi je razmerje znašalo približno 7 proti 1 (6). Skupno je trg zdravil brez recepta in sorodnih izdelkov v prvi polovici tega leta dosegel 54,4 milijona evrov, kar je pomenilo 1,0 % rast glede na leto prej. V največji meri so se prodajala zdravila brez recepta za lajšanje bolečine.

2.2 Način informiranja starejših oseb o zdravju in zdravilih

Starejše osebe pogosto zbolevajo zaradi več sočasnih bolezni in jemljejo tudi več zdravil hkrati. Zaradi spremljajočih bolezni starejše osebe težje spremljajo informacije o zdravju in zdravilih. Poleg tega velik del starejših oseb ni seznanjen z napredno tehnologijo, ki bi jim olajšala spremljanje informacij.

Pri raziskovanju iskanja informacij o zdravju oseb so ugotovili, da starejši od 55 let ocenjujejo zdravstvene delavce kot najbolj zanesljiv vir informacij o zdravju (7). Raziskovalci zaradi tega poudarjajo pomen orodij za izboljšanje komuniciranja med osebami te starosti in zdravstvenimi strokovnjaki. Obenem omenjajo pomen pomoči osebam iz tega starostnega segmenta, da bodo uporabljale in v večji meri zaupale zanesljivim spletnim virom.

3. BERLJIVOST IN DOLOČANJE RAZMERJA MED APELI

V svetovnem merilu je objavljenih več raziskav o berljivosti, s poudarkom na področju zdravja in izobraževanja.

Berljivost se navezuje na branje in razumevanje besedila. Če je sposobnost branja znatno pod nivojem berljivosti dokumenta, se razumno predvideva, da posameznik ni sposoben popolnoma razumeti besedila (8).

3.1 Določitev berljivosti besedil in opredelitev apelov v besedilih o zdravju in zdravilih

Razvili so več formul za določitev berljivosti, ki vsebujejo različne spremenljivke. Ena bolj uporabljenih formul je Flescheva formula za določitev berljivost besedila oziroma Flesch-Kincaidova formula za določitev stopnje berljivosti (9). Na osnovi te formule se berljivost določi iz števila besed v stavkih oziroma števila zlogov v besedah. S stopnjo berljivostjo določimo, kateri stopnji izobrazbe ustreza zadevno besedilo. Če ugotovljena stopnja berljivosti besedila presega priporočeno stopnjo, predvidevamo, da razumevanje besedila ne bo ustrezno.

Obstajajo tudi druge formule določanja berljivosti besedil, ki upoštevajo dodatne spremenljivke, na primer število črk, delež lažjih in delež zahtevnih besed ter druge spremenljivke.

Smisel določanja berljivosti na področju izobraževanja je, da so učbeniki prilagojeni ustrezni stopnji berljivosti, kar se povezuje z večjim razumevanjem besedila. Tudi pri gradivih z informacijami o zdravju in zdravilih velja povezanost med stopnjo berljivosti in razumevanjem besedila, ki nadalje vpliva na jemanje in ravnanje z zdravili. Stopnje berljivosti besedila morajo biti čim bližje priporočeni stopnji berljivosti besedil. Ustrezne stopnje berljivosti pa so seveda eden izmed dejavnikov za zagotavljanje dobrega razumevanja besedila.

Rezultati raziskave slovenskih gradiv so pokazali, da berljivost besedil o zdravju in zdravili ne ustreza priporočenim stopnjam (10). Podobne ugotovitve so objavili tuji raziskovalci (11). Stopnje berljivosti slovenskih besedil so bile neustrezne tako pri analizi gradiv, namenjenih strokovni javnosti, kot tudi gradiv, namenjenih splošni javnosti (10).

Pomembno je analizirati tudi apele v besedilih in njihovo razmerje, za oceno vpliva na razumevanje sporočila. V raziskavi (12) smo določili razmerje med apeli o učinkovitosti in apeli o tveganjih zdravil. Raziskovalci smo pri analizi slovenskih besedil ugotovili, da apeli o prednostih analiziranih zdravil brez recepta niso bili uravnoteženi z apeli z opisanimi tveganji teh zdravil (12).

3.2 Berljivost z vidika starejših oseb

Raziskovalci ugotavljajo (13), da starejši odrasli pogosto težko razumejo pisna gradiva o zdravju in zdravilih. Težave z razumevanjem besedil povezujejo s posledičnim poslabšanim zdravstvenim stanjem in več sprejemi v bolnišnico. Obenem ta težava zadeva tudi zdravstveni sistem, zaradi visokih stroškov za zdravstveno varstvo. Raziskovalci poudarjajo pomen izboljšanega razumevanja besedil, z uporabo z zdravjem povezanih gradiv, ki vsebujejo ustrezne stopnje berljivosti.

Raziskava (13) je pokazala, da je razumevanje z zdravjem povezanih besedil odvisno od več dejavnikov. Predlagajo dve strategiji za izboljšanje razumevanje pisnih, z zdravjem povezanih besedil. Prva strategija zajema uporabo kratkih besed in kratkih stavkov, da bi izboljšali berljivost, skladno s Fleschevo formula za določanje berljivosti. Pri starejših odraslih je treba upoštevati tudi možnost zmanjšane sposobnosti pomnenja, kar lahko vodi do težav z razumevanjem. Druga strategija je ponavljanje pomembnih besed, fraz in zamisli, da bi povečali celovitost besedila. Opisani strategiji se morata uporabljati sočasno, da se doseže pričakovani učinek.

4. PRIPISOVANJE POMEMBNOSTI ATRIBUTOM O UČINKOVITOSTI IN TVEGANJIH ZDRAVIL BREZ RECEPTA

Raziskovalci (14) smo izvedli pilotno raziskavo, s katero smo določali preference 85 respondentov. Opredeljeni atributi so opisovali prednosti: to so pretežno atributi, ki v analiziranih besedilih opisujejo učinkovitost in delno prikladnost jemanja zdravil brez recepta, ki so indicirana za lajšanje simptomov virusnih bolezni. Naslednja skupina atributov je opisovala morebitna tveganja, povezana z jemanjem teh zdravil; zadnja skupina atributov je opisovala ceno. Atributi so vzorčeni deli besedila iz navodil za uporabo zdravil brez recepta.

4.1 Atributi o učinkovitosti in tveganjih zdravil brez recepta ter ceni

S preliminarnimi rezultati smo dobili podatke o delnih preferencah (14). Uporabljali smo conjoint metodo, s katero respondenti skladno s svojimi preferencami pripisujejo pomembnost posameznim atributom.

Rezultati (14) kažejo, da so respondenti primerjalno večjo pomembnost pripisovali skupini atributov s tveganji in sicer 49,77, glede na skupino atributov, ki opisujejo prednosti jemanja zdravil brez recepta, to je učinkovitost oziroma prikladnost jemanja (20,62 oz. 18,64). Ceni za razliko od rezultatov drugih raziskav (15) respondenti niso pripisovali velike pomembnosti. To razlagamo s primerjalno nizko ceno zdravil brez recepta in obenem z manjšo razliko med cenami zdravil (14), glede na primerljivo raziskavo (15).

Iz teh preliminarnih rezultatov (14) izhaja velika razlika v preferencah med atributi o prednostih zadevnih zdravil brez recepta in atributi, ki opisujejo tveganja. Tem rezultatom glede zaznane pomembnosti atributov o tveganjih pritrjujejo tudi rezultati primerljive, objavljene raziskave (16).

4.2 Zbolevanje in izdaja zdravil brez recepta glede na spol, starost in izobrazbo respondentov

Respondenti so v spletni anketi odgovarjali glede pogostnosti nakupa zdravil brez recepta v lekarni (14). Največji delež in sicer 75,3 % oseb je ta zdravila nabavilo do nekajkrat letno, kar je skladno z odgovori o zbolevanju zaradi virusnih bolezni od enkrat do trikrat letno, ki je znašalo 78,9 %. Manjši delež respodentov je zdravila brez recepta nabavil enkrat ali večkrat na mesec. 92,3 % respondetov, ki so kupovali zdravila brez recepta večkrat na mesec, je sodilo v starostno skupino nad 50 let, vsi pa so imeli podiplomsko izobrazbo.

Med osebami, ki so prebrale navodilo za uporabo, jih je bilo malo več kot polovica starejših od 50 let in malo manj kot polovica s podiplomsko izobrazbo (14).

5. ZAKLJUČEK

Izsledki raziskav kažejo pomembnost rezultatov za ustvarjanje strategij z namenom povečanja razumevanja besedil o zdravju in zdravilih. Razumevanje besedil vpliva na odločitve pacientov, jemanje in ravnanje z zdravili ter posredno na učinkovitost in varnost zdravljenja.

Rezultati raziskav kažejo, da besedila o zdravju in zdravilih pogosto niso prilagojena razumevanju oseb. Posebno pozornost je treba nameniti ranljivim skupinam prebivalcev, vključno s starejšimi osebami, ki jim spremljajoče bolezni nemalokrat onemogočajo ustrezno razumevanje besedil. Rezultati raziskav so odlična osnova za ukrepanje, ki obsega spremljanje pisnih besedil in drugih vrst komuniciranja ter prilagoditev vsebin z namenom boljšega razumevanja.

Zaradi staranja prebivalstva v razvitih družbah se bo predvidoma povečeval problem razumevanja informacij o zdravju in zdravilih. Nadaljnje raziskovanje bo imelo raziskovalni pomen, pa tudi pomen za zdravje prebivalstva, posebej ranljivih skupin prebivalstva.

Bodoči raziskovalni napori bodo predvidoma usmerjeni k analizam besedil o zdravju in zdravilih, tudi na večjih vzorcih in z vključevanjem dodatnih skupin zdravil, ob hkratnem sodelovanju z drugimi ustanovami.

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STANOVANJSKE RAZMERE STAREJŠIH V SLOVENIJI IN SPREJEMLJIVOST RAZLIČNIH OBLIK BIVANJA

HOUSING CONDITIONS OF THE ELDERLY IN SLOVENIA AND THE ACCEPTANCE OF DIFFERENT HOUSING FORMS

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IZVLEČEK

Prebivalstvo Slovenije se pospešeno stara. Zaradi soočanja s povečevanjem finančnih potreb, med drugim tudi za zagotavljanje ustrezne stanovanjske oskrbe in storitev za starejše je problematika postala vroča politična tema. Z vidika naraščanja deleža starejših v družbi in njihove stanovanjske oskrbe je v Sloveniji še posebej zaskrbljujoče to, da smo do sedaj razvijali predvsem institucionalno obliko stanovanjske oskrbe za starejše, ki je med vsemi oblikami stanovanjske oskrbe najdražja. V zelo omejenem obsegu so za starejše na voljo še najemniška in oskrbovana stanovanja, druge stanovanjske ponudbe pa skoraj ni. Po drugi strani je za Slovenijo značilna visoka lastniška zasedenost stanovanj. V članku so predstavljene bivalne razmere starejših ljudi v Sloveniji in odnos do izbranih oblik bivanja, s katerimi bi lahko v Sloveniji povečali raznovrstnost stanovanjske ponudbe za starejše.

Ključne besede
staranje prebivalstva, starejši ljudje, stanovanja, bivanje

ABSTRACT

The population of Slovenia is rapidly aging. Due to the increase in financial needs, including the provision of adequate housing and services for the elderly, the problem has become an important political issue. With regard to the provision of housing for the increasing share of the elderly in Slovenia, it is especially alarming that Slovenia has so far primarily developed institutional housing for the elderly, which is the most expensive among all forms of housing. To a very limited extent, rental housing and assisted-living facilities are also available to the elderly, but there are nearly no other forms of housing. On the other hand, Slovenia has a high level of home owners. The article presents the living conditions of older people in Slovenia and the attitudes towards selected different forms of living, which could increase the diversity of housing for older people in Slovenia.

Key words
ageing population, elderly, housing, living

1. UVOD

Za zahodno družbo je značilno, da se vse bolj stara. Problem staranja prebivalstva je, bolj kot drugod po svetu, izpostavljen v Evropi. Slovenija glede tega ni izjema. Še več, slovenska družba se stara celo hitreje od evropskega povprečja. Po projekcijah Statističnega urada Republike Slovenije [1] se bo delež starejših od 65 let do leta 2060 povečal na 31,6 %, kar bo nad evropskim povprečjem, delež starih nad 80 let pa bo do takrat že presegel potrojitev. Z vidika naraščanja deleža starejših v družbi in njihove stanovanjske oskrbe je v Sloveniji še posebej zaskrbljujoče to, da je za Slovenijo značilna visoka lastniška zasedenost stanovanj in da prevladuje institucionalna oblika stanovanjske oskrbe za starejše. Po osamosvojitvi smo izvedli zelo radikalno privatizacijo nekdanjih javnih najemnih stanovanj in, kot pravi Mark Stephens [2], postali »superlastniki stanovanj«. Po Richardu Sendiju et al. [3] ima bivanje starejših v lastnem domu sicer številne pozitivne učinke (npr. občutek domačnosti, socialne vezi), prinaša pa tudi številne ovire (npr. stroški vzdrževanja nepremičnine, grajene ovire v bivalnem okolju, dostop do storitev). Po drugi strani smo do sedaj za bivanje v starosti gradili predvsem domove za starejše, vendar pa je ta stanovanjska oblika med vsemi oblikami stanovanjske oskrbe najdražja. Poleg tega zmogljivosti v domovih za starejše zadoščajo le za okoli 5 % prebivalcev Slovenije, starih 65 let in čeprav se kapacitete stalno povečujejo, v prihodnje ne bo mogoče zadostiti vse večjemu povpraševanju po institucionalni oskrbi [4]. Poleg omenjenih oblik, drugih oblik stanovanjske oskrbe za starejše pri nas skoraj ni. V zelo omejenem obsegu so na voljo sicer še oskrbovana stanovanja in najemniška stanovanja za starejše. Premalo različnih oblik bivanja za starejše in drugih instrumentov povezanih s tem, odsotnost raznolikosti storitev oskrbe za starejše in vse večje povpraševanje po institucionalnih oblikah bivanja (zlasti po bivanju v domovih za starejše) so pri nas že začeli sprožati vse resnejše probleme. V Evropski uniji že nekaj časa prevladuje spoznanje, da problema ne bo mogoče reševati le z do sedaj uporabljanimi modeli stanovanjske in druge oskrbe za starejše, ampak bo treba razviti nove rešitve, ki bodo učinkovitejše in finančno manj zahtevne. V raziskavi smo zato preučili, katere tovrstne rešitve bi bile primerne za Slovenijo oziroma kako sprejemljive bi bile te rešitve za starejše ljudi v Sloveniji.

2. RAZISKAVA

V letih 2014–2017 sta Urbanistični inštitut Republike Slovenije in Fakulteta za družbene vede izvedla raziskavo z naslovom Inovativne oblike bivalnih okolij za starejše v Sloveniji, ki jo je financirala Agencija Republike Slovenija za raziskovalno dejavnost. Cilj je bil opredeliti inovativna bivalna okolja za starejše, ki bi ustrezala potrebam, željam in navadam starejših ljudi v Sloveniji in bi omogočala, da bi starejši čim dlje časa ostali aktivni člani družbe, hkrati pa bi bila finančno vzdržnejša za starejše ljudi in slovensko družbo nasploh. Podatke za analizo sta sodelujoči organizaciji pridobili z anketiranjem, ki ga je novembra 2015 izvedel Center za raziskovanje javnega mnenja in množičnih komunikacij. Šlo je za telefonsko anketiranje, t. i. CATI tehnika anketiranja, v katerega je bilo vključeno prebivalstvo Slovenije, staro 50 let in več, obeh spolov, iz vseh statističnih regij in tipov naselij (mestnih in podeželskih). Končnih veljavnih anket je bilo 930, ki predstavlja reprezentativni vzorec anketirane populacije. Anketa je obsegala vprašanja povezana z bivalnimi razmerami starejših in odnosom starejših do morebitne preselitve, njihovimi stališči do različnih bivalnih okolij za starejše s poudarkom na oblikah bivanja, ki so v slovenskem okolju manj pogoste oziroma še niso prisotne, ter vprašanja povezana z odnos vprašanih do različnih stanovanjskih rešitev, ki omogočajo pridobitev dodatnih prihodkov iz lastništva nepremičnine.

3. REZULTATI

Kot je bilo pričakovano iz poznane lastniške strukture v Sloveniji, kjer prevladuje lastništvo stanovanja, je bilo med vprašanimi 97 % lastnikov, od tega v skoraj treh četrtinah lastnikov hiš in v eni četrtini pa lastnikov stanovanj. Pri tem je z vidika dostopnosti in grajenih ovir zaskrbljujoče, da je kar 84 % tistih, ki živijo v stanovanju, biva v nadstropju ter da med tistimi, ki živijo v stanovanju, velik delež (70 %) biva v zgradbi brez dvigala. Z vidika vzdrževanja nepremičnin je skrb zbujajoče predvsem to, da po eni strani 92 % starejših živi v stanovanjih z vsaj dvema sobama oziroma jih 80 % biva na več kot 50 kvadratnih metrih, po drugi strani pa več kot dve tretjini starejših živi v eno ali dvočlanskem gospodinjstvu oziroma štiri desetine je takih, ki živijo v gospodinjstvih z manj kot tisoče evrov mesečno. Vse to pomembno vpliva na kakovost bivanja v starosti. Zahteva namreč nujen razmislek o ustrezni prilagoditvi grajenega bivalnega okolja in o zmožnostih starejših za vzdrževanje lastniških nepremičnin. To je še posebej pomembno zato, ker bi radi starejši ljudje čim dlje časa bivali v svojih stanovanji in prehod v drugo obliko bivanja preložili na kasnejši čas. To se sklada s spoznanji relativno nizki mobilnosti prebivalstva Slovenije [5], kar potrjujejo tudi rezultati raziskave, po kateri je 63 % anketirancev prebivalo v obstoječem domu več kot 30 let, kar 84 % pa jih še ni nikdar razmišljalo o selitvi. To je v prvi vrsti posledica močne navezanosti starejših na svoje nepremičnine in domače bivalno okolje. Kar 91 % jih je izrazilo, da so navezani oziroma zelo navezani na svojo nepremičnino, več kot tri četrtina pa, da so navezani ali močno navezani tudi na svojo sosesko oziroma kraj, v katerem bivajo. Največ vprašanih je odgovorilo, da se v svojem domačem okolju počutijo samostojne in neodvisne in da se v tem okolju znajdejo (95 %). Ob močni navezanosti in nizki želji po preselitvi je skrb zbujajoče dejstvo, da je 47 % vprašanih potrdilo, da s sedanjimi prihodki ravno še shajajo 13 % pa, da se le težko ali izjemno težko preživljajo.

Pri vprašanju: »Starejši ljudje se včasih znajdejo v situaciji, ko ne bi mogli več sami skrbeti zase niti s pomočjo sorodnikov; za vsako izmed naštetih možnosti povejte, kako sprejemljiva bi bila za vas?«, so starejši izbirali med nekaterimi bolj poznanimi in manj poznanimi bivanjskimi rešitvami. Po pričakovanjih so bile bolj znane oblike stanovanjske oskrbe bolje sprejete med starejšimi. Najbolj sprejemljivo bi bilo za njih bivanje v obstoječem stanovanju/hiši s podporo (sprejemljivo 68 % anketirancem), kar potrjuje, spoznanje o navezanosti starejših na svoj dom. Enak delež starejših je izrazil naklonjenost tudi za preselitev v dom za starejše, ki je najbolj znana in najbolj razširjena oblika bivanja v Sloveniji. Sledi oskrbovano stanovanje (49-odstotna sprejemljivost) in bivanje v obstoječem stanovanju/hiši z obiskovanjem dnevnega centra (46-odstotna sprejemljivost). Večjo zadržanost so vprašani pokazali do drugih predstavljenih rešitev, ki so v našem okolju manj poznane ali nepoznane. Tako je bilo bivanje v večgeneracijski stanovanjski stavbi sprejemljivo za 30 % anketirancev, gospodinjska skupnost za 27 % vprašanih, sobivanje starejših v skupnosti je bilo sprejemljivo za 24 % starejših, medtem ko je bilo bivanje z drugo družino ali posameznikom oziroma bivanje pri oskrbniški družini sprejemljivo desetini anketirancev ali manj. Se pa je izkazalo, da so mlajše generacije starejših bolj odprte za različne/inovativne oblike bivanja. Drugače je pri različnih možnostih in stanovanjskih rešitvah, ki omogočajo pridobitev dodatnih dohodkov iz lastništva stanovanja oziroma hiše (na primer obratna hipoteka, prodaja z odloženim prenosom lastninske pravice, prodaja in hkratni povratni najem/rentni odkup, prodaja stanovanja in nakup manjšega stanovanja, oddaja dela nepremičnine najemniku itd.). Za večino vprašanih so bile namreč vse predstavljene možnosti nesprejemljive [6]. Ugotovljeno podpira tudi podatek, da so med vsemi vidiki, kaj vprašanim pomeni stanovanje, najnižje ocenili mnenje, da je njihovo stanovanje/hiša finančna naložba.

4. SKLEP

Rezultati raziskave so pokazali, da stanovanjske razmere starejših niso posebej vzpodbudne, predvsem z vidika dostopnosti in morebitnih grajenih ovir ter z vidika potreb po vzdrževanju in finančnih zmožnosti starejših pri tem. Po drugi strani starejši izkazujejo močno navezanost na svoja domača bivalna okolja in zelo nizko stopnjo želje po preselitvi. Z namenom, da se ugodi željam in potrebam starejših ljudi, je zato treba razmišljati, kako starejšim omogočiti, da bi lahko čim dlje časa ostali v svojih znanih domačih bivalnih okoljih, da bi bilo njihovo bivanje čim bolj kakovostno ter da bi čim dlje časa ohranili svojo samostojnost, neodvisnost in da ostali aktivni člani svoje skupnosti. To je mogoče doseči s prilagajanjem grajenega bivalnega okolja in storitev. Starejšim ljudem bi moralo biti omogočeno, da si svoja stanovanja arhitekturno prilagodijo za bivanje v starosti. Podobno kot za povečanje energetske učinkovitosti stavb (kot posledica blaženja podnebnih sprememb in povečanih potreb po energiji), bi morala Slovenija subvencije namenjati tudi prilagoditvam stanovanj za lažje bivanje v starosti (kot posledica na izzive demografskih sprememb v družbi). Menimo, da bi bil vložek za fizične prilagoditve domačega bivalnega okolja znatno nižji, kot pa če bi se morali starejši zaradi neprimernega stanovanja (predčasno in pod prisilo) preseliti v institucionalno bivanje. Ustrezen državni organ (po našem mnenju je to ministrstvo za okolje in prostor), bi moral sestaviti seznam podjetij, ki bi takšne prilagoditve lahko opravljala. Ne seznam bi bila uvrščena le tista podjetja, za katere bi se na podlagi ustreznih strokovnih preverjanj potrdilo, da so verodostojna in primerno usposobljena za naloge, ki bi jih morala izvajati. Seznam bi moral biti narejen za vsako slovensko občino posebej, tako da bi lahko pri prilagoditvah stanovanj sodelovala lokalna podjetja oziroma bi starejši ljudje imeli možnost izbirati med podjetji in ljudmi, ki jih poznajo in jim zaupajo. Glede priprave takšnega seznama je urbanistični inštitut, ki ima za to potrebno znanje, seznanil direktorat na ministrstvu za okolje in prostor. Inštitut bi tudi pripravil ustrezne predloge za spremembo zakonodaje in pravilnikov ter priprave strokovnega priročnika za prilagoditve stanovanj in stanovanjskih objektov za potrebe varnega in samostojnega bivanja starejših v domačem bivalnem okolju. Vzporedno z zagotavljanjem možnosti za bivanje v domačem bivalnem okolju, bi bilo treba omogočati vzpostavitev različnih oblik bivanja za starejše ljudi, pri tem pa bi bilo treba izhajati iz njihovih potreb in želja. Raznovrstnost oblik stanovanjske oskrbe za starejše je bila na predlog urbanističnega inštituta in ministrstva za delo družino in socialne zadeve ter enake možnosti vključena tudi v strategijo dolgožive družbe. Strategija kot naslednji korak predvideva pripravo ustreznih akcijskih načrtov, pri katerih bi urbanistični inštitut sodeloval kot strokovna podpora. Menimo še, da bi bilo treba za razširitev raznovrstnosti stanovanjske oskrbe starejših nujno spremeniti ali vsaj dopolniti stanovanjski zakon in v njem izbrane oblike bivanja ustrezno opredeliti. Nujno pa je treba starejše in tudi mlajše ljudi začeti na učinkovit in razumljiv način ozaveščati o različnih oblikah bivanja za starejše ter možnostih in stanovanjskih rešitvah, ki omogočajo pridobitev dodatnih dohodkov iz lastništva stanovanja oziroma hiše. Seznanjati bi jih bilo treba o primerih dobrih praks iz domačega, slovenskega okolja – starejše bi morali nagovarjati drugi starejši, ki imajo glede drugačnih oblik bivanja pozitivne izkušnje. Ozaveščanje bi moralo potekati na lokalni ravni, med ljudmi, ki se med seboj poznajo. Vsakemu bi moralo biti zato omogočeno, da bi v domačem okolju od lokalnih informatorjev pridobil vse ustrezne informacije o možnostih bivanja in prilagajanju stanovanj. To bi po našem mnenju pripomoglo, da bi se s časom spremenila miselnost, ukrepi in pobude od »zgoraj navzdol« in od »spodaj navzgor« pa bi dosegli sinergijske učinke in bi pozitivno vplivali eden na drugega.

5. ZAHVALA

Zahvaljujemo se Agenciji Republike Slovenije za raziskovalno dejavnost za financiranje temeljnega raziskovalnega projekta *Inovativne oblike bivanja za starejše ljudi v Sloveniji,* ki je potekal med letoma 2014 in 2017 pod šifro J5–6824 in temeljnega raziskovalnega projekta *Model za staranje starejših v domačem bivalnem okolju v Sloveniji,* ki je potekal med letoma 2017 in 2020 pod šifro J5–8243. V projekt sta bila vključena Urbanistični inštitut Republike Slovenije in Fakulteta za družbene vede.

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Družina kot sistem in pomen družinske terapije

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POVZETEK
Vsak posameznik se v družini razvije, oblikuje in odide v svet z doto, ki jo prejme od svojih najbližjih. Čeprav so ti odnosi ključni za naše poznejše interakcije z okoljem, so samo ogrodje, ki ga lahko dograjujemo. Sistemska teorija razume družino kot sistem odnosov, katerega člani vzajemno vplivajo drug na drugega, družina pa kot celota na vsakega posameznika. Prvi odnos s starši ima ključno vlogo za razvoj možganov in zdravo psihično strukturo. Nefunkcionalni vzorci in razne travmatične izkušnje posameznikov se lahko uspešno predelujejo z družinsko relacijsko terapijo, ki tako pripomore tudi k urejanju odnosov na ravni osnovne družbene celice.

Ključne besede
Družina, odnosi, razvoj možganov, relacijska družinska terapija

1. SISTEMSKO RAZUMEVANJE DRUŽINE
Vsi prihajamo iz družine. Vsakemu izmed nas se, ko pomisli na svojo družino, prebudijo različna občutja, od prijetnih občutij veselja, zadovoljstva in sreče pa vse do težkih občutij tesnobe, zavrženosti, nesposobnosti, nehotenosti in zapuščenosti. Ko govorimo o družini, ne govorimo samo o posameznikih, ki jo sestavljajo. Družina je namreč veliko več. Je najpomembnejši prostor človeškega razvoja. Tu gre najprej za odnos med staršema, za odnos med starši in otroci, nato za odnos med vrstniki, za odnos do šole in družbe [10]. Torej lahko rečemo, da je družina sistem odnosov, ki zaznamujejo delovanje tako posameznika kot skupnosti [12] oziroma družina je sistem odnosov, v katerem njeni člani vzajemno vplivajo na drugega in v katerem družina kot celota vpliva na vsakega družinskega člana. To je sistemski pogled na družino, ki se je uveljavil po razmahu splošne sistemske teorije in njenem prenosu na področje psihologije. Splošna sistemska teorija, ki je temeljila v biologiji, matematiki, tehniki in fiziki, je izhajala iz ugotovitev, da različni pojavi v svetu nosijo v sebi značilnosti sistema, ki je organiziran v celoto in sestavljen iz med seboj odvisnih delov. Komunikacija in samoregulacija sta bistvena za delovanje sistema, ta pa procesira informacije, se na spremenjene pogoje prilagodi, kar vpliva na nadaljnje vedenje in s tem na njegovo samovzdrževanje [4]. Ugotovitve, ki jih je prinesla splošna sistemska teorija, so prevzele različne veje znanosti, tudi psihiatrija in preko nje družinska terapija. S tem je prišlo do spremembe paradigme v razumevanju družine, ki je prenesla opazovanje in razumevanje iz individualno orientirane paradigme k raziskovanju družine kot sistema elementov, ki stalno sodelujejo in medsebojno vplivajo [15].

Najpomembnejša predpostavka sistemskega pristopa je sistemska celovitost, kar pomeni, da je »sistem kot celota vedno večji in močnejši od njegovih posameznih delov ali podsistemov« [5]. Družina je tako vedno več kot le vsota družinskih članov, saj je vsaka družina organska celota, živ organizem, ki je tudi notranje, sistematično organiziran [5].

Tako kot so elementi v sistemu povezani, saj vsak del v sistemu vpliva na celoten sistem [4], tako so med seboj povezani tudi družinski člani. Vsaka sprememba, ki se zgodi enemu članu družine, vpliva tako na celoto kot na vse druge družinske člane. Razni dogodki, ki se dogodijo v družini, npr. bolezen, smrt, poroka, rojstvo, izguba službe ipd., vedno vplivajo na celotno družino. Če družina želi obstati, mora te spremembe sprejeti, se prilagoditi, preoblikovati oz. se drugače organizirati.

Če želimo zares razumeti družino, moramo vedno opazovati odnose med vsemi člani. Posameznega vedenja nekega člana družine ne moremo popolnoma razumeti, če ne razumemo delovanja celotnega družinskega sistema. Na tem temelji tudi družinska terapija, pri kateri vedno opazujemo in razumemo individualno simptomatiko v kontekstu zakonitosti delovanja cele družine [12].

Družinski sistem deluje preko manjših delov, t. i. podsistemov, ki so hierarhično urejeni in razmejeni [5]. Hierarhija je pomembna za funkcionalno delovanje družinskega sistema [12], tako kot je hierarhija pomembna za funkcionalno delovanje različnih skupnosti, mest, okrajev, države itd. [4]. Hierarhija in sistemska razmejitev temeljita na jasnih pravilih in vlogah, kar omogoča razvoj in delovanje družinskega sistema v obliki čustvene stabilnosti in zmožnosti predvidevanja vedenja družinskih članov [12].

2. ODNOSI V DRUŽINI
Lahko se vprašamo, zakaj včasih nikakor ne more priti do spremembe, čeprav bi bila ta dobra. Kaj je tisto, kar nekaterim ljudem preprečuje, da bi se rešili nefunkcionalnih vzorcev oziroma da se ne bi vedno znova zapletali v odnose, ki niso primerni? Odgovor lahko najdemo v razumevanju oblikovanja navezanosti v odnosu in pripadnosti družinskim odnosom [12].

Ljudje potrebujemo odnose, ker je pripadnost vrojena potreba vsakega posameznika [12]. Pripadnost pa je tudi temelj družinskega sistema [10]. Prvi odnos, ki ga ne moremo izbrati, prav tako ga tudi nikoli ne moremo zapustiti, je odnos s starši [12], zato je tudi tako pomembno, kako varen, zaupen in iskren je bil ta odnos. To pa ne pomeni, da se naš razvoj konča z odnosi, ki jih oblikujemo s starši, saj se razvijamo celo življenje [12] oziroma se razvijamo v vseh odnosih, v katere vstopamo v svojem življenju. Vendar je ravno odnos s starši tisti, ki nas najbolj zaznamuje in vpliva, na kakšen način bomo vstopali v vse prihodnje odnose, v njih vztrajali ali jih zapuščali. V odnosih se namreč rodijo samozavedanje, vrednote, spomin ali stališča, prav tako se v odnosi rodijo tudi dvomi in strah [12]. Odnos, ki ni varen, morda celo zaznamovan z zlorabami ali travmatičen, odnos, v katerem ne dobimo občutka pripadnosti, je za otroka ena najhujših travmatičnih izkušenj, ki pa ne vpliva samo na tega otroka in na njegovo nadaljnje življenje, ampak se prenaša celo v naslednje generacije. Sistem namreč toliko časa ponavlja iste vzorce odnosov, dokler neuresničena potreba po pripadnosti ne bo zadovoljena [10].

John Bowlby je bil prvi, ki je uporabil pojem navezanost. Svoja raziskovanja je začel z opazovanjem živalskega sveta in ugotovil, da ima vsaka žival sposobnost, da prepozna svojo mater in se zateče k njej [10]. Bowlby je šel še korak dlje in svoja odkritja apliciral na človeški svet. Ob opazovanju dojenčkov in otrok v sirotišnicah in bolnišnicah je ugotovil, da so dojenčki po rojstvu tako nebogljeni, da lahko preživijo samo pod pogojem, če je prisotna odrasla oseba, ki jim nudi varnost in skrb [8]. Bowlbyjeve ugotovitve, da je za normalni razvoj otroka nujna prisotnost odrasle osebe, na katero se lahko naveže, so trčile ob do takrat trdno zasidrano Freudovo teorijo o nagonskih temeljih otrokovega razvoja [7]. Trdil je celo, da je mati tista, ki mora biti fizično prisotna, da bo omogočen zdrav otrokov razvoj. Kljub temu da danes Bowlbyjevih ugotovitev glede škodljivosti materine deprivacije ne moremo jemati kot izključen razlog za nezdrav razvoj otroka, saj je poleg njene prisotnosti za razvoj pomembna tudi čustvena kvaliteta odnosov v družini [7], pa je dejstvo, da je premik paradigme ugodja kot motivacijske sile na pomembnost odnosov ustvaril novo polje za raziskovanje psihološke sfere človeške duševnosti.

Pri navezanosti gre za vrojen sistem v možganih, ki otroka motivira, da poišče bližino staršev ali drugih primarnih skrbnikov ter z njimi vzpostavi komunikacijo. S takšnim vedenjem si otrok poveča zmožnosti za preživetje [14]. Vendar ko govorimo o odnosih v družini in o razvoju posameznika, zmožnost preživetja ni dovolj. Raziskave so pokazale, da je oblika navezanosti, ki jo otrok vzpostavi zgodaj v otroštvu, povezana s kasnejšimi procesi regulacije emocij, razvojem samozavedanja in razumevanja sebe [10], v osnovi pa gre pri navezanosti za njegovo zaščito pred nevarnostjo. Zato navezanost delimo na varno in nevarno navezanost. Otrok se lahko varno naveže, ko se mati nanj uglasi, kar pomeni, da vedno znova prepoznava njegove potrebe in nanje ustrezno odgovarja. Občutek varnosti in zaščite je za otroka najpomembnejši dejavnik za njegov zdrav čustveni in socialni razvoj [7]. Prav tako pa varna navezanost omogoča možnost raziskovanja oziroma celo velja, da bolj kot je večji občutek varnosti, širši je krog raziskovanja [1]. Otrok namreč ve, da mu skrbniki ob stiski nudijo varno zatočišče, hkrati pa tudi varno izhodišče, od koder lahko raziskuje okolico [7].

3. RAZVOJ MOŽGANOV

Najnovejše raziskave na področju nevropsihologije kažejo, da je za razvoj možganov ključnega pomena odnos s starši. Možgani se lahko namreč v polnosti razvijajo takrat, ko je aktivno prisoten nekdo tretji [3]. Razvoj možganov je od samega začetka zelo odvisen od odnosov, ki jih ima otrok s starši, predvsem z materjo. Dotiki nežnosti, ljubkovanje, dojenje, način, kako se mu mama približa, skratka občutja, ki jih otrok dobi od svoje mame v intimnih trenutkih, so tisti prvi impulzi, ki se zapišejo v njegov organski, implicitni spomin in ki postanejo osnova za nadaljnje navezovanje stikov z drugimi [6].

Ko se rodimo, so možgani najbolj nediferenciran organ v telesu [1]. Možgani se zelo hitro razvijajo in že v prenatalni dobi vsako minuto proizvedejo 250 000 novih celic, do rojstva pa ustvarijo milijardo nevronov. Pri štirih letih so otrokovi možgani že 95 % strukturno razviti [2]. V prvih mesecih življenja se razvije tudi navezanost, medtem ko se sposobnost regulacije afektov, ki temelji na navezanosti, najbolj razvije med prvim in drugim letom starosti [1]. Otroški možgani so veliko bolj dojemljivi in prilagodljivi kot možgani odraslega človeka, so pa tudi zelo senzitivni in zelo ranljivi, predvsem kar se tiče zlorabe in zanemarjenosti, saj lahko pustita na otrokovih možganih nepopravljive vtise in lahko celo povzročita, da se v določenih segmentih sploh ne razvijejo oziroma zaostanejo v razvoju. Travmatične oz. kronične izkušnje, ki jih dojenček doživi v času hitrega razvoja možganov, tako lahko pustijo trajne, nepopravljive vtise na strukturi in mehanizmu delovanja možganov [2,11].

Pri zgodnjem razvoju možganov po rojstvu je bolj vključena desna hemisfera možganov, kjer pa se nahaja tudi center možganov za odzivanje na stres. Zato lahko travmatične izkušnje prizadenejo ravno te strukture možganov, ki so odgovorne za regulativne mehanizme in za odgovor možganov na stres [10]. To lahko pomembno vpliva tudi na regulacijo stresa in posledično na kakovost življenja v kasnejšem obdobju. Možgani se oblikujejo na podlagi tega, koliko so bili uporabljeni, koliko novih izkušenj dobijo in koliko se te izkušnje ponavljajo. Utrdijo se tiste nevronske poti in povezave, ki jih največkrat uporabimo. Če izkušenj ni oziroma če so izkušnje neprimerne, se možganski centri ne povezujejo in začnejo propadati [2]. Pri otroku, ki je večkrat podvržen stresu, se bo utrdil tisti odgovor na stres, ki ga bo otrok največkrat uporabil. Veliko otrok je soočenih s kroničnim stresom zaradi nasilja v družini, revščine ter fizične ali duševne bolezni staršev. Dolgotrajna izpostavljenost stresu v tem zgodnjem obdobju razvoja možganov lahko posamezniku povzroči trajne spremembe, te pa lahko vodijo v pogosta fizična obolenja [10].

4. DELO Z DRUŽINAMI – RELACIJSKA DRUŽINSKA TERAPIJA

Pomoč otrokom se začne s pomočjo njihovim staršem. Odnosi so namreč vedno vzajemni, kar pomeni, da starši ne morejo zagotoviti razvoja otroka, če se ob njem tudi sami ne razvijajo [12]. Včasih starši ne zmorejo sami in potrebujejo pomoč. Družinska terapija je primeren način, s katerim lahko pomagamo družinam v stiski, saj poskuša med seboj povezati odnose, vedenje in dogodke. Družino razume kot dinamičen sistem, ki se razvija v okolju in času ter ima svoj življenjski cikel, v katerem se dogajajo različne prilagoditve glede na pričakovane in nepričakovane stresorje [13]. Družinska terapija se s simptomatiko posameznika vedno sooča v kontekstu celotne družine. Pomembno je, da se z družinami, zakonci in posamezniki dela že ob prvih znakih nemoči, stisk in težav, s katerimi se sami ne zmorejo soočiti. Predvsem pa je nujno in smotrno, da začnemo z njimi delati že pred pojavom raznih psihopatologij oziroma bolezenskih stanj. Raziskave namreč kažejo, da so travmatične izkušnje v otroštvu pomemben dejavnik za razvoj raznih psihiatričnih bolezni v kasnejšem življenju, od posttravmatske stresne motnje, depresivne motnje in anksionzne motnje [1].

Na družinske odnose pa ne vplivajo samo sedanje potrebe in pričakovanja družinskih članov, ampak tudi preteklost družinskega sistema ter pričakovanje prihodnosti [12]. Včasih je ravno zaradi travmatične preteklosti, ki jo je doživel nek posameznik, težko delovati v sedanjosti in takrat je primeren čas za vstop v terapevtski odnos. Ta nam pomaga spoznati, da preteklosti ne moremo spremeniti, prav tako ne moremo vplivati na prihodnost, lahko pa v sedanjih odnosih vplivamo na odzive in doživljanje [12]. S sprejetjem in osmislitvijo preteklosti lahko spremenimo svoje odzive v sedanjih odnosih.

Družinska terapija sega na različna področja delovanja in se dokazano učinkovito sooča s partnerskimi problemi, konflikti v družini, odvisnostmi, zlorabami, nasiljem, problemi v šoli, osebnostno rastjo, žalovanjem itd. Relacijska družinska terapija [5], je terapevtski model, ki je znanstveno preverjen v mnogih raziskavah in dokazano učinkovit v klinični praksi [9] in ima danes pomemben položaj med različnimi vrstami terapije v slovenskem prostoru.

5. ZAKLJUČEK

Pomen zdravega temelja v družini je nedvomno med najpomembnejšimi pogoji za normalen razvoj človeške psihične strukture. Razni nefunkcionalni in razboleli odnosi v družini imajo lahko pogubne vplive na vse posameznike te družine, prav tako pa tudi na ljudi, s katerimi ti potem vzpostavljajo odnose. Terapija je način, da se posamezniki kar se da temeljito soočijo s svojo travmatično izkušnjo in vzorci, ki jim onemogočajo uspešno delovanje. Pomaga jim lahko, da vzpostavijo zdrav in urejen odnos s svojimi bližnjimi in okolico ter ustvarijo pogoje za uspešno in polno življenje. Terapevtska obravnava namreč nujno pomeni tudi soočenje z družinsko izkušnjo, saj je ta temelj posameznikovega delovanja, katerega težave pogosto izvirajo iz izkušenj v ožjem družinskem okolju. V tem pogledu družinska terapija pomembno prispeva k urejanju odnosov na ravni posameznika, pa tudi družine kot osnovne družbene celice s pozitivnimi posledicami tako na okolje kot na prihodnje družinske generacije. Zdravo družinsko okolje pa gotovo vpliva tudi na blaginjo celotne družbe.

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Dolgotrajna oskrba – zahtevna demografska naloga in izjemna priložnost za krepitev sodobne solidarnosti

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POVZETEK
Članek izhaja iz podatkov o prihajajoči demografski krizi staranja prebivalcev ter iz dejstva, da je razvoj sistema humane in finančno vzdržne dolgotrajne oskrbe starostno onemoglih, kronično bolnih in invalidnih ljudi skupaj z uvajanjem sodobnih programov za zdravo staranje in za krepitev medgeneracijske solidarnosti osnovna naloga za reševanje te krize. Na osnovi antropoloških spoznanj trdi, da je nagel razvoj na teh treh področij nujen zaradi velikega zaostanka na področju kakovosti medčloveškega sožitja za materialnim razvojem in za razvojem na področju zdravja in dolžine življenja. Zaradi novih znanj je pospešen razvoj medgeneracijskega sožitja danes možen, obenem pa je ta razvojna potreba glavna notranja antropološka energija za reševanje nalog demografske krize. V prvem delu članka so povzeta današnja slovenska in svetovna spoznanja o dolgotrajni oskrbi, v drugem je navedenih 12 tez o oblikovanju sodobnega nacionalnega sistema za dolgotrajno oskrbo; po dveh neuspešnih poskusih slovenske vlade (2010 in 2017), da bi s sprejetjem Zakona o dolgotrajni oskrbi začela dohitevati četrt stoletni zaostanek za evropskimi sosedi na tem področju, so te teze pomoč gerontološke stroke politiki in upravi, da pripravi in sprejeme kakovosten sodoben sistem dolgotrajne oskrbe tudi v Sloveniji.

Ključne besede
demografska kriza, dolgotrajna oskrba, medgeneracijska solidarnost

ABSTRACT
The article is based on the data about forthcomming demographic crysis. The fact is, that the primary focus for overcoming this crysis should be on the development of humane and financially sustainable system for long-term care and also on the implementation of healthy ageing and intregenerational solidarity programs. It stands on the anthropological knowledge and explains how fast advancements are needed, due to shortfalls that were made on the field of interpersonal relations in the past, when economic, medicine and life-ecpectancy development was a priority. At the present time there is enough knowledge on this topic to adress the issue and at the same time this societal need is the main anthropological energy resource for dealing with the tasks, that the demographic crysis places on us. The first part of the article summarizes today's knowledge on long-term care. In the second part the 12 thesis on the development of national long-term care system are stated. Slovenian government was unsucceseful in acomplishing the formation and implementation of long-term care legislations twice (2010 and 2017). For the purpose of compensating for the lost time, the gerontological thesis are suggested to help the politics and administration on preparation and obtainment of quality long-term care system in Slovenia.

Keywords
demographic crisis, long-term care, intergenerational solidarity

1. UVOD
Zagotoviti humano in finančno vzdržno dolgotrajno oskrbo starostno onemoglim, kronično bolnim in invalidnim ljudem je ena od osnovnih nalog za rešitev demografske krize ob staranju prebivalstva v 21. stoletju; enako pomembni in s prvo neločljivo povezani sta: poskrbeti učinkovite programe za zdravo staranje ter za krepitev solidarnosti med generacijami (Svet EU, 2005). Te tri naloge so med seboj neločljiva komplementarna celota. Sedanja demografska kriza ni samo zahtevna naloga, ampak tudi ugodna priložnost za hiter razvoj evropske kulture na področju kakovosti

sožitja in sodelovanja v družini, službi in družbi; ta razvoj sedaj zaostaja vsaj za eno stoletje za materialnim in tehnološkim razvojem ter za razvojem telesnega zdravja in podaljševanja življenja. Razmere za pospešen razvoj kakovosti sožitja so danes ugodnejše kakor kdajkoli doslej, za ta razvoj imamo danes na voljo toliko znanj kakor nikdar doslej v zgodovini (Ramovš, ured., 2013; 2017). Nadaljnji razvoj družbe in naše evropske kulture kot celote – Slovenci in vsak od evropskih narodov pa tudi za razvoj svoje nacionalne kulture – je verjetno motiv z največ notranje antropološke energije, ki ga imamo na voljo za uspešno rešitev demografske krize. Razvoj humane in finančno vzdržne dolgotrajne oskrbe je odločilen za nadaljnji razvoj humanosti evropske in slovenske družbe.

2. SPOZNANJA O DOLGOTRAJNI OSKRBI

Dolgotrajna oskrba je pomoč sorazmerno bolj zdravih ljudi tistim, ki ne morejo sami opravljati ene ali več od sedmih osnovnih vsakodnevnih opravil, ki so: vstajanje, osebna higiena, oblačenje, gibanje, hranjenje in jemanje zdravil, izločanje in dnevno navezovanje človeškega stika, ter pri opravljanju instrumentalnih opravil za življenje, ki so: kuhanje, čiščenje stanovanja, pranje in likanje perila, nakupovanje, denarni posli, prevoz in druga za človeka pomembna opravila. Odvisnost pri opravljanju osnovnih in funkcionalnih opravil je merilo za vstop v sodobni sistem socialne varnosti za dolgotrajno oskrbo, ki ga evropske države uvajajo po letu 1990, Slovenijo pa s četrt stoletnim zaostankom ta naloga še čaka; leta 2010 in 2017 sta bila predloga zakona o dolgotrajni oskrbi v javni obravnavi (Republika Slovenija, 2010; Vlada RS, 2017). Oba predloga sta imela nekaj dobrih strani in nekaj usodnih pomanjkljivosti – temeljiti analizi zadnjega predloga je bila posvečena celotna zadnja številke slovenske znanstveno-strokovne revije *Kakovostna starost* letnika 2017 (Kakovostna starost, 2017), strokovno poglobljena stališča je revija zavzela tudi ob predlogu leta 2010 (Inštitut, 2010), ves čas pa objavlja svetovna in domača spoznanja ter dobre izkušnje o dolgotrajni oskrbi. Iz teh virov ter iz preglednih del o dolgotrajni oskrbi v Evropi (Leichsering in sod., 2013) navajamo nekaj osnovnih spoznanj o dolgotrajni oskrbi.

Sodobni sistem dolgotrajne oskrbe odgovarja na navedeno odvisnosti od pomoči pri vsakdanjih opravilih starostno onemoglih, kronično bolnih in invalidnih ljudi. Danes v Evropi potrebuje dolgotrajno oskrbo 25 % ljudi, ki so stari nad 65 let, v Sloveniji je to okrog 80 tisoč ljudi. Četrtino od njih oskrbujejo ustanove (domovi za stare ljudi), tri četrtine pa domači in drugi neformalni oskrbovalci na njihovem domu. V prihodnjih letih se bo delež ljudi, ki so stari nad 85 let trikratno povečal. Ker v tej starosti večina potrebuje pomoč pri enem ali več vsakdanjih opravilih, se bo tudi delež prebivalstva v dolgotrajni oskrbi vsaj podvojil.

Programi, metode in sistem dolgotrajne oskrbe so danes med najhitreje razvijajočimi se področji. Usmeritve pri tem so:

1. oskrbovanje v domačem okolju,
2. usposabljanje in razbremenilna pomoč družinskim in drugim neformalnim oskrbovalcem,
3. komplementarno povezovanje v celoto vseh virov oskrbe:
    - družinskih in drugih neformalnih oskrbovalcev z dobro usposobljenimi in sodobno organiziraziranimi strokovnimi oskrbovalci in oskrbovalnimi ustanovami,
    - javnih virov v krajevni skupnosti in državi ter
    - lastnih virov in zmožnosti človeka v dolgotrajni oskrbi in njegovih najbližnjih.

Tako sestavljena in na oskrbovančevo osebo usmerjena dolgotrajna oskrba je tudi najučinkoviteljši način za preprečevanje pogostega nehotenega verbalnega in fizičnega nasilja ter zanemarjanja v domačem okolju in oskrbovalnih ustanovah.

Danes se hitro razvija IKT za svetovanje oskrbovalcem, za fizično pomoč pri dolgotrajni oskrbi, za spodbujanje in pomoč pri ohranjanju, krepitvi in rehabilitaciji oskrbovančevih zmožnosti ter za varovalno in opozorilno kontrolo njegove varnosti in oskrbe.

Enako pomembna družbena naloga, kakor vzpostavljanje in vodenje humane in finanačno vzdržne dolgotrajne oskrbe, je organizirana javna pomoč za zdravo staranje preostalim 75 % upokojenske generacije, ki ne potrebujejo dolgotrajne oskrbe. Za ohranjanje njihove samostojnosti se danes naglo razvijajo zlasti:

- ozaveščanje in javne spodbude za prilagajanje lastnega stanovanja za starostno pešanje,
- organizirani programi za krepitev telesnega, duševnega in socialnega zdravja z zdravo prehrano, gibanjem, spanjem, osvajanjem veščin za preprečevanje padcev v starosti, življenje s povišanim krvnim tlakom, sladkorjem v krvi, razvijajočo se demenco in drugimi kroničnimi nenalezljivimi boleznimi,
- medgeneracijsko povezovanje in kakovostno osebno povezovanje starejših za preprečevanje osamljenosti,
- usposabljanje za lepše komuniciranje in sožitje v družini in z drugimi, za prenašanje svojih življenjskih izkušenj in spoznanj na starejših na mlajše in obratno ter za iskanje smisla starosti.

Po reprezentativni raziskavi (Ramovš, 2013, ured.) opravlja v Sloveniji dolgotrajno oskrbo v domačem okolju nad 220.000 neformalnih oskrbovalcev, ki nekaj ur tedensko ali celodnevno brezplačno oskrbujejo starega, kronično bolnega ali invalidnega človeka. Med njimi je velika večina – 200.000 družinskih oskrbovalcev, to je sorodnikov, in dobrih 20.000 drugih, največ sosedov, nekaj prostovoljcev in prijateljev. Po podatkih uradnega evropskega združenja za neformalne oskrbovalce Eurocarers, ki ne upoštevajo, koliko časa in kako pogosto oskrbujejo, pa je neformalnih oskrbovalcev kar 20 % evropske populacije (Yghemonos, 2018), v Sloveniji torej 400.000. Družinski oskrbovalci oskrbujejo v Sloveniji 60.000 starejših ljudi doma, 6.000 oskrovancem pomagajo po nekaj ur tedensko poklicni oskrbovalci v organizaciji javne pomoči na domu. Domovi za stare ljudi oskrbujejo 20.000 starih ljudi, v njih je blizu 10.000 zaposlenih. Za kakovost življenja v oskrbovalni ustanovi je odločilno tudi sodelovanje domačih in prostovoljcev.

Raziskave in vsakdanje izkušnje kažejo, da je pomoč svojcem tako za oskrbovalce kakor za oskrbovance lahko zelo dobra izkušnja. Naša reprezentativna raziskava o potrebah, zmožnostih in stališčih nad 50 let starih prebivalcev Slovenije (Ramovš, ured., 2013) je pokazala, da ostaja svojcem v lepem spominu na oskrbovanje predvsem izkazana hvaležnost oskrbovanca, etično zadoščenje ob opravljeni dolžnosti, lastni občutki zadovoljstva, veselja, topline, sreče in koristnosti, poglobitev odnosa s svojcem in/ali med družinskimi člani. Oskrbovanci pa navajajo zlasti naslednje lepe spomine na čas oskrbovanja: na svojca, ki je zanje skrbel, na njegovo prijaznost, potrpežljivost, požrtvovalnost ipd., pa tudi na dobro oskrbo, na dejstvo, da so jim svojci pomagali in na poglobitev odnosa.

Isti raziskovalni podatki kažejo tudi pereče potrebe oskrbovalcev pri oskrbovanju. Svojci navajajo kot največje težave zlasti naslednje: pomanjkanje veščin in znanja o negi, o boleznih, o komunikaciji z bolnim človekom, pomanjkanje časa za oddih, spopadanje z lastnimi zdravstvenimi težavami in duševnimi stiskami (npr. soočanje z nemočjo, strah pred poslabšanjem). Mnogi se v vlogi družinskega oskrbovalca znajdejo čez noč, nekateri za svojce skrbijo praktično 24 ur dnevno. V Sloveniji, kjer še nimamo sodobnega sistema za dolgotrajno oskrbo, so družinski oskrbovalci prepuščeni sami sebi. Brez podpore politike, strok in širše javnosti so v današnjih življenjskih razmerah težko kos tej zahtevni nalogi.

Dolgotrajno oskrbovanje – in vsako domače, prostovoljsko ali poklicno delo za ljudi v potrebi in stiski – ima dve razsežnosti:

1. je storitev ali opravilo, ki drugemu stvarno zadovolji potrebo, ki je sam ne more,
2. je osebni odnos človeka s človekom.

Storitev lahko bolje, hitreje in ceneje opravimo s poklicnimi veščinami in tehnološkimi orodji, zlasti s sodobno IKT; ta bo v prihodnje lahko v celoti kakovostno opravljala oskrbovalne storitve. Pri opravljanju storitve je komunikacijski kanal odprt enosmerno od oskrbovalca do oskrbovanca – ta je res uporabnik storitve.

Druga bistvena razsežnost oskrbovanja je človeški odnos med nemočnim, ki za preživetje potrebuje pomoč, in (bolj) močnim, ki mu zmore to narediti. Človeški odnos z obojestransko odprto komunikacijo ohranja človeško dostojanstvo nemočnega in močnega.

Močni ob človeški pomoči nemočnemu (otroku, bolniku, umirajočemu ...) razvija svojo temeljno človeško zmožnost solidarnosti, sočutja, empatije, vživljanja v drugega in sodoživljanja z njim, človeško občilnost. Te človeške zmožnosti so pogoj za vsako kakovostno komuniciranje in sodelovanje v družini, službi in družbi, razvijamo pa jih lahko samo v praksi pomoči nemočnim, ki ni brezosebno opravljanje storitve in ne premoč močnejšega človeka nad slabotnejšim človekom – človeka sta namreč oba enako.

Nemočni s storitvami, ki mu jih opravijo drugi, telesno preživi in se razvija; toda na tej ravni bo v prihodnje lahko opravila vse pametna tehnologija, danes pa storitveno oskrbuje profitno organiziran oskrbovalni trg. Na človeški ravni je odločilen osebni odnos med oskrbovalcem in oskrbovancem, pri katerem oskrbovalec doživlja, da se ob tem, ko daje (storitev) potrebnemu, sam človeško razvija. Zaradi tega odnosa oskrbovanec poleg storitve za telesno preživetje, ohranja in dobiva tudi duševno, socialno in duhovno moč, da ostaja celovito človeško bitje s kljubovalno močjo duha v svoji omejenosti.

Množična potreba po oskrbovanju v času staranja prebivalstva je zato izjemna priložnost za humani razvoj tisočletne evropske kulture, ki se je zadnji dve stoletji posvetila uspešnemu materialno-tehničnemu razvoju in s tem telesnemu zdravju in podaljševanju življenja, pri tem pa ji je povsem zaostal razvoj medčloveškega sožitja in celovite človekove osebnosti. Socialni kapital desettisočletne tradicije z njenimi vzorci solidarnosti za razvoj in preživetje v poljedeljsko-obrtniško-stanovskih družbenih razmerah, se v tem času izčrpava, zato EU v *Zeleni knjigi o odzivu na demografske spremembe* (2005) govori o nujnosti razvijanja *»nove solidarnosti med generacijami«*. Podvojena potreba po oskrbi starih ljudi je za to vsaj tako dobra priložnost, kakor je bila v tradicionalni družbi skrb za otroke, katerih se je tedaj rodilo nekajkrat več na žensko kakor danes. Učenje aktivnega človekovanja in občestvovanja se dogaja v pretežni meri ob človeški vzgoji otrok in osebni pomoči nemočnim v njihovi bolezni, onemoglosti, invalidnost ali materialni revščini; edini način učenja človekovanja in občestvovanja je pristno človeško pomagati ljudem v njihovih težavah in od njih hvaležno prejemati pomoč. Samo razvita osebna solidarnost pri večini ljudi (empatija, komuniciranje, sprejemanje sebe in ljudi z našimi stvarnimi razvojnimi možnostmi in mejami) omogoča ob naglem materialnem in tehnološkem razvoju tudi razvoj humane človeške družbe, posameznikom pa doživljanje srečnosti in smisla celotnega življenja, sožitja in razvoja.

Dolgotrajna oskrba je torej danes največja priložnost za razvijanje sodobne solidarnosti in z njo celotnega kakovostnega sožitja v družini, službi in družbi. Da bomo v Sloveniji in Evropi to priložnost izkoristili, moramo zavestna usmeriti veliko osebne in družbene pozornosti na usposabljanje vsega prebivalstva za odnosno človeško oskrbovanje in hvaležno sprejemanje oskrbe.

3. TEZE O SODOBNEM SISTEMU DOLGOTRAJNE OSKRBE

Inštitut Antona Trstenjaka za gerontologijo in medgeneracijsko sožitje dela od osamosvojitve Slovenije raziskovalno na tem področju. Razvija in izvaja na terenu po Sloveniji in tujini sodobne programe za zdravo staranje ter za usposabljanje oskrbovalcev, zlasti družinskih. Ves čas sodeluje z gerontološkimi in medgeneracijskimi strokovnjaki v Sloveniji in po svetu. Na tej osnovi smo povzemamo naslednja spoznanja o sodobni humani in finančno vzdržni dolgotrajni oskrbi; poleg domačih in tujih raziskovalnih spoznanj in uspešnih praks smo jih oblikovali tudi ob zgoraj navedenih analizah obeh slovenskih predlogov zakona o dolgotrajni oskrbi, nekatera pa so bila oblikovana na 1. slovenski konferenci o družinski in drugi neformalni oskrbi, ki jo maja 2018 organiziralo Ministrstvo za zdravje RS, izvedel pa Inštitut; prispevki so objavljeni v 2. in 3. številki revije *Kakovostna starost* 2018 (http://www.inst-antonatrstenjaka.si/tisk/kakovostna-starost/stevilka.html?ID=201802). Spoznanja naštevamo v obliki tez.

1. Pogoj za vzpostavitev sodobnega sistema dolgotrajne oskrbe je politična odločitev, da za dolgotrajno oskrbo namenimo najmanj 1,3 % BDP, kakršno je povprečje evropskih držav; v Sloveniji je to le 0,9 % BDP.
2. Sistem mora izhajati iz celovitega gledanja na oskrbovanca, ki potrebuje predvsem pomoč pri opravljanju vsakodnevnih opravil, in šele nato iz logike storitev zdravstvenih, socialnih in drugih strok ter ustanov. Čeprav so storitve eden od bistvenih vidikov oskrbe, izhajanje iz njih (kakor je to bilo v predlogu zakona o dolgotrajni oskrbi) onemogoča celovito

sodobno humano oskrbo, razvoj njene kakovosti in finančno vzdržnost ob večanju potreb po oskrbi v prihodnje.

3. Sistem mora povezati v dopolnjujočo se celoto vse glavne vire: družinske in druge neformalne oskrbovalce, ki oskrbujejo 75 % potrebnih, znanje in metode vseh relevantnih strok in oskrbovalnih ustanov, primerno motivacijo lokalne skupnosti, da poskrbi za svoje občane, ter državo, ki je regulatorka in garant humanega, razvojno naravnanega in finančno vzdržnega sistema dolgotrajne oskrbe. Sodobni sistem dolgotrajne oskrbe je lahko human in finančno zdržen le, če sistemsko povezuje neformalno in formalno oskrbo v dopolnjujočo se sinergično celoto.

4. V sistemu je treba povezati v celoto zdravstveni, socialni, arhitekturno-infrastrukturni in vzgojno-kulturni vidik oskrbovanja. Nepogrešljivo celoto sodobne dolgotrajne oskrbe sestavljajo: znanja in metode zdravstvenih in socialnih strok, arhitekturno urejanje bivalnih prostorov, ki so primerni za starostno pešanje, sodobni tehnični pripomočki pri oskrbovanju ter vzgojni, medijski in ostali kulturni vplivi na razumevanje in krepitev medgeneracijske solidarnosti v današnjih razmerah. Učinkovit sistem dolgotrajne oskrbe lahko vzpostavimo in razvijamo le, če so v njem vse navedene stroke enovita celota, njihovi politični in upravni resorji v državi in občini pa intersektorsko povezani.

5. Dolgotrajna oskrba mora biti decentralizirano umeščena v krajevno skupnost, enako kakor je otroško varstvo in osnovno zdravstvo; država mora celovit sistem dolgotrajne oskrbe regulirati z zakonodajo, jamčiti njegovo organiziranost in enakost v dostopnosti, voditi vzdržen sistem financiranja, zagotavljati minimalne standarde kakovosti, izvajati mora kontrolo nad delovanjem izvajalcev in skrbeti za razvoj sistema.

6. Individualna upravičenost do financiranja iz sistema dolgotrajne oskrbe omogoča – ob sodobni informacijski tehnologiji, dobrih kriterijih za vstop, zagotovljenih standardih oskrbovanja in učinkoviti kontroli nad izvajalci – minimalno porabo sredstev za administracijo. To se doseže z dobro organizacijo obstoječih javnih služb za vstopanje v javno mrežo. Stroški za administracijo otežujejo finančno vzdržnost sistema, predvsem pa onemogočajo razvoj njegove vsebinske in metodične kakovosti. Koncesije za oskrbovalne ustanove in organizacije (poleg dovoljenja za delo in kontrole storitev) po Evropi ne uporabljajo, saj zmanjšajo pobudo skupnosti in povečajo škodljivo birokratizacijo centraliziranega sistema.

7. Vlada mora skupaj s pripravo in sprejemanjem sistema in Zakona o dolgotrajni oskrbi poskrbeti za permanentno in kakovostno informiranje in ozaveščanje javnosti o dolgotrajni oskrbi v okviru celote sodobnih potreb in možnosti na področju staranja in s tem povezane krepitve solidarnosti med generacijami. O delovanju nacionalnega sistema dolgotrajne oskrbe mora biti vzpostavljeno zelo dobro informiranje vseh prebivalcev.

8. Učinkoviti možnosti za preprečevanje nenujne potrebe po dolgotrajni oskrbi sta usposabljanje za zdravo staranje ter strokovna in finančna pomoč pri prilagajanju hiš in stanovanj za samostojnost ob starostnem pešanju, boleznih in drugih oviranostih.

9. Za krepitev sodobne solidarnosti med generacijami pri oskrbi potrebnih članov družbe je smiselno ob sprejemanju nacionalnega sistema za dolgotrajno oskrbo uvesti po zgledu nekaterih razvitih držav za mlade med 18. in 30. letom starosti *socialno leto* organiziranega služenja v skupnosti (mnogi ga opravljajo prav v sistemu dolgotrajne oskrbe) ter *socialno služenje* ljudi, ki v času brezposelnosti prejemajo socialno pomoč skupnosti.

10. Usodna zapreka pri vzpostavljanju sodobnega sistema dolgotrajne oskrbe je prevlada kateregakoli lobija, ki vede ali nevede enači ta stvarni nacionalni interes s parcialnim interesom svoje skupine, pa najsi je to kapital, katera od zdravstvenih ali socialnih strok, upravni aparat, zavarovalnica ali politična stranka. Kakovostno staranje – vključno s humano oskrbo v onemoglosti – je temeljna potreba slehernega človeka, pereča naloga ob staranju prebivalstva je skupna naloga naše države, obvladovanje demografskega staranja slovenskega naroda pa življenjski interes vsakega, ki se razvija v moči slovenske kulture. Ti skupni interesi in naloge so dobra priložnost za sodelovanje vseh političnih, strokovnih in civilnih deležnikov.

11. Svojci – družinski oskrbovalci so danes najšibkejši člen med deležniki dolgotrajne oskrbe. Ker v Sloveniji in vsej Evropi pa opravljajo nad 75 % celotne dolgotrajne oskrbe in ker so glavni nosilec človeškega odnosa z oskrbovancem, so nepogrešljivi del kakovostne in finančno zdržne dolgotrajne oskrbe. Pogoj za kakovost nacionalnega sistema dolgotrajne oskrbe je intenzivni razvoj sodobnih programov za razbremenitev družinskih oskrbovalcev: njihovo usposabljanje, krajevni programi za pomoč in pravna zagotovitev njihovih pravic. Usodna posledica zanje, za razvoj oskrbovalne stroke in oskrbovalnih programov nastane, če politika v boju za moč izkorišča njihovo nevidnost in ranljivost.

Dolgotrajna oskrba je v času velikega povečanja deleža ljudi, ki so odvisni od dolgotrajne oskrbe, glavna priložnost za nagel razvoj kakovosti sožitja in sodelovanja v sodobni družbi, v kateri postajajo neuporabni tradicionalni vzorci solidarnosti.

4. ZAKLJUČEK

Sodobna ureditev humane in finančno vzdržne dolgotrajne oskrbe je pogoj za uspešno reševanje današnje demografske krize in za nadaljnji human razvoj družbe. Brez dobre rešitve te naloge ni rešljivo niti kakovostno in zdravo staranje velike deleža starejših ljudi ob staranju baby boom generacije, niti vzpostavitev nove medgeneracijske solidarnosti ob koncu tradicionalne družbe. Evropske države sistematično rešujejo to nalogo od leta 1990, Slovenijo večinoma še čakajo, med drugim tudi uvedba in zakonska ureditev sodobnega sistema dolgotrajne oskrbe. Na osnovi raziskovalnih spoznanj in dobrih praks v tujini in doma ima vlada dobre možnosti, da to področje uredi ne le kot zagotavljanje oskrbovalnih storitev, ampak ob njih celovito učenje vseh generacij za novo, posttraciionalno solidarnost med ljudmi.

To je najboljša in verjetno edina možnost, da kakovost medčloveškega sožitja in sodelovanja v družini, službi in družbi doseže razvoj na materialnem področju, v telesnem zdravju in dolžini življenja.

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Močna družinska medicina je najboljši način zdravstvene obravnave starajočega se prebivalstva

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POVZETEK

Zdravstveni sistemi težijo k fragmentaciji, poudarku na bolnišnicah in komercializaciji zaradi zakonov ponudbe in povpraševanja. Ljudje pričakujejo, da zdravstvena politika zmanjšuje neenakosti in pospešuje solidarnost.

Države, ki so bolj orientirane v primarno zdravstveno varstvo imajo nižje stopnje smrtnosti in boljše zdravstvene izide. Ljudje, ki imajo dobro primarno zdravstveno oskrbo v 10 do 15% verjetneje poročajo o dobrem zdravju v primerjavi z ljudmi, ki le-te nimajo.

Družinska medicina je v zadnjih desetletjih v Sloveniji dosegla nesluten razvoj in je priznana tako v slovenski kot tudi mednarodni medicinski stroki. Hitremu strokovnemu, znanstvenemu in akademskemu razvoju družinske medicine pa ne sledi tudi močan položaj družinske medicine v zdravstvenem in političnem sistemu v Sloveniji.

Ključne besede

Družinska medicina, starostniki, zdravstveni sistem.

...brez zdravja nima nič nobene vrednosti, niti denar niti karkoli drugega...

Demokrit, peto stoletje pred Kristusom

...ohranitev zdravja je... ...brez dvoma prva dobrina in osnova vseh drugih dobrin v tem življenju...

René Descartes, Discours de la Méthode, 1637

1. UVOD

Zdravstveni sistemi se spontano ne nagibajo k vrednotam osnovne zdravstvene dejavnosti in ne odgovarjajo učinkovito na nove zdravstvene izzive. To je še posebej resnično, kadar ni prisotnih močnih voditeljev ali trdne politične volje. V današnjem svetu so trije trendi, ki spodkopavajo zdravstveni sistem: osredotočenost na bolnišnice, fragmentacija in nebrzdana komercializacija zdravstva. Bogate države so običajno lahko delno ublažile negativne učinke teh trendov. Manj bogate države, kjer nadzor nad zdravstvenim sistemom bolj šepa, so imele zaradi tega več težav [1,2].

1.2 Sprememba vrednot

Zdravstveni sistemi težijo k fragmentaciji, poudarku na bolnišnicah in komercializaciji zaradi zakonov ponudbe in povpraševanja. Zdravstveni sistem je odsev globalne potrošniške družbe. Vendar pa se vedno bolj krepijo prepričanja da potrošniški tip zdravstvenega sistema ni ustrezen odgovor na resnične potrebe ljudi. Zdravje je vedno bolj čislan del vsakdanjega življenja. Ljudje želijo zdravstven sistem, ki bo v njih videl posameznike s pravicami in ne samo stranke zdravstvenih programov. Ljudje so pripravljeni spoštovati zdravstvene delavce vendar želijo da so tudi sami spoštovani v ozračju medsebojnega zaupanja [3]. Ljudje pričakujejo da zdravstvena politika zmanjšuje neenakosti in pospešuje solidarnost. V večini družb se ljudje strinjajo, da bi moral vsak imeti dostop do kakovostne zdravstvene oskrbe, ko jo potrebuje, ne da bi zaradi tega bankrotiral ali padel v revščino.

1.3 Primarna zdravstvena oskrba

Države, ki so bolj orientirane v primarno zdravstveno varstvo imajo nižje stopnje smrtnosti in boljše zdravstvene izide [2]. Ljudje, ki imajo dobro primarno zdravstveno oskrbo v 10 do 15% verjetneje poročajo o dobrem zdravju v primerjavi z ljudmi, ki nimajo dostopa do dobre primarne zdravstvene oskrbe [4]. Ena raziskava je pokazala, da če na vsakih 10000 prebivalcev ZDA dodamo enega družinskega zdravnika se to pokaže v 5,3% boljših zdravstvenih kazalnikih (celotna smrtnost, smrtnost zaradi srčno-žilnih bolezni, smrtnost dojenčkov, nizka porodna teža, pričakovana življenjska doba in samoocena zdravja) [5]. Pregled literature je pokazal da tako količina kot tudi kakovost oskrbe na primarni ravni vpliva na zdravje populacije in na delovanje celotnega zdravstvenega sistema. Primarna raven zdravstvene oskrbe preprečuje bolezni in smrti ne glede na to ali je oskrba boljša zaradi večjega števila zdravnikov, zaradi boljše dostopnosti do primarne zdravstvene oskrbe ali zaradi večje kakovosti storitev na primarni ravni [5].

1.4 Družinska medicina v Sloveniji

V Socialistični federativni republiki Jugoslaviji je primarna raven medicine slonela na zdravstvenih domovih, kjer so bili zaposleni zdravniki. Prvi zdravstveni dom v Sloveniji je bil sicer ustanovljen že leta 1926 v Lukovici pod vplivom Andrije Štamparja. Leta 1961 je bila prvič uvedena specializacija iz splošne oziroma družinske medicine v Zagrebu, leta 1974 je bil ustanovljena katedra za splošno medicino na Šoli javnega zdravja Andrija Štampar (Andrija Štampar je bil leta 1946 predsednik prve Svetovne zdravstvene skupščine, odločevalskega organa Svetovne zdravstvene organizacije). Od leta 1966 je bila specializacija splošne medicine tudi v Sloveniji, trajala je tri leta, 2 leti v bolnišnici, eno leto pa je bil podiplomski tečaj iz javnega zdravja, vodil ga je tedanji Nacionalni inštitut za javno zdravje. Prvi specialist splošne medicine v Sloveniji je bil leta 1966 Janez Schrott. V Sloveniji so bili neuspešni poskusi ustanovitve katedre za splošno oziroma družinsko medicino leta 1950 in 1975. Leta 1966 pa se je ustanovila sekcija zdravnikov splošne medicine pri Slovenskem zdravniškem društvu. Leta 1983 je bila v Sloveniji prvič organizirana učna delavnica splošne medicine. Leta 1988 je bil prvič izdan priročnik Nujna stanja, leta 1992 pa prvi učbenik splošne medicine.

Leta 1995 se končno na MF v Ljubljani ustanovi katedra za družinsko medicino, sekcija splošne medicine se leta 1998 preoblikuje v Združenje zdravnikov družinske medicine, ki postane največji organizator skupaj s katedro strokovnih srečanj vseh vrst za družinske zdravnike. Program specializacije iz družinske medicine je bil sprejet šele leta 1999.

Preko Združenja je vsak zdravnik družinske medicine včlanjen tudi v Svetovno združenje zdravnikov družinske medicine (WONCA). Leta 2003 je bila letna konferenca evropske WONCA v Ljubljani. Slovenci sodelujemo v delovnih telesih WONCA, prof. Igor Švab je bil od leta 2004 do 2010 predsednik WONCA evropske regije, od tedaj je še vedno tajništvo evropske WONCA v Ljubljani. V Ljubljani sta tudi tajništvi EURACT (European Academy of Teachers in General Practice/Family medicine) ter Europrev (European Network for Prevention and Health promotion in Family Medicine and General Practice). Predsednik EURACT-a je bil od 2010 do 2015 prof. Dr. Janko Kersnik. Europrev je od leta 2010 naprej vodila doc. dr. Mateja Bulc. Pomembno je tudi članstvo v EGPRN (European General Practice Research Network) ter EURIPA (European and Rural Isolated Practitioner Association). Katedra in Združenje sta in še vedno sodelujeta v veliko mednarodnih raziskovalnih projektih, v zadnjih letih objavijo člani raziskovalne skupine družinske medicine vsaj 50 člankov, ki so citirani v Medlinu.

Sodelavci katedre so sodelovali v projektih Svetovne banke za krepitev primarne ravni zdravstvene oskrbe v Črni gori, Makedoniji, Gruziji in Turčiji. Katedra je povezana z Imperial college iz Londona in Maastrichtsko medicinsko fakulteto. Z veliko evropskimi univerzami je vzpostavljena izmenjava študentov in učiteljev prek Erasmusa.

Leta 2012 je izšel nov učbenik Družinska medicina. Leta 2013 je bil ta učbenik z manjšimi dopolnitvami izdan v hrvaščini v Zagrebu, leta 2017 pa je v Zagrebu izšel še angleški prevod učbenika iz leta 2013.

Od leta 2011 poteka projekt referenčnih ambulant, kjer se zdravniku družinske medicine in srednji medicinski sestri v ožjem timu ambulante družinske medicine pridruži še diplomirana medicinska sestra, s čemer se okrepi preventiva v družinski medicini.

Leta 2017 je dekan medicinske fakultete v Ljubljani postal profesor Igor Švab, predstojnik katedre za družinsko medicino.

2. ZAKLJUČEK

Družinska medicina je v zadnjih desetletjih v Sloveniji dosegla nesluten razvoj in je priznana tako v slovenski kot tudi mednarodni medicinski stroki. Hitremu strokovnemu, znanstvenemu in akademskemu razvoju družinske medicine pa ne sledi tudi močan položaj družinske medicine v zdravstvenem in političnem sistemu v Sloveniji. Od leta 2005 je bilo že vsaj pet poskusov sprejetja Nacionalne strategije razvoja osnovne zdravstvene dejavnosti v Sloveniji, ki pa je vsakokrat obtičala v predalih Ministrstva za zdravje Republike Slovenije.

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RAZŠIRJENI POVZETEK

Usposabljanje menedžmenta za obvladovanje staranja zaposlenih

JOŽE RAMOVŠ, TJAŠA GREBENŠEK

Inštitut Antona Trstenjaka za gerontologijo in medgeneracijsko sožitje

KLJUČNE BESEDE
Demografska kriza, staranje zaposlenih, usposabljanje menedžmenta, sodelovanje med generacijami zaposlenih

Razviti svet se prvič v zgodovini nahaja v krizi staranja prebivalstva, ko je starejših ljudi več kakor mladih; v zadnjih desetletjih namreč z rojstvi nadomeščamo le dve tretjini za ohranitev istega števila domačih prebivalcev. Ena od treh bistvenih nalog za obvladovanje demografske krize je ohranjanje gospodarsko vzdržne družbe in socialno pravične evropske družbe ob naglem staranju zaposlenih.

Podatki o zaposlenih v Sloveniji in Evropi kažejo, da se delež starejših naglo veča. V zadnjih desetih letih se je delež zaposlenih, ki so starejši od 55 let, v nekaterih podjetjih in ustanovah celo potrojil: iz manj kakor 10 % na blizu 30 %. V prihodnje bo v veliko evropskih podjetjih več kakor polovica zaposlenih starih nad 50 let. Lastniki in vodstva podjetij, evropska in državne politike, gerontološka stroka in drugi deležniki imamo zahtevno nalogo, da ustreznimi programi preprečimo škodljive poslovne posledice tega demografskega razvoja med zaposlenimi.

V podjetjih doživljajo ob globalni konkurenci iz dežel z veliko mladega prebivalstva in poceni delovno silo vsi zaposleni hud pritisk – mladi zaposleni drugače, starejši drugače in vodje drugače. Starejši zaposleni se neredko počutijo iztrošeni, težko sledijo razvojnim zahtevam ter se učijo uporabe novih tehnologij in postopkov, z nezaupanjem gledajo v mlade. Neredko naveličani čakajo upokojitev, pri tem pa računajo na posebne ugodnosti. Navade in mentaliteta mladih zaposlenih so zelo drugačni od nekdanjih. Imajo veliko novih znanj, zlasti v nenadomestljivi elektronski tehnologiji, malo pa življenjskih izkušenj, starejših ne razumejo. Mlajši in starejši težko navezujejo med seboj dober stik in učinkovito sodelujejo. V teh razmerah je vodenje v podjetju zelo zahtevno. Trg in dejstva so neizprosna: tukaj in zdaj je treba biti uspešen, sicer podjetje propada.

Za reševanje tega kriznega stanja je na voljo zadostna, toda neizkoriščena možnost: sestaviti v sinergijo nova znanja mladih in življenjske izkušnje starejših ter uporabiti doslej neizkoriščene človeške razvojne zmožnosti. Edini vzvod, ki lahko vse to poveže in ob staranju zaposlenih sproži nov razvoj, je vodstvo. Vodenje zaposlenih zahteva danes zaradi demografskega staranja tri nova znanja:

1. veščine za učinkovito vključevanje starejših delavcev v delovni proces,
2. veščine za organiziranje dobrega sodelovanja med starejšimi in mlajšimi zaposlenimi,
3. sodobna znanja o staranju na delovnem mestu, ki so pogoj za pridobivanje prvih dveh veščin.

Ta možnost nam nudi dve odločilni prednosti. Prva: zadostuje, da lahko ohranimo konkurenčne prednosti. In druga: če jo izkoristimo, nam rešuje probleme slabega sodelovanja v delovnem in vsakdanjem sožitju, ki so se nam nakopičili v dveh stoletjih, ko je evropska kultura posvečala vse sile materialnemu razvoju. Menedžmentu na vseh ravneh vodenja se torej zelo splača osvajati veščine za vodenje medgeneracijskega sodelovanja ob staranju zaposlenih.

Na Inštitutu Antona Trstenjaka za gerontologijo in medgeneracijsko sožitje smo za reševanje te naloge razvili intenzivni seminar *Menedžment sodelovanja ob staranju zaposlenih.* Z njim usposabljamo vse ravni vodstva v podjetjih in ustanovah, vključno z lastniki. Izvajamo ga v skupinah od 7 do 9 direktorjev in drugih vodij na treh učnih srečanjih po štiri ure, praviloma v treh zaporednih tednih. Edina učinkovita metoda pri tem je aktivno skupinsko socialno učenje po načelu *vsi smo učitelji in vsi učenci – razlike nas bogatijo.*

Udeleženci osvajajo spoznavanje in veščine za zgoraj navedena tri področja z učenjem:

- iz lastnih dobrih izkušenj ter spoznavanjem orodij za učinkovito obdelavo slabih izkušenj,
- s spoznavanjem celote človeških potreb, zmožnosti in motivacije v telesno-materialni, duševni, duhovni, socialni, razvojni in bivanjski razsežnosti,
- osvajanjem veščin za uresničevanje sinergične komplementarnosti novega znanja mlajših in življenjskih izkušenj starejših delavcev,
- namesto posredovanja spoznanj v obliki predavanj, dobijo dva priročnika, v katerih smo kratko in ciljno zbrali sodobna znanja z vidika potreb in možnosti menedžerjev,
- vsak udeleženec s seminarsko nalogo reši en svoj konkretni vodstveni primer ob staranju zaposlenih.

Ker je demografski problem velikega deleža starejših zaposlenih nov, je glavni učinkoviti vir potrebnega znanja in veščin za njegovo reševanje učenje iz izkušenj. Metoda skupinskega socialnega učenja omogoča ustrezno obdelovanje konkretnih dobrih in slabih izkušenj menedžerjev na tečaju. Na ta način postanejo njihove izkušnje učinkovit vir osebnega razvoja vodij in razvoja podjetja. Zaradi te sodobne metode je seminar kljub poglobljenim sodobnim strokovnim spoznanjem v celoti praktičen po meri konkretnih potreb udeležencev.

Seminarje izvajamo interno za velika podjetja z več sto vodij ali pa v sestavljenih skupinah, kamor pridejo posamezni menedžerji iz malih podjetij, zavodov ali društev. V prvem primeru je določena prednost skupna identiteta in podobnost problemov staranja zaposlenih, v drugem pestrost različnih izkušenj. Evalvacija več deset seminarjev z nekaj sto udeleženci kaže, da so menedžerji in njihova podjetja zelo zadovoljni. Čeprav so učna srečanja raztegnjena na tri tedne in so menedžerji zelo zaposleni, so se tečaja udeleževali redno, vzdušje je bilo prijetno, sodelovanje zavzeto.

Seminar *Menedžment sodelovanja ob staranju zaposlenih* in metodično podoben, vsebinsko pa zelo različen seminar za zaposlene po 50. letu starosti, sta naš odgovor na raziskovalna spoznanja o staranju zaposlenih in na čedalje bolj perečo potrebo po poznavanju med mlajšimi in starejšimi zaposlenimi ter nasploh po boljšem sodelovanju.

Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek G

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume G

Sodelovanje, programska oprema in storitve v informacijski družbi
Collaboration, Software and Services in Information Society

Uredil / Edited by

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http://is.ijs.si

9. oktober 2018 / 9 October 2018
Ljubljana, Slovenia

PREFACE

This year, the Conference "Collaboration, Software and Services in Information Society" is being organised for the eighteenth time as a part of the "Information Society" multi-conference. As in previous years, the papers from this year's proceedings address actual challenges and best practices related to the development of advanced software and information solutions as well as collaboration in general.

Information technologies and the field of Informatics have been the driving force of innovation in business, as well as in the everyday activities of individuals for several decades. Blockchain technology, Big Data, intelligent solution, reference models, open standards, interoperability and the increasing responsiveness of IS/IT experts are leading the way to the development of intelligent digital service platforms, innovative business models and new ecosystems where not only partners, but also competitors are connecting and working together. On the other hand, quality assurance remains a vital part of software and ICT-based service development and deployment. The papers in these proceedings provide a better insight and/or propose solutions to challenges related to:

- Self-Assessment of Sustainability of ICT in SMEs;
- Ontology-based knowledge sharing on BPMN graphical signs using semiotics;
- Influence of notations used for conceptual design on knowledge perception;
- Application of machine learning techniques to obtain new knowledge;
- Establishment of domain specific reference models;
- Introduction of Blockchain technology into real-life use cases;
- Architectural design proposals for ensuring scalability of Blockchain platforms;
- Application of usability questionnaires when evaluating gamification and serious games
- Visualization, analysis and comprehension of complex software systems;
- Continuous software development, integration and delivery;
- Integration of source code repositories and QA tools.

We hope that these proceedings will be beneficial for your reference and that the information in this volume will be useful for further advancements in both research and industry.

Prof. Dr. Marjan Heričko
CSS 2018 – Collaboration, Software and Services in Information Society Conference Chair

PREDGOVOR

Konferenco "Sodelovanje, programska oprema in storitve v informacijski družbi" organiziramo v sklopu multikonference Informacijska družba že osemnajstič. Kot običajno, tudi letošnji prispevki naslavljajo aktualne teme in izzive, povezane z razvojem sodobnih programskih in informacijskih rešitev ter storitev kot tudi sodelovanja v splošnem.

Informatika in informacijske tehnologije so že več desetletij gonilo inoviranja na vseh področjih poslovanja podjetij ter delovanja posameznikov. Tehnologija veriženja blokov, velepodatki, inteligentne storitve, referenčni modeli, odprti standardi in interoperabilnost ter vedno višja odzivnost informatikov vodijo k razvoju inteligentnih digitalnih storitvenih platform in inovativnih poslovnih modelov ter novih ekosistemov, kjer se povezujejo in sodelujejo ne le partnerji, temveč tudi konkurenti. Napredne informacijske tehnologije in sodobni pristopi k razvoju, vpeljavi in upravljanju omogočajo višjo stopnjo avtomatizacije in integracije doslej ločenih svetov, saj vzpostavljajo zaključeno zanko in zagotavljajo nenehne izboljšave, ki temeljijo na aktivnem sodelovanju in povratnih informacijah vseh vključenih akterjev. Ob vsem tem zagotavljanje kakovosti ostaja eden pomembnejših vidikov razvoja in vpeljave na informacijskih tehnologijah temelječih storitev.

Prispevki, zbrani v tem zborniku, omogočajo vpogled v in rešitve za izzive na področjih kot so npr.:

- samoocenitev kakovosti in zrelosti IKT podpore v malih in srednje velikih podjetjih;
- deljenje znanja o grafičnih simbolih BPMN z uporabo semiotike;
- vpliv notacije, uporabljene pri oblikovanju konceptualih modelov, na dojeti nivo pridobljenega znanja;
- uporaba tehnik strojnega učenja za ekstrakcijo znanja;
- vzpostavitev domenskih referenčnih modelov;
- vpeljava tehnologije veriženja blokov v realne primere uporabe;
- arhitekturni predlogi za rešitev razširljivosti platform tehnologije veriženja blokov;
- uporaba standardnih vprašalnikov uporabnosti pri vrednotenju učinkov vpeljave igrifikacije in resnih iger;
- vizualizacija, analiza in razumevanje kompleksnih programskih sistemov;
- neprekinjen razvoj, integracija in dobava informacijskih rešitev;
- integracija repozitorijev izvorne kode z orodji za zagotavljanje kakovosti.

Upamo, da boste v zborniku prispevkov, ki povezujejo teoretična in praktična znanja, tudi letos našli koristne informacije za svoje nadaljnje delo tako pri temeljnem kot aplikativnem raziskovanju.

prof. dr. Marjan Heričko
predsednik konference CSS 2018 – Collaboration, Software and Services in Information Society Conference

PROGRAMSKI ODBOR / PROGRAM COMITTEE

Self-Assessment Tool for Evaluating Sustainability of ICT in SMEs

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ABSTRACT

The ever-increasing demand for ICT may compromise global objectives for emissions reduction if the aggregate effects of ICT sustainability are not considered in the business digitalization processes. In this paper, we present a free self-assessment tool enabling small and medium sized companies to evaluate the utilized ICT in terms of sustainability. The ICT4S is a free e-service, in effect, a web-based self-assessment tool that was developed in co-operation with Swiss Green IT SIG. The assessment is currently divided into five categories of sustainability questions. The categories are strategy, procurement and recycling, practices, servers and network, and Green ICT. As the result, organizations will gain a general understanding about their state of sustainability, and practical suggestions for greater eco-friendliness and sustainability of their ICT operations.

Categories and Subject Descriptors

• **Social and professional topics~Sustainability** • Information systems~Web applications

General Terms

Measurement, Performance, Human Factors.

Keywords

Sustainability, Assessment, ICT, Metrics, Web tools, E-services.

1. INTRODUCTION

The study presented in this paper aims at contributing to the business activity digitalization of companies concerning the reduction of carbon footprint and improvement of sustainability. The paper introduces a self-assessment tool developed in the research project that allows companies to self-evaluate the sustainability of the ICT exploited in the organization. The objective is to provide companies with concrete tools and proposals for actions enabling more ecological procedures in the organization. Additionally, the knowledge gained by using the self-assessment tool allows companies to become generally more aware of the distribution of energy consumption in a modern ICT infrastructure as well as the factors affecting sustainability of ICT.

2. BACKGROUND

There is a lot of evidence for significant benefits in terms of productivity and cost savings through the exploitation of ICT in the daily business activity of organizations. However, the increasingly dependent use of ICT also brings about "invisible" effects (e.g., electricity used by database servers, cloud servers, and network routers) that may not be consciously recognized [1, 2, 3, 4]. Typically users are concerned only of the electricity consumption of their own devices. The increasing demand for ICT may, in fact, compromise the national objectives for emissions reduction if the aggregate effects of ICT un-sustainability (Figure 1) are not considered in the business digitalization processes.

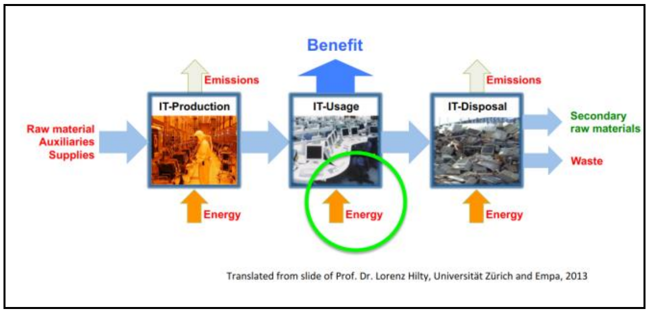


Figure 1. Environmental impacts of the ICT. [5]

In 2017, it was estimated that ICT accounted for 12% of the overall electricity consumption around the globe, and the percentage is expected to increase twice as rapidly in the future (by approximately 7% per year). Most of the energy is consumed by networks, server rooms, and computing centers, (Figure 2) the efficiency of which should urgently be improved.

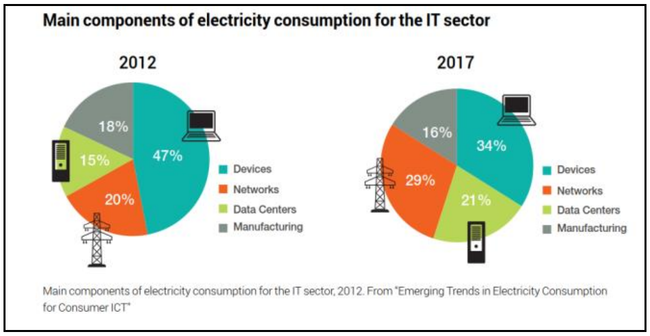


Figure 2. Electricity consumption in the ICT sector. [6]

As most of the electricity is still being generated by using fossil fuels (Figure 3), the current ICT, and its heavy usage of electrical energy, constitutes a global issue that is, unfortunately, little known outside the expert field [7, 8]. This is partly due to the users not perceiving the energy consumption of data systems operating invisibly or in the background, but rather only noticing the consumption of the terminal device, which, in reality, comprises a fraction of the overall energy consumption (Figure 2).

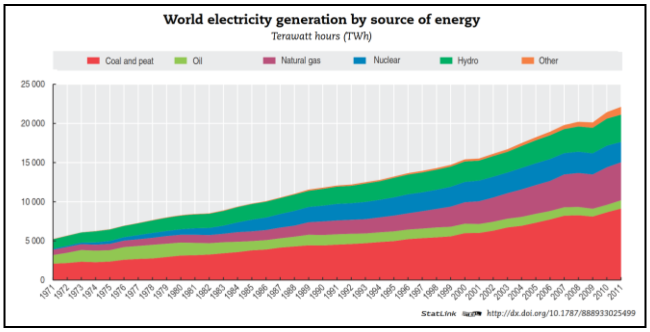
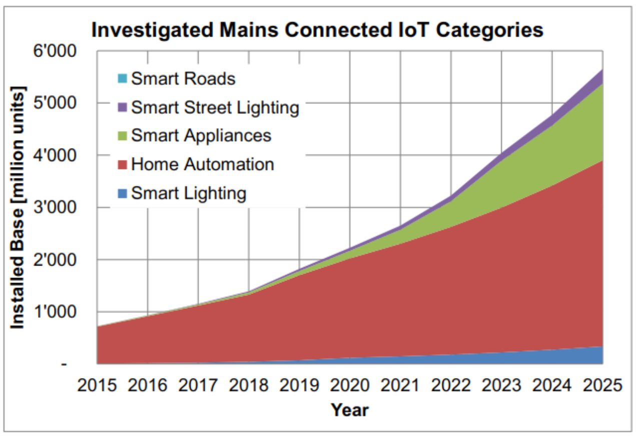
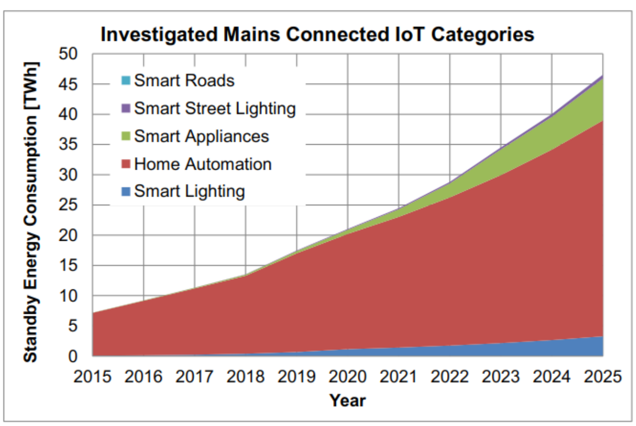


Figure 3. Electricity generation by source of energy. [9]

The problem of energy consumption due to the constantly increasing utilization of ICT is expected to further worsen (Figures 4a and 4b) through the amount of IoT devices and automatic steering systems [10]. If the majority of the predicted IoT devices and information systems supporting them are implemented by the current practices, a near-catastrophic peak demand in terms of electricity will ensue. This, in turn, will result in an increase in emissions rather than their reduction.



(a) Estimated growth.



(b) Estimated standby energy consumption.

Figures 4a and 4b. Estimated growth and impact of IoT devices. [10]

Therefore, it is essential to establish instructions and an assessment procedure to support system planning to improve sustainability of ICT, and, thus, to promote methods for a low-carbon economy.

In 2015 through 2017, the TUT Pori Department implemented a research project (AjaTar) with the aim of improving the digitalization of organizations and companies while promoting a low-carbon economy and sustainability. As part of the project, a technology enabling organizations to self-evaluate their ICT sustainability was developed, tested, and studied, aiming at increasing general awareness of the distribution of electricity consumption in a modern IT infrastructure in order for the organizations to be able to make ICT-related decisions more consciously than before.

The most notable added value of the project comprise an increase in knowhow and knowledge promoting easy and lightweight assessment of sustainability in terms of the organization's business activities and support processes, as well as a freely available tool for evaluating the sustainability of the ICT used in the organization. By making the sustainability issues visible, the objective was to change attitudes and conventions related to the utilization of ICT in organizations: indeed, during the project, several organizations distinctly declared their need to recognize practices promoting sustainable development as well as invest in an eco-friendly image.

3. ICT4S SELF-ASSESSMENT TOOL

During the last six years, the SEIntS research group from TUT Pori Department has studied, developed, and piloted innovative ICT solutions in cooperation with local organizations. Additionally, SEIntS has collaborated with, for example Keio University in Japan as well as with various information society associations, for example, in Switzerland regarding the Green IT and assessment of datacenters. As a result of the AjaTar project, an open self-assessment website for organizations to quickly and easily evaluate the ecological aspects of their ICT-related operations was published at the end of 2017. The self-assessment tool, developed in collaboration with Green IT SIG, a Swiss Green IT information special interest group, is based on the assumption that most of the ICT equipment used in an organization is controllable, enabling the relatively easy adjustment of various functions. With the assessment tool developed in the project, it is possible to increase knowledge about the ecological aspects related to the use of ICT in organizations and, thus, affect their operations and practices. Based on the self-assessment, the organization is offered overall evaluation of the current state and propositions for practices for more sustainable ICT operations.

The self-assessment tool is freely available on a dedicated website for sustainable ICT [11]. On the landing page of the tool (Figure 5) there is a welcoming message that explains the goals of the assessment. There is also information of the privacy solution that is used to guarantee all the information of the assessor's company. The privacy solution is based on the HTML5 local storage concept. The assessment menu is currently divided into five categories of sustainability questions and the information of the organization to be evaluated. The categories are: *strategy*, *procurement and recycling*, *practices*, *servers and network*, and *Green ICT*.

Figure 5. Welcoming the assessors.

Each of the categories comprises several questions and additional text that explains the current issue to the assessor. While trying to answer the questions, the assessor also receives background information on the current topic. In Figures 6 and 7, the assessor is facing questions concerning the strategy and practices at the office.

Figure 6. Assessing the strategy.

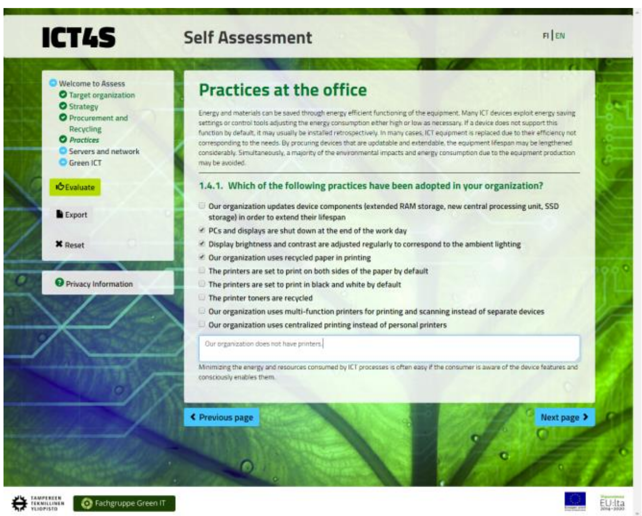


Figure 7. Assessing practices at the office category.

After assessing all categories, the assessment tool calculates and shows an evaluation of the given answers. The results are first shown in a short form as in Figure 8, but users can explore the results more carefully by selecting "Display detailed evaluation." The percentage and the color of the beams give a fast response of the maturity of the different categories. In the case of 100% and a green beam, the user can be satisfied with the sustainability state of their company in that certain category. In the case of low percentages (0 - 70%) or yellow or even red beams, the evaluation shows that there is room for improvement. In such a case, the user may find the detailed evaluation useful when planning concrete actions for these improvements.

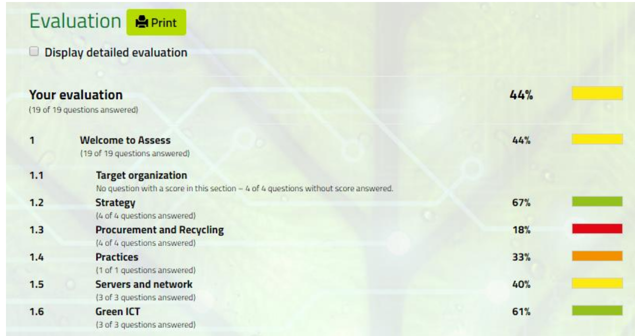


Figure 8. Brief results of the assessment.

The detailed evaluation can be shown by selecting the corresponding option in the user interface (see Figure 9). The user is also able to print the results – hopefully in a sustainable way, for example using an e-format such as Portable Document Format (PDF).

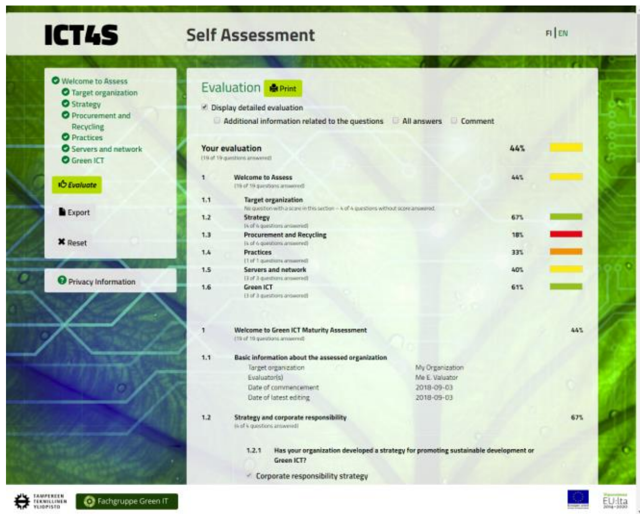


Figure 9. Detailed results of the assessment.

The assessment tool has now been in use for several months. Unfortunately, we do not have the exact statistics concerning the usage of the tool. However, we piloted the tool with the assistance of local companies before launching it last December. Since the piloting groups were satisfied with the tool and because we wanted to keep our promises regarding the privacy of the assessments, we did not implement any logging system in it.

We have planned to enhance the tool with a new capability – aiming to enable an easy way to estimate the carbon footprint of the ICT usage in a company. It will not be fully scientific life cycle assessment (LCA) but a practical version of such targeted to non-professionals in the field of sustainability. The reasoning for this new capability is that we anticipate that by introducing easy assessment tools we will be able to raise the awareness of companies in terms of sustainability issues and thus help them to develop their business processes toward a sustainable state.

4. RESULTS AND FUTURE WORK

This paper presented the ICT4S self-assessment tool enabling companies and other organizations to evaluate the utilized ICT in terms of a low-carbon economy and sustainability and thus improve their image as well as resource efficiency. As the result, organizations will gain a general understanding of the current sustainability state of their ICT and practical suggestions for more eco-friendly and sustainable operations.

The role of the TUT Pori Unit was to function as a producer and facilitator of new knowledge. The applied project aimed at contributing to the business development with TUT Pori Unit acting as a distributor of knowledge and knowhow as well as an innovator. Within the project, the accumulation of diverse energy-related knowhow and knowledge and exploitation of sustainable solutions of ICT in organizations were successfully implemented.

Further development is planned to be realized in the ICT4LC project launched at the beginning of 2018. It focuses on examining contemporary information processing that is based on mobile and 'thin clients' as well as the increasing utilization rate of information networks and cloud computing. The new project explores tools for assessing the energy efficiency of business activities and support processes as well as planning procedures of business processes, promoting responsible and sustainable utilization of ICT in organizations.

5. ACKNOWLEDGMENTS

Our thanks to Niklaus Meyer and Beat Koch from Swiss Green IT SIG for collaboration.

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Reference Standard Process Model for Farming to Support the Development of Applications for Farming

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ABSTRACT

The paper introduces the idea and the concepts of a Reference Standard Process Model (RSPMF) which are based on the concepts of COBIT, an IT governance framework used worldwide. Our research on RSPMF is focused in two directions. First, RSPMF is aimed at becoming a support for Product Managers in software companies developing software products or IoT systems. Namely, each process in RSPMF is described through the following components: Process goals, process metrics, KPI's (Key Performance Indicators) and process activities, Second, RSPMF is aimed to help managers or owners of bigger farms in farm management. The paper introduces research in the progress state of our research.

Categories and Subject Descriptors

D.2.2 [**Requirements/Specifications**]: *Tools.*

General Terms

Farming, Standardization, Process model.

Keywords

Standard Process Model, COBIT, Transformation of model.

1. INTRODUCTION

In recent years, farming has become an area with extensive need for the use of information systems and IoT technologies [1]. The experience gained in an EU funded project has revealed that software companies have diverse and unequal knowledge and understanding of farming processes, activities within processes and metrics. This causes a problem when software products and IoT systems need to be integrated. There are many software products and IoT systems on the market today, but each of them covers a quite narrow functional area and, for the treason the integration, is simply a necessity [2].

The Reference Standard Process Model is one way to help Product Managers at software companies in removing the gap of diverse and unequal knowledge and understanding of farming processes, activities within processes and metrics. The reference model can become a common denominator, a kind of *Esperanto,* as a knowledge base for the development of software products and IoT systems for farming. The reference model, on the other hand, will also help farm managers and owners in farm management.

We built and designed a *Reference Standard Process Model for Farming* (RSPMF) based on the idea and concepts of the COBIT framework, which is defined for the area of *IT governance* [3], [4]. This paper introduces the research in progress and the concepts we have managed to define so far: Domains, processes and elements of process description. We also introduce the current list of processes and domains.

The structure of the paper is as follows. The second chapter introduces the EU funded project AgroIT, during which the idea for the Reference Standard Process Model arose. Only aspects of the project relevant for the content of this paper are introduced. The third chapter introduces key findings from the AgroIT project which led to the idea of RSPMF. To support the idea of RSPMF the COBIT framework for IT governance is also introduced, since many concepts of RSPMF are taken from the COBIT framework. The fourth chapter introduces the RSPMF, its concepts, draft list of domains and their processes, and the methodology to facilitate the sustainability of RSPMF. The last chapter contains the conclusion and directions for future work on the RSPMF.

2. EXPERIENCE GAINED IN THE AgroIT PROJECT

AgroIT was an EU funded project covering various previously mentioned aspects and problems in today's implementation of IT and IoT in farming [5], [6]. First, the project included the implementation of ERP systems for farming: A traditional ERP system for small and medium enterprises which, additionally, also has modules for livestock, fruit growing, winery, etc. [7]. This area of farm management was covered, which was the subject of several papers in recent years [8][1], [2], [6], [7], [9], [10]. Second, the project included the implementation of a decision support system based on advanced methods to support decision processes in farming [8]. This way, the area of the use of decision support within farm management was covered [1], [6]. Third, the project included the implementation of IoT systems where various sensors were used to collect data about several measurements [2], [11], [12]. Having (a lot of) data available is the basis for farm management and operations of farms [13]. Fourth, the project also covered the implementation of the cloud integration platform. All applications and IoT systems were integrated through the cloud integration platform to facilitate data exchange between them [6], [12], [14].

Six software companies (they were called *software partners* during the project) cooperated in the AgroIT project with their software products: Applications, IoT systems and the cloud integration platform. Each software company "contributed" their product to the project and, during the project, software products were improved significantly, i.e. upgraded and extended. They were also improved implicitly through integrations between each other.

For the *pilot use* of integrated software products and IoT systems several *pilot projects* were organised in 5 EU countries by *pilot* *partners*. *Pilot partners* did not do software implementation in the project, but supported pilot farms in the use of software products. For that reason, pilot partners were organisations with extensive knowledge in agriculture and experience in consulting for farming.

3. KNOWLEDGE OF FARMING FOR IMPLEMENTATION OF SOFTWARE PRODUCTS AND IoT SYSTEMS FOR FARMING

Improving software products and IoT systems was based on and extending existing functionalities of software products and IoT systems and upgrading them with new ones. The key goal of the project was to design functionalities which base on integration between software products and IoT systems. This means that a software product also can use data from another software product or IoT system.

During the analysis and design phase it has become apparent that software partners have diverse and unequal knowledge and understanding of farming processes, activities within processes and metrics. The gap was even bigger when compared to the knowledge and understanding of the *pilot partners*.

The diversity mentioned, and having the expertise of COBIT, has, step-by-step, led to the idea of transferring the idea of COBIT to be used for farming [3], [4].

3.1 COBIT framework for IT governance

COBIT has, in recent years, become a de-facto Standard for IT governance in companies and organisations. COBIT defines a set of generic processes (IT processes) for the management of IT. For each IT process the following is defined: Process inputs and outputs, goals of the process, key process activities, metrics of the process (performance measures), and levels of process maturity (maturity model) [3]. The development of COBIT has been progressing since 1996, from version 1 to the current version 5. COBIT is the result of several working groups of highly experienced experts as coordinated work owithin ISACA, which is an international professional association focused on IT governance.

COBIT is defined as a process model which divides IT into four domains: Plan and Organise, Acquire and Implement, Deliver and Support, and Monitor and Evaluate). Domains have altogether 34 defined IT processes.

The schema below shows a meta model of COBIT and all of its concepts. The schema reveals the business orientation of COBIT: The aim of defining the COBIT framework is to align IT and business where business goals dictate IT goals [3], [4].

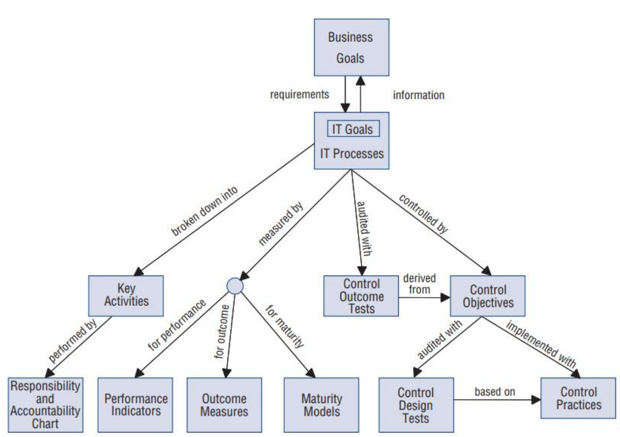

Figure 1. COBIT meta model [3]

A detailed explanation of the schema, i.e. a detailed explanation of the concepts and relations between them is beyond the scope of this paper.

3.2 The idea of the Standard Process Model for Farming

The idea and concept of the previously introduced COBIT framework and the problems based on the diversity of knowledge of partners in the project initiated the idea of a Standard Process Model for farming. COBIT is,, therefore based on various concepts, and those concepts can be used and adapted in other areas as well, not only in IT governance. The idea and concepts of COBIT were already transferred and used in the governance of Flood Management [15] and Nursing [16].

The transfer of the idea and concepts of a particular Standard or framework to another area, in this case the transfer of COBIT to the area of farming, does not mean a one-to-one transfer. Some concepts of *source area* (in this case, IT governance), might not be relevant or have any sense in the *destination area* (in this case farming). For this reason, a successful and significant transfer with useful outcome can only be achieved through:

- Good understanding of the idea and concepts of the framework of the *source area* (in this case COBIT),
- Extensive knowledge and experience on the *destination area*: Processes and their activities, metrics, responsibilities, rules, etc.

4. REFERENCE STANDARD PROCESS MODEL FOR FARMING (RSPMF)

As can be concluded based on the previous discussion, we designed RSMPF on the idea and concepts of COBIT 4.1 [3]. In the literature we so far haven't found any paper representing a Standard Process Model for Farming.

4.1 The concepts of RSMPF

Processes are divided on three hierarchical levels which are called *domains*: *Govern and Monitor* (GM), *Plan and Manage* (PM) and *Implement and Execute* (IE).

Farming has several branches: Livestock, fruit growing, agriculture, winery (viticulture), etc. RSMPF enables modular definition of processes for every branch of farming. For the *Govern and Monitor* domain only *common processes* are defined, for the other two domains, a *process module* is also added for every branch of farming. For now, only the *process module* for *livestock* is defined for domains PM and IE.

Each process is described through the following components: *Process goals*, *process metrics*, KPI's (*Key Performance Indicators*) and *process activities*.

Each process has a *unique code*, which reveals the *domain* to which the process belongs and the *process module*. The code of *Common Processes* is CP and the code for *LiveStock* is LS.

The aim of defining RSPMF is not to prevail over any existing Standard for farming. RSMPF is defined and structured to be opened and enables the reference to any existing Standard in the *process description section*.

4.2 Target groups and aimed benefits of RSPMF

When designing a Standard Process Model, regardless of the area it is intended for, the group designing it must first decide which are the target groups who will use the model, and what should be the benefits of its use. For target groups this should become a Reference Standard Process Model.

We designed RSPMF for the following groups:

- **Product Managers** in software companies which develop software products and IoT systems for farming. As can be revealed from our discussion, we noticed the need for a Standard Process Model,
- **Managers and owners of bigger farms**: COBIT is the first place aimed at bigger companies. Each Standard Process Model should, in our opinion, be sized for bigger institutions (organisations in general). Smaller institutions then use it to the extent for which they believe is suitable for them. We followed this approach in the designing of the RSPMF.

The aimed benefits for Product Managers are as follows:

- Based on experience from the AgroIT project, we can state that there is a diversity of farming knowledge of Product Managers in software companies. RSPMF will become a common denominator, a kind of *Esperanto* as a knowledge base for the development of software products and IoT systems for farming,
- We expect the integrations between various software products and IoT systems to be more straightforward and "softer" if Product Managers will base functionalities on RSPMF.

We are designing RSPMF to reach several aimed benefits for managers and owners of bigger farms:

- Knowledge and experience of farming experts and academics will, step by step, be transferred to RSPMF. We could say that RSPMF introduces the best practices for farming,
- RSPMF provides the best practice guidelines for processes and their activities on farms. This helps managers ensure that the processes perform according to best practice,
- Metrics and KPI's are defined for processes. This helps managers to set goals and execute monitoring. This lowers various risks,
- Managers can identify gaps in process execution and monitoring. This helps them close the gaps identified and improve processes,
- Managers can be better prepared for any auditing. If a particular audited farm will be "RSPMF compliant", then this will increase the trust of auditors,
- Not only managers, but also other personnel working on farm can learn about processes, metrices and KPI's.

4.3 Draft list of domains and their processes

We already have defined a draft list of domains and their processes.

Govern and Monitor (GM):

- GM.01: Define and maintain strategy
- GM.02: Ensure profitability
- GM.03: Ensure risk governance
- GM.04: Ensure machinery and equipment governance
- GM.05: Ensure IT and innovation governance
- GM.06: Ensure compliance with legislation
- GM.07: Enable external and internal control
- GM.08: Manage and monitor process definition and change
- GM.09: Implement and monitor implementation of strategy

Plan and Manage (PM) – Common Processes (CP):

- PM.CM.01: Manage implementation of strategy and investments
- PM.CM.02: Manage budget and cost
- PM.CM.03: Manage financials
- PM.CM.04: Manage risks
- PM.CM.05: Manage human resources
- PM.CM.06: Manage buildings and security
- PM.CM.07: Manage products sales
- PM.CM.08: Manage suppliers
- PM.CM.09: Manage sub-contractors
- PM.CM.10: Manage certifications
- PM.CM.11: Manage environment and protection
- PM.CM.12: Manage energy consumption
- PM.CM.13: Manage energy production
- PM.CM.14: Manage farming machinery
- PM.CM.15: Manage equipment
- PM.CM.16: Manage IT
- PM.CM.17: Manage information system
- PM.CM.18: Manage innovations
- PM.CM.19: Manage investment projects
- PM.CM.20: Manage needs and expectations
- PM.CM.21: Manage knowledge and legislation
- PM.CM.22: Manage changes based on legislation demands
- PM.CM.25: Manage changes based on IT and innovation
- PM.CM.26: Manage assets
- PM.CM.27: Manage technical capacity
- PM.CM.28: Manage internal control

Plan and Manage (PM) – LiveStock (LS):

- PM.LS.01: Manage animal sales
- PM.LS.02: Manage animal purchases
- PM.LS.03: Manage animals` health and veterinary service
- PM.LS.04: Manage animal welfare
- PM.LS.05: Manage hygiene
- PM.LS.06: Manage animal feeding and grazing
- PM.LS.07: Manage animal reproduction
- PM.LS.08: Manage animal breeding plan

Implement and Execute (IE) – Common Processes (CP):

- IE.CM.01: Perform internal control
- IE.CM.02: Perform farm accounting
- IE.CM.03: Perform maintenance of buildings
- IE.CM.04: Perform employments and other Human Resource issues
- IE.CM.05: Perform product sales
- IE.CM.06: Perform purchases of equipment
- IE.CM.07: Perform purchases of farming machinery
- IE.CM.08: Perform purchases and implementation of software products
- IE.CM.09: Perform asset maintenance
- IE.CM.10: Perform purchases

Implement and Execute (IE) – LiveStock (LS):

- IE.LS.01: Perform animal feeding
- IE.LS.02: Perform animal movements and grazing
- IE.LS.03: Preform animal health checking and health treatment
- IE.LS.04: Perform sales of animals

- IE.LS.05: Perform purchasing of animals
- IE.LS.06: Perform animal selection
- IE.LS.07: Perform animal reproduction

4.4 Concepts of methodology to facilitate the sustainability of RSPMF

COBIT was first issued in 1996, and this means that it has been going through evolution, where experts from the whole world participated. COBIT is now version 5, but had several versions before that [3], [4].

To facilitate the sustainability of RSPMF, we plan a similar approach. We have plan to issue the first version in a year or year and a half. The first version will cover only livestock. We will form an international panel of experts of various profiles: Consultants, academics, Product Managers, farmers and government officials.

5. CONCLUSION AND FUTURE WORK

We have introduced the research in progress for the idea and concepts of the Reference Standard Process Model for Farming. Our aim of the design of reference model is to improve the support for managers and owners of bigger farms in farm management. Another aim is to facilitate Product Managers in development of software products and IoT systems.

In midterm, we also want RSPMF to be suitable for government and EU officials who are responsible for farming. At the moment, we plan to add the concept of maturity levels of a process. The maturity level of a process will show or indicate the level of detail and expertise with which a farm executes a process. This way, the comparison of different farms will also be possible.

We are aware that there are two phases of defining RSPMF: First, to define its concepts and structure; second, to put content in the structure of processes` descriptions. Those two phases overlap, because, while inserting the content, for sure some ideas to change structure will appear. The definition of concepts and the structure is our research mission for the next 12 months, that is how we plan it.

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Semiotics of graphical signs in BPMN

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ABSTRACT
The terminology of graphical signs (e.g. icons, symbols, pictograms, markers etc.) is ambiguous in academic articles. This is the same with articles focusing on graphics in business notations, although concepts of graphical elements in notations are well defined. In semiotics, on the other hand, the concepts related to signs are defined in detail. In this paper, we examined linguistic terms that are used for describing graphical elements in BPMN specifications (BPMN being the de-facto Standard of business notations), and related them to the terminology specified in semiotics. We created a Sign ontology with BPMN graphical signs as ontology instances. The ontology can be used by researchers to share common knowledge about concepts of signs, symbols, icons, and indices, as well as the knowledge on BPMN graphical signs.

Categories and Subject Descriptors
H.1.m [**Information Systems**]: Models and Principles, Miscellaneous.

General Terms
Management, Documentation, Design, Languages, Theory.

Keywords
Business Process Model and Notation, BPMN, Semiotics, Ontologies, Graphical signs, icons.

1. INTRODUCTION
Business process diagrams provide a graphical notation for specifying business processes. Among many business notations, Business Process Model and Notation (BPMN) is known as the de-facto Standard [1]. BPMN consists of execution semantics and notation, the latter including graphical elements such as shapes, arrows, icons, and labels. Those elements are all signs where each has a defined meaning and represents a certain concept.

However, terminology for graphical elements (e.g. icon, sign, or shape) is not used consistently among researchers in this domain. If one, for example, wants to perform a literature search on icons in BPMN, the term *icon* does not incorporate all linguistic terms that different authors use in their articles (other words for *icon* can be *pictogram*, *symbol*, *sign*, *marker* etc). Even in BPMN specifications [2], those terms are not used uniquely, but with loosely defined synonyms.

With this situation in mind we formulated the following research questions:

RQ1: What are the linguistic terms that are used in the BPMN specification for graphical shapes, graphical icons, and other visual signs?

RQ2: Can we categorize graphical signs from BPMN according to semiotic studies?

We organized the remainder of the article as follows. The next chapter presents the theoretical background. Chapters 3 and 4 represent the main objective of this paper – answering the research questions. The conclusion is given in the last chapter.

2. BACKGROUND

2.1 Semiotics
Semiotics is the study of signs and symbols (not only visual) and their use or interpretation. For the purpose of the terminology definition, we will sum the book of Daniel Chandler *Semiotics: The basics* [3], which offers a comprehensive explanation of the field, including many views of modern theoreticians. There are two main traditions in contemporary semiotics: From Ferdinand de Saussure and Charles Sanders Peirce.

Saussure's model of signs consists of two parts: **Signifier** (the form that the sign takes) and **signified** (the concept to which it refers). The **sign** is then the whole that results from the association of the signifier and the signified (Figure 1 on the left). For Saussure, both signifier and signified take non-material form rather than substance. Nowadays, common adoption of his model takes a more materialistic form, where the signifier is commonly interpreted as the material that can be seen, heard, touched, smelled or tasted. Being concerned mostly with linguistics, Saussure stressed that the relationship between the signifier and the signified is relatively arbitrary: There is no inherent, essential, transparent, self-evident or natural connection between the signifier and the signified – between the sound of a word and the concept to which it refers [3].

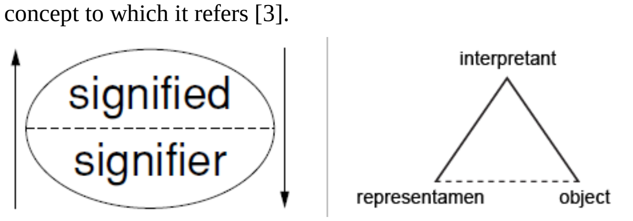

Figure 1: Saussure's model of signs on the left and Peirce`s model of signs on the right

Peirce, on the other hand, introduced a three-part model consisting of: **Representamen** (the form which the sign takes, also called "*sign vehicle*" or, in the Saussurean model, the *signifier*), **interpretant** (the sense made of the sign, or *signified* in Saussure's model). and **object** (something beyond the sign to which it refers, also called the *referent*). In this model, the **sign** is the unity of what is represented (the *object*), how it is represented (the *representamen*) and how it is interpreted (the *interpretant*) (Figure 1 on the right). The term sign is often used loosely and confused with signifier or representamen. However, the signifier or representamen is the form in which the sign appears, whereas the sign is the whole meaningful unity [3].

2.1.1 *Symbol, Index, Icon*

In addition to his sign model, Peirce offered a classification of signs, based on the relationship between representamen and its object or its interpretant, or, in Sausurres' terms, the *relationship between signifier* and *signified*. Dependent upon the relationship being more arbitrary, directly connected, or more resembling, three types of signs are possible: **Symbol**, **index,** and **icon** respectively.

SYMBOL represents a relationship where the signifier does not resemble the signified, but which is *arbitrary* or conventional. The relationship must be agreed upon and learned, such as in language (letters, words, phrases, and sentences), numbers, Morse code, traffic lights or national flags.

INDEX denotes a relationship where the signifier is not arbitrary, but *connected directly* (physically or causally) to the signified, which can be observed or inferred. An index *indicates* something (that is, necessarily, existent). Examples are natural signs (smoke, thunder, footprints), medical symptoms (pain, a rash, pulse-rate), measuring instruments (thermometer, clock), 'signals' (a knock on a door, a phone ringing), recordings (a photograph, a film, video shot), personal 'trademarks' (handwriting, catchphrases).

ICON represents a relationship where the signifier is perceived as *resembling* or *imitating* the signified – being *similar* in possessing some of its qualities, like a portrait, a cartoon, a scale-model, onomatopoeia, metaphors, sound effects in radio drama, a dubbed film soundtrack and imitative gestures. [3]

2.1.2 *Synonyms of terms*

The terminology from semiotics is used rarely in popular language. The term *sign* in semiotics is frequently replaced by the term *symbol* in popular usage [3]. Also, several meanings of the term *icon* can be found in everyday language: a) To be iconic means that something or someone is recognized as famous, b) In computing, an icon is a small image intended to signify a particular function to the user (in semiotic terms these are *signs* which may be iconic, symbolic or indexical), c) Religious icons represent sacred, holy images [3]. If not stated otherwise, we will continue to use terms as defined in semiotics throughout this paper.

2.2 Ontologies

Ontologies are explicit formal specifications of the terms in a domain and the relationships among them [4]. They define common vocabulary and can, among other things, be used by researchers, who need to understand and share the structure of information in a domain [5]. Because of these reasons, we find them appropriate for terminology clarification in the domain of Graphical Signs in BPMN. Our research purpose is mainly definition of terms, so our ontology will, according to Obrst [6], be of the weak to moderately strong semantics, not intended to be used for machine processing or machine interpretation (at least not at this stage of our research).

3. LINGUISTIC TERMS IN BPMN SPECIFICATION

To answer the first RQ (What are the linguistic terms that are used in the BPMN specification for graphical shapes, graphical icons, and other visual signs?) we examined the BPMN specifications and mapped the specifications' terms to semiotics' terms. In BPMN specifications the signs are denominated as follows: The term BPMN element represents the term signified, the terms shape, object, marker, indication, icon and depiction stand for signifier. The answer to RQ1 and a detailed meaning of each BPMN term is provided in Table 1.

Table 1: Linguistic terms used in BPMN specifications

Semiotics' terms	BPMN terms	Detailed meanings in BPMN specification
Signified	BPMN element	Concepts in business notation
Signifier	Shape	Graphical element
	Object	Basic shape (e.g. circle representing simple event)
	Marker, Indicator or Icon	Graphical icon that can be included in an object (e.g. message icon)
	Depiction	Graphical example of the usage

As we can observe from the Table above, many linguistic terms are used for *signifier*, some of which are not used consistently (e.g. marker, indicator, and icon). The only term from semiotics that is used in BPMN specifications is the term *icon,* that is used to denote a graphical icon and stands for the term *signifier*.

4. ONTOLOGY CONSTRUCTION

For the purpose of Ontology construction and answering RQ2 (Can we categorize graphical signs from BPMN according to semiotic studies?), we followed recommendations in *Ontology Development 101: A Guide to Creating Your First Ontology* [5]. The authors suggest taking the following 7 steps for ontology creation: Step 1. Determine the domain and scope of the ontology, Step 2. Consider reusing existing ontologies, Step 3. Enumerate important terms in the ontology, Step 4. Define the classes and the class hierarchy, Step 5. Define the properties of classes, Step 6. Define the facets of the slots, and Step 7. Create instances. Steps 4 and 5 are closely intertwined and can be executed simultaneously.

4.1 Domain and scope of BPMN Sign ontology

For the domain definition, the authors [5] propose answering several questions. Our answers are provided below, after the proposed questions.

What is the domain that the BPMN Sign ontology will cover?
Signs in BPMN

What are we are going to use the ontology for?
To share a common understanding of knowledge about signs among researchers, and to be able to reuse and analyze domain knowledge.

For what types of questions should the information in the ontology provide answers?
Definitions of concepts in semiotics and relationships among them, categorization of BPMN graphical signs according to semiotics' concepts, and the frequency of occurrence of sign types in BPMN.

Who will use and maintain the ontology?
The ontology will be maintained and used by us and will be available for other interested researchers.

To determine the scope of the ontology, a list of **competency questions** can be used that ontology will be able to answer [5].

The competency questions we defined are listed next.

- What does the term icon mean?
- How do icons, indices, and symbols correlate?
- Which type of sign (icon, index or symbol) is used most in BPMN?
- Are symbols always arbitrary, or can they convey a certain degree of meaning?

4.2 Reuse of existent ontology

With a literature search we found no existing ontologies in the domain of signs or icons. However, we identified a Business Process Modelling Ontology (BPMO) that has been built automatically, starting from the XML schemas contained in the BPMN 2.0 specifications from OMG [7]. It contains all the BPMN elements and their relationships as defined BPMN specifications. The class that is related most closely to our research domain (Graphical Signs) is *DiagramElement* and its subclasses (Figure 2). This class is, in BPMN specifications, defined under BPMN Diagram Interchange (BPMN DI) meta-model and schema for the purpose of the unambiguous rendering of BPMN diagrams in different tools [2].

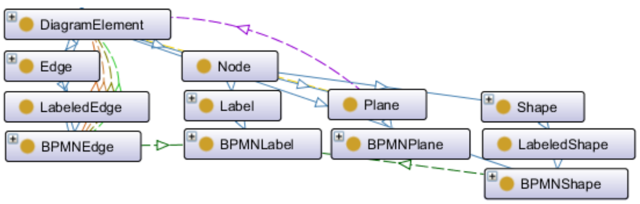

Figure 2: *DiagramElement* class and its subclasses in BPMO, visualized by the OntoGraf plugin for Protégé

As our focus in Sign Ontology is mainly on graphical signs that are, as such, not contained in BPMO, we will start our own ontology and, later, consider the options of merging both ontologies.

4.3 Definition of concepts in Sign Ontology

The next step in ontology creation is the enumeration of important terms. We defined the concepts for BPMN sign ontology from semiotics (*Sign*, *Icon*, *Index*, and *Symbol*), and from BPMN (*BasicShape*, *Activity*, *Event*, *Gateway*, and *Data*).

4.4 Relationships among concepts

For the definition of a hierarchy of classes and their properties, we will next define the relationships among three types of signs, again from semiotics.

At first sight, the relationship among the *signifier* and the *signified* (and, consequently, the types of signs) seems unambiguous, but that is not always the case. We should keep in mind that signs denote concepts (not material objects), and each person has their own understanding of a certain concept in his or her mind. Concepts cannot be represented precisely [8] therefore *icons*, for example, cannot be denoted simply as *similar*. They are defined by *perceived similarity* [3]. Also, as stated in [9], the process of sign-making is the process of the constitution of metaphor, and, therefore, *symbols* are never only *arbitrary*. Within each type, signs vary in their degree of conventionality. Therefore, we must not speak of types of signs but of modes of relationships where the difference between signs lays in the hierarchy of their properties rather than in the properties themselves [3].

Also, over time, a mode can change. Originally signs were in part iconic, in part indexical (primitive writing), and symbols come into being by development out of other signs, particularly from icons [3].

4.5 Sign Ontology construction

With the utilization of the Protégé 5.2.0 software tool and according to semiotic concepts and their relationships, we created simple Sign Ontology as follows. We created a class *Sign* (with disjoint subclasses *Icon*, *Index* and *Symbol*), a class *Relationship* (with subclasses *PrimaryRelationship* and *SecondaryRelationship*), and a class *BPMNElement* (with subclasses *BasicShape*, *Activity*, *Event*, *Gateway*, and *Data)*. We also created 2 object properties: *hasRelationshipType* (with subproperties *hasPrimaryRelationshipType* and *hasSecondaryRelationshipType*), and its inverse property *definesModeOf* (with subproperties *definesPrimaryModeOf* and *definesSecondaryModeOf*). The range of *hasPrimaryRelationshipType* is the class *Sign*, and the domain is the class *PrimaryRelationship*. We then defined 3 instances, *Arbitrary*, *Indicative* and *Similar*, and included them in the classes *PrimaryRelationship* and *SecondaryRelationship*. Next, we defined that, if a *Sign* has a *hasPrimaryRelationshipType* property of value *Similar*, it is included in the class *Icon*. Similarly, we defined classes *Index* (with *hasPrimaryRelationshipType* property value *Indicative*) and *Symbol (*with *hasPrimaryRelationshipType* property value *Arbitrary)*.

4.6 BPMN graphical shapes as Instances in Sign Ontology

To decide whether graphical signs in BPMN are of the mode icon, index or symbol, we invited 5 BPMN experts to evaluate BPMN signs and define one sign mode for each. We chose BPMN experts as they are fully familiar with the concepts (signifieds) in BPMN. Before the evaluation, the experts were acquainted with concepts from semiotics. The results of the evaluation are given in Table 2.

On six shapes, the experts agreed on the sign mode, thus defining the primary relationship between signifier and signified. For other shapes, where experts had different opinions, the mode was defined with the primary and the secondary relationship. The mode that was defined most often by experts was set for the primary relationship, and the mode that ranked second in choices was set for the secondary relationship.

As we can observe from Table 2, the majority of the signs were specified as symbols (the primary relationship is arbitrary). 6 symbols were also the only signs where experts agreed fully on the sign mode. Furthermore, in all but one symbols, the secondary mode was set as an index, and, similarly, the other way around; in all indices, the secondary mode was set as a symbol. The consensus on the primary relationship was not possible for two signs (Script task and Data object), and on the secondary relationship for one sign (Manual task). Thus, for the Script task and the Data object, the primary relationship was not set, but two secondary relationships were set. For Manual task only the primary relationship was set.

After the modes of signs were defined we included the signs into Sign Ontology. The ontology, including the instances, is shown in Figure 3. The figure represents classes as circles and relationships as lines connecting the circles. The size of the circle corresponds to the number of instances included in the class.

Table 2: Modes of BPMN signs

*	Signifier	Signified	Secondary relationship
Primary relationship: Arbitrary (Symbol)			
		Activity	
		Gateway	
5		Signal event	
		Multiple event	
		Ad-hoc sub-process	
		Complex gateway	
		Event	Indicative (index)
		Parallel event	Indicative (index)
		Escalation event	Indicative (index)
4		Link event	Indicative (index)
		Service task	Indicative (index)
		Inclusive gateway	Indicative (index)
		Parallel gateway	Indicative (index)
		Error event	Indicative (index)
		Send task	Indicative (index)
		Receive task	Indicative (index)
3		Business rule task	Indicative (index)
		Sub-process	Indicative (index)
		Exclusive gateway	Indicative (index)
		Data object collection	Similar (icon)
Primary relationship: Indicative (Index)			
		Conditional event	Arbitrary (symbol)
4		Flow	Arbitrary (symbol)
		Cancel event	Arbitrary (symbol)
		Data store	Arbitrary (symbol)
3		Compensation event	Arbitrary (symbol)
Primary relationship: Similar (Icon)			
4		Message event	Indicative (index)
		Timer event	Indicative (index)
3		User task	Arbitrary (symbol)
		Manual task	Not set
Primary relationship: Not set			
		Script task	Similar/indicative (2*)
		Data object	Similar/arbitrary (2*)

* - The number of experts who decided on this primary mode

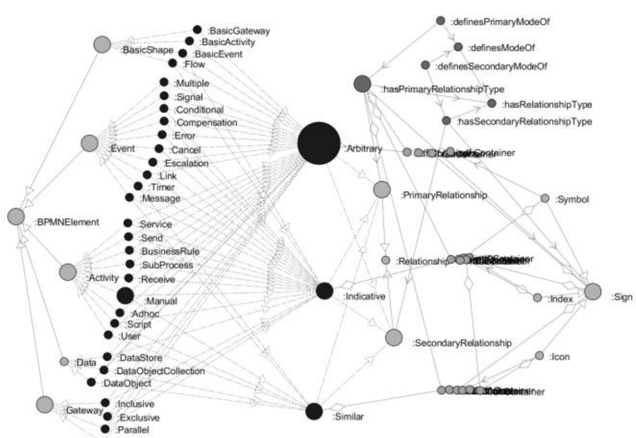

Figure 3: Sign Ontology with BPMN shapes rendered in the NavigOwl plugin for ProtégéCONCLUSION

In this paper, we mapped the linguistic terms from semiotics to linguistic terms regarding signs in BPMN specifications. We found that, in BPMN specifications, many terms are used for the term signifier, some of which inconsistently.

To correlate concepts from semiotics to BPMN graphical signs, we developed the BPMN Sign Ontology based on definitions from semiotics. We categorized each BPMN graphical sign in a mode that represents the relationship between signifier and signified. The majority of the BPMN signs are of mode symbol, following by mode index. As the meaning of symbols needs to be learned, this indicates a possible correlation with the principle of Semantic transparency from [10]. Addressing this issue, we will, in future work, examine our results further with those from [11] and other related articles.

Since the current study included only 5 experts in BPMN, resulting in possible bias, empirical research with more users is planned, as well as a thorough literature search. At this point, the BPMN Sign Ontology can, in the BPMN domain, serve for unambiguous knowledge definition and sharing.

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Knowledge Perception influenced by Notation Used for Conceptual Database Design

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ABSTRACT

The paper presents an experimental study which examined the influence of the notation used for conceptual design on students' knowledge perception at higher educational study level. The results demonstrate that students' knowledge perception is higher than actual knowledge throughout the entire learning process and is correlated with the used notation.

Categories and Subject Descriptors

H.2.1 [**Database Management**]: Logical Design; K.3.2 [**Computers and Education**]: Computer and Information Science Education

General Terms

Theory, Experimentation

Keywords

entity relationship models, conceptual design, database design learning, Barker, Bachman, knowledge perception

1. INTRODUCTION

The relational databases are fundamental part of any information system. Conceptual and logical design represent important segment of almost every application. Therefore, different issues related to teaching approaches of database fundamentals and design must be adequately addressed. The introduction to databases course is one of the fundamentals of computer science and/or informatics higher education programs. It is mostly a single semester course that covers data requirements elicitation, conceptual database design, normalization, logical database design, and physical database design [3, 4, 5]. There is much research addressing issues related to teaching computer science and informatics disciplines including various aspects of databases [3, 5, 9], some research has dealt with the effectiveness of teaching approaches to database design (conceptual and logical modeling) [1, 2, 7, 8]. However, to the best of our knowledge there are no researches that dealt with knowledge perception within the databases learning environment. In order to examine the effectiveness of learning database fundamentals, depending on the notation used for conceptual design, we set-up a multi-level experimental study [7]. Different experimental instruments to evaluate the effectiveness of a teaching approach using Barker or Bachman notation for conceptual database design were developed. In contrast to Barker notation, Bachman notation incorporates elements of logical design (i.e. foreign keys) in the conceptual design level. Students' achievements were examined with regard to influencing factors throughout the learning process. Results indicated that introducing the Bachman notation and a manual transformation from a conceptual into a logical data model increased students' understanding of conceptual, logical and relational data model concepts (CLR concepts). Here we present another aspect of this study. The influence of notation used for conceptual design on student knowledge perception is examined. Research questions that are addressed and answered in the paper are (RQ1) How does the notation used for conceptual design influence students' knowledge perception? and (RQ2) Does the correlation between student's knowledge perception and actual knowledge about CLR concepts change throughout the learning process?

The structure of the paper is as follows. In Section 2, a methodological framework and experimental setting are provided. The main contribution of the paper is presented in Section 3 where results and discussion are detailed. Finally, the conclusions are presented in Section 4.

2. METHODOLOGY

2.1 Experimental framework

The study was carried out during the academic year 2016/2017 at the Faculty of Electrical Engineering and Computer Science at the University of Maribor. The experiment was performed within the Database I course. It is a single semester course that includes 45 hours of theory/practice lectures and

30 hours of laboratory work in the form of computer exercises.

The focus of the experiment was on the evaluation of students' laboratory work. Students were randomly split into two approximately equal size groups. Both groups worked on the same database modeling tasks, using the Oracle SQL Developer Data Modeler design tool. One of the groups used Bachman notation which explicitly includes the foreign key in the E-R diagram, while another group used the Barker notation, which does not explicitly include the foreign key in the E-R diagram [6].

2.2 Experimental instruments

In this section, a detailed presentation of the experimental instruments used during the study is given. The questionnaire was conducted twice: Intro-Questionnaire and Final-Questionnaire. The participation was optional in both occurrences. The questionnaire used in the study is available on the web (http://bit.ly/2wMvrVQ).

The questionnaire is split into three parts. The first part consists of mainly closed-ended questions related to basic demographic information and database design tools (Questions 1 - 6). The second part consists of a Likert scale-like multi-level table (Question 8), where participants have to cross one of the multi-level options for five basic database terms and concepts: Entity, Relationship, Attribute, Primary Key (hereinafter PK) and Foreign Key (hereinafter FK). The values of the Likert scale are as follows: (1) - I am not familiar with the term, (2) - I am familiar with the term, but not with the meaning, (3) - Undefined, (4) - I am familiar with the meaning but I do not know how to use it and (5) - I am familiar with the meaning and I know how to use it. The third part included open-ended questions, given in the form of a short test (Question 9). The short test consists of three consecutively simple tasks, whereby each is related to the previous and each presents an increase in difficulty. In order to solve the test correctly, the participants have to use a form of one-to-many (hereinafter 1:N) and many-to-many (hereinafter M:N) relationship. The participants should not be given any instructions on how to solve the test. They should be left to use any means and techniques that seem appropriate. The foreseen time limit is 20 minutes.

The purpose of the questionnaire was to examine if there was any correlation between the participant's perception of knowledge of CLR concepts (Question 8) and their actual knowledge (score on the test questions 9a, 9b, 9c). When the questionnaire was handed out the second time during the experiment, an additional closed-ended question was added to the first part (Question 7), whereby students were asked which notation they used during the laboratory work. The purpose of this particular question was to examine if there was any correlation between the notation used during the laboratory work and their knowledge (score on the test questions 9a, 9b, 9c).

In order to evaluate the questionnaire a scoring structure for the third part is needed (Question 9). The test consists of three consecutive tasks (9a, 9b, 9c), whereby each relates to the previous and each constitutes an increase in difficulty. In order to solve the first task (9a) correctly, the participants have to model an entity (i.e. person) and give it some attributes and possibly a primary key. For the second task (9b), the participants have to model an additional entity (i.e. phones) and present an 1:N relationship between the previous entity and the newly added one. For the third task (9c), the participants had to add a third entity (i.e. address), and correctly use a form of M:N relationship between the previous entities and the newly added one. In order to be able to analyze the results, five concepts are evaluated: entity, relationship, attribute, PK and FK. The scoring is as follows: if they used any possible form of the concept in their solution and if the presented use of the concept was correct, participants got a point for the concept. Thus, five points could be scored in total.

3. RESULTS AND DISCUSSION

In the next sections we report on the results achieved in the experiment. Statistical analyses were performed using IBM SPSS Statistics version 23.

3.1 Knowledge perception

An analysis was performed on related samples of the perception score and test score. It was based on data gathered from the Intro-Questionnaire and Final-Questionnaire. The data for each questionnaire was analyzed separately.

In the analysis we excluded all those records where students rated one of the concepts as undefined, thus the total number of records taken into account were 116. Therefore, we got four levels of knowledge and five different concepts. As mentioned in the previous section, part of the questionnaires was a short test. We will refer to the total test score as the test score. In order to effectively compare the actual knowledge with the perception, we normalized the results of knowledge perception so that the total score (max. 20 points) was divided by five. We will refer to the normalized perception results as the perception score. Table 1 reports on the results of the analysis which was performed using a Wilcoxon signed-rank test for related samples.

Table 1: Correlation of results for perception score and test score.

Experimental instrument	Related Samples	Asymp. Sig. (2-tailed)	N	Decision
Intro-Questionnaire	Percep. score - Test score	**0.000****	107	**Reject the null hypothesis**
Final-Questionnaire	Percep. score - Test score	**0.000****	116	**Reject the null hypothesis**

**Significant at 1%

We used the Wilcoxon signed-rank test in order to compare two not normally distributed sets of scores, one actual score and another normalized perception score, that came from the same participants, since each participant had to solve tasks and evaluate their knowledge on the aforementioned CLR topics. The Shapiro-Wilk test of normality indicated that data significantly deviates from a normal distribution (p-value below 0.05). The Wilcoxon signed-rank test returns an asymptotic significance lower than 0.01, thus rejecting the null hypothesis for related samples. The null hypothesis states that the median of difference between the perception score and the test score will equal zero. There is a statistically significant difference between the perception score and the test score, suggesting that students' perception of their knowledge is not in accordance with their actual knowledge on CLR concepts. Figures 1 and 2 depict the correlation between students' actual knowledge and their knowledge perception, which indicates a higher knowledge perception than the actual knowledge in both questionnaires. The results indicate that the correlation between the knowledge perception and actual knowledge is corrected by the end of the course (Final-Questionnaire), which is due to higher knowledge achieved by the end of the course. However, the knowledge perception remains at a high level.

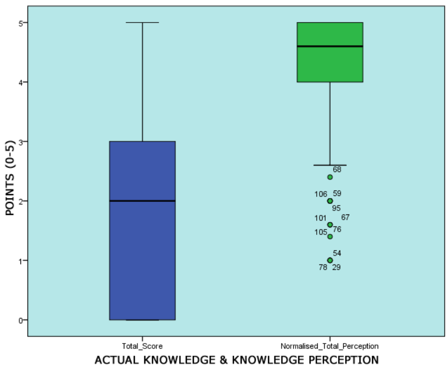

Figure 1: Correlation between students' actual knowledge and their knowledge perception. Intro-Questionnaire (course start).

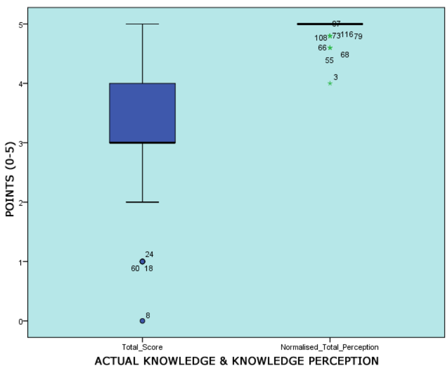

Figure 2: Correlation between students' actual knowledge and their knowledge perception. Final-Questionnaire (course end).

Table 2 reports on the ranks of the performed Wilcoxon signed-rank test. There were 100 out of 107 participants at the Intro-Questionnaire who assessed their knowledge higher than their actual knowledge was. On the contrary, only two participants reached the opposite results and only five assessed their knowledge correctly. The Final-Questionnaire results showed a slight increase in correctly assessed knowledge. There were 100 out of 116 participants at the Final-Questionnaire who assessed their knowledge as being higher than their actual knowledge was. On the contrary, only one participant reached the opposite result, while 15 assessed their knowledge correctly. A further indication of wrong knowledge perception can be deduced from the mean of the scored results. The mean of the perception score during the Intro-Questionnaire is 4.095, while the mean for the test score stood at 1.74. In addition, the means for the Final-Questionnaire were 4.957 and 3.35, respectively. We conclude that students overestimated their knowledge of CLR concepts throughout the entire course.

Table 2: Cases of knowledge perception scores versus actual knowledge scores.

Experimental instrument	Related Samples		N	Mean Rank	Sum of Ranks
Intro-Questionnaire	Percep. score - Test score	Negative Ranks	2 [a]	17.25	34.5
		Positive Ranks	100 [b]	52.19	5218.5
		Ties	5 [c]		
		Total	107		
Final-Questionnaire	Percep. score - Test score	Negative Ranks	1 [a]	1	1
		Positive Ranks	100 [b]	51.5	5150
		Ties	15 [c]		
		Total	116		

a Perception score $<$Test score
b Perception score $>$Test score
c Perception score = Test score

Conclusions regarding RQ2: Students overestimated their knowledge of CLR concepts throughout the entire course. The correlation between the students' knowledge perception and actual knowledge is corrected by the end of the course, due to higher knowledge reached by the end of the course. However, the knowledge perception remains at a high level.

3.2 Knowledge perception and notation

Additionally, we analyzed the results of the students' knowledge perception and actual knowledge considering the notation used in the learning process. Normalized results of students' self-assessment of their knowledge and results of our assessment of their knowledge was summarized and used to assess the students' perception of knowledge in terms of the dependence of the notation. The range of the summed score is thus 1 - 10. As the summed score approaches the extremes, the students were better able to assess their knowledge. It means that their perception of their knowledge and their actual knowledge were very close. On the contrary, the closer the results were to the middle, the more students incorrectly assessed their knowledge. It means that they either overestimated or underestimated it. For example students could assess their knowledge as high and reach five points for the perception and also score all five points on the test, thus collecting ten points. On the contrary, students could assess their knowledge as high, but reach a minimum or even none points on the test, thus scoring five points in total. The analysis of the impact of the notation was based on the data gathered from the Final-Questionnaire only, because the impact of the notation can only be seen after the notation was used in the learning process. Table 3 reports on the results of the Mann-Whitney U test for independent samples. We used the Mann-Whitney U test in order to compare differences between two independent groups (students using

Table 3: **Correlation of summed perception and test score and influencing factor (notation used).**

Exper. instr.	Independ. variable	Depend. variable	N	Asymp. Sig.	Decision
Final-Quest.	Notation	Summed perc. and test score	116	**0.008****	**Reject the null hypothesis**

*Significant at 5%; **Significant at 1%

Bachman or Barker notation) and the dependent variable (students' summarized test score and normalized perception score), while the groups are not normally distributed. The Shapiro-Wilk test of normality indicated that data significantly deviates from a normal distribution (p-value below 0.05).

The Mann-Whitney U test returns an asymptotic significance lower than 0.01 for the notation variable, therefore rejecting the related null hypothesis. The null hypothesis states that the distribution of the summed score is the same across categories of both Bachman and Barker notations. Considering the results, there is a statistically significant difference between the summed results scored by notation used in the learning process. There were 68 out of 116 students who used the Barker notation during the learning process, and their summed mean score stood at 8.1. The Bachman notation was used by 48 students, whereby their summed mean score was 8.608. According to Figure 3, it is evident that there were more students who used the Bachman notation and better assessed their knowledge.

Figure 3 depicts the correlation between the summed perception score and test score, and the notation used during the learning process.

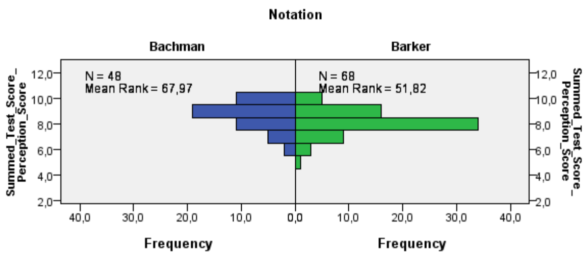

Figure 3: Summed perception score and test score in correlation with the notation used during the learning process.

On the contrary, there were students who used the Barker notation with a summed score of five which indicates the worst assessment of knowledge. We conclude that students who used the Bachman notation in the learning process better evaluated their knowledge than students who used the Barker notation.

Conclusions regarding RQ1: Bachman notation positively influences students' ability of knowledge self-assessment. By the course's end, the difference between knowledge perception and actual knowledge lowers.

4. CONCLUSIONS

The paper reported on the results of an experimental study aimed at analyzing the influence of notation used for the conceptual design on students' knowledge perception. The study continues on the work already presented in [7], while reporting on students' knowledge perception being higher than the actual knowledge.

We examined whether students' perception of knowledge is in accordance with their actual knowledge of CLR concepts. The results confirm that their perception is higher than the actual knowledge throughout the entire learning process. By the end, their knowledge increases and perception remains at a similar level as at the beginning. Additionally, the results prove that students who used the Bachman notation during the learning process were able to better estimate their knowledge. In the future we plan to analyze the correlation between students' educational background and their success rate while learning the CLR concepts on the higher education degree level.

5. ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (Research Core Funding No. P2-0057).

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The Use of Standard Questionnaires for Evaluating the Usability of Gamification

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ABSTRACT

Usability has a significant impact on the satisfaction and frequency of use of a designed system. Nowadays, gamification and serious game approaches are implemented in software solutions to increase their usability. We present a literature review of 32 identified studies measuring usability, with established questionnaires in gamified systems and serious games. We identified 18 different questionnaires used for measuring usability, and found System Usability Scale to be the most widely used. An immense issue exists in the field, with only 22% of studies measuring usability actually describing or defining what usability is.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: User-centered design

General Terms

Measurement, Experimentation, Standardization, Theory, Verification

Keywords

Usability Evaluation Method, Formal Questionnaires, Gamification, Serious Games

1. INTRODUCTION

In recent years, gamification has become an essential part of varieties of domains, from Education to Medicine. It is used for facilitating the use of developed products. They cannot achieve its purpose if the usability of the product is inadequate. Therefore usability evaluation should present a crucial step of development.

Solutions utilising (1) gamification or (2) serious game approach should be evaluated separately, due to them being inspired by games which have very specific (and different) natures. The primary function of games is to entertain through experience whereas serious games and gamification have some intended useful purpose [10]. Because gamification and serious games' approaches utilise elements from games, this leads to solutions where even other needs of solutions intended for an audience are being met to varying degrees. In solutions this causes an increase of user satisfaction.

In the web area of expertise, only 18% of the reviewed papers in [7] present usability evaluation methods relying on the standardised definitions of usability. Fernandez et al. [7] found that 59% of the reviewed papers reported end-user-based usability testing, while 35% of the reviewed papers used the inquiry methods (such as focus group, interviews, questionnaires and surveys). Based on these facts, this research focuses on inquiry methods, more specifically on technique questionnaires, and investigates which standard questionnaires are used most commonly for usability evaluation in The Gamification domain. Within the presented paper, we focus on the research question: *Which standard questionnaires are used for evaluating the usability of gamification?* Using a literature review, we study the use and popularity of established usability questionnaires in the Gamification domain.

A similar study, made by Yáñez-Gómez et al. [18], presents the review of academic methods for usability evaluation of serious games. The scope of the study is broader, aiming at finding the preferred approach for evaluating the usability of games. As the results show, standard questionnaires are the second most used technique applied in post-use analysis [18]. They mention three questionnaires in use, but detailed analysis is not provided. Also, in comparison to the presented study, our search string differs. Another review is presented by Calderón and Ruiz [5], also covering the domain of Serious Games' Evaluation. One of the research questions concerned evaluation techniques, and discovered that questionnaires are the most commonly used, but the categorization or detailed analysis of the used questionnaires was not provided.

The paper is structured as follows. We start by presenting the research background covering usability evaluation and gamification, we continue by presenting and discussing the results of the literature review. We close our paper by presenting the conclusions reached by our review.

2. USABILITY EVALUATION

The term usability represents a combination of several properties and attributes [13]. Regardless of the variety of definitions by different authors [1, 3, 9, 13, 15, 17], Jeng [12] states that Nielsen and ISO 9241-11 definitions are the most widely cited. ISO 9241-11 defines usability as "the extent to which a product can be used by a specified user to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [11], while Nielsen [15] defines usability as an aggregation of five attributes: Learnability, efficiency, memorability, errors and satisfaction.

The usability evaluation method is defined as "a procedure, composed of a set of activities for collecting usage data related to end user interaction with a software product, and/or how the specific properties of this software product contribute to achieving a certain degree of usability" [7]. According to Battleson et al. [2], the usability evaluation methods are classified into three categories: (1) Inquiry methods (such as focus group, interviews, questionnaires and surveys), (2) Formal usability testing (such as interactions with a website by performing tasks) and (3) Inspection methods (such as heuristic evaluation, cognitive walk-through, pluralistic walk-through and formal inspection). The first two categories involve real-users, while inspection methods are based on reviewing the usability aspects of web artifacts, which have to comply with established guidelines, and are performed by expert evaluators or designers [7].

3. GAMIFICATION

Gamification is the use of design elements characteristic for games in non-game contexts [6]. Gamification should not be confused with serious games. Whereas the goal of introducing gamification is influencing learning related behaviuors and attitudes without providing knowledge, the use of serious games should influence learning and provide knowledge by the experience itself [14]. Another way to compare gamification and serious games is that gamification represents using only parts (game elements) from games, while serious games represent the whole immense gaming experience [6].

4. EVALUATING THE USABILITY OF GAMIFICATION

4.1 Research

Our research aims to find available standard questionnaires used for evaluating the usability of gamification. Using the following search string *"usability" AND ("gamification" OR "serious games" OR "educational games")* we conducted a search in the following digital libraries: *ScienceDirect*, *IEEE Xplore*, *ACM Digital Library* and *Sage journals*. Determined inclusion and exclusion criteria guided the study selection process. We considered the papers evaluating usability with the help of established and well-known questionnaires. Therefore, we excluded primary studies using ad-hoc questionnaires.

After the review process, we selected *33 primary studies*. The list of primary studies we used as input into the data extraction and data synthesis step is available at: *https://tinyurl.com/CSS2018-IJS*. 26 out of 33 primary studies are conference papers, whereas seven papers are journal articles. Figure 1 shows the number of primary studies by year of publishing. We selected 23 primary studies from the IEEE Xplore digital library, six from the ACM Digital Library, three from ScienceDirect and one from Sage journals.

4.2 Results

Within data extraction, we focused on two main areas. First, we searched for used definitions of usability, since the latter was evaluated in the analysed studies. Extracted data

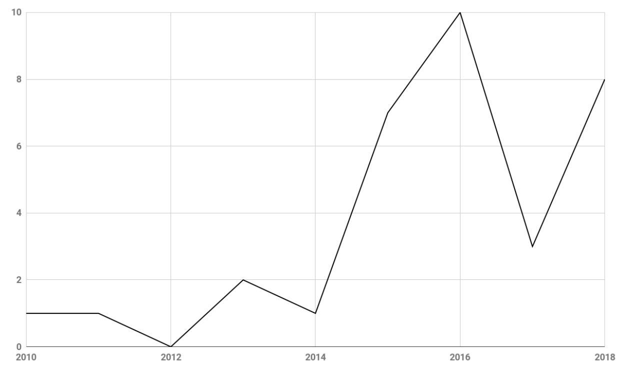

Figure 1: Primary studies by years

from selected primary studies showed that only seven primary studies (22%) defined and described the term of usability. Two of them indicated usability as a concept (S5, S10), while five researches treated usability as construct, namely two studies (S11, S21) used Nielsen's definition, one research (S4) used the ISO definition, one research (S18) described usability as "ease of use of the game", while study S25 defined usability similar to ISO, but expanded the definition with two new concepts ("simple" and "operating with ease"). The remaining studies (78%) used the term usability without providing the meaning of usability.

Studies are classified by domain in Table 1. Over half (56%) of all studies were from the field of Health and Medicine. Most of the studies from the domain addressed (1) Training of health care personnel (S8, S17, S18), (2) Rehabilitation and exercise for patients (S3, S6, S7, S16) and (3) Assessing patients (S1). The second most popular domain (37%) was Education and Learning. All other identified domains had only 1 study per domain.

Domain	Primary studies
Agriculture	S27
Business Intelligence	S5
Computer Science	S5
Education & Learning	S2, S8, S10, S13, S14, S16, S17, S18, S23, S28, S29, S31
Entertainment	S4
Health & Medicine	S1, S3, S6, S7, S8, S11, S12, S16, S17, S18, S19, S20, S21, S22, S24, S29, S30, S32
Social Science	S25
Task Management	S9
Travel	S15

Table 1: Domain

We continued the data extraction by identifying standard questionnaires used for usability evaluation. We followed the explanation provided by Yáñez-Gómez et al. [18], which states that *standard questionnaires are the ones that are validated statistically.* Table 2 presents used questionnaires in connection with primary studies. The majority of studies evaluated usability by using the System Usability Scale

(SUS). It was used in 78% of primary studies. Although Technology Acceptance Model (TAM) is used in the model-driven analysis for measurement of users' acceptance and usage of technology and it is not classified as a standard questionnaire for usability evaluation, it was used for assessment of gamification in four primary studies. On the other hand, Game Experience Questionnaire (GEQ), Task Load index (TLX), Game Engagement Questionnaire (GEQ), Post-Study System Usability Questionnaire (PSSUQ) and Net Promoter Score (NPS) are each used in two primary studies. We extracted other questionnaires that are used only in one primary study, such as Presence Questionnaire (PQ) and Software Usability Measurement Inventory (SUMI). To achieve

Questionnaire	Primary studies
System Usability Scale (SUS)	S1, S3, S6, S7, S10, S11, S12, S14, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31, S32
Technology Acceptance Model (TAM)	S2, S3, S11, S20
Game Experience Questionnaire (GEQ)	S1, S4, S30
Task Load index (TLX)	S1, S22
Game Engagement Questionnaire (GEQ)	S11, S18
Post-Study System Usability Questionnaire (PSSUQ)	S8, S15
Net Promoter Score (NPS)	S31-S32
User Engagement Scale (UES)	S5
Computer System Usability Questionnaire (CSUQ)	S13
Software Usability Measurement Inventory (SUMI)	S7
Intrinsic Motivation Inventory (IMI)	S16
User Interaction Satisfaction (QUIS)	S18
Presence Questionnaire (PQ)	S10
Usefulness, Satisfaction, and Ease of use (USE) Questionnaire	S9
Pick-A-Mood (PAM)	S10
Technology Affinity - Electronic Devices (TA-ED) Questionnaire	S20
Game User Experience and Satisfaction Scale (GUESS)	S19
Differential Emotions Scale (DES)	S10

Table 2: Standard questionnaires in use

a comprehensive usability evaluation, it is crucial that measurement instruments used are utilised appropriately according to the attribute they are measuring. 41% (13/32) of primary studies (S6, S12, S17-S19, S25-S30, S32) used the most established questionnaire SUS for measuring usability, but did not define the measured attribute in their research. Table 3 presents the connection between the used questionnaires and measured attributes that were measured at least in two primary studies. The most frequently measured attributes were "ease of use" and "usability" and both were used in six primary studies. In all cases, the attribute "usability", was measured with SUS, while the attribute "ease of use" was measured with three different questionnaires: SUMI (S7), USE (S9) and TAM (S2, S3, S11, S20). The second most frequent measured attribute was attribute "usefulness". In three primary studies (S2, S11, S20), it was treated and determined as one of the two factors defined in TAM, while, in one case, it was measured with USE (S9) and PSSUQ (S15). The attribute "satisfaction" was the third most commonly used attribute measured by two different questionnaires: SUS (S21, S22, S31) and USE (S9).

Measured attribute	Questionnaires
Ease of use	SUMI (S7), USE (S9), TAM (S2, S3, S11, S20)
Usability	SUS (S10, S11, S16, S23, S24, S31)
Usefulness	TAM (S2,S11,S20), USE (S9), PSSUQ (S15)
Satisfaction	USE (S9), SUS (S21, S22, S31)
Flow	GEQ (S1, S4, S11)
Learnability	SUMI (S7), USE (S9)
Competence	GEQ (S1, S4)
Overall	CSUQ (S13), SUMI (S7)
Quality of Information	CSUQ (S13), PSSUQ (S15)
Quality of interface	CSUQ (S13), PSSUQ (S15)

Table 3: Connection between the measured attributes and used questionnaires

The most popular devices on which developed/proposed solutions were run were computers (62%), virtual reality equipment (22%) and mobile devices (16%) as seen in Table 4.

Device	Primary studies
Computer	S1, S2, S4, S5, S6, S7, S8, S10, S11, S13, S14, S16, S21, S22, S23, S25, S26, S28, S29, S31
Customised system	S19
Mobile device	S9, S12, S15, S20, S27
Smart TV	S3
Virtual reality	S10, S15, S17, S18, S24, S30, S32

Table 4: Devices on which the studied system runs

4.3 Discussion

An extensive collection of standard questionnaires were found for evaluating the usability of gamification, with System Usability Scale (SUS) as the prevailing choice (84% of all studies). Since SUS is a well-known questionnaire, which is easy to perform and analyse, this is not a surprise. As SUS was developed for providing a subjective assessment of usability [4], its extensive use is even more understandable. The majority of researchers that used SUS in their studies did not quote explicitly which attribute of usability was measured; the remaining studies, where the SUS were used, defined two different attributes that can be measured with SUS. The first attribute was "usability" and it is in accordance with description of SUS usage purpose [4], while the second one was "satisfaction", which is recommended by the ISO/TS 20282-2:2013 [8] Standard, where the SUS is defined as a questionnaire for measuring satisfaction.

Another aspect is also if standard usability questionnaires can evaluate the usability of gamification adequately. Shegawa et al. [16] claims that the SUS questionnaire is a verified instrument for measuring usability in the Serious Games domain. Technology Acceptance Model (TAM) is widely used in the Information System domain to investigate how accepted the use of technology is among their target users. Although it is not classified as a standard questionnaire for usability evaluation, but rather as a model combining constructs ease of use and usefulness, it was the second most used measuring instrument for usability evaluation in reviewed literature. On the other hand, it is also seen that questionnaires, like Game Experience Questionnaire (GEQ) and Game Engagement Questionnaire (GEQ), that originate from Gaming domain, are nowadays used to evaluate the usability of gamification. Therefore, the fusion of two fields is perceived.

5. CONCLUSION

The paper presents conducted literature review which was aimed at finding standard questionnaires used for usability evaluation of gamification and serious games. We found that the majority (84%) of studies evaluate usability using a System Usability Scale (SUS), though some other questionnaires were also detected and used independently, or in combination with SUS. We, as prospective researchers, can determine only in a minority of cases what primary studies were measuring, because only 22% of primary studies measuring usability defined or described what usability is. That is an immense issue on validity of their measurements of usability, since multiple definitions of it exist. We propose that methods for measuring usability in the field of Gamification and Serious Games should be formalised in the future. Although researchers are already using standardised methods for measuring usability, research should also present what *usability* means for them, what they are *measuring*.

6. ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (Research Core Funding No. P2-0057).

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Analyzing Short Text Jokes from Online sources with Machine Learning Approaches

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ABSTRACT

This paper presents the whole data mining process of analyzing jokes in Slovenian language gathered from various online sources. The gathering was done with the help of web scrapping system and the analysis was carried out on the gathered jokes to determine the properties of various types of jokes. In addition, with the help of various text-mining methods, we analyzed different types of jokes and built a machine learning model for classifying jokes into categories. These results are supplemented with the visualization of different categories and the interpretation of constructed machine learning classification models.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous;

I.2.m [**Artificial Intelligence**]: Miscellaneous;

General Terms

Machine Learning, Data Mining, MDS, SVC

Keywords

Data mining, Machine Learning, Joke analysis, Short text analysis, Text mining

1. INTRODUCTION

Due to the ever-advancing technology, opportunities are opening for analyzing all types of data, so we can make the most of this and use it for our benefit. By studying and examining various types of texts, scientists were already involved in the initial phases of textual analysis [8, 9, 10], but studying the meaning and connection of texts presents a rather new direction of research, where there is still a lot of room for improvement. While there has been a lot of work done on various short text types, i.e. tweets [12], reviews [11], recipes [13] and others, there is a lack of research published on the topic of jokes analysis.

In our paper, we present a process of gathering, parsing and pre-processing jokes and applying various data- and text-mining techniques to extract patterns and new knowledge from jokes data. By semantic text processing, we identify more than just a sequence of symbols, we can assign them meaning, which can influence the classification of jokes. In our case, we undertook the processing of various jokes that we analyzed in order to determine how the categories of such texts are interconnected by their content and find out which categories of jokes share the most similar content. Based on the texts, we created a classification model for the classification of jokes into predefined categories.

The rest of the paper is structured in the following way. The following section presents the method for gathering and parsing jokes from the online sources. Third section presents the individual steps of data- and text- mining in details. It consists of machine learning method description, applications and techniques used in the process and the results itself. We finish up with the conclusion and the discussion on the topic of joke analysis with various data mining methods.

2. GATHERING AND PARSING OF THE JOKES FROM THE ONLINE SOURCES

In order to fulfill the set goals of analyzing jokes, we obtained these from various sources. Three different sources were used:

– From the first source, a web site called **VERZIVICI** [2], joker already classified into categories;

– Jokes from the second source **NAJVICI** [3];

– Jokes from a third source **MLADINSKI** [4].

For the data acquisition we developed a program in the Visual Studio IDE, using the C# programming langauge, which acquired jokes from the selected sources and saved them in a suitable text format. Due to the unstructured data of selected web resources, we used HAP (HTMLagilityPack) for processing. HAP is a HTML parser written in C# for reading/writing the DOM (Document Object Model) and supports plain XPATH or XSLT [1]. Using the HAP library and XPATH, we could easily access individual sections, which contained content known as a "joke".

Jokes from VERZIVICI, which were categorized when gathered, were manually entered, since the program for collecting jokes from different categories used the category name in the creation of a URL, which is used for scrolling between categories. For NAJVICI, we manually created a URL for gathering jokes so we can easily access all jokes on the site.

On the website MLADINSKI, jokes were already grouped and the jokes were sequentially recorded on one side of the web page. For the purpose of processing and subsequent manipulation, a simple VIC class was created, which contains two textual attributes of Text and Category. Both attributes can store values in string format, Text attribute is for raw text of a joke, Category is for type of category in which joke is categorized. When we were capturing blank spaces, we encountered redundant badges before text and between texts. Also, unreadable machine records were created instead of symbols due to coding. All badges with associated symbols and non-nominal groups of words, which were created instead of symbols, were manually entered into the program and then programmatically removed.

As a result of obtaining and processing the data from the selected sources, we received the data, which are used as the basis below:

– VERZIVICI [2] – 13 categories, a total of 1729 jokes,

– NAJVICI [3] – a total of 297 jokes, and

– MLADINSKI [4] – a total of 145 jokes.

We have saved the acquired data in the CSV format. Due to the characteristics of the CSV format, the comma symbol "," was changed to the XX symbol, addressed below, because comma in CSV represents a separator between lines, in jokes commas can have different meaning. All of the jokes were in Slovenian language, so this had to be taken into consideration during the text analysis.

3. DATA ANALYSIS

In this section, we will present the methods and techniques for analyzing the jokes and the results of these analysis. The whole process of cleaning, preprocessing, and the analysis itself was done with the Python programming language, and its libraries.

3.1 Cleaning and preprocessing the data

As mentioned, we use the Python programming language to process data in which you can simply import information in a CSV format using the Pandas library [5]. Pandas is an open source, BSD-licensed library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language [5, 14]. The imported data is then appropriately structured using the DataFrame class with the following columns (attributes):

– Index,

– Category, and

– RawText.

The XX symbols are also removed and replaced with the comma symbol ",". From the text, we also removed stop-words, which is a list of common words that do not carry any semantic meaning and information. Stop words occurred in texts in high frequency but are of little significance and consequently uninteresting. A sample of stop words in Slovenian language are the following:

"in" (En. and),	"ali" (En. or),
"je"(En. is),	"za" (En. for),
"to" (En. this),	"na" (En. on),
"to" (En. this),	"ti" (En. you),
"ko" (En. when),	"bi" (En. would),
"ne" (En. no),	"da" (En. yes),
"že" (En. already), "le" (En. only).	

In addition, the punctuations were removed, so the resulting text was in the form of one sentence without most common stop words.

From the resulting text, we built a representation of every joke in the format appropriate for the analysis. We used the method of counting the frequency of individual words called word frequency. This number was normalized by the word frequency of the word in all categories, so the more common words got the lower score and the less common and maybe unique words got higher score. This process is called tf-idf (term frequency-inverse document frequency) and is a common word scoring method in text mining [17]. The new dataset was built in such way, that all of the identified words represented one attribute of the joke, and the corresponding value of that attribute is the tf-idf score of that word in that joke.

3.2 Classification of jokes in the predetermined categories

We used the classification machine learning technique in order to construct a model of classification that would learn how to classify yet unseen jokes to one of the predetermined categories. This can be useful if one would want to automate joke categorization on an online joke portal without any need for human intervention. The classification is a supervised machine learning method, which means that machine learns to classify jokes from the already solved (classified) examples [15].

There are numerous different classification algorithms [18], but for our case we used the Support Vector Machine (SVM) classifier, developed by Vapnik in 2000 [16]. This method learns the boundaries that separate instances (jokes in our case) from one category to another, by finding a linear separation border called hyper-plane that has a maximum distance from the entire instance set, which is called the maximum margin. The instances that are closest on the hyper-plane (on the hyper-plane itself) are called support vectors. This SVM method also uses a kernel trick [19], which maps the attribute space of the classification instance to a higher dimensional space. In our case, we used a linear kernel, which uses a liner function to transform the attributes in such a way, that the margin of the hyper-plane is maximized.

We used the implementation of SVM from the library liblinear [20], which has high flexibility in the choice of penalties and loss functions and should scale to large numbers of samples. This library supports both dense and sparse input and the multiclass support is handled according to a one-vs-the-rest scheme [6].

Upon preliminary data preparation, the whole joke dataset is divided into train and test sets, where the training set is used to build the SVM classification model, and the test set is used to test the quality of the model – the ability to correctly classify yet unseen jokes. In our experiment, we applied stratified sampling to split the data and used 60% of data for training test and the rest 40% for the test set. The results of the experiment show, that the resulting classification model classifies test jokes with 61% accuracy. The classifier has correctly classified more than half of jokes into their proper category out of 13 possible categories.

The default classification of instances in one of 13 categories would result in only 0.08 accuracy, so our resulting classifier improves the default classifier significantly. This represents a high percentage of precision as was not foreseen at first glance. Additionally, we also manually examined some of the jokes that were misclassified. Interestingly, although the predicted categories were not correct, several of the examined jokes would fit well into the predicted category as well, as the semantics of a joke is not always monolithic.

3.3 Word frequency analysis and visualization

From the dataset of jokes, with attributes of individual word's tf-idf scores, we built word cloud diagrams for every category of the joke. The word clouds were made with the help of libraries matplotlib [21] and wordcloud for the Python programming language. In the word cloud, the most common words (or rather those with higher tf-idf scores) are written in larger font, while those with lower frequency (lower tf-idf scores) are written in smaller font. The color of the words only serves to make words more differentiable and thus improves the readability of word clouds.

Also, these word cloud show which highly informative words (non-stop words) are common for each category and can be used for manual classification, this way we can check whether a joke, which reads: "pride nekega dne k janezkovemu očetu domov nek njegov nadležen prijatelj tone potrka vpraša dober dan oče doma janezek tone ja kje janezek vem grem vprašat" was appropriately classified into a category (the original category is called "janezek", "Solski" was predicted). As we can see in Figure 1, our model correctly decided to classify the joke in the category "Solski", because the word “janezek” prevails in this category and is the dominant word in the content of the joke.

Figure 1: Word-clouds for ten joke categories.

3.4 Hierarchy of the categories

With the help of the scipy [22] Python library, we also built a dendrogram of relations between the categories using a hierarchical clustering method, which is shown in the Figure 2. Here we also included the category from sources NAJVICI and MLADINSKI, so that we can visually display the content linkage between different categories. The dendrogram is a hierarchical diagram, which shows which terms (in our case joke categories) are closer together by putting the more similar categories closer together on the Y-axis. The more similar are the categories, shorter are the lines connecting these categories, and vice versa.

From the dendrogram we can see that the categories MLADINSKI (En. young ones) and SOLSKI (En. School ones) are most similar, since the school is usually visited by young people. Based on the names of the categories NAJVICI and Mesane sale (En. Random jokes), it can also be assumed that these categories are very similar. From the dendrogram we can also see that groups of categories marked by red and green connections are very different. We can conclude that this division can be attributed primarily to slang expressions, which are more commonly used in foreign jokes as well as older jokes.

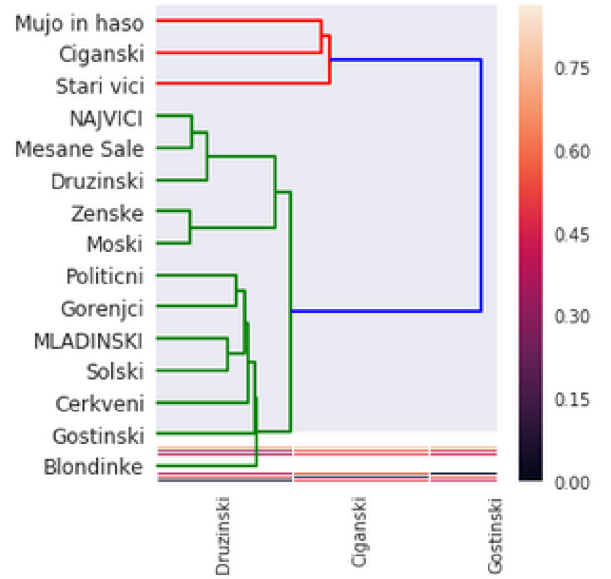

Figure 1: Hierarchical clustering of joke categories.

3.5 Multidimensional scaling

Multidimensional scaling (MDS) enables the visualization of the level of similarity of individual cases of a dataset by lowering the number of different attributes to only two. It refers to a set of related ordination techniques used in information visualization, in particular to display the information contained in a distance matrix [7]. By using the MDS in the sklearn.manifold[23] library and the mpl_toolkits.mplot3d[24] library, we can observe relations between categories even more efficiently, as shown in a 2D graph in the Figure 3. This plot shows which categories are closer together and which categories differ the most. Contrary to the dendrogram, we can see that “Mujo in Haso” are not so close to “Ciganski” and “Stari vici”, but these three categories differ the most from the rest.

Figure 2: 2D Multidimensional scaling plot, which shows the similarity of different joke categories

This shows the seclusion of three categories (a group of categories marked in a dendrogram with red color, which includes Stari Vici, Mujo in Haso and Ciganski) in relation to other categories. These make up a kind of circle around the categories “NAJVICI” and “Mesana Sale”. Categories “NAJVICI” and “Mesana Sale” are the closest neighbors, which also suggests an exceptional similarity between the categories.With the help of Figure 3, we can see the relationship between categories even better; in the case of the categories “Moski” and “Zenske”, we can see that according to their content, these two are very similar categories.

As depicted in the Figure 4 is a 3D graph of relations for use in further discussions for the show. By using the 3D graph (Graph 4), we can even more accurately determine the differences between the categories of texts. This display mode can turn out to be even more useful in a larger number of data and when looking for interesting patterns in these texts.

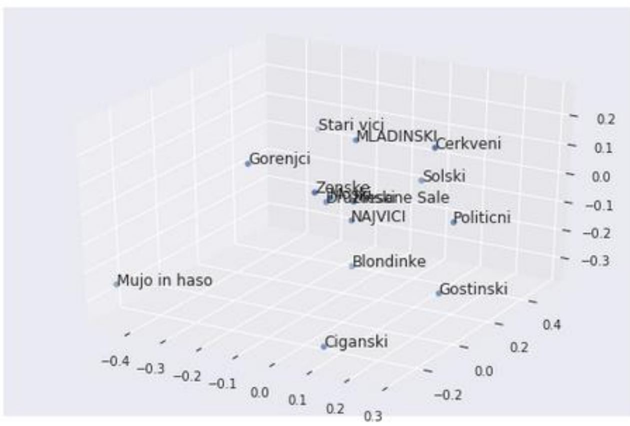

Figure 3: 3D Multidimensional scaling plot, which shows the similarity of different joke categories

4. CONCLUSION

This paper presents a use case of machine learning methods in the analysis of short texts in a form of jokes. We presented the process of gathering, cleaning and preprocessing the jokes, which was followed by the description of the analysis done with machine learning methods and various visualization techniques. We demonstrated how jokes could be automatically categorized in the predefined categories using the Support Vector Machine classification method. With two different visualizations: the dendrogram and the multidimensional scaling plot, we showed how different joke categories are similar one to another. With these methods, we demonstrated, how we could perform different comparisons, which can serve us in the further processing of data, and the connection of data between us is visualized in a useful and interesting way.

In this paper, we only analyzed the jokes in Slovenian language. For future work, we could compare jokes in different languages to find similarities and differences of jokes and their popularity across different languages and cultures.

ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0057).

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A Data Science Approach to the Analysis of Food Recipes

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ABSTRACT

In this paper, we explore the correlation between cuisine and text-based information in recipes. The experiments are conducted on a real dataset consisting of 9,080 recipes with data science approaches focusing on enhancing cuisine prediction and providing a detailed insight on the characterization of food cultures. The findings suggest that information about ingredients is the most relevant predictor of cuisines, however, despite being less efficient, recipe name, preparation instructions, preparation time, skill level and nutritional facts can be considered as well.

Categories and Subject Descriptors

I.2.m [**Artificial Intelligence**]: Miscellaneous.
I.5.m [**Pattern Recognition**]: Miscellaneous.

General Terms

Algorithms, Measurement, Experimentation.

Keywords

Data Science, Machine Learning, Text mining, Classification, Food Recipes, Cuisines.

1. INTRODUCTION

In response to technological advancements and social changes in the last decades, the tendency to collect and store recipes only in cookbooks has changed. Numerous online recipe portals started to rapidly accumulate food-related content, with more and more recipes being published online daily. The growth in the amount of user-generated recipe data available on the Internet has raised several issues that researchers have been trying to address in recent years. The objective of this paper is to explore the correlation between cuisine and text-based information in recipes, including recipe name, list of ingredients, preparation instructions, preparation time, skill level, calories and nutritional information. The results of this study address the issue of automatic recipe cuisine categorization, making it easier to submit a new recipe and preventing possible additional noise in recipe database – this can be helpful for both the contributors as well as for the culinary website curators.

We conducted a series of experiments on a real dataset retrieved from BBC Good Food[1] consisting of 9,080 recipes from various cuisines with data science approaches focusing on the following: (1) Providing a detailed insight on the characterization of various food cultures. (2) Identifying necessary text-based information from recipes needed to perform well at cuisine prediction. (3) Enhancing cuisine prediction.

This paper is organized as follows. Section 2 gives a brief overview of related work. Section 3 presents the dataset used in our research. Section 4 describes the applied methodologies. Section 5 provides results of our research. Section 6 concludes the paper by summarizing the main results of our work.

2. RELATED WORK

The correlation between recipes and their cuisines has been the subject of several recipe analysis related research. Mostly, there have been previous studies conducted on classifying recipes into respective cuisines based on ingredients. H. Su et. al. [1] evaluated data collected from Food[2] and used the techniques of associative classification and support vector machine to classify 226,025 recipes to one of six cuisines, using ingredients as inputs, with a precision and recall of about 75 %. The researchers in [2–8] further studied cuisine-ingredient connection, using 39,774 recipes from twenty cuisines provided by Yummly[3]. Similar studies were conducted on data from Epicurious [9], Epicurious and Menupan[4] [10] and Food, Epicurious[5] and Yummly [11]. A variety of machine learning algorithms, including k-means [2, 9], random forest classifier [2, 5, 6, 8, 9, 10], support vector machine [3, 5, 6, 7, 10, 11], logistic regression [4, 5, 6, 10, 11] and naive Bayes [5, 6, 7, 9, 10, 11], were used in these studies. From several tested algorithms, linear support vector machine, reaching up to 80,9 % accuracy in [7], was found to be the most efficient for this cuisine prediction task based on ingredients.

Other studies focused on the importance of other information extracted from recipes for cuisine prediction. H. Kicherer et. al. [12] evaluated the use of ingredients and preparation instructions for cuisine prediction, conducted on recipes from German website Chefkoch[6]. The study revealed that ingredients alone are as good an indicator as the recipe instructions. Whereas a combination of information from both – nouns from the instructions and the list of ingredients – performs better. T. Ozaki et. al. [13] also demonstrated that, based on Japanese recipes from Cookpad Data[7], certain sets of ingredients and preparation actions deeply correspond to cuisine types.

Previous studies have already noted that ingredients reveal important information about cuisines and that predicting cuisines

[1] https://www.bbcgoodfood.com/

[2] https://www.food.com/
[3] https://www.yummly.com/
[4] https://www.menupan.com/
[5] https://www.epicurious.com/
[6] https://www.chefkoch.de/
[7] https://cookpad.com/

based on the ingredients is possible. Though, to our knowledge, few researchers have considered using additional text-based information from recipes, for instance, preparation instructions, preparation time and nutrition facts, as possible attributes in cuisine prediction. Therefore, there is little understanding of how they are related to cuisine types. In contrast to the work presented above, we performed a richer analysis of recipes with a wider range of attributes extracted from recipes, whereas the dominant approach appears to deal only with ingredients as attributes.

3. DATASET

Our research was conducted on the crawled data collected from an online food recipe portal BBC Good Food. A dataset of 9,429 recipes was scraped with Python[8], using Scrapy framework[9] and CSS selectors, in June 2018.

For each recipe, the following information was provided: recipe name, cuisine, list of ingredients, preparation instructions, preparation time, skill level and nutrition facts, including the amount of calories, total fat, saturated fat, total carbohydrate, sugars, protein, fiber and salt per serving. More details are presented in Table 1.

Table 1. Characteristics of text-based information in recipe

Information	Data Type	Description
Recipe name	Unstructured	Arbitrary string described in natural language.
Cuisine	Categorical	One of 45 cuisine types.
List of ingredients	Unstructured	Arbitrary string depicting needed ingredients for preparation, each ingredient normally consisting of an ingredient type, an amount and a unit.
Preparation instructions	Unstructured	Step-by-step instructions for preparation using ingredients described in natural language.
Preparation time	Numerical	A number representing time measured in minutes needed for preparation.
Skill level	Categorical	One of 3 difficulties: easy, more effort or a challenge.
Nutrition facts	Numerical	A number representing nutrition per serving measured in kcal for calories intake or in grams for fat, saturated fat, carbohydrate, sugars, protein, fiber and salt.

4. METHODOLOGY

The methodology in this paper was implemented in Jupyter notebook environment[10] running Python code and using a combination of Python libraries comprising pandas[11], scikit-learn[12], NLTK[13], seaborn[14], matplotlib[15] and wordcloud[16].

[8] https://www.python.org/
[9] https://scrapy.org/
[10] http://jupyter.org/
[11] https://pandas.pydata.org/
[12] http://scikit-learn.org/
[13] https://www.nltk.org/
[14] https://seaborn.pydata.org/
[15] https://matplotlib.org/
[16] http://amueller.github.io/word_cloud/

4.1 Data Preprocessing

For the dataset to be feasible for the analysis, preprocessing was performed on the raw scraped data.

During the data cleaning step, missing values and duplicates were resolved by removing these recipes from the original dataset, leaving a subset of 9,080 recipes.

The original dataset included 45 cuisine categories, many of them only consisted of few recipes. In the next step of data preparation, based on the findings of previous researches of cuisines being location-dependent [14], we combined smaller cuisines into bigger regional cuisine categories (e.g. Balinese, Thai, Vietnamese and Indonesian into Southeast Asian cuisine) and therefore reduced cuisine categories to the following 13: African, Middle Eastern, South Asian, Southeast Asian, East Asian, Oceanic, American, Latin American, Western European, Northern European, Central European, Eastern European, Mediterranean.

As highlighted in Table 1, preparation time and nutrition facts are numerical, cuisine and skill level are categorical, whereas recipe name, list of ingredients and preparation instructions are described in natural language. For all of them, additional preprocessing was needed prior to conducting analyses. Numerical attributes were standardized, considering certain algorithms used in our research are sensitive to varied number scales and intervals used [15]. As scikit-learn algorithms only work on numerical data, categorical data needed to be encoded as numerical. This was done by converting categorical data into dummy variables [16]. For unstructured data to be used for classification, several more text preprocessing methods were needed: tokenization, stop word removal, stemming and tf–idf term weighting. Tokenization is the process of segmenting a text into identifiable basic linguistic units called tokens, such as words and punctuation [17]. For better processing, all tokens were converted to lowercase. Stop words are frequently used common words, such as 'and', 'the' and 'this'. Because their presence in a text fails to distinguish it from other texts and are therefore not useful in classifications, they were removed before further processing [18]. We also made a custom list of stop words, where we included numbers that represent amounts and words that represent units, e.g. '2' and 'tbs', that would not be of value in the analysis. The same applies to punctuation, therefore they were filtered out as well. Next, stemming using the Porter stemming algorithm, the process of removing morphological affixes from words, which conflate variant forms of a word into a unified representation [19], was performed. Lastly, for words counts being suitable for usage by a classifier, tf–idf transform was conducted. Tf–idf, short for term-frequency times inverse document-frequency, is used to re-weight a words importance based on a frequency of a world in a document compared to the appearance in other documents [20].

4.2 Exploratory Data Analysis

To get an overall view of the data, exploratory data analysis was made on preprocessed data using graphs, word clouds and tables. Visualization was especially used to provide clarity on the characterization of various cuisines.

4.3 Classification

Various classification algorithms were used to perform the cuisine prediction based on the information from the recipes. The recipe dataset was randomly divided into training (75 %) and testing set

(25 %). The training set was used to train, while the test set was used to assess models.

4.3.1 Naive Bayes

Naive Bayes is based on applying Bayes' theorem with the naïve independence assumption between every pair of features. Gaussian naive Bayes assumes the probability of features is Gaussian. Multinomial naive Bayes implements the algorithm to the usage for text classification [21].

4.3.2 Support Vector Machine

A linear support vector machine constructs a hyper-plane or set of hyper-planes in a high or infinite dimensional space using linear algebra [22].

4.4 Evaluation Metrics

To measure classification performance the following metrics were used: accuracy and F-score. Accuracy is the percentage of correct predictions. F-score is a weighted average of the precision and recall, where precision represents the ability of the classifier not to label as positive a sample that is negative and recall the ability of the classifier to find all the positive samples [23].

5. RESULTS

As an initial step, we carried out an exploratory data analysis to get a better understanding of cuisines and their characteristics. Table 2 lists average preparation time and calories per serving for each cuisine. Given the analysis, recipes from Northern Europe, Middle East and Western Europe take the longest to prepare, whereas recipes from East Asia, Latin America and Southeast Asia are generally the quickest to prepare. Furthermore, on average, Mediterranean, Oceanic and American cuisines are high in energy, on the contrary, Southeast Asian, East Asian and South Asian have recipes with lower energy values.

Table 2. Overview of the cuisines

Cuisine	Common ingredients	Average preparation time [min]	Average calories [kcal]
African	Oil, onion, lemon, clove, coriander.	51,73	399,68
Middle Eastern	Oil, onion, tomato, garlic, clove.	76,67	409,11
South Asian	Onion, oil, coriander, chili, clove.	53,74	367,50
Southeast Asian	Sauce, lime, chili, oil, sugar.	45,00	350,78
East Asian	Sauce, oil, onion, chili, rice.	40,49	363,18
Oceanic	Sugar, oil, egg.	60,36	430,70
American	Sugar, butter, oil, flour, egg.	57,68	422,37
Latin American	Onion, oil, chili, coriander, lime.	43,17	399,30
Western European	Sugar, oil, butter, egg, flour.	66,59	394,85
Northern European	Oil, sugar, onion, egg, cream.	119,59	374,61
Central European	Sugar, butter, egg, flour, oil.	62,73	402,85
Eastern European	Oil, butter, egg, flour, garlic.	57,96	390,04
Mediterranean	Oil, garlic, clove, tomato, onion.	48,68	433,36

To give an idea of the ingredients that form an integral part of each cuisine, we extracted the most common ingredients in every cuisine and visualized unigrams from the ingredient list in word clouds. As detailed in Table 2, many ingredients are frequent in all the cuisines, e.g. oil and onion, hence, these will not be useful for prediction. While others are typically used only in certain cuisines, e.g. soya sauce and clove.

Figure 1 represents word clouds consisted of the most common unigrams extracted from the ingredient list for East Asian cuisine. Although most common ingredients did not give us much insight, these word clouds do show some typical ingredients, based on which they can be distinguished from other cuisines, e.g. sugar, flour, milk, cream, chocolate, egg, mayonnaise, butter in American cuisine and soy sauce, rice, ginger, soy, chili in East Asian cuisine.

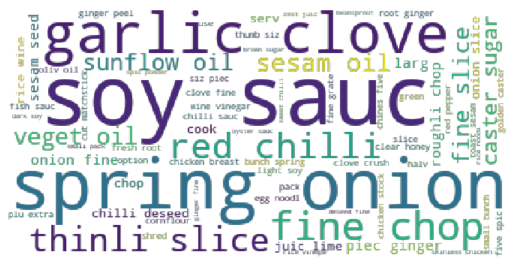

Figure 1. Word cloud for East Asian cuisine

Cuisines also differ on nutrition facts. In Figure 2, for every cuisine an average value of each nutrition per serving is presented.

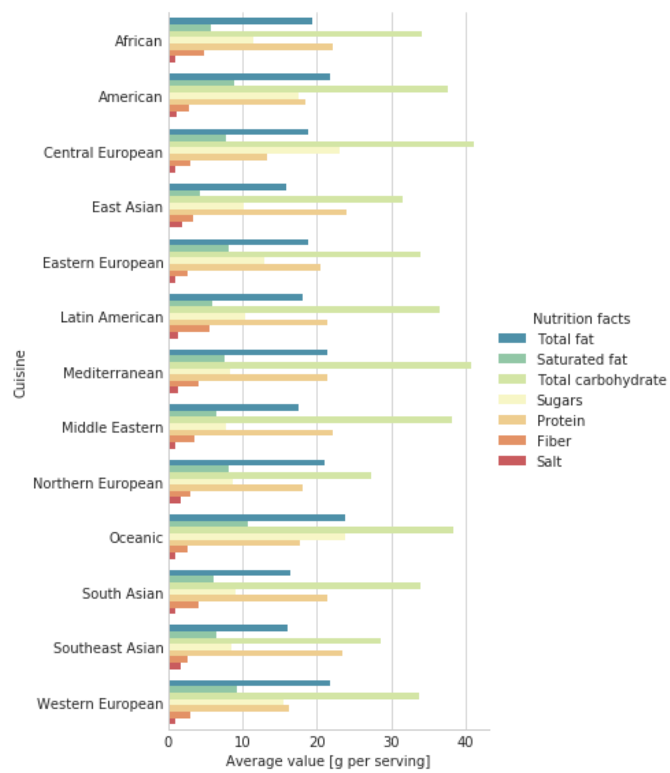

Figure 2. Nutrition facts for cuisines

In the next step, classification algorithms were applied to identify which text-based information from recipes is needed to perform well at cuisine prediction. A classification with multinomial naive Bayes, based on the list of ingredients, proved to be the most efficient. This model yielded an accuracy of 73,8 %. Less than 1 % lower was the accuracy obtained with classification based on recipe name and more than 2 % based on preparation instructions. Classifications based on skill level, preparation time, calories and nutritional information all performed with an accuracy of about 56 %. Classification performance based on accuracy and F-score are summarized in Table 3.

Table 3. Results of classification

Information	Classifier	Accuracy	F-score
Recipe name	Multinomial naive Bayes	72,73 %	72,73 %
List of ingredients	Multinomial naive Bayes	73,83 %	73,83 %
Preparation instructions	Multinomial naive Bayes	70,97 %	70,97 %
Preparation time	Gaussian naive Bayes	55,29 %	55,29 %
	Linear SVM	55,68 %	55,68 %
Skill level	Linear SVM	56,12 %	56,12 %
Calories	Gaussian naive Bayes	55,68 %	55,68 %
	Linear SVM	55,68 %	55,68 %
Nutritional information	Gaussian naive Bayes	53,48 %	53,48 %
	Linear SVM	57,00 %	57,00 %

6. CONCLUSION

Thousands of recipes from various cuisines were analyzed with data science approaches with the objective of providing a deeper understanding of culinary cultures and cuisine prediction. While previous research efforts have mostly used only ingredients for cuisine prediction, our findings demonstrate that other text-based information extracted from recipes can be used as well. While ingredients with an obtained accuracy of almost 74 % remain to be the most efficient, cuisine prediction from recipe name and preparation instructions also performs well. Whereas prediction based on preparation time, skill level and nutrition facts were discovered to be less effective, with about 56 % accuracy.

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Introducing Blockchain Technology into a Real-Life Insurance Use Case

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ABSTRACT
The paper presents an analysis of a possible introduction of the blockchain technology into an insurance business use case. The analysis is focused on the implications such an attempt can have from various standpoints and the technical workaround needed for a prototype to be implemented.

Categories and Subject Descriptors
H.3.4 [**Information Storage and Retrieval**]: Systems and Software

General Terms
Performance, Economics, Reliability, Experimentation, Security, Legal Aspects, Verification.

Keywords
Blockchain; Smart contracts; Ethereum; Insurance

1. INTRODUCTION
Blockchain technology nowadays is considered as the new IT revolution and even as the messiah for all IT-based problems. Nevertheless, as with other innovative technologies, public's hype about the technology is fading. Experts now know that the technology is useful only for specific domains and use cases as public, virtual and untrusted environment or cryptocurrency-based scenarios. Nonetheless, media is full of articles and news about corporations and companies using blockchain technology for some specific use case, which may or may not be fully meaningful. The result of such news is rising prices of cryptocurrencies and more importantly, rising stock prices of organisations [1].

The outcome of such approaches is various: (1) proposal and prototypes of blockchain-based use cases, which unnecessarily use this technology, (2) prototypes which are consistent with the technology's purpose but are unpractical and not user-friendly, and (3) failed attempts to produce a practical prototype or a production system. In this article, we explore the possibility of introducing the blockchain technology in an insurance-based use case. The aim was to explore the possible reasonableness of such a use case, its possible restrictions, limitations, advantages and disadvantages. The focus of the paper is on thus the implications of such a use case on all related processes and the overall picture of a possible implementation.

2. BLOCKCHAIN
A blockchain is an invention that can be seen as a distributed ledger of all transactions or events that have been executed and shared among distributed participants. All transactions are verified with distributed consensus inside the system. Considering basic blockchain platforms, once a transaction is recorded, it cannot be removed [2]. Group of verified transactions are stored in a block. Each block contains a cryptographic hash of the previous block and a timestamp. New linked block strengthens the integrity of the previous one, making the chain extremely tamper resistant and secure. With a public blockchain, a copy of the entire transaction database (ledger) is distributed to the network. Every person can view transactions and even participate in a consensus process.

Blockchain enables a more effective way to solve the virtual currency problem. It solves it in a distributed manner, without the need for a central authority [3]. Central authority represents costs and must be trusted to act honestly.

Public blockchain is not the only type of possible blockchain platforms. There are also private and consortium blockchains [4]. Private blockchains have write permission kept centralized to one organization. That can be useful for a single company for database management, auditing, etc. In a consortium blockchain partner companies are joined together in a trusted and adaptable network. The right to read in such blockchain types may be public or restricted to the participants.

2.1 Smart contracts

The concept of smart contract has been known since 1994, when Nick Szabo defined it as a "computerized transaction protocol that executes the terms of a contract". Inside the blockchain context, smart contracts are stored on the blockchain. They can be presented as stored procedures in relational databases. Given that smart contracts are deployed on the blockchain, they have their own unique addresses. A smart contract is invoked by executing a transaction to the unique address of the contract. It is then executed independent and automatically on each node in the network [8].
The contract has its own state and can manage assets on the ledger. It allows expressing the business logic within a programming code. A well-written smart contract should describe all the possible outcomes of the contract. This means that a function would refuse to execute in case of incorrect (inconsistent with business logic) parameters [8]. Smart contracts are deterministic - this means that the same input will always produce the same output. Implementation of smart contracts on known platforms (e.g., Ethereum), written for example in the Solidity programming language, the developer is prevented from writing non-deterministic contracts, since the programming language does not contain non-deterministic constructs. All communication with a smart contract is done through cryptographically signed transactions. This means that all blockchain stakeholders will receive a cryptographically verified trace of a contract operation.

2.2 Oracles

Smart contracts on the Ethereum blockchain platform run within the Ethereum ecosystem, where they communicate with each other. External data can only enter the blockchain (i.e. smart contracts) through external interaction using a transaction. This is also a shortcoming of the platform, because the majority of business logic is based on external data, which is thus not part of the blockchain ledger (e.g., weather, currency price) [9]. To overcome such a shortcoming an oracle can be used. Oracle is a trusted data source that sends external data to a smart contract in form of a transaction. By doing so, it relieves the smart contract of the need to directly access the desired data outside of the network. Oracles are usually offered as a third-party solution [8].

The oracle service behaves like a data courier where communication between the service and smart contract is asynchronous. First, the transaction performs the function within a smart contract in which the instructions for service are sent. The Oracle service will then obtain a result based on the parameters that will be returned to the smart contract via a special function (callback) implemented in the main smart contract in which we want data (result) from the service [9].

3. USE CASE

To test the concept of introducing the blockchain technology in a real-life business use case, we chose the insurance domain, which is also one of the promising domains for the blockchain technology [5].
A preliminary result of a market analysis has shown that a possibly meaningful, but not yet implemented use case would be the lost baggage insurance. This specific real-life use case nowadays still represents long-term problems for passengers and airlines. To make it as user-friendly and meaningful as possible, an app was envisaged. The key functionalities of such an app, as presented in Figure 1, would be: (1) user scans QR code of the flight ticket, (2) confirms read data, (3) scans barcode of baggage, (4) acknowledges terms of the smart contract, (5) info about the possible payout is provided. With help of RFID trackers at the airports the system would be able to surveillance the position of passenger's baggage based on the newly confirmed IATA resolution 753. In case of a lost or delayed baggage, an activation of a blockchain-based smart contract is executed. A compensation could be given in crypto or fiat currencies (ex. ETH, EURO), within 4 levels of payout.

Figure 1: Poster for a possible lost baggage insurance.

4. IMPLICATIONS

This section provides the implications of a possible implementation of a blockchain-based solution as presented in section 3 on three domains, legal, economic and organizational.

4.1 Legal implications

Blockchain technology as presented in section 3 raised up some legal issues. The main legal question is the General Data Protection Regulation (GDPR). GDPR is a legal framework for personal data privacy, it has been written by the European Union (EU) and became effective on May 25th. This framework is drastically changing business of any digital venture. The Regulation granted EU citizens new rights, e.g., the right to be forgotten and right to request all data storage and acquisition links. The latter allows an individual to ask an organization to delete all their personal data they store. This specific right is also the main problem in the blockchain technology. Blockchain technology relies on the principles of decentralization and immutability, which means that data stored on the ledger cannot be deleted. When this data includes personal data, we have a problem in the GDPR area. This is the main implication of this domain, since the use case worked on required the processing of personal data. The main question is thus how to process personal data with the blockchain, but still being able to delete it if needed or to process it outside the blockchain. Research shows that many experts are trying to find a solution [7]. Majority of the solutions are focused on the off/on chain paradigm, whereby personal data is never dealt with on the blockchain. Nonetheless, new problems arise as how to link off/on chain data and if the link itself is a GDPR violation.

4.2 Economic

The main goal of the solution is to enable air passengers to sign an ad hoc luggage insurance, which is tied to an airline ticket. The blockchain technology will be used for the insurance coverage and the payout of an insurance premium. The solution should allow the payment of the insurance coverage through cryptocurrencies to get the biggest customer coverage. It is a new business model, where the target group are all airline users.

The biggest negative factor associated with the possible solution is the volatility of cryptocurrencies. In practice, this represents the possibility that we lose some of our assets as a customer or as airlines. In addition to volatility, problems can occur in certain processing delays. The application itself is also linked to airline and airport data. If the system fails, automatic payment is not made possible, nor can the insurance be concluded. From an economic point of view, the application also brings many positive aspects. It is about introducing the possibility of speeding up the rigid process of current luggage insurance and redress. The cost of maintaining a blockchain network and smart contracts is not negligible. These can be covered through the annual contribution of airlines for their usage of such a possible solution. At the same time a certain percentage can be collected from each insurance.

The economic advantages of such a solution are many: (1) introduction of new technology, (2) the possibility of ad hoc insurance, and (3) a new business model.

4.3 Organizational

One of the main problems of a possible solution are of organizational structure. For it to make sense, a platform should be implemented, where all willing airlines could register and provide baggage insurance to all possible consumers. Each airline can and should have a partnership with an insurance company. Thus, to complete the registration, the airlines must provide their insurance price and max payout in case of a lost baggage. Furthermore, the solutions must be automatic and enable easy baggage check and insurance claim. A simplification of such a request comes with the IATA Resolution 753, which states that by June 2018, airline members must be able to, among others, demonstrate delivery of baggage when custody changes [6]. This furthermore implies that the ecosystem must include airports which will provide the data mentioned about the status of the baggage. Technically, a link to a web service is required, where data about the baggage is accessible.

5. PROTOTYPING

It should be emphasized that blockchain technology is a rather unexplored thing. In most cases there are no examples of good practice on process of how the introduction of the blockchain should start.

After analyzing the possible use-case and its implications we propose a prototype in a form of a decentralized application (dApp), based on the Ethereum smart contracts. The front end of the solution could be a simple Angular 2 web application with an intuitive, user-friendly interface, accessible on multiple devices. The main advantage of using a web application as opposed to device-specific applications, is the support of various operating systems and models. If a user selects to pay with cryptocurrency, he/she can use the plugin MetaMask to connect to the Web3 part of the application and send a signed transaction to a smart contract on the blockchain. According to GDPR laws, personal information needs to be delible, therefore it should be stored in a separate database off-chain, accessible through an API. Such an architecture can be given by storing airline information off-chain and non-identifying user insurance data on the blockchain.

Figure 2 presents the architecture of the possible solution. Users connect to the service through a dApp with the option to pay with crypto or fiat currencies. For clarity, the former option will be marked with the letter (a), and the latter with (b). There are two blockchains used, the Ethereum's MainNet to process payment transactions and our InsurNet for business logic (private Ethereum network). Crypto transactions are first processed on the MainNet (2a), where an oracle is triggered to convert the value into fiat (2.1a), before sending it to the InsurNet (2.2a), whereas fiat requests are processed directly through the API and if successful, forwarded towards the InsurNet (2b) to create the insurance (smart) contract. The InsurNet smart contract uses an oracle deployed at an airline to retrieve the status of the baggage (3.1 and 3.2) before processing the business logic to determine the validity of the claim. If the user is entitled to a payout, the payout oracle is called (4) to determine the correct payment method and convert currency if needed. In case the user paid in cryptocurrency (5a), the payout is processed on the MainNet (6a). Otherwise the FIAT payout is handled off-chain (5b).

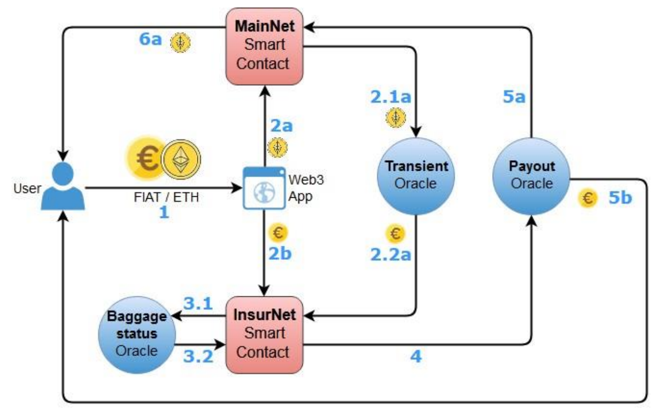

Figure 2: Architectural model of the proposed solution.

6. DISCUSSION

Due to the Ethereum Protocol, where every transaction must be validated by miners and added to the block, these can be slowly processed. When a user pays insurance with the cryptocurrency Ether into the smart contract on the MainNet and the transaction is confirmed, the function in our smart contract will trigger an event, which we can listen from outside of our dApp. We will detect the event only when the transaction is confirmed. Once our server detects the "Paid" event from the MainNet, it will create a new smart contract on our private blockchain InsurNet. This is reflected in some latency for the user. With the aforementioned oracle, we have two more. One is to verify the location of the luggage, while the other one is to process the payment when the event is triggered on InsurNet.

We can consider the following example where the user pays insurance for one luggage in the cryptocurrency. We will assume the average time to validate the transaction on MainNet is 25 seconds. The user transfers the cryptocurrency to our smart contract, where the validation of this transaction takes 25 seconds. Then, on a triggered event, oracle performs a new transaction on our network, where the transaction validation time is defined for 10 seconds. Because the user does not have the luggage yet, after three hours of landing, he performs a payout using the dApp. Transactions are done within 10 seconds. An oracle then performs a new transaction to write the current location information in the smart contract (+ 10 seconds). Since baggage is not yet available, the user is entitled to a payout, which is reflected in a new event where an oracle performs a transaction on the MainNet. The validation of this transaction takes 25 seconds. Thus, it takes at least 80 seconds for all transaction validations to complete.

7. CONCLUSION

By proposing the concept of a fully workable prototype, we demonstrate that a solution is possible. Nevertheless, after considering all the implications, we conclude that such a solution would be unpractical and not user friendly, due to all workaround needed in order to prepare a fully working technical solution. Considering the current evolutional stage of the blockchain technology, we conclude that a fully crypto-based solution can be met with approval, thus advocating the idea of the blockchain technology being seen as business disruptor in the sense of digital money.

ACKNOWLEDGMENTS

Our thanks to the public scholarship, development, disability and maintenance fund of the Republic of Slovenia and the project Following the Creative Path to Knowledge 2017 – 2020 (Po kreativni poti do znanja 2017 – 2020) - SmartInsTech.

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A Brief Overview of Proposed Solutions to Achieve Ethereum Scalability

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ABSTRACT

Blockchain technology is part of Gartner's top technological trends in the following five years, whereby already moving away from the peak of the inflated expectations on its hype cycle, towards the slope of enlightenment. With the development of the blockchain technology, the emergence of completely new business processes is anticipated, as well as changes to existing business processes, which will include the use of blockchain technology in its implementation, partially or completely, thereby taking advantage of the benefits that the technology itself offers. Nevertheless, the technology has several drawbacks, whereby the most vivid is the scalability problem. With the introduction of Blockchain 2.0 and the Ethereum platform, the scalability problem seemed settled out for a moment, which proved otherwise with first generations of non-fungible tokens and high traffic. Although Ethereum is in its infancy, progress is on high tracks, with this year's focus on the infrastructure. A lot of research and work is being done on the Ethereum's layer 2 scaling solution such as the state channels, plasma and sharding. This paper presents a brief overview of the current state of the mentioned proposed solutions and some ongoing projects, which are focused on their implementation.

Categories and Subject Descriptors

H.3.4 [**Information Storage and Retrieval**]: Systems and Software

General Terms

Performance, Design, Reliability, Experimentation, Security

Keywords

Blockchain, scalability, Ethereum, channels, plasma.

1. INTRODUCTION

In recent years, on the basis of an increase in the market capitalization [1] of the Ethereum platform, the performance of which is based entirely on the blockchain technology, we can conclude that it is becoming increasingly popular. The increase in popularity consequently affects the increased number of transactions performed within the Ethereum blockchain network [2], whereby we can assume that the number of business processes that are implemented with the help of blockchain technology and Ethereum is also increasing.

All transactions transmitted on the blockchain network are irreversibly recorded in a shared ledger among all network nodes [3, 4]. Nodes in the blockchain network perform a protocol, defining the ability to create new blocks with associated transactions in an approximate 15 seconds time frame. This allows the frequency of transactions executed in the network to be approximately 7 - 15 transactions per second (tp/s) [5]. The open source Ethereum platform is based on a permisionless and publicly accessible blockchain network, which is at the same time a distributed and decentralized operating system for running smart contracts via its Ethereum Virtual Machine (EVM). Because of the platform indigenous crypto currency called Ether, generated by the blockchain network and defined by the protocol, the platform is often used as a payment system, like the Bitcoin. Therefore it is often compared to existing non-crypto payment solutions, such as Visa, which, unlike the Ethereum platform, is capable of processing a much larger number of transactions (56,000 tp/s) [6].

In the paper, we will present the problem of scaling the Ethereum network and the proposed solutions. These solutions could increase the number of transactions carried out on the Ethereum platform, thus getting closer or exceeding the processing capacity of existing non-crypto payment systems. This would enable the development and implementation of new business processes with the blockchain technology.

2. ETHEREUM SCALING PROBLEM

The current implementation of the Ethereum protocol requires the processing of all, within the network transmitted transactions, as well as the storage of all states, from each node in the network, that acts as a validator [7]. To confirm a change of the network state with a transaction, the transaction must be included in a block created by a node, which must solve the calculation puzzle defined by the distributed consensus protocol, which is in the current Ethereum version the Proof of Work (PoW). The processing speed of the transactions is limited by the capacity of each individual node participating in the network as the transaction validator. Such an implementation of the protocol provides increased safety in terms of secure processing of transactions within the network, which is one of the key properties of such systems. At the same time, the way in which an increased security is achieved, is a major obstacle achieving a greater number of transactions carried out within the blockchain network, due to its need for heavy computation [8].

The number of transactions one block can include is limited by the number of gas (fee for processing the operations within the transaction), that can be consumed by all transactions in the block. In the future, it is possible to expect a change in the way of reaching consensus between the individual nodes in the Ethereum network. Namely, the transition to the use of the Proof of Stake (PoS) protocol is planned, which would mean that the time of block generation within the Ethereum network with associated transactions could be reduced to an average of four seconds [5]. The transition to a new protocol for reaching consensus among the nodes in the blockchain network will thus reduce the current scaling problems. In addition, the switch to PoS distributed consensus will decrease the required computational power and thus energy consumption of the network.

Changing the network consensus protocol between nodes will have a positive effect on the transaction processing frequency within the blockchain, but it is expected that the number of processed transactions will still be significantly smaller compared to the existing payment systems. Described problems in the terms of achieving greater efficiency of blockchain, assuming knowledge of its structure and understanding of the concepts of the blockchain technology, offer so-called "simple" theoretical solutions, such as:

1. It envisages the use of different "altcoins" within a variety of separate blockchain networks, which results in a strong increase in the flow rate of the performance of individual transactions within the separate blockchain networks. As a result, due to the increased number of different blockchain networks, a reduced number of nodes within different blockchain networks are expected, which would mean that separate blockchain networks will be more susceptible to attacks by malicious nodes than if all network nodes are merged within a single common blockchain network [9, 10].

2. Increasing the limit of the number of transactions per block or increasing the ceiling of fuel consumption in the case of the Ethereum protocol, theoretically implies a large number of processed transactions. Nevertheless, this requires significantly more computational power (for using the PoW protocol, or the percentage (stake) when using the PoS protocol) to validate a block with an increased number of transactions of an individual node in the network [9, 11].

3. Combining computational power (when using the PoW protocol) or stake (when using the PoS protocol) between the different blockchain networks, can theoretically increase the flow of transaction processing, but this could burden each individual node in the network due to the need for processing transactions of blockchain networks [12].

The described "simple" solutions directly relate to the so-called trilemma of blockchain technology, which says that the blockchain network can contain only two of the three features, such as:

- Decentralization
- Scalability
- Security

In the case of the use of different altcoins, this would mean increasing the efficiency (scalability) of transaction processed within the blockchain network, while in contrary a reduction of security of the network itself. The increase in the limit of number of transactions in a single block and the aggregation of computational power or the share between different blockchain networks would theoretically increase the efficiency (scalability), which would require greater use of computational power for the processing of all requirements within the blockchain network from the network nodes. This reduces the possibility of equal participation in the network by nodes with less computational power, which can lead to a reduction in the decentralization of the blockchain network by nodes who have greater computing power [8].

In the following chapters, we will present some solutions that could solve the described problem of efficiency, whereby not to affecting one of the described properties of the trilemma of the blockchain technology.

3. PROPOSED SOLUTIONS

The main concern of blockchain technology is the security and a distributed consensus in a decentralized network. The processing of every transaction by all nodes of the network is a process that provides these characteristics but does not provide enough measure for increasing efficiency and scalability. Below we describe some already proposed solutions, which can help increasing the efficiency and scalability of the Ethereum blockchain network without undermining the security and decentralization of the network as such.

3.1 State channels

One of the proposed solutions, which is currently considered to be the most mature and used, is based on the transaction processing approach outside the blockchain network (i.e. off-chain) through the establishment of state channels [13]. The proposal of the solution derives from the so-called payment channels, the purpose of which was to allow multiple micro-transactions between two users of the system without the need of transmitting each transaction through the blockchain network [14].

While payment channels focus on off-chain processing of payment transactions, the purpose of the "state channels" is to establish a channel, through which the state can be changed outside the blockchain network, between predefined participants [15]. This is because Ethereum blockchain holds the state of each defined variable of every deployed smart contract. The need to process a transaction within a blockchain network occurs only in case of disagreement about the state changed by a transaction within the established channel by any participant or in the case of a closed communication within the channel. In case that there is no disagreement about the changed state during the communication within the established channel, this solution significantly increases the number of transactions, since it aggregates micro transactions and issues them as one in a predefined time [16].

State channels are implemented with the help of dedicated smart contracts. The establishment of communication through such a channel is carried out with a special “channel smart contract”, aimed at ensuring fair communication between participants that perform operations and record the final state into the blockchain network, after the communication has ended. In case of a conflict between participants in communication outside the blockchain (within the channel), the smart contract has the task of selecting the most relevant last state that the users still agreed on when communicating within the channel [17]. The security of such an off-chain communication approach is based on the fact that each message sent through the status channel is cryptographically signed, with the aforementioned channel smart contract having an implementation for verifying these messages. Each participant can cancel the communication at any time, and the final state that is recorded in the blockchain is that which is recognized by all participants in the off-chain communication [15].

This type of communication allows the implementation of more complex operations defined within smart contracts, completely independent of the blockchain network. Consequently this means almost instantaneous execution of operations with very low total costs of execution of all implemented channel transactions, since all transactions carried out within the established off-chain channel are aggregated into a single transaction [17, 13].

3.2 Plasma

The scalability of the Ethereum network with theoretically trillion transactions per second should be achieved by the introduction of a strategy called Plasma. Similarly, as in the solution described in Chapter 3.1, the purpose of Plasma is to implement transactions without the need for individual confirmation of each of them by the blockchain network. The solution envisages the introduction of several side chains, whereby the last state of the newly created chain being recorded in i.e. the main blockchain network. This could be implemented without any need to change the current protocol and Ethereum network. The most important factor in terms of achieving security in the Plasma solution, relates to the privilege of every user to perform transactions within any side chain (with the exception of the main Ethereum chain) and to leave the side-chain and write the final state in the main Ethereum chain - where the final valid state is defined. To prevent the recording of a false state into the main chain, the Plasma solution suggests a "Challenge mechanism", which assumes that the state that a user wants to record in the main chain is frozen for a certain period. During this period, other users can prove that the proposed state is not relevant. Because of the above mechanism, the user must provide a sum of the Ether cryptocurrency into such a transaction that writes the state into the main Ethereum chain, which if another user proves that such a transaction contains an invalid state, loses and is acquired by that user, who proved the invalid state. This mechanism could trigger a lot of false evidence of invalid transactions; therefore, a user wishing to prove an invalid transaction must pledge a sum of the Ether cryptocurrency, which in the case of false evidence of invalidity, is acquired by the user of the original transaction [18, 19].

3.3 Sharding

With the current implementation of the protocol, each node that is part of the Ethereum network must validate every transaction, which ensures a high level of network security. One solution is sharding, where the protocol would separate the network state into smaller partitions, called shards. Each shard would store its separate state and transaction history. By implementing such a protocol, certain nodes would process only the transactions of certain shards. Transactions on different shards at the same time would increase the permeability of these [20].

Sharding is a general technique used in distributed computing, the implementation of which can be expected in Ethereum by 2020 [21]. Implementation of sharding is the only one of the described scaling solutions that will practically have no impact on end users, as well as not on smart contract developers on the Ethereum platform. The system for storing states will remain the same. The change will be at layer 1 of the Ethereum Protocol. Solutions mentioned in 3.2. and 3.1. will work on layer 2 [22]. Sharding eliminates the need for the entire network (each node) to process all transactions. The result is increased number of processed transactions per second [21].

Prior to implementing sharding in the protocol, various challenges must be addressed. The main challenge is a single-shard take over attack. With such an attack, an attacker could possibly take control of the entire shard, which may result in the avoidance of sufficient validations, or even worse, to validate the blocks that are incorrect. These attacks are usually prevented by random sampling schemes. The next challenge is the availability of states between different shards. The most appropriate approach for addressing this challenge is that the effect of a transaction depends on the events that happened before in the second shard. A simple example is the transfer of money where the user A (e.g. in shard 2) transfers money to user B (e.g. in shard 7). First, a debit transaction is executed that destroys the tokens at user A (in shard 2), after which a "credit" transaction is created that creates the tokens of user B (in shard 7). This transaction has an account indicator on a "debit" transaction, which proves that the "credit" transaction is legitimate [8].

4. CONCLUSION

In the paper, we presented several different solutions, the common purpose of which is to achieve greater efficiency of scalable transaction processing in the Ethereum blockchain network. State channels move state modifications outside of the main blockchain network. The Plasma solution envisages the introduction of several blockchains, whereby each chain is used for a specific purpose. Both solutions allow users to record the final state in the main Ethereum blockchain network. We also descried the sharding solution, the introduction of which, in contrast to the above-mentioned solutions, requires the change of the lowest layer of the Ethereum protocol. All the described solutions pursue the goal of not reducing the current level of transaction processing security, as well as maintaining the decentralization of the blockchain itself in order to achieve scalability. In the future, due to the increase in the number of transactions transmitted within the Ethereum network, it is reasonable to expect several concrete implementations (Loom Network, OmiseGO, Raiden,...) of the described solutions, as well as an increased use of these in practice, since it is the increase in the efficiency of the transaction processing which is one of the key factors in achieving the optimization of existing and new business processes, supported by the blockchain technology.

5. ACKNOWLEDGMENTS

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0057).

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Integration Heaven of Nanoservices

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ABSTRACT

Microservices have become an essential software architecture in the last few years. Nanoservices as a generalization of microservice architecture are getting more and more popular recently. However, this means that every component has more and more public interfaces, and the number of components is increasing, as well.

Integration hell had been appeared when the number of developers was increased. The developers work parallelly, so it is necessary to merge their work. Collaboration requires software support, such as version controll tools and continuous integration servers.

However, modern software development tools such as build systems, testing frameworks and continuous integration servers become sensitive regarding the version of source code to deal with. This can result in exponential explosion in many ways when nanoservices are in the focus.

In this paper, we argue for workflow that can handle this exponential explosion. This workflow can be included into continuous integration servers as jobs in order to execute test cases in a reproducible way even if the test cases deal with special environment specifications. Moreover, the workflow is able to deal with building and artifact publishing processes, as well.

Categories and Subject Descriptors

D.2.7 [**Software Engineering**]: Distribution, Maintenance, and Enhancement; K.6.3 [**Computing Milieux**]: Software Management

Keywords

Nanoservices, Integration, version control

1. INTRODUCTION

Microservices and nanoservices are essential software architectures recently. These software architectures have many benefits, improved scalability, separate responsibilities, better maintainability to name but a few [17]. On the other hand, having a software architecture utilizing more than 70 own built nanoservices in active development requires special care for build processes.

In terms of continuous integration (CI) and continuous delivery (CD) – modern software development process frameworks pipelines are defined as composable parts of the process describing how the product is created, transformed and delivered from making source code and configurations on developers workstations to serving them to end users [16].

The pipelines mentioned in this paper are executed by automation systems following deterministic scripts referred as "pipeline scripts".

This paper discusses the topic of bulk management of unified pipeline scripts in aspects of reproducibility, replayability, compactness and overhead of change management.

This paper is organized as follows. We present the problem of integration hell in section 2. We describe the problem in section 3. Our proposed workflow is presented in section 4. Finally, this paper concludes in section 5.

2. INTEGRATION HELL

2.1 Case

The subject of the study is a software running on top of a container orchestration system operating over multiple nodes. Using event sourcing with Command Query Responsibility Segregation (CQRS), the software utilizes over 70 services.

Every own built service is stored in its own version controller system (VCS) repository [14]. Most of them are identical in the aspect of programming language, project structure, packaging system, types of artifacts, testing frameworks, static analysis system (e.g. [11]). The discussion continues about this kind of services.

2.2 Orchestration

A container orchestration tool manages resource allocations, configurations, credentials of containers. Provides common internal network with service discovery, domain services, serving well defined endpoints for outer network communications.

In terms of scalable services, operating with nanoservices an orchestration tool must provide load balancer service over multiple nodes ensuring high availability. Also provides declarative configuration and deployment management with the ability of rolling updates and rollbacks between configuration and deployment versions also.

Currently the industry standard for a real battle tested, serious production-grade orchestration tool is Kubernetes, developed by Google [9].

2.3 Build tools

Modern programming laguage ecosystems have their own (sometimes multiple) *package manager* for dependency handling and easy build, test, install and deploy management [12]. The common pipeline script utilizes those package managers, reaching higher level of abstraction [10]. For example:

- Java, Scala: Gradle[3], Maven[5], Ant[1]
- JavaScript - NodeJS: NPM[6], Yarn[8]
- C++: Conan [13]
- Python: Pip[7]
- Haskell: Cabal[2]
- Docker (images): Docker (registry) [15]

Closed source software projects as the subject utilize *artifact repository systems* which can serve repositories for multiple type of packages for own artifacts and serve as cache for public domain packages (in case of outage and lowering network traffic). For example: Nexus, JFrog Artifactory.

2.4 Pipelines

The services are built automatically on VCS commit on marked branches. Build pipeline scripts of actively developed services have to be in sync in order to guarantee the same level of quality and compatibility with environment (following its changes).

2.4.1 Pipeline script

A *pipeline script* is interpreted by a CI tool, a build system (e.g. Jenkins [4]), is a sequence of commands optionally separated into stages.

2.4.2 Pipeline script stage

A *pipeline script stage* is a named sequence of commands. Used for visualizing the main parts of the script, leveraging process status display during execution, variable scope segregation.

2.4.3 Pipeline command

Each *pipeline command* can be variable declaration and definition (including functions), function invocation, shell invocation.

Ideally, a *build system* has its own pipeline script domain-specific language (DSL) with an application-programming interface (API) library for common operations like VCS checkout, packaging operations, status notifications, common configuration and secret storage operations.

2.4.4 Build job

In common CI tools, each pipeline script invoked by a corresponding *build job*. These jobs contain metadata for running the pipeline script, like the location of the pipeline script itself. Storing and passing variables like job name, parameters (given on job invocation via API call or web UI).

2.4.5 Common pipeline

The subject project uses mostly Java Spring Boot nanoservices, which kind of services have a common pipeline script actively developed.

The common pipeline script contains the following stages:

- VCS checkout
- Build source code using *package manager* (like npm, Gradle, Cabal, etc.)
- Run tests on the artifact using package manager
- Sending the source code to the static analysis system
- Building Docker image artifact
- Uploading artifacts
- Announcing build status on channels (email, instant messaging)

Since these are nanoservices, their Docker images differ only on the built artifact. The configurations, including environment variables, configuration and secret files, are handled by the orchestration tool and building them into an image is an anti-pattern in this use case.

2.5 Integration hell definition

Integration hell is a place where developers have to maintain all the pipeline scripts manually for each service or use a common pipeline script and update all the source codes and configurations on each service repository to be compatible with the pipeline script. Also called *one pipeline script over all.*

3. PROBLEM STATEMENT

3.1 Build job generation

The jobs are generated depending on the VCS repository path structure. The generator job accepts the list of the service names to make build job for. The build jobs are generated from template, the only difference is in the source code repository URL and the project name.

3.2 Single pipeline script repository approach

Having dozens of services with identical pipeline scripts, it would come in hand to use the exactly same pipeline script file checked out from one build script repository.

3.2.1 Limitations of updates

The single pipeline script repository approach has multiple pitfalls. Since the the job configuration has only the repository, the branch name and the path of the pipeline script, any change on the pipeline script would affect all the build jobs at once. In this case either the ability to create experimental changes on the build scripts is lost or the ability to recreate all the build jobs without breaking any of them.

3.2.2 Lack of replayability

Other problem regarding the single repository approach is the lack of replayability. Having a case when recreating an artifact based on an older state of the service source code repository is needed, there is no guarantee the current state of the pipeline script in its repository is backward

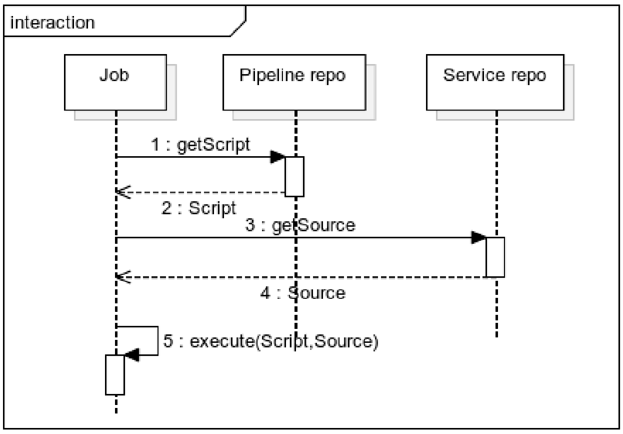

Figure 1: Sequence diagram of the proposed workflow

compatible, so there is the risk of broken or unstable build (in worse case it turns out in production). The correct build script should be searched in the history of the pipeline script repository (see Figure 1).

3.2.3 *Growing overhead*

The mentioned problems are getting harder to resolve as the size of the software project (the number of services) is growing. The maintenance cost of those pipeline scripts is high. Onboarding a new developer-, handing out the development of such project could be extremely difficult due to the multiple tools and sytems, scripts and their difficult dependency graph.

4. PROPOSED WORKFLOW

Addressing these problems a reasonable solution could be a property file in each service source code repository. This approach makes the generator job more difficult since every invocation it should parse the property file of every repository and generating the job according to that. An other problem is the synchronization of those property files.

4.1 Single source of truth

There is an other, more compact, more robust and more redundant way to address the problems. The *single source of truth* for service artifact build workflows should be the repository of their source code. This approach leverages the compactness of each service. The service VCS repository should contain the source code of the service, package descriptor (build scripts included) and the pipeline script. This approach can be seen on Figure 2.

4.2 Utilization of VCS

Since the VCS repository handles the pipeline script along with the source code, any arbitrary snapshot (commit) of the repository in any time of its history should contain the pipeline script which executes exactly the same pipeline with exactly the same result any time.

4.3 Keeping job generator simple

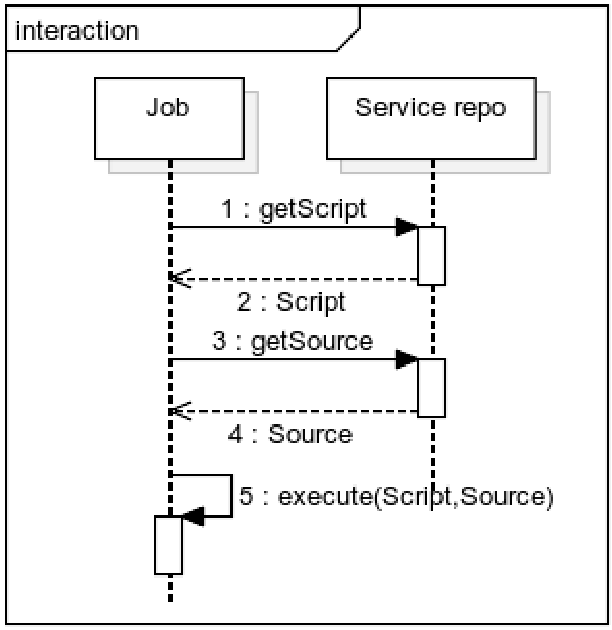

Figure 2: Sequence diagram of the single source of truth approach

This solution does not introduce the problem of difficult generator job but still carries the synchronization problem.

Pipeline scripts are being modified in multiple cases. There are cases which are not strictly drived by source code changes. Having the case of enriching the log of the pipeline script in order to leverage traceability of the process. This change is made only in the pipeline script and the side effects are present only on the pipeline script log. Has no side effect on the artifacts or test results. There are multiple open questions about which service VCS repository has to be updated first, which should be the subject of experimental changes and how to update all the other service pipeline script?

4.4 Automatized script updating

Addressing these questions, there is a pipeline script in the VCS repository but unlike the single pipeline script repository approach (see 3.2), the service build jobs are not referring to the script repository. There is a synchronization job introduced instead. The pipeline script synchronization job takes service name list as its arguments as the service build job generator job does. The pipeline script updater job has permission to update the service VCS repositories. To enforce traceability an issue id referencing an issue describing the change and its cause is recommended to be present in the commit message in all affected VCS repository. The figure 3 presents this workflow.

5. CONCLUSION

Microservices and nanoservices are popular software architectures. On the other, dealing with complex software development processes and many different development software tools, the maintenance can be a critical problem because of the combinatorical explosion.

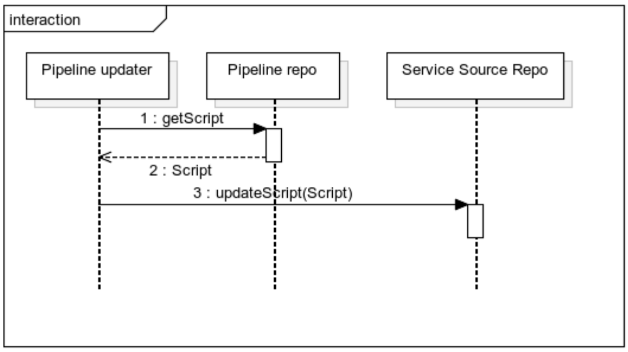

Figure 3: Sequence diagram of the proposed workflow

This solution holds some security concerns like the updater pipeline execute right has to be available for restricted group of users since the VCS enables Jenkins to commit to the master (trunk) branch.

The current prototype version is restricted to only one kind of services to upgrade their build pipeline. Enabling modular build scripts and their modular upgrade could be a next iteration. The bulk update problem could be derivated to a version controll system problem, updating common files in two or more repositories. In context of build systems like Jenkins (git) submodules could not be an optimal solution increasing complexity.

The proposed solution grants the robust script handling workflow allowing bulk pipeline script updates and replayability. It introduces some additional difficulty with the update process but it has been automatized. The approach reached a *single source of truth* state for each service artifact creation process and the refered source is the VCS repository which is a great tool to manage and observe the whole development of its content through time. The approach reduces the cost of maintaining pipeline scripts.

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Service Monitoring Agents for DevOps Dashboard Tool

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ABSTRACT

DevOps is an emerging approach that aims at the symbiosis of development, quality assurance and operations. Developers need feedback from the test executions that Continuous Integration servers support. On the other hand, developers need feedback from deployed application that is in production.

Recently, we are working on the dashboard tool which visualizes the runtime circumstances for the developers and architects. The tool requires runtime circumstances from the production environment. In this paper, we introduce our background mechanism which uses agents to retrieve runtime information and send it to our tool. We present many specific agents that we have developed for this software. Our approach deals with many useful services and tools, such as Docker and Tomcat.

Categories and Subject Descriptors

D.2.5 [**Software Engineering**]: Testing and Debugging; D.2.8 [**Software Engineering**]: Metrics

Keywords

Agents, Monitoring, DevOps

1. INTRODUCTION

DevOps is an emerging approach in modern software engineering. The key achievements of DevOps are comprehensive processes from building source to deployment, continuous synchronization of development and operations in order to make every new feature delivered to the end users. DevOps emphasizes the feedback from every phase.

DevOps-culture uses a wide range of software tools. Automation of build processes is essential solution for many years. Continuous Integration (CI) servers track the version control system if a change of the source has been commited [7]. In this case, the CI server (e.g. Jenkins [1]) starts the compilation process and executes the test cases and finally, sends report to the developers regarding the changes and their effects [6]. Deployment of the compiled application and its necessary dependencies can be launched in various infrastructures [4]. Virtual machines in cloud, Docker containers on a host take part in the deployment frequently [5]. Configuration management tools (e.g. Ansible) can execute specific code snippets for the deployment. Monitoring and logging of the started application is useful to detect every kind of runtime phenomenon and orchestrate the application seamlessly [3].

However, tools landscape is missing good tools which are able to present the runtime performance of applications in staging or production environment regarding the changes of the source code. We are working on a dashboard tool to visualize how the deployed application behaves in specific environment. Many typical use-cases can be mentioned. Does the memory consumption decrease when a feature's new implementation is deployed? Which commit may cause a memory leak, if it is suspicious. Does the introduction of a new feature or API cause increase in the number of end-users? How can one compare the performance of the system if the webserver or a database server is replaced?

For our dashboard tool, we have developed many tool-specific agents to report runtime perception. Our tool visualizes the reports come from agents. We have developed agents that deal with Docker, Tomcat webserver, etc. In this paper, we present our agent-based approach and illustrate some agents' internal high-level functions.

This paper is organized as follows. In section 2, we briefly present the main concept of our tool. After, we present our agent-based approach in a detailed way with some examples in section 3. Finally, this paper is concluded in section 4.

2. DASHBOARD TOOL

A safe software development requires control over the entire software development lifecycle (SDLC). During the development, it is essential to avoid memory leakage, or overuse of the CPUs. To get a good overview of the resource utilization engineers, DevOps engineers have to keep their eyes on these units that means they have to monitor their environments by using tools that can reflect the status of the different services, databases, network I/Os, or the amount of written/read blocks.

In this chapter, we would like to give a brief introduction about our Dashboard tool which can help developers to get metrics about their environments. Developers can declare new environments on the board and assign charts to them. A chart represents a single observable unit from the real environment. Metrics are provided by agents which run on the machine where the application is deployed. A continuously running agents send the gathered information back to the Listener. This way software and DevOps engineers can get an accurate picture immediately. A screenshot can be seen in Figure 1 about how a chart looks like.

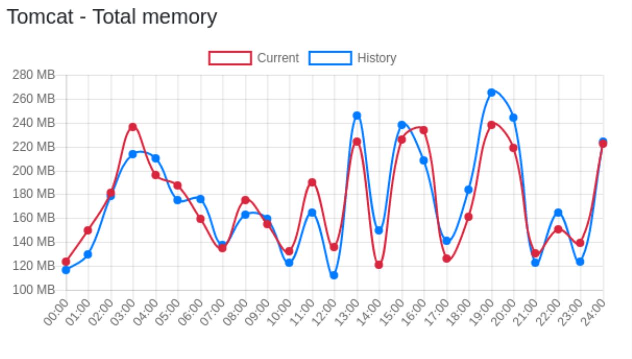

Figure 1: Memory consumption of a Tomcat instance

3. AGENTS IN OUR APPLICATION

In this section, we give a detailed view of how our agents work and what the main steps are that we kept in focus during the implementation. Before we go through the agents listed below, we would like to introduce system requirements. The target hosts are always based on Debian images, or any of its derivatives, like Ubuntu or Linux Mint. As we present later, we have strived to use as less dependencies as possible, like OS-related functionalities or commands. Most of the commands come with the basic OS, like `ps`, but some of the switches can be different on other OS, like `-eo` is Unix syntax, but using `axo` is acceptable on both Unix and BSD OS, as well.

The architecture consists of a server, the Listener and nodes which serve as hosts for the agents. In our solution, an agent is responsible for the following steps:

- After start, it runs endlessly
- Collects the information about the observed unit
- Transforms and if necessary aggregates the collected data
- Transfers the data towards the Listener server in JSON format

At first, we have to start the agent with an agent-specific sub-command and a configuration file which contains all the information that are necessary to observe the chosen unit (e.g. see Listing 1).

```
$ tomcat-agent start --file config.yml
```

Listing 1: Launching the agent

When it starts running, it validates the arguments and then parse and validates the file against the expected configuration settings that are required to the unit. Then it starts monitoring and collecting metrics in a specified time period. Beside these steps, an agent also has minor characteristics, like

- Runs as a daemon
- Validates the configuration file to have proper keys
- Validates the values in the configuration yml file
- Checks whether the related OS-level dependencies exist
- Transfers the collected metric to JSON

Beside these steps, an agent also has minor characteristics. It runs as a daemon. It checks whether the related OS-level dependencies exist. It transfers the collected metric in JSON.

All agents require a file that contains specific information for the observed unit, as well as, parameter for the connection to the Listener. One file can be used by many agents, and one file can contain configurations for multiple observed units.

Here we detail some of the agents mechanism, how they work and what information we can get from the unit.

3.1 Tomcat

Tomcat is one of the most popular and widely-used application server among Java developers. It provides a simple dashboard-like landing page where software and DevOps engineers can manage the deployed packages. Via this page those users, who are dedicated to enter the server, can check the state of their applications. This can be a simple health-check, the number of threads or how much memory is available for Tomcat to allocate more space for the applications.

The tomcat agent monitors both the inside status page and the process itself as well. In the configuration file (see Listing 2), DevOps engineer has to declare specific parameters.

```
uri: 'localhost'
port: 8080
username: 'admin'
password: 'admin'
pid: 24567
```

Listing 2: Agent configuration file example

If `pid` is not available, agent monitors the inside status page only. An example metric that the agent is intended to send towards the Listener can be seen in Listing 3.

```
{
  "status": {
    "jvm": {
      "memory": {
        "free": 2335645,
        "total": 88234123,
        "max": 2453422
      }
    },
    "connector": {
      "requestInfo": {
        "maxTime": 12,
        ...
      },
      "threadInfo": {
```

```
        "maxThreads": 1,
        "currentThreadCount": 1,
        "currentThreadBusy": 0
      }
    }
  }
}
```

Listing 3: Example metric sent by the tomcat agent

3.2 Docker

Containerization is new directive in virtualization: this lightweight approach supports operating system-based isolation among different pieces of the application. Containerization is on the crest of a wave since Docker has been developed. Docker provides a systematic way to automate the fast deployment of Linux applications inside portable containers [2].

The name of docker is basically almost equivalent of *container* for most of the engineers. Docker, just like Tomcat, provides a calculation on how much memory it consumes or what the total bytes of the received and transmitted data is over the network for each container. These are the *stats*. Without declaring any specific container name in the config file, the agent sends information about all the containers at the same time that are shown up in the stats. An example message can be seen in Listing 4.


```
{
  "containers" : [
    {
      "pid": 38,
      "name" : 'jingle_bell',
      "cpu" : 1.86,
      "mem": {
        "usage": "168.2M",
        "limit": "15.43G",
        "percentage": 1.06
      },
      ...
    }
  ]
}
```


Listing 4: JSON message example sent by agent

3.3 Log

One of the most important mirror of the status of an application is its logs. It could contain all the steps that an execution takes and provide those steps in different granularity.

The two main approaches in case of this agent are, first, get the last n messages from the log and forward it to the Listener, and second, get the number of the different severity levels. The earlier can provide a view of the latest messages, which is a talkative information based on the error or exception messages raised in the code. The latter one can show the ratio of the different levels giving a clear overview how much warnings or errors get hit during the execution. To get these two metrics we mentioned above, engineers have to use such a configuration seen in Listing 5.

```
...
path: '/logs'
file: 'observed'
format: 'SEVERITY||'
number_of_lines: 10
```

Listing 5: Example configuration for the log agent

The `path` tag is responsible for the path of the folder which is considered as a log folder and `file` is the observed unit. To distinguish an *ERROR* leveled message from other messages that contains the word *error*, engineers have to declare the format of the log. The last key is responsible for the number fetched and forwarded messages. A sent message example sent can be seen in Listing 6.


```
{
  "lines": ["..."],
  "severity": {
    "info": 655,
    "warning": 848,
    "error": 2,
    "fatal": 0
  }
}
```


Listing 6: JSON message example sent by the log collection agent

Since an agent is run on a machine by an arbitrary user, the software, DevOps and test engineers have to take care that the observed log can be any file depends on the privileges of the user.

3.4 Host Machine

The host machine which the agent is executed on, can be a real machine, a virtual machine or a container whether it is on local or on remote. Whichever the host machine is, from the agent perspective they are the same. From inside out it seems that machine has memory, CPU (or GPU), hard disk and other resources. These resources are reachable for the agents that means agents can use them. Having a picture about the usage and consumption of these resources are essential.

With this agent, we can monitor the above-mentioned resources and gather their metrics. These metrics are cumulated, agent takes, for example the total memory, the total swap memory or the size of the available space on the hard disk, regardless which processes use them.

Here we would like to give a view which metrics are taken during the agent's execution. We arranged the resources into three groups. All the metrics belong to the *memory*, or *CPU*, or *disk storage* (volume).

3.4.1 Memory

Memory has multiple parts from total to used to swap. To get an accurate picture about the consumption we use, multiple commands that can help calculating the usage of the different parts. The agent uses `free` (see Listing 7), `/proc/meminfo` and the `vmstat` commands to get metrics about the memory (see Listing 8). All of them provide information about how much total memory is in that host, what the size of the cached swap or how much memory is free or how much is available for allocating new processes.

```
$ free -m
```

```
      total  used  free ...
Mem:  15802  5485  5707 ...
Swap:  2047     0  2047
```

Listing 7: Using the free command

```
{
  "Mem": {
    "total": 15802,
    "used": 5485,
    "free": 5707,
    "shared": 2088,
    "buff/cache": 4609,
    "available": 7894
  },
  "Swap": {
    "total": 2047,
    "used": 0,
    "free": 2047
  }
}
```

Listing 8: Sent message about memory consumption

3.4.2 CPU

There are plenty of tools that provide the opportunity to monitor the usage of the CPU. Some of them are part of the default OS, then the rest come as a third-party tool and require installation with privileges. We took the focus on those tools that are part of the OS, or used in wide range, like `vmstat`, or `iostat` (see Listing 9). Both tools can provide a picture of the CPU utilization in percentage.

```
$iostat -c
Linux 4.15.0-32-generic 2018-08-25 _x86_64_ (8 CPU)

avg-cpu: %user %nice %system %iowait %steal %idle
         24,97  0,03    6,07    0,03   0,00 68,90
```

Listing 9: Using the iostat command

The agent sends the above information towards the Listener as it seen in Listing 10.

```
{
  "user": 24.97,
  "nice": 0.03,
  "system": 6.07,
  "iowait": 0.03,
  "steal": 0.00,
  "idle": 68.9
}
```

Listing 10: Sent JSON message about CPU usage

3.4.3 Volume

Volume usage does not belong to the major metrics of the previously mentioned three units. Though it can tell useful information about a running application. To get a metric about the volume agent uses `df` (see Listing 11) and `du` commands. Both of them are responsible for giving a view of how much space is taken by a folder or how the size of the local storage changes. Moreover, agent can be parameterized. It takes the path to the observed folder or partition of the storage of type of the disk. The agent sends aggregated information as it seen in Listing 12.

```
$ df -t ext4
Filesystem     1K-blocks     Used Available Use% Mounted on
/dev/nvme0n1p5 120462064 77259492  37040396  68% /
```

Listing 11: Using the df command

```
{
  "filesystem": "/dev/nvme0n1p5",
  "1k_blocks": 120462064,
  "used": 77259492,
  "available": 37040396,
  "use": 68,
  "mounted_on": "/"
}
```

Listing 12: Sent JSON message about volume usage

4. CONCLUSION

DevOps is an emerging approach that aims at the symbiosis of development, quality assurance and operations. Developers need feedback from the test executions that CI servers support. On the other hand, no tools have been created that support feedback from the production enviroment to the developers to follow up the code changes and its effect on the end-users and the production or the staging environment.

In this paper, we argue for a new tools into the DevOps toolset. The aim of this tool is retriving and visualizing the runtime circumstances of deployed application because this information can be essential for the developers and architects. For this tool, we have developed many agents to collect the runtime performance information from specific services. In this paper, we presented the mechanism of some specific agents in Linux environment.

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Incremental Parsing of Large Legacy C/C++ Software

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ABSTRACT

CodeCompass is an open source project intended to support code comprehension by providing textual information, source code metrics, version control information and visualization views of the file and directory level relations for the analyzed project. Regarding the typical software development methodologies (especially the agile ones), only a smaller portion of the code base is affected by any change during a shorter amount of time (e.g. between nightly builds), therefore parsing the entire project each time is unnecessary and expensive. A newly introduced feature, incremental parsing is intended to solve this problem by only processing files that have been recently changed and leaving the rest alone. This is achieved by the maintenance of the project workspace database followed by the partial parsing of the project. The feature has been tested both on medium and large scale projects and proved to be an effective tool in CodeCompass.

Categories and Subject Descriptors

D.2.3 [**Software Engineering**]: Coding Tools and Techniques; D.3.4 [**Programming Languages**]: Processors

General Terms

Management, Languages

Keywords

code comprehension, software maintenance, static analysis, incremental parsing, C/C++ programming language

1. INTRODUCTION

One of the main tasks of a code comprehension software tool is to provide exact textual information and visualization views regarding the analyzed codebase to support the (newcomer) developers in understanding the source code. For an enterprise software under development this requires the frequent static reanalysis of the program, which could take several hours for a large legacy software.

Performing a complete static analysis each time is a significant waste of computational resources, since in most cases (e.g. between nightly builds) only a few percent of the file set has been affected by any change. In order to boost the parsing and compilation process and to provide richer user experience in integrated development environments (IDEs) [8], the concept of incremental parsing and compilation has been researched since decades. More recently further approaches, like the involvment of version control systems into incremental parsing [14] and the lazy analysis [10] have been studied. A great overview of pratical algorithms and the exsiting methodology is given by Tim A. Wagner in [13]. C/C++ language-specific compilation tools [12, 4] and programming environments [7] supporting incremental parsing have also emerged as an advancement.

CodeCompass [9] is an open source, scalable code comprehension tool developed by Ericsson Ltd. and the Eötvös Loránd University, Budapest to help understanding large legacy software systems. Its web user interface provides rich textual search and navigation functionalities and also a wide range of rule-based visualization features [5, 6]. The code comprehension capabilities of CodeCompass is not restricted to the existing code base, but important architectural information are also gained from the build system by processing the compilation database of the project [11]. The C/C++ static analyzer component is based on the LLVM/Clang parser [1] and stores the position and type information of specific AST nodes in the project workspace database together with further information collected during the parsing process (e.g. the relations between files). By introducing the concept of *incremental parsing* into CodeCompass we can detect the added, deleted or modified files in the program and carry out maintenance operations for the database of the code comprehension tool in only the required cases. Thus the required time of the reanalysis can be reduced by multiple magnitudes.

In this paper first we present our research in Section 2 on how we extended the static analytical capabilities of the CodeCompass code comprehension tool with incremental parsing. Then Section 3 demonstrates the usability of the concept by showcasing incremental parsing and measuring its performance on a medium and a large size C/C++ software. Finally, Section 4 concludes the results and discusses further research opportunities.

2. METHODOLOGY

A major consideration of the introduced incremental parsing feature was to integrate it seamlessly into the existing parsing process by not differentiating in how an initial or a follow-up incremental parse should be initiated. This was achieved by utilizing the *partial parsing* feature of CodeCompass, which means that the tool is capable of continuing a previously aborted analysis, by omitting the already parsed files which are present in workspace database.

Therefore the main concept of the introduced incremental parsing feature consists of two steps: *i*) perform a *database maintenance* operation, where the project workspace is restored into a state that *ii*) the existing *partial parsing* can finish the procedure.

2.1 Determining file states

When a new parse is being done in incremental mode, the state of each file is determined first. Let F_{DB} be the file set stored in the workspace database and F_{DISK} be the file set stored on the disk. An $f \in F_{DB} \cup F_{DISK}$ file may take one of the three states listed as follows.

Added files f is added to the project since the latest parse if $f \in F_{DISK}$ but $f \notin F_{DB}$.

Deleted files f is deleted from the project if $f \in F_{DB}$ but $f \notin F_{DISK}$.

Modified files f is modified when $f \in F_{DB} \cap F_{DISK}$ at the time of the new parse but its content has changed since the latest. This can be determined by comparing the contents that are stored in the database and on the disk, or by their respective hashes for performance optimization.

2.2 Header inclusion traversal

Specifically when parsing a C or C++ language project, changes in header inclusions provide one more challenge to tackle. Upon the modification of a header file all further files in the inclusion chain depending on it should be considered as modified, even without containing any direct changes themselves. Therefore when determining the *modified* state of a file as defined in Section 2.1, the set of files defined by the header inclusion relationships transitively should be checked for changes. There are two approaches for this, as described below and shown in Figure 1.

Definition 1. For files a, b and c, given that a is included by b and b is included by c, we say that file a is in an upward connection with b and accordingly file c is in a downward connection with b.

Upward traversal model The upward traversal model depends on the upward connection between files. When resolving the state of file a, its included headers have to be checked for modifications transitively.

Downward traversal model Similarly, the downward traversal model uses the downward connections that can be found between files. If a file a is resolved as modified, all files that include a can be marked as modified transitively. Note that with this method, the state of any marked files can be considered final and can be omitted from further inspections.

THEOREM 1. *The downward traversal model has better computational complexity over the upward traversal model, and therefore is preferred to be used through the incremental parsing.*

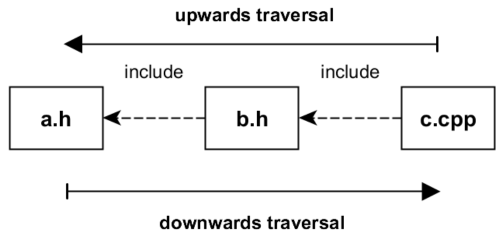

Figure 1: Traversal directions

PROOF. Let $G = (V, W, E)$ be the directed acyclic graph (DAG) of header inclusions with V containing the file set as vertices and E being the set of upward connections, $n := |V|$, $e := |E|$. Let $W \subseteq V$ denote the set of directly changed files, $k := |W|$.

Let $N_G(v)$ be the neighborhood file set of vertex v in G, so $w \in N_G(v) \Leftrightarrow (v, w) \in E$. Therefore for a file v we can define the directly included file set as $N_G(v)$ and the includer files of v as $N_{G^T}(v)$, where G^T is the transpose graph of G.

We define $up(G, v)$ and $down(G, v)$ as the file set result of the upward and downward traversal for $v \in V$ in G by the corresponding traversal model, as formally described below:

$$up(G, v) = \{v\} \cup \forall_{w \in N_G(v)} : up(G, w) \quad (1)$$

$$down(G, v) = \{v\} \cup \forall_{w \in N_{G^T}(v)} : down(G, w) \quad (2)$$

As a simplification in our model lets assume a uniform distribution of header inclusions among the files. Since $\sum_{v \in V} deg^+(v) = \sum_{v \in V} deg^-(v) = e$, the average in-degree and out-degree for a file v is $deg^+(v) = deg^-(v) = \frac{e}{n}$, which will be denoted with d henceforth. As a consequence the length of the longest path in G is $log_d n$, which is the length of the longest header inclusion chain in the project, since G was defined as a DAG.

Therefore the asymptotic tight bound both for $up(G, v)$ and $down(G, v)$ can be calculated as:

$$\Theta(up(G, v)) = \Theta(down(G, v)) = d^{log_d n} = n \quad (3)$$

We define $up(G)$ and $down(G)$ as the upward and downward traversal algorithms which determines indirectly changed files in V through header inclusions from W by the corresponding traversal model. We define the computational complexity of the algorithms as the number of files checked for changes in their content (or by their hash). Based on Equation 3, the asymptotic tight bound both for $up(G)$ and $down(G)$ can be calculated as:

$$\Theta(up(G)) = \sum_{v \in V} \Theta(up(G, v)) = n^2 \quad (4)$$

$$\Theta(down(G)) = \sum_{w \in W} \Theta(down(G, w)) = k * n \quad (5)$$

Since $k \leq n$ and in a typical use case for incremental parsing $k \ll n$: $\Theta(down(G)) < \Theta(up(G))$. $\square$

An example for the downward traversal model is showcased in Figure 2. On the left side of the figure the example file set is shown with header inclusion dependencies denoted as arrows between them. Directly modified files are marked with a dark background, while files requiring expansion through traversal to find indirectly changed files are marked with an italic font. Note, that these two categories are equivalent in the initial stage. On the right side of the figure the effects of downward traversing `a.h` is demonstrated: files `c.h`, `d.h`, `f.cpp` and `g.cpp` are also detected as indirectly changed files. While `c.h` was also a directly modified file, observe that it no longer requires downward traversal.

2.3 Database maintenance

As mentioned above, incremental parsing includes some maintenance of the existing database depending on the state of changed files.

1. *Added files* are perceived as new files to the project and therefore are registered into the database.
2. *Deleted files* need to be purged from the database as they have been removed from the project.
3. *Modified files* are handled as if they were a combination of deleted and added files. First, they are completely wiped out from the database – meaning that all their AST related information and file level relations are erased –, thus considering them deleted, then re-registered like newly added files. Directory level relations are not sufficiently maintainable, but these relations can be effectively computed runtime, on-demand from the file level relations.

3. EXPERIMENTAL RESULTS

The go-to projects on which CodeCompass is usually tested are the Xerces-C++ [3] and LLVM [2] projects. Both are open source projects that have been under development for several years and therefore are considered legacy projects. Incremental parsing was also tested on these two as Xerces-C++ is a medium size and LLVM is a large-scale project and contain enough files (respectively 347 and 2845) to produce a significant difference in runtime between even small portions of changes in the number of files.

Incremental parsing is aimed to reduce the parsing time of builds, especially nightly builds, therefore it was tested on 1, 5 and 10 percent change of the file set, since no bigger difference between two builds is presumable. The changeset was generated automatically by random selection of files.[1] Table 1 shows the results for Xerces-C++, while Table 2 and Table 3 depict the results for LLVM. All measurements were carried out on a standard notebook computer, parsing on 2 processor cores.

In order to keep database consistency in case of a graceful abort or unexpected termination of the parser module, the basic concept is that the maintenance operation of incremental parsing must be performed in a transactional mode, in one of the following ways:

[1]Only leaf nodes from graph G introduced in Section 2.2 were included in the changeset, so header inclusions did not affect the number of changed files.

Table 1: Time measures for incremental parsing the Xerces-C++ project

Parse type	Changed files	Time
Full parse	–	2 min 49 sec
1% change	3	10 sec
5% change	17	21 sec
10% change	35	49 sec

Table 2: Time measures for incremental parsing the LLVM project by one atomic transaction

Parse type	Changed files	Time
Full parse	–	5 h 46 min
1% change	28	7 min 30 sec
5% change	142	1 h 58 min
10% change	284	2 h 45 min

- Carry out all deletions from the database in one *single transaction*, so the maintenance is either completely executed, otherwise no changes are performed.
- Generate multiple *file level transactions*, so information regarding a file is either cleaned from the database or the file is untouched, therefore a consistent state of the database is always kept.

Table 2 and Table 3 compare the differences when the database maintenance is executed through a single and by file level transactions. It is clear that the extensive size of the database rollback log containing all the deletion operations for a larger quantity of files can significantly hinder the effectiveness of incremental parsing, providing significant difference in the timespan of incremental parsing for large size projects like LLVM. Hence while a single transaction may provide stronger guarantees, file level transaction proved to be a more adequate solution, where the required time is more or less linear with the quantity of parsed files, depending on the length and content of the files in question.

Table 3: Time measures of incremental parsing the LLVM project by file level transactions

Parse type	Changed files	Time
1% change	28	9 min 30 sec
5% change	142	49 min
10% change	284	1 h 21 min

4. CONCLUSIONS

Incremental parsing was introduced into CodeCompass to reduce the costs of parsing, both time and computational resources, by omitting unchanged files in the project. The feature distinguishes added, deleted and modified files and handles them accordingly. The early tests of incremental parsing were run on the Xerces-C++ and LLVM projects and showed that it works according to its original purpose, especially in decreasing the timespan of parsing. While the results are promising, further challenges include the improved reduction of the timespan required by incremental parsing through parallelizing the process.

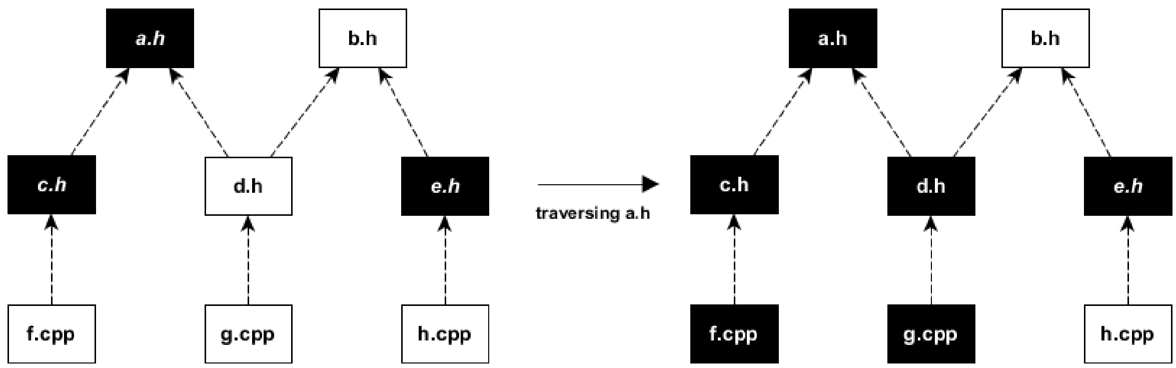

Figure 2: Downward traversing of *a.h* demonstrated on a showcase file set.

5. ACKNOWLEDGMENTS

This work is supported by the European Union, co-financed by the European Social Fund (EFOP-3.6.3-VEKOP-16-2017-00002).

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Visualising Compiler-generated Special Member Functions of C++ Types

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ABSTRACT

In the C++ programming language, special member functions are either user-defined or automatically generated by the compiler. The detailed rules for when and how these methods are generated are complex and many times surprise developers. As generated functions never appear in the source code it is challenging to comprehend them. For a better understanding of the details under the hood, we provide a visualisation method which presents generated special functions in the form of C++ source code that in effect identical to their implicit versions.

CCS CONCEPTS

• **Software and its engineering** → **Source code generation**; **Software maintenance tools**; • **Human-centered computing** → *Information visualization*;

GENERAL TERMS

programming languages, software development, visualisation

KEYWORDS

C++ programming language, compilers, code comprehension, code design

1 MOTIVATION

Languages supporting the Object-oriented programming (OOP) paradigm define a central principle of object *lifetime* which is surrounded by construction/initialisation and destruction/finalisation. In the **Java** programming language, apart from the basic default construction – where everything is initialised to the respective zero value – the developer must explicitly state their intent for different construction logic, custom finalisation. A special case is when a new object is created from an already existing one, where deep copy (*clone*) operations or conversions might be warranted. In **C++**, however, the Language Standard specifies that these aforementioned actions, in the form of *special member functions* [8], should have a default implementation automatically generated by the compiler if the user does not explicitly write them. The rules which dictate the conditions for generating the special member functions and their behaviour can appear dauntingly complex, and subsequent versions of the language standard may revise and elaborate these rules, increasing their complexity. The most recent, and most significant such change was with the release of the *C++11* standard, which introduced *move semantics* [9].

Modernising code initially written for an older standard can be cumbersome as the behaviour of special members are never directly expressed, yet relied upon by the most trivial codes. What's more, the compiler is free to lazily evaluate the generation of these members, which results in one such member's non-availability to only be reported when its usage was attempted. In case the used software library is outdated or not easily modifiable, or not open source, this can result in loss of run-time performance or development effort wasted on having to redesign parts of the software. For discovery and understanding of the existence and behaviour of these methods, developers can either consult the Language Standard, read Abstract Syntax Trees (ASTs), or view the disassembly of the binary — none of which is favourable for the average developer.

```
#include <iostream>
struct A { int x };
int main() {
  A a1;       // <- Default constructor called.
  a1.x = 5;
  A a2(a1);  // <- Copy constructor called.
  a1.x = 6;

  // Will print "6 5".
  std::cout << a1.x << " " << a2.x;
}
```

Listing 1: Example code which uses a default and a copy constructor.

To aid ongoing development and code comprehension of projects we introduced a tool that allows pretty-printing the visual representation of special member functions that is the closest to how they would be written by developers. To further this aid, we don't only show the compiler-generated special members, but provide a subset of the type's all member functions which shows both user-written – e.g. a constructor that initialises from a different data type – and the standard, implicit ones. We used the open source LLVM/Clang Compiler Infrastructure [16] for parsing and generation.

The rest of the paper is organised as follows. In Section 2 we discuss the purpose and rules of C++ special member functions. Then, Section 3 describes the implementation approach and challenges faced with respect to pretty-printing and presentation to the developers. The paper concludes in Section 4.

2 C++ SPECIAL MEMBER FUNCTIONS

Special member functions in C++ denote the functions that are necessary for the management of instances' lifetime. [12] These are the *constructors*, the *assignment operator* and the *destructor*.

2.1 Constructors

Constructors are responsible for the initialisation of an object. They are usually executed together with the memory allocation for the instance. Unless the user specifies and provides any constructor function, both C++ and Java will generate a *default constructor*. In Java, this function initialises every data member to their respective zero value, such as integer `0`, rational `0.0`, the `\0` character, or a `null` reference. In C++, the initial state of the members depend on the storage scope of the object – in most cases, the memory garbage is retained from the memory block where the object is allocated. Unlike Java, however, the default constructor is not created if at least one data member does not have a default constructor.

Another case of construction is when a new object is initialised from the state of another, already living object of the same type. In Java, this functionality can be achieved in multiple ways, one of which is by using the special `clone()` function. This function is defined in `Object`, and performs a *shallow copy* of the instance in question, only initialising the new object's members to the same value of the cloned one [4, 11]. In case of references to other objects results in *aliasing*, the sharing of the same resource – usually an internal buffer – by two separate entities. Another problem with `clone()` is that the existence of the cloneability marker and the respective method must exist through the whole chain of the type hierarchy – it is usually referred to as an epidemic [10]. What's more, cloning does not actually invoke a construction, but rather creates a copy of the memory's snapshot, which means that business logic strictly bound to a constructor, such as initialisation of read-only members, cannot be done. In C++, the default behaviour of the copy constructor is to run the copy construction of every data member. For fundamental types, this means a copy of the value, and for more complex types their respective copy constructors are called. Thus, in case a custom resource which can be properly deep-copied is used the copy constructor that is generated for the object using this resource will be sufficient.

2.2 Destructor

The destructor or finalise is called at the end of an instance's lifetime and is responsible for tearing down the state of the instance. This most commonly means releasing resources, performing cleanup tasks and committing changes, e.g. to a database. In Java, the `finalize()` method's implementation is run for an object at an unspecified point in time when the runtime's garbage collector decides that the object is to be reaped. [3] The behaviour differences between Java Virtual Machine versions and the general looming of a finalisation never happening for an instance resulted in a consensus on not using `finalize()` – it has also been deprecated since Java 9. Instead, the *AutoCloseable* design pattern is used that explicitly requires writing a `close()` method which executes teardown logic, but can be called arbitrarily by the developers when teardown is deemed necessary, such as at the end of finishing a database operation. In C++, a destructor can be written by the user or is automatically generated by the compiler. It is always executed immediately when an instance's lifetime ends. The generated destructor does nothing in its body, and then the destructor of each data member is executed individually – as their lifetimes also expired. Thus an implicit destructor always exists unless a data member's destructor is explicitly hidden – this is a common practice for scenarios where a controller has to ensure an orderly or batch destruction.

2.3 Assignment operators

Contrary to Java, where there exists only primitive types and references, C++ is a language with value semantics. Assigning to a reference in Java only results in the actual memory modification of a memory address' size. The object that is no longer referred by the assigned-away reference is then left for garbage collection, if applicable. In C++, however, this means that assigning an object to another object of the same type results in the *assigned-to* object having the *assigned* object's state's copy within its own memory region. Traditionally, *copy assignment operators* have a "destructor" part where the current object's resources and buffers are released, and then a "copy constructor"-like logic where the copy of state takes place, however, the developer is free to choose a different implementation. The compiler-generated copy assignment operator implements a memberwise copy assignment for the entire object. Thus, the copy assignment operator is not generated by the compiler due to type infeasibility if one of the data members cannot be copy-assigned.

It is noteworthy to mention that not every language has defined the = assignment operator as an operator: in some languages, such as Ada or Pascal, assignment is defined as a statement/instruction, rather than an operator application. This has led to the inability to write copy assignment logic in Ada. To avoid use of assignment on types that are not designed for memberwise copy the `limited` keyword [18] and type-annotation is used.

In C++ it is commonly referred as *The Rule of Three* that if any of the copy constructor, copy assignment operator, and destructor is written explicitly by the developer, all of them should be written explicitly. This rule of thumb is not enforced by compilers but considered a good practice, because, as discussed earlier, explicitly specifying either will not stop the compiler from automatically creating the implicit definitions of the other special member functions.

2.4 Members for move semantics

The release of the C++11 Language Specification has introduced *move semantics*, which allows resources to be directly "stolen" by a variable from another, as opposed to a copy-constructed and the original data's memory destroyed. [13] This is used heavily with temporary objects which would get destroyed in the next statement. The move special members' default implementation executes a *move construction* or *move assignment* of every data member, however, the rules for their existence are more exquisite. Move members are not generated automatically if any explicit destructor, copy or move member exists, and an explicitly defined move member also turns off the automatic generation of copy members.

Accordingly, the Rule of Three has been extended to also include the two move members, and is referred to as *The Rule of Five*.

3 IMPLEMENTATION

3.1 Syntax transliteration

We used the open source LLVM/Clang Compiler Infrastructure for parsing and generation of special member visualisations because Clang's object-oriented *Abstract Syntax Tree* (AST) API allows for an optimised and maintainable application. An example subtree of the AST corresponding to the source code in Listing 1 can be seen in Listing 2. The *copy constructor*'s body corresponds to copying the right-hand record's single data member into the current record's corresponding data member.

```
CXXConstructorDecl </tmp/main.cpp:3:8>
|   implicit used constexpr A void
|   (const struct A &) noexcept inline
|-ParmVarDecl 20f90c0 used const struct A &
|-CXXCtorInitializer Field x int
| └-ImplicitCastExpr int <LValueToRValue>
|   └-MemberExpr const int lvalue .x
|     └-DeclRefExpr const struct A
|         lvalue ParmVar 20f90c0 ''
|         const struct A &
└-CompoundStmt

CXXConstructExpr <col:7, col:11> struct A
    void (const struct A &) noexcept
```

Listing 2: The Clang *AST* representation of the implicit copy constructor's body, and the call to it in `main()`.

Other compilers, might use different internal representations, on which these transformations would be infeasible to execute – in case of GNU/GCC, the *Register Transfer Language* (RTL) is only meant to be used by compiler-internal applications and code generation is organised into various steps called *loops*. The example of the same copy construction can be seen in Listing 3, which has already been stripped of semantic information and only the memory access for the data member can be studied from it by humans. It should be noted that the presented representation is the earliest and shortest where copy construction is apparent on the inner data member level. Previous transformation loops only show the copy constructor's call source line in it's original form, i.e. `A a2(a1);`.

```
(insn 7 6 8 2
  (set (mem/c:SI (plus:DI (reg/f:DI 82
        virtual-stack-vars)
     (const_int -8 [0xfffffffffffffff8]))
       [1 a2+0 S4 A64])
  (reg:SI 91)) "/tmp/main.cpp":6 -1
(nil))
```

Listing 3: The GNU *RTL* of the copy constructor call in line 9 of Listing 1.

We have utilised Clang's architecture to perform a parsing on the translation unit, and then performed a traversal on the built AST searching for all records, or a particular record with a name specified by the user. Once the record is found, we visit every special member's body, and in the case of constructors their *initialiser lists* [5] too. The AST nodes found in the subtrees of these nodes are then manually converted into a textual, source code representation.

```
struct A {
  A() {} // The default constructor.
  // The copy constructor.
  A(const A & rhs) : x(rhs.x) {}
};
```

Listing 4: The special members of the example class in Listing 1 translated back to source text.

There are three interesting cases that need to be noted, where explicit source code differs from what a compiler generates for itself automatically. First of all, the compiler generates the implicit members' arguments without an argument name. One such example can be seen in Listing 2, where the `ParmVarDecl` (parameter variable declaration) has no name, and the initialiser's `DeclRefExpr` (declaration reference expression) only refers to this `ParmVarDecl` by its memory address, `20f90c0`. Such a construct cannot exist in actual source code. As a remedy, we manually assign the name `rhs` to the variable – or in case multiple parameters would be possible, number them as `arg_1`, `arg_2`, … – and use it in the pretty-printed code.

Another such interesting case is about move constructors and move assignment operators, namely that the compiler generates the argument as a temporary, an *xvalue*, from which move operations can be done. However, `T&& rhs` written in source code specifies a named variable, an *lvalue*, from whose members move must explicitly be specified by using a type annotation `std::move`, which casts the members to be *xvalue*s which denote variables that are essentially transformed into a temporary and their resources can be *moved from*. The pretty-printer annotates the right-hand sides of move initialiser or assignment expressions with `std::move` to ensure the same semantics. We only do this for record types, as no fundamental type supports move operations.

The third case is with regards to inheritance. In case a class has at least one superclass, the special members' default behaviour is to cast the current instance to the base class and call the appropriate constructor or assignment operator for each base class. A core principle in object-oriented programming is that *up-casting* – cast to any base class – is always possible and well-defined, however, this would result in unintelligible source code lines, such as `*this = rhs;` – which would lead to an infinite recursion if written in source code verbatim. The type system allows us to see that this = is for the base class, so we explicitly wrap the statement into a cast at the appropriate location to show base class initialisation to the developer. Examples of these cases are depicted in Figure 1.

We have encountered that the Standard only specifies generating a body for a special member if the currently compiled translation unit *ODR-uses* [7] the function. While no compiler error is given at compilation for an infeasible, *implicit deleted* special member unless used, the type system in Clang annotates the forward declaration of the function if it is deleted. Thus by using this annotation and the related diagnostics, we can, for each member without a body achieve either an explicit body generation or printing the reason behind the member being deleted by the type system in a single pass. It should be noted that generating the body for members which are

class Multiple

```
class Multiple : public D1, Base2
{

public:

Multiple()
  : D1()
  , Base2()
{
}

Multiple(const Multiple& rhs)
  : D1(static_cast<D1>(rhs))
  , Base2(static_cast<Base2>(rhs))
  , fooBar(rhs.fooBar)
{
}

Multiple(Multiple&& rhs)
  : D1(std::move(static_cast<D1>(rhs)))
  , Base2(std::move(static_cast<Base2>(rhs)))
  , fooBar(rhs.fooBar)
{
}

Multiple& operator=(const Multiple& rhs)
{
  static_cast<D1>(*this) = static_cast<D1>(rhs);
  static_cast<Base2>(*this) = static_cast<Base2>(rhs);
  fooBar = rhs.fooBar;
  return *this;
}

Multiple& operator=(Multiple&& rhs)
{
  static_cast<D1>(*this) = std::move(static_cast<D1>(rhs));
  static_cast<Base2>(*this) = std::move(static_cast<Base2>(rhs));
  fooBar = rhs.fooBar;
  return *this;
}

~Multiple();


};
```

Figure 1: Special member overview for a class with two base classes and a single `char` data member.

allowed to have one, and it is only an optimisation that generation didn't take place is a non-functional change and does not affect the semantics of the generated code – thus this transformation can safely be integrated into other compilation steps.

3.2 Special member overview

To facilitate better code comprehension, we have decided not only to show the implicit special members but every related overload of constructors and assignment operators. This allowed us to show a subset of the class' members which are related to the instance's lifetime.

The full overview proves useful when a special member is *defaulted*. If for example, a class contains some constructors and a user-defined copy constructor, the move members will not be generated automatically, however, the developer can explicitly ask the compiler to generate the methods with the implicit body rules by using the `= default` specifier, available in *C++11* and onwards. This is the suggested approach for modern C++, practised by most open-source projects. In this case, we show these members' body along with the rest of the class with the annotation that the user requested the body generation.

Another case for the full view is showing the reason why a special member was not automatically generated by printing a hint from the semantic analysis' diagnostics.

4 CONCLUSION

In this paper, we have discussed the rules and behaviour of automatically generated special member functions, an intrinsic feature of the C++ programming language. We have introduced an approach to transliterate the compiler's internal representation of these special members to source text to promote understanding of software projects without resorting to unfavourable techniques such as reading syntax trees manually.

We have implemented our solution in the open-source code comprehension tool CodeCompass [1, 14, 15] — `http://github.com/Ericsson/CodeCompass` — as an additional visualisation over C++ files. The upstreaming of this addition is underway at the writing of this paper.

ACKNOWLEDGMENTS

This work presented in this paper was supported by the European Union, co-financed by the European Social Fund in project EFOP-3.6.3-VEKOP-16-2017-00002.

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How Does an Integration with VCS Affect SSQSA?

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ABSTRACT
Contemporary trends in software development almost necessarily involve version control system (VCS) for storing and manipulation of source code and other artifacts. Consequently, tools supporting the development process such are software analysis tools integrate with VCS. In most of cases tools support only analysis of the resources in VCS repositories, while some of them rely on VCS to improve analysis process and results. In this paper we explore how an integration of the SSQSA platform with VCS influences some of its performances.

Categories and Subject Descriptors
D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*

Keywords
Software quality analysis, intermediate representation, Version Control System

1. INTRODUCTION
Quality of a software product is observed through the level of satisfied requirements. It could be assessed by its execution by applying different techniques of dynamic analysis. These techniques are applicable when the product is ready for testing which might be late to recognize weaknesses or issues. On the other side, static analysis techniques are traversing source code and its various intermediate representations which makes them applicable already in the early phases of software development process [5].

Contemporary software development practice relies on source code repositories and their synchronization implemented by various version control systems (VCS). VCS are used to store the whole history of activities in the evolution of a software product, from version information to the finest details about every individual change in the repository, including information about contributors to the changes.

Consequently, software analysis tools integrate support for VCS. Usually this support means possibility to analyze code stored to VCS repositories. In some cases tools also rely on advantages of VCS to improve analysis performances or results.

In this paper we explore potential advantages of integration of SSQSA (Set of Software Quality Static Analyzers) platform [9] with GIT [2] as a representative VCS. First, we introduce a concise background by describing VCS (Section 2) and SSQSA (Section 3). Prerequisites for the integration and the integration are described in the section 4. We discuss results in the section 5 and possible application models and scenarios in the Section 6, that is followed by comparison to related integration solutions (Section 7). We conclude the paper in the Section 8. This paper is summary of a master thesis described in [8] (in Serbian).

2. VERSION CONTROL SYSTEMS
Version control systems (VCS) might have very broad application in different areas of content manipulation for personal or professional purposes. These are tools used primarily to support teams and individuals in development and maintenance of a software products. These systems remember all the changes of separate files, so that at any time we can recover a specific version, or follow and compare changes over the time. In this way, all data is safer, good synchronization between the team members is ensured, the possibilities for errors are significantly reduced, and therefore the project development process is improved.

VCS are divided into two large groups [2]:

CVCS: Centralized Version Control System where all the data are stored to a centralized server. This approach is certainly easier to maintain, but in case of system failure, all information about the project will be lost. Additionally, availability of a network connection is very important. Previously, this was the standard way to execute version control. Representatives of this group are CVS: Concurrent Versions System [4] and Subversion [3].

DVCS: Distributed Version Control System where clients map the whole repository. If a server failure occurs, any of the client repositories can be copied back to the server to restore it. However, local copy enables us to work on changes independently of a network connection while

Property	Git	Mercurial
Simple GUI	-	+
Getting started for beginners	-	+
Simplicity branches visualization	-	+
Speed (Windows OS)	-	+
Speed online	+	-
Changing the history	+	+
Using the index	+	-
PL independent extensions	+	-
Repo. migrating to another system	+	-

Table 1: Comparison between Git and Mercurial

the connection is necessary only for saving changes at the remote repository or taking a version from it. Files stored on the hard disk are of small size, and hence this does not pose a problem problem of a storage space.

An additional advantage of DVCS is that we can share the changes with other team members before they are shared globally. On the other hand, there is little advantage of centralized systems compared to distributed ones. Centralized systems offer us an easier way to control all the people who access the server, as well as easy provision of a central point where all the changes are in place. They also offer us the option of downloading only a piece of code, if we only need to work on a project module. However, if needed, one copy of the project in the DVCS can be announces as the main one, and thus we can simulate the centralized system.

Distractions that can be addressed to distributed systems are more technical. For example, in case of a project with many large files that can not be compressed, more storage space is required. Additionally if we are working on a large project that contains many customized changes, downloading a full version of the project can take longer than expected, and also take up more space on the hard drive than expected.

All described differences bring to the decision to conduct the first experimental integration SSQSA platform with a DVCS. Therefore, we compare Git [2] and Mercurial [6] as the main representatives of DVCS in order to compare their properties to our requirements (Table 1). We can conclude that Mercurial has better characteristics from the users point of view, but for our integration these characteristics do not have value. On the other hand easiness to integrate with other systems, possibility to migrate to an other system and speed are extremely important to us. Therefore, in this work, we integrate SSQSA with Git.

3. THE SSQSA PLATFORM

The SSQSA (Set of Software Quality Static Analyzers) [9] is a set of tools that enables language independent static software product analysis based on its source code. Language independence is ensured by a universal intermediate representation of a source code called eCST (enriched Concrete Syntax Tree). Once when this representation is produced for any system, written in any set of programming languages, it can be transformed to some of derived intermediate representations such are dependency networks, at different abstraction levels, or flow graphs. The fact that derived representations are generated based on eCST, by a unique implementation of the derivation process, ensures their language independence and universality, too.

By traversing all or some of these universal intermediate representations different analysis algorithms are implemented. Therefore, it is possible to have a single implementation of every functionality that we integrate in the SSQSA which ensures consistency of the results across different languages, but also adaptability to a new language and extendability by a new analysis [9]. Described process and a corresponding platform design is illustrated by the Figure 1.

Current version of the SSQSA platform manipulates input source code from an local directory (components colored by gray color), while our primary goal in this research is to integrate it to analyze the code stored in a Git repository. Additionally, we will explore how usage of Git repository for storing intermediate representation affects SSQSA platform and its performances. This level of the integration will enable us to traverse only changed fragments of the structures, which might further lead to improvement of performances of the analyses. The first prototype includes only results of generation of eCST in the repository. New components that implement integration are yellow-colored in the Figure 1.

4. THE SSQSA AND GIT INTEGRATION

To enable collaboration of SSQSA with Git, it was necessary to connect eCSTGenerator to Git repository and to enable it to process the source code stored in it. After the first connection eCSTGenerator is processing the whole content of the repository and generates its eCST representation. Every next time, eCSTGenerator will process only changed files. This feature was not easily implementable before the integration with Git.

In addition, SSQSA uses advantages of its integration with Git at one more level. Namely, after the set of eCST is generated, it is stored to a Git repository so that other components can also process only changes between versions. For these purposes we do not use the same repository as it is a dedicated development repository, while developers do not have to be affected by the analysis.

5. RESULTS

To explore applicability aspects of the described integration solution, we measure time needed for generation of eCST representation of a JavaScript project "proton-native"[1].

First, we observe time needed only for generation of eCST representation of the source code from the local folder and compare it to the time needed to generate it for the code stored in a Git repository (Table 2).

As we can see, for the first commit generation process lasted for significantly longer time. The reason for this is time needed for the connection to the Git repository. However, even though process spends additional time on the connection, in later commits we get better results from the version integrated with Git.

[1] https://github.com/kusti8/proton-native

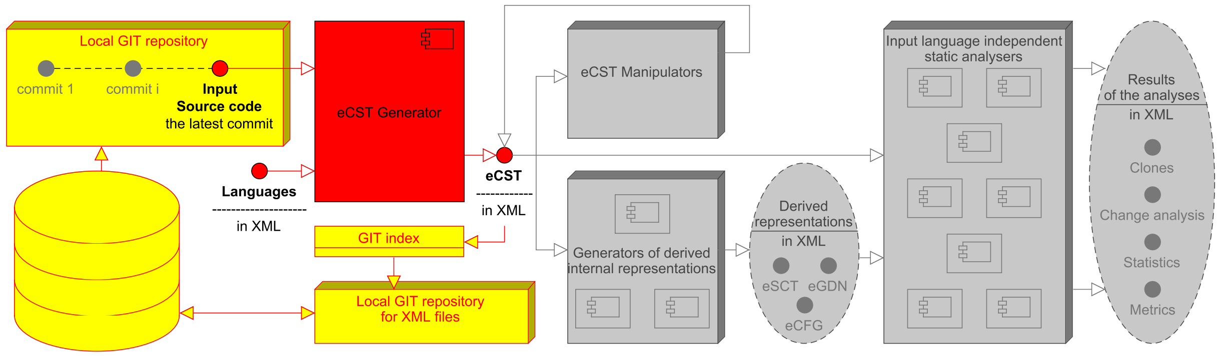

Figure 1: SSQSA platform and its integration with Git

Version no. of commit	from a local dir	from a Git repo	Time for the Git connection
7.	744 ms	1250 ms	720 ms
14.	812 ms	1270 ms	754 ms
34.	1589 ms	1353 ms	739 ms
80.	1601 ms	1520 ms	870 ms
126.	1650 ms	1515 ms	780 ms

Table 2: Comparison between time needed for eCST generation proccess from a local directory and from a Git repository.

Eventually, if we include functionality for committing of generated eCST to a repository, time needed for whole process goes over 6000ms. Obviously, in this scenario integration reduces performances of SSQSA. Still, further integration will utilize benefits of version control to improve generation of derived intermediate representations. Finally, it will be integrated with the analyzers. It can be expected that, with the growth of data that will be saved up in the exchange, traverse and analysis process, the benefits from the integration will also grow. Therefore, effects of the integration on other components still have to be explored (Section 8.

6. APPLICATION SCENARIOS

Depending on a scenario, Git has three common application models: a *centralized model*, a *pull-request model*, and *a Director and Lieutenants model*[2]. In a centralized system, all members of the team synchronize their changes in a central repository that stores all source code. In the pull-request model, developers can make changes to his local repository, and he commits them to his own repository, and can see the changes that other team members make. In this model one repository is considered the main repository. In order to accomplish the changes in it, a request is sent to the project leader to pull the changes. The project leader can add developer's repository as a remote repository, locally test changes, and if everything is fine, save them to the main repository. In a Director and Lieutenants model the project is divided into sub-projects and distributed among teams. Each team (sub-project) has its own repository and its leader, and usually works according to the pull-request model on the local level.

The most practical model for implementing a new implementation for the use of Git is the pull-request model. A project leader can start an eCST generator on a new repository commit to analyze the modified file. If a developer wants to create XML trees, it can also launch an eCST generator at each commit. The problem can arise if more teams are made and the eCST generation process is lunched then only. In this case it must be adapted to go through all the commits, not only looking at the latest changes.

The "Director and Lieutenant" model is also suitable for new implementation. Each sub-project has its own leader who can create XML trees. Also, the leader of the repository may generate eCST when joining new changes to a branch of a project (merge). Also, if developers want to generate XML trees, the same rules apply as with the Pull-Request model.

The centralized model is the most unpractical model for using the new implementation. All team members commit their changes to a centralized repository, which in this case contains a lot of commits through which traversal should be conducted.

7. RELATED SOLUTIONS

Many tools also support code analysis from various VCS such as BCH: Better Code Hub[2] and SonarQube[3], primarily because the repositories have become the standard code storage. However, only some tools rely on versions for more advanced analysis.

Lean Language Independent software analyzer (Lisa) is a software that analyzes the quality of software projects. The main goal of Lisa is to analyze a large number of project revisions asynchronously with minimal redundancy. Analyses are aimed to cover as many analyzes, and as many program-

[2]https://bettercodehub.com/
[3]https://www.sonarqube.org/

ming languages as possible. These goals are comparable with the goals of SSQSA, as well as the new implementation presented in this paper. However, Lisa currently supports three programming languages, while the SSQSA framework currently allows us to work with more than ten programming languages. Concerning the subject of this paper, We can note certain differences in the approach to the problem and the concrete solution implementation. For the needs of the Lisa analyzer, a special interface called SourceAgent has been developed. It supports the asynchronous access to the Git repository and file revisions [1]. On the other hand, SSQSA, with the current implementation, uses all the benefits of the Git and the library for interactions with it, looks at the differences between the last two committees, and reads all the files that have been changed, and generates XML trees for them. Furthermore, Lisa communicates directly with the Git repository by making a local copy of the remote repository to a local hard disk, while our implementation allows reading from a local disk and thus does not require an internet connection. Internet connection is only needed if we want to save the generated XML tree in a remote repository.

The Analizo is a solution that analyzes source code written in different programming languages, whose emphasis was on C, C ++ and Java. The analysis supports the reading of content from remote repositories for each audit in which the source code has been changed in the project [10] and, unlike the SSQSA which currently allows reading of contents only from the Git repository, allows reading from the Git and Subversion repositories, and then generates CSV files. SSQSA also compares file revisions and decides from which files to create an XML tree. An advantage over Analizo is that we can monitor file versions on a remote repository. Again, the difference is in the number of supported languages: Analyzo supports three languages, while SSQSA currently supports more than ten programming languages.

EvoJava is a tool for static code analysis of an input from a Java repository. It uses a VCS to access the code, mines the source repository, and calculates metrics. Unlike the SSQSA platform, EvoJava uses Subversion (SVN) and processes only *.java* files. The output file is also in .XML format, but containing metric results. EvoJava takes a list of the code versions that is in the repository and thus creates a model based on the XML-generated files [7]. SSQSA, on the other hand, observes the latest changes that are committed to a remote repository, finds these files in the file system and creates XML files based on them. Later it automatically commits them to a special local or remote repository, where we can track what changes were made during the evolution of our software. We cane also note the variety in supported programming languages in SSQSA while EvoJava only supports Java programming language.

8. CONCLUSION AND FUTURE WORK

Following actual trends in software development and software analysis SSQSA frameworks goes into a direction of integration with VCS. In this paper we compare characteristics of different VCS and select Git as a first candidate for the integration. Furtehr, we describe its integration with Git and explore possible benefits from this integration for the performances of the platform.

Integration is developed at two levels. At the first level the platform is connected to the Git repository in order to enable processing source code stored in it. At the next level of the integration we use Git repository to store XML file containing eCST intermediate representation of the source code so that we can always look only for changes, and not traverse all the code, or more precisely, eCST representation of it. This is very important if we have in mind that one input file (compilation unit) is represented by one eCST.

At the first look, the results of the integration are not promising. Namely, Git connection used the time that we can save by looking only in the changes and not in the whole source code. However, Without storing trees to the Git repository we are already saving some processing time. In case when we store eCST in a Git repository we are spending more time but in the future work we will explore if this cost may be payed off after extending this integration on generation of derived representations and analyzers. For example, generation of dependency network currently traverses all the trees while after the full integration with Git it will also look only for changes. The similar expectation we have from an integration of analyzers with Git. Therefore, these integration activities will be subject of the a future work, as well as analysis of potential costs and benefits, and selection of the most suitable usage scenarios.

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Zbornik 21. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2018

Zvezek I

Proceedings of the 21st International Multiconference

INFORMATION SOCIETY – IS 2018

Volume I

Delavnica za elektronsko in mobilno zdravje ter pametna mesta

Workshop Electronic and Mobile Health and Smart Cities

Uredila / Edited by

Matjaž Gams, Aleš Tavčar

http://is.ijs.si

8.–9. oktober 2018 / 8–9 October 2018
Ljubljana, Slovenia

PREDGOVOR

V letu 2016 je bil sprejet Raziskovalno Razvojni in Inovacijski (RRI) program EkoSMART v domeni pametne specializacije S4 na področju pametnih mest in skupnosti, kjer EMZ predstavlja enega od šestih nosilnih stebrov programa v obliki RRP (Raziskovalno-Razvojnega Projekta). V okviru javnega razpisa »RRI v verigah in mrežah vrednosti« − sklop 1: »Spodbujanje izvajanja raziskovalno-razvojnih programov (TRL 3-6)« je predvidenih 5,9 milijona evrov nepovratnih javnih sredstev za program EkoSMART.

V letu 2017 smo pripravili tretjo delavnico na temo »EM-zdravstva« (elektronsko in mobilno zdravstvo, kratko **EMZ**), tj. predlog izvedbe infrastrukture in vpeljave uporabe informacijsko in mobilno podprte celostne zdravstvene oskrbe za izboljševanje preventivne, diagnostične in terapevtske obravnave državljanov, ki bi zmanjšala stroške, obenem pa povečala dostopnost zdravstvene oskrbe v obdobju 2016-2020.

V letu 2018 smo izpeljali četrto delavnico na temo EMZ in jo združili s pametnimi mesti.

Program EkoSMART sestavlja 6 projektov:

RRP 1 – Zasnova ekosistema pametnega mesta
RRP 2 – Pametna mobilnost
RRP 3 – Aktivno življenje in dobro počutje
RRP 4 – Elektronsko in mobilno zdravstvo
RRP 5 – Integrirane zdravstvene storitve
RRP 6 – Prototipi rešitev

Projekt EMZ (RRP 4) sestavlja 5 delovnih sklopov oziroma delovnih paketov (DP), ki jih vodijo UKCL, IJS, FERI UM in FRI UL:

- Informacijske tehnologije za podporo celostni oskrbi / bolnice
- Podpora na domu za zdrave, starejše in za kronične bolnike / doma
- Mobilno spremljanje vitalnih in okolijskih podatkov / mobilno
- Računalniška podpora, podatki, kreiranje novih znanj /algoritmi
- IKT platforma

Delavnica EMZ omogoča celoletno pregledovanje in usklajevanje sklopa EMZ znotraj programa EkoSMART. Podobno kot v letu 2018 se bodo partnerji javno predstavili vsem drugim z že precej usklajenim predlogom. Vse predstavitve bomo nato dokončno uskladili in pripravili specifikacijo dela na programu za naslednje obdobje. Določili bomo podskupine partnerjev, ki bodo integrirale svoje prispevke v smiselno celoto in jih skušale premakniti naprej po TRL lestvici v smeri dejanske uporabe. Povezovali jih bomo najprej znotraj delovnih sklopov (delovnih paketov), nato znotraj RRP EMZ, nato pa še znotraj celotnega programa EkoSMART. Na delavnici bomo vse prispevke poskušali povezati tudi z osnovno integrirno platformo oz. z več platformami, ki se razvijajo znotraj EkoSMARTa.

Program EM-zdravstvo so vzpodbudile potrebe po uvajanju novih IKT rešitev v Slovenijo, po horizontalnem in vertikalnem povezovanju. Predlagana pobuda EM-zdravje vpeljuje v zdravstveno oskrbo nove koncepte, ki bodo s svojimi multiplikacijskimi in sinergijskimi učinki sprožili hitrejšo in učinkovitejšo prilagoditev obstoječega sistema celostne zdravstvene oskrbe na današnje izzive. Ključna strokovna komponenta je umetna inteligenca, ki bo po napovedih strokovnjakov revolucionirala zdravstvo skupaj z novimi IKT rešitvami. Javno zdravstvo po vsem svetu se otepa izrednih problemov, najboljšo rešitev pa strokovnjaki po svetu vidijo v vpeljavi storitev IKT in umetne inteligence.

EM-zdravstvo (EMZ) vidimo kot eno najbolj perspektivnih smeri v več pobudah od zdravstva do pametnih mest. EM-storitve nudijo izboljšano kvaliteto življenja državljanom ob zmanjšanih stroških, hkrati pa omogočajo preboj Slovenije v svet na EM-področju. EM -zdravstvo se bo predvidoma vsebinsko oblikovalo delno kot samostojna pobuda s svojo platformo, organizacijo in projekti, ki bo povezana tako s pametnimi mesti kot z zdravjem. Ključne komponente za uspešno izvedbo EMZ so inovativni človeški viri, njihovo usklajeno delovanje in vpeljava EMZ v Sloveniji.

ZDA generirajo dvakrat več pomembnih inovacij v zdravstvu kot EU ter vlagajo štirikrat več sredstev v nova, z medicino povezana podjetja. Kitajska namenja največ sredstev za znanost, medtem ko je Slovenija tretja najslabša po državnem financiranju znanosti v Evropi. Leta 2025 bo več kot milijarda, ali skoraj osmina svetovnega prebivalstva, starejša od 60 let. Stroški za zdravstveno oskrbo starejše populacije predstavljajo v EU skoraj polovico vseh stroškov za zdravstvo, kar pomeni, da grozi zdravstvenemu in gospodarskemu sistemu in kvaliteti življenja zlom, če ne bomo vpeljali storitev EM-zdravja.

Druga pomembna komponenta je povezovanje in ustvarjanje kritične mase komplementarnih partnerjev, ki edino omogoča uspešen prodor na svetovna tržišča. Slovenija potrebuje sodelovanje in koordiniranje že zaradi svoje relativne majhnosti, kar dokazuje relativno slaba izkušnja z velikim številom malih in razdrobljenih projektov, ki nimajo dovolj podpore za vpeljavo novih rešitev.

Tretja ključna komponenta je vpeljava EMZ v slovensko zdravstvo, ki bo na ta način dobilo novo priložnost, da vzpostavi nacionalno platformo in mednarodne standarde, preseže ujetost v nedopustno dolge čakalne dobe za pregled pri specialistih, poveže razdrobljene in nekompatibilne sisteme in že samo s tem opraviči vložena sredstva. Po zadnjem povečanju sredstev za področje zdravstva so se čakalne vrste povečale, kar kaže, da sedanji tradicionalni pristop ne zmore prinesti realnih izboljšav ob povečanih zahtevah zaradi staranja prebivalstva.

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POVZETEK

Atrijska fibrilacija (AF) je najpogostejša kronična motnja ritma. Predstavlja pogost zaplet po operaciji srca. Eden od vzrokov je porušen avtonomna modulacija, ki jo lahko določamo s pomočjo analize variabilnosti srčne frekvence, predvsem nelinearni kazalci. Poleg 12-kanalnega elektrokardiograma (EKG) se vse bolj uveljavlja tudi snemanje visokoločljivostnega EKG signala, v zadnjem času tudi na brezžični način.

Ključne besede: atrijska fibrilacija, Savvy, nelinearni kazalci avtonomne modulacije, P-val

1. UVOD

1.1 Atrijska fibrilacija

Splošno

Atrijska fibrilacija je najpogostejša kronična motnja ritma [1,2], katere prevalenca znaša okoli 1% in narašča s starostjo [2,3]. Znaki in simptomi se pri bolnikih razlikujejo. Pri nekaterih poteka AF popolnoma brez simptomov, drugi so prisiljeni poiskati zdravniško pomoč zaradi utrujenosti, slabše telesne zmogljivosti, palpitacij, bolečine v prsih ali omotice. Najhujši zaplet je trombembolija [4]. Med morfološke dejavnike tveganja spadata tudi povečan volumen in debelejša stena levega preddvora [3,5,6]. Povečano tveganje predstavljajo tudi stanja, ki zmanjšajo hitrost prevajanja oz. skrajšajo refraktarno dobo [8]. Glede na trajanje ločimo paroksizmalno (manj kot 7 dni), perzistentno (več kot 7 dni), dolgotrajno perzistentno (več kot 1 leto) in permanentno (ne vzpostavimo sinusnega ritma) [5,7,8,9]. Pri napredovanju iz ene oblike v drugo imata pomembno vlogo električna in strukturna remodelacija [6,8,9].

Diagnostika

Diagnostika atrijske fibrilacije temelji na anamnezi in kliničnem pregledu, potrdi pa se z EKG posnetkom v vsaj 1 odvodu med aritmijo in z ustaljenimi kliničnimi protokoli nadzora. Tako lahko v ta namen uporabimo večdnevno (več)kanalno snemanje EKG. Pomembno diagnostično orodje predstavlja tudi ultrazvok. Sodobni trendi in razvijajoča se tehnologija težijo k poenostavitvi in tem bolj intuitivni uporabi diagnostičnih orodij, zato ne preseneča, da je v ospredju znanstvenih prizadevanj uveljavitev enokanalnih EKG senzorjev, ki bi jih bolniki lahko imeli nameščene na sebi nepretrgoma po več dni skupaj, lahko tudi v domačem okolju.

Po operaciji srca

Atrijska fibrilacija je še posebej značilen zaplet po operacijah na srcu. To je do neke mere pričakovano, saj se veliko dejavnikov tveganja za atrijsko fibrilacijo pojavi takoj po operaciji (ishemija atrijev, draženje epikarda s sproščanjem faktorjev vnetja, hipoksija, kirurška poškodba) [10,11,12]. Po dosedanjih ugotovitvah se atrijska fibrilacija najpogosteje pojavlja 2. in 3. dan po operaciji [2,11,13,14]. Pogosteje se pojavlja po ponovnih operacijah zaradi zapletov, pri podaljšani ventilaciji ali ob potrebi po ponovni intubaciji [4].

Dejavnike tveganja med drugim lahko delimo na preoperativne, perioperativne in pooperativne. Med preoperativne štejemo starost, hipertenzijo, sladkorno bolezen, hipertiroidizem, moški spol, predhodno epizodo atrijske fibrilacije, srčno popuščanje, povečan levi atrij [2,4,15,16]. Raziskave kažejo, da je pomemben dejavnik tudi interatrijski blok, ki se kaže kot podaljšan in morfološko spremenjen P-val na EKG [13]. Med perioperativne dejavnike sodijo čas pretisnjenja aorte, mesto venske kanulacije, bikavalna kanulacija, ishemija miokarda in poškodba srčne mišice med operacijo [17]. Med pooperativne dejavnike tveganja pa štejemo respiratorne zaplete, ventilacijo, ki je daljša od 6 ur, hipotenzijo, vnetje, atrijske ekstrasistole, neravnovesje avtonomnega živčevja in podaljšan čas hospitalizacije [4,10,11,13,18,19,27].

1.2 Variabilnost srčne frekvence

Avtonomni sistem ima pri nastanku pooperativne AF zelo pomembno vlogo. Eden izmed načinov kako opredeliti njegovo aktivnost je preko neinvazivnega določanja variabilnosti srčne frekvence. Slednjo lahko določamo z linearnimi in nelinearnimi metodami. Med linearne spadata časovna in frekvenčna analiza, ki pa imata slabo napovedno vrednost pooperativne AF, saj ne uspeta prikazati najbolj občutljivih sprememb v stanju avtonomne regulacije, ki privedejo do pojava aritmije [20,21]. Nelinearne metode po drugi strani temeljijo na teoriji kaosa, ki skuša pojasniti lastnosti signala s t. i. fraktalno geometrijo oz. s fraktalno analizo fizioloških časovnih serij [22]. Tako govorimo o samopodobnosti, kjer neko fiziološko časovno serijo razdelimo na manjše dele, od teh pa vsi odražajo strukturo prvotne celote [21]. Samopodobnost ima določene meje, znotraj katerih govorimo, da omenjena lastnost podenot drži. Pri detrendni fluktuacijski analizi (DFA) jo opisujemo z eksponentom α, za katerega velja, da bližje kot je vrednosti 1, večja je samopodobnost [22].

Variabilnost srčne frekvence vsebuje vrsto pomembnih informacij. Razpad fraktalne organizacije variabilnosti srčne frekvence v prekomeren red ali v nepovezano naključje je znak zmanjšane sposobnosti prilagajanja srčno-žilnega sistema na zunanje dejavnike in je značilno prisoten pred pojavom atrijske fibrilacije, česar pa linearne metode ne pokažejo [21].

2. HIPOTEZE

Prva hipoteza, ki smo jo preverjali, govori o tem, da brezžični enokanalni EKG senzor Savvy zazna več epizod atrijske fibrilacije kot obstoječi trenutni klinični protokoli. Z drugo hipotezo smo preverjali ali ima skupina bolnikov z atrijsko fibrilacijo statistično značilne različne vrednosti trajanja P-vala in statistično značilno različno obliko P-vala predoperativno od skupine bolnikov brez atrijske fibrilacije. S tretjo hipotezo pa smo preverjali, ali se obe skupini razlikujeta v vrednostih indeksov DFA α1 in α2 po operaciji in ali sta razliki obeh parametrov pred in po operaciji statistično značilno različni.

3. METODE

Leta 2015 izvedena pilotna študija o pooperativni atrijski fibrilaciji je bila prvič predstavljena na konferenci Informacijska družba IS 2015 [23], leta 2016 tudi v reviji Informatica [24]. Medtem ko je bil pilotni sistem zasnovan za sočasno spremljanje 6 oseb, smo v izvedbi študije leta 2018 uporabili komercialno dostopen EKG senzor Savvy, s katerim smo sočasno merili do 10 oseb.

Soglasje komisije za medicinsko etiko za izvedbo raziskave smo pridobili v začetku leta 2018 – za soglasje smo zaprosili v začetku leta 2017 in prošnjo med letom dopolnili.

Raziskava je bila prospektivne narave. Izvajala se je na Kliničnem oddelku za kirurgijo srca in ožilja UKC Ljubljana, od marca do julija 2018.

Študijo je uspešno zaključilo 47 bolnikov. Vsi so sodelovanje v študiji potrdili s podpisom obveščenega pristanka, prav tako so vsi izpolnjevali vključitvene kriterije in nobenega od izključitvenih (kronična atrijska fibrilacija predoperativno, AV blok II. ali III. stopnje, srčni spodbujevalnik, urgentni bolniki, bolniki iz drugih oddelkov UKC Ljubljana). Meritve so tekle predoperativni dan in nato od 1. dne pooperativno nepretrgoma do 5. pooperativnega dne. Predoperativni dan smo bolniku izmerili 20-minutni visokoločljivostni EKG (Cardiax), obenem smo mu namestili brezžični enokanalni EKG senzor Savvy, ki ga je imel bolnik nameščenega do jutra pred operacijo. Prvi pooperativni dan smo bolniku zopet namestili brezžični enokanalni EKG senzor Savvy in ga pustili na njem do 5. dne nepretrgoma; 2., 3. in 5. dan smo izmerili tudi 20-minutni visokoločljivostni EKG posnetek (Cardiax). Meritve smo izvajali z 10 napravami Savvy, 10 pametnimi telefoni oz. tablicami ter visokoločljivostnim 12-kanalnim EKG aparatom (Cardiax).

Pri analizi dokumentacije smo bolnike razvrstili v skupino z atrijsko fibrilacijo in skupino brez atrijske fibrilacije. V prvi skupini so imeli bolniki na katerikoli način (Savvy ali s klinično ustaljenimi protokoli) dokazano atrijsko fibrilacijo. AF je morala trajati vsaj 30 sekund, da smo jo označili kot epizodo AF.

4. REZULTATI

Izmed 47 bolnikov jih je 13 razvilo atrijsko fibrilacijo. Od tega smo vseh 13 zaznali z napravo Savvy, medtem ko jih je bilo s klinično ustaljenimi protokoli in napravami zabeleženih 9. Izključno z napravo Savvy smo tako na novo odkrili 4 primere atrijske fibrilacije. Skupina z atrijsko fibrilacijo je imela povprečno daljši čas intubacije. Izmed elektrofizioloških parametrov je imela skupina z atrijsko fibrilacijo večjo razliko v trajanju P-vala (računana kot razlika pooperativne in predoperativne vrednosti), daljši PQ interval, nižjo vrednost DFA α1 pooperativno, večjo absolutno razliko DFA α1 ter večjo absolutno razliko DFA α2.

5. RAZPRAVLJANJE

Izsledki kliničnih študij pri bolnikih s ponavljajočo atrijsko fibrilacijo potrjujejo hipotezo, da pojav aritmije lažje opazimo v daljših obdobjih merjenj – drugače: dlje trajajoči nadzor pomeni več opaženih motenj ritma [25,26]. Stalni nadzor z enokanalnim EKG-jem je v naši študiji zaznal skoraj 1/3 več bolnikov s pooperativno atrijsko fibrilacijo, kot jih je bilo zabeleženih na temperaturnem listu, kar je v kliničnem smislu pomembno več. Pri tem količina dodatnega dela, morebitno bolnikovo neudobje in stroški niso zelo povečani. To ponuja številne možnosti in ideje za prihodnje študije, taki načini spremljanja srčnih aritmij predstavljajo v prihodnosti velike možnosti in še neizkoriščen potencial.

Pri dveh izmed štirih primerov atrijske fibrilacije, ki smo ju videli samo s Savvyjem, opažamo, da je bil vzrok temu manj intenziven nadzor. Oba bolnika sta bila namreč takrat že na oddelku, hkrati pa sta razvila epizodo atrijske fibrilacije v večernih urah. Boljše spremljanje bolnikov izven enot intenzivne terapije ali nege tako predstavlja enega izmed pomembnih izzivov sodobne medicine.

Mehanska ventilacija povzroča spremembe v intratorakalnem tlaku, ki imajo direkten vpliv na srce, osrčnik in krvne žile, saj s pozitivnim tlakom poveča intratorakalni tlak in s tem tlak v desnem atriju. Slednji pa je povezan z nastankom atrijske fibrilacije. Obenem mehanska ventilacija poveča aktivnost simpatika, ki igra pomembno vlogo pri nastanku atrijske fibrilacije [13,27].

Bistveno krajši čas trajanja P-vala pooperativno glede na predoperativno vrednost pri skupini z atrijsko fibrilacijo govori v prid temu, da je tudi povečana prevodnost med atrijema proaritmogena [28].

Daljši PQ interval govori o tem, da je AV blok povezan z nastankom atrijske fibrilacije, kar so pokazale pretekle študije [6,29,30,31].

Nižja vrednost DFA α1 pooperativno pri skupini z atrijsko fibrilacijo nakazuje na razpad fraktalne geometrije oz. samopodobnosti signala, ki smo ga dobili iz RR intervalov pred pojavom prve epizode pooperativne atrijske fibrilacije [32,33]. Podobno lahko gledamo tudi na večjo absolutno razliko DFA α1 pri skupini z atrijsko fibrilacijo. Ker se je pooperativna vrednost pri skupini z AF relativno bolj zmanjšala glede na predoperativno vrednost, to prav tako kaže na razpad samopodobnosti signala in bi lahko v prihodnosti služil kot pomemben napovedni dejavnik za razvoj atrijske fibrilacije [32,33]. Večja absolutna razlika DFA α2 pri skupini z atrijsko fibrilacijo nakazuje na, podobno kot opisano zgoraj, razpad samopodobnosti signala, tokrat pri nizu RR intervalov večjih od 11. To govori v prid porušenemu simpatično-vagalnemu ravnovesju pooperativno, kar se odraža v znižanju obeh kazalcev DFA α [21].

6. ZAKLJUČEK

Z brezžičnim enokanalnim EKG senzorjem Savvy smo odkrili več bolnikov z atrijsko fibrilacijo, kot jih je bilo zabeleženih s klinično ustaljenimi protokoli, zato smo potrdili prvo hipotezo. Pri analizi dolžine P-vala in njegove morfologije nismo odkrili razlik med obema skupinama, zato smo drugo hipotezo zavrnili. Razloge iščemo predvsem v majhnem naboru preiskovancev. Kljub temu smo z analizo razlike trajanja P-vala pred in po operaciji pokazali relativno večje skrajšanje P-vala po operaciji glede na stanje pred operacijo pri skupini z atrijsko fibrilacijo. Opazili smo pomembno razliko v trajanju PQ intervala po operaciji, s čimer smo potrdili daljše trajanje tega intervala kot dejavnik tveganja za pojav atrijske fibrilacije. Potrdili smo nižjo vrednost DFA α1 pooperativno ter večjo absolutno razliko v

DFA α1 in DFA α2 pri skupini z atrijsko fibrilacijo, s čimer smo prepoznali porušeno avtonomno modulacijo srca tik pred pojavom atrijske fibrilacije, zato lahko potrdimo tretjo hipotezo - avtonomni kazalci so pri bolnikih z atrijsko fibrilacijo različni kot pri bolnikih, ki atrijske fibrilacije ne razvijejo.

Naša študija predstavlja pomemben korak v smeri lažje in hitrejše zaznave motenj ritma s pomočjo pametnih tehnologij. Rezultati kažejo na velik potencial takega načina merjenja in na številne možnosti, ki se odpirajo s prepoznavo novih napovednih kazalcev za pojav atrijske fibrilacije po operacijah srca. Verjamemo, da nas v prihodnjih letih čaka velik razmah na področju odkrivanja motenj srčnega ritma. Hkrati upamo, da bo ta študija predstavljala kvalitetno podlago naslednjim obširnejšim raziskavam, ki bodo sčasoma vodile do novih rešitev za izboljšanje kakovosti življenja bolnikov.

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EMZ in EkoSMART-asistent

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POVZETEK

V prispevku "EMZ in EkoSMART-asistent" je podrobneje opisan program EkoSMART, ki je razdeljen na šest projektov, med njimi je tudi projekt EMZ (Elektronsko in mobilno zdravje). Le-ta je podrobneje opisan v 3. poglavju, v nadaljevanju pa je povezan z občinami in zdravjem (4. in 5. poglavje). EkoSMART-asistent, ki je bil razvit na Institutu "Jozef Stefan", se nahaja na spletni strani EkoSMART [6], v 6. poglavju so naštete in podrobno opisane vse aplikacije, ki jih asistent ponuja.

Ključne besede

elektronsko in mobilno zdravje, virtualni asistent, občine, EkoSMART-asistent

1. UVOD

Prispevek "EMZ in EkoSMART-asistent" obravnava sestavo programa EkoSMART v 6 raziskovalno-razvojnih projektih, med njimi je tudi RRP 4 – EMZ (Elektronsko in mobilno zdravje). V današnjem času tehnologije sta umetna inteligenca in IKT zelo pomembna faktorja k napredku v znanosti, k implementaciji na nove produkte ter, kar je bistveno, k aplikativni uporabi v vsakdanjem življenju. Namen projekta EMZ je bil izboljšati varstvo in varnost zdravih, starejših, kroničnih bolnikov in ljudi s posebnimi potrebami z vpeljavo sodobnih informacijsko-komunikacijskih tehnologij (IKT) v celostno elektronsko in mobilno zdravstveno oskrbo (EMZ). Namen je nadgraditi kakovost obravnave in oskrbe omenjenih skupin s pomočjo elektronskih in mobilnih naprav ter s pripadajočimi programskimi rešitvami, zlasti z uporabo telesnih senzorjev in nosljivih pripomočkov, ki omogočajo spremljanje počutja in zdravja na podlagi meritev ter umetne inteligence nad podatki v EkoSMART-platformi. Za lažji dostop do informacij je bil razvit tudi EkoSMART-asistent z vsemi pripadajočimi aplikacijami.

2. PROGRAM EKOSMART

Ekosmart Pametnega Mesta (EkoSMART) [1] je program, ki je bil sprejet na Javnem razpisu »Spodbujanje izvajanja raziskovalno-razvojnih programov (TRL3-6)«, in sicer prednostno področje S4: Pametna mesta in skupnosti. Glavni cilj tega programa je razviti ekosistem pametnega mesta z vsemi podpornimi mehanizmi, ki so potrebni za učinkovito, optimizirano in postopno integracijo posameznih področij v enovit in povezan sistem vrednostnih verig. Z zagotavljanjem kakovostnih storitev za državljane in gospodarstvo želimo omogočiti dvig kakovosti življenja in rast splošne blaginje.

Program EkoSMART sestavlja šest projektov, ki vsak po svoje prispevajo k uresničevanju vizije programa (kratica RRP pomeni Raziskovalno-razvojni projekt).

• RRP 1: Zasnova ekosistema pametnega mesta

• RRP 2: Pametna mobilnost - sistemi za nadzor in upravljanje prometnih tokov

• RRP 3: Aktivno življenje, dobro počutje

• RRP 4: Elektronsko in mobilno zdravje (EMZ)

• RRP 5: Pametni sistem integriranega zdravstva in oskrbe

• RRP 6: Razvoj prototipov

Poleg štirih projektov, ki se ukvarjajo z digitalizacijo izbranih področij (RRP2-RRP5), sta v program predvidena še dva skupna projekta. Eden se ukvarja s skupnim jedrom oziroma arhitekturo ekosistema (RRP1), eden pa je namenjen razvoju prototipnih rešitev in njihovemu preskušanju v relevantnih okoljih (RRP6).

S takšno projektno sestavo sledimo dobrim praksam, ki pravijo, da je sisteme sistemov, kar pametna mesta so, potrebno graditi upoštevajoč oba razvojna modela: od spodaj navzgor (RRP2 do 5, začenši s posameznimi področji in potem z njihovo integracijo v celoto) in od zgoraj navzdol (RRP1, izhajajoč iz strateških usmeritev mesta in potem z osredotočanjem na posamezna področja). Ključno je enostavno dodajanje novih storitev pametnih mest, kar omogoča univerzalna skupna arhitektura.

Slika 1. Spletna stran EkoSMART, dostopna na [2].

3. PROJEKT EMZ

Projekt RRP4: EMZ (Elektronsko in mobilno zdravje) [1] je bistveni del programa EkoSMART. Namen projekta EMZ je izboljšati varstvo in varnost zdravih, starejših, kroničnih bolnikov in ljudi s posebnimi potrebami z uporabo modernih tehnologij in pristopov. Cilj projekta je bil tudi izdelati sisteme za pomoč slepim in slabovidnim, gluhim, kognitivno, vedenjsko in gibalno motenim ter starejšim, ki so sami doma, in omogočiti kvalitetnejše življenje ljudem s kroničnimi boleznimi, ki občasno ali stalno potrebujejo zdravniško oskrbo.

Projekt EMZ je nastal iz širše iniciative elektronskega in mobilnega zdravstva, ki zajema okrog 300 partnerjev, ki želijo sodelovati in si želijo biti seznanjeni z dogajanjem na tem področju. Za potrebe izvedbe projekta RRP4 so bile iz nabora partnerjev EMZ skrbno izbrane naslednje organizacije:

1. Institut »Jožef Stefan« (IJS)
2. UL - Medicinska fakulteta (MF)
3. Univerzitetni klinični center Ljubljana (UKCL)
4. Marand d.o.o. (MAR)
5. UL - Fakulteta za računalništvo in informatiko (FRI)
6. UM - Fakulteta za elektrotehniko, računalništvo in informatiko (FERI)
7. URI-Soča (SOČA)
8. ZD Adolfa Drolca (ZDM)
9. Cosylab (CSL)
10. Elgoline d.o.o. (ELGO)
11. SRC sistemske integracije d.o.o. (SRC)
12. Špica International d.o.o. (ŠPI)
13. Inova IT d.o.o. (INO)
14. Medis d.o.o. (MED)
15. Nela razvojni center d.o.o. (NELA)

4. EMZ in OBČINE

Razvili smo ogrodje in večino sistemov občin [3,4] kot korak dlje od pametnih mest in oboje sistematično vpeljali v občine, društva upokojencev in druga društva ter v širšo družbo z namenom, da Slovenija ponudi boljšo izkušnjo mest oz. občin Slovenije za vse, domače in turiste. Asistenti za posamezne občine ponujajo pomembne informacije o občini, storitve in podporo kvalitetnejšemu življenju. Umetna inteligenca in IKT napredujeta zelo hitro, raziskovalni oddelki razvijajo zelo dobre nove sisteme, poleg tega pa se razvijajo tudi sistemi, ki jih lahko namestijo in vzdržujejo lokalne inštitucije in družba.

Sistem sestavljajo naslednji bloki:

- Občinska televizija – vsakdo lahko razvije svojo občinsko televizijo s sledenjem navodilom. Potreben je prenosnik in kamera in nekaj znanja računalništva. Običajno občinska TV prenaša ali sprotno dogajanje v živo, ali pa se vrti vnaprej pripravljena datoteka z informacijami za tekoči teden.
- 3D virtualni asistent – ponovno je z nekaj znanja računalništva po navodilih možno izdelati sistem 3D virtualnega asistenta, ki vodi po stavbah, recimo upravni stavbi občine.
- Turizem – sistem omogoča informiranje o turističnih znamenitostih v naravnem jeziku in načrtovanje turističnih obiskov. Sistem vsebuje preko 3000 znamenitosti v Sloveniji in je zato izjemno uporaben.
- Asistenti – za vsako izmed 200 slovenskih občin je narejen občinski asistent, ki odgovarja na vprašanja v naravnem jeziku. Obstajata tudi pokrajinski asistent in slovenski asistent – slednja sta sestavljena iz pripadajočih občinskih asistentov. Asistent za starejše občane (ZDUS) se imenuje Zdusko, le-ta je v pomoč starejšim ljudem, ki iščejo informacije. V poglavju spodaj je bolj podrobno opisan EkoSMART-asistent, vključno z namenom razvoja asistenta in njegovimi aplikacijami [3]. Več o asistentih si lahko preberete v prispevku za IS 2018: "Pregled IJS E9 asistentov".

5. EMZ in ZDRAVJE

Na spletni strani Občin [4] je Zdravje najpomembnejši blok EMZ-ja [3,5]. Tu so informacije o prvi pomoči, zdravstveni nasveti iz Slovenije in tujine, informacije iz NIJZ, iz programa pametne specializacije EkoSMART ter podprojekta Elektronsko in mobilno zdravje, repozitorijev domen in prototipov, sistemov za nadziranje stresa in o skrbi za starejše. Storitev je dostopna v asistentih – kliknete na svojo občino, levo zgoraj, izberete aplikacijo »Zdravstvo in sociala«.

Slika 2. Del spletne strani Zdravje[5], kjer so podsistemi za zdravje.

Asistent vam ponudi sledeče podsisteme:

- **Prva pomoč**: Tu dobite nasvete v primeru nujne pomoči (Mobilno Android IOS).
- **Zdravstveni nasveti (slovensko)**: Če potrebujete zdravstveni nasvet, si lahko pomagate s strokovnjaki na spletu.
- **Zdravstveni nasveti (angleško)**: Poučne spletne strani o zdravstvu v angleškem jeziku.
- **NIJZ (Nacionalni inštitut za javno zdravje)**: Povezava na njihovo spletno stran.
- **PROJEKTI:**

- IN LIFE: Pametna varnostna ura je najpomembnejši produkt, ki je bil razvit v okviru projekta IN LIFE. Ura je namenjena starejšim ljudem za izboljšanje njihove varnosti in podaljšanju avtonomije. Ura je že pripravljena za prodajo.
- E-gibalec: mobilna aplikacija, razvita z namenom povečanja športnih aktivnosti in gibanja osnovnošolcev. Hkrati smo s tem preprečevali debelost v otroštvu, ki je v današnjem času čedalje pogostejša [7].
- ASPO: spletna aplikacija za prepoznavanje in informiranje o spolno prenosljivih okužbah.
- Zaznavanje stresa: Spletni pogovorni svetovalec OSVET je namenjen zaznavanju stresa in nudenju psihosocialne pomoči preko spleta. Z anketo lahko preverite stopnjo svojega stresa.
- EkoSMART, EMZ: namen programa EkoSMART je razviti ekosistem pametnega mesta. Prav tako je bil razvit tudi EkoSMART-asistent, ki je podrobneje opisan v spodnjem poglavju.
- HEP-Y: Spletna aplikacija za prepoznavanje in informiranje o virusnih hepatitisih.
- Čakalne vrste: Asistent Čakalne vrste je namenjen iskanju čakalnih dob za določene zdravstvene posege pri posameznih ustanovah (več v prispevku "Pregled IJS E9 asistentov").

6. EKOSMART-ASISTENT

Kratek opis: Asistent je namenjen posredovanju informacij o programu pametne specializacije EkoSMART. V trenutni realizaciji odgovarja na vsebinska vprašanja o posameznih projektih, ki so vključeni v program. Posreduje organizacijske podrobnosti in podatke o prototipih produktov, storitvah in izdelkov, ki se razvijajo v okviru programa. V končni različici pa bo asistent omogočal iskanje različnih vrst podatkov v zdravstvenih platformah in razviti integracijski platformi pametnega mesta [2,5].

Aplikacije:

- Opis: Ekosmart-asistent odpre v ozadju na spletni strani EkoSMART zavihek "Rešitve", kjer je navedeno, da je program EkoSMART sestavljen iz šestih projektov. V nadaljevanju so projekti našteti, ob kliku na projekt pa lahko vidimo njegov opis.

- Partnerji/ljudje: V Ekosmart-asistenta lahko vpišete ime in priimek osebe zaposlene na projektu EkoSMART, nato pa vam asistent sporoči kontaktne podatke. V ozadju se na spletni strani EkoSMART odpre zavihek "Partnerji", kjer je naštetih 25 partnerjev.

- RRP 1 - Zasnova ekosistema pametnega mesta: EkoSMART-asistentu lahko postavite vprašanje glede projekta RRP 1. Na spletni strani v ozadju pa se odpre zavihek "Rešitve" in opis slednjega projekta. V opisih projektov najdete vodjo projekta, namen, ključne partnerje ter glavne cilje in rezultate. Bistvena je povezava pametnega mesta v celovit ekosistem.

- RRP 2 - Pametna mobilnost: EkoSMART-asistentu lahko postavite vprašanje glede projekta RRP 2. Na spletni strani v ozadju pa se odpre zavihek "Rešitve" in opis projekta. Projekt se osredotoča na problem rigidnih semaforskih sistemov, ki so neodzivni na realno stanje v prometu.

- RRP 3 - Aktivno življenje in dobro počutje: EkoSMART-asistentu lahko postavite vprašanje glede projekta RRP 3. Na spletni strani v ozadju pa se odpre zavihek "Rešitve" in opis projekta. Poudarjena je pomembnost družine kot osnovne celice ter možnosti medgeneracijskega povezovanja znotraj družine. Poslovni cilj je programska rešitev MyFamily, ki bo v ekosistemu EkoSMART omogočala večjo povezanost družine ter vključevanje v medgeneracijsko povezanost za boljšo kakovost življenja.

- RRP 4 - Elektronsko in mobilno zdravstvo (EMZ): V ozadju se na spletni strani odpre širši opis projekta. Glavni poslovni in tehnološki cilji RRP 4 so sledeči: izkoristiti potencial gospodarstva, medicine in znanosti za razvoj celovitega Sistema EMZ v Sloveniji, ki bo znižal naraščajoče stroške na področju zdravstva in sociale, okrepiti, obogatiti in nadgraditi ponudbo proizvodov in storitev, podprtih z IKT na področju zdravstva ter drugi.

- RRP 5 - Integrirane zdravstvene storitve: EkoSMART-asistentu lahko postavite vprašanje glede projekta RRP 5. Na spletni strani EkoSMART v ozadju se odpre zavihek "Rešitve" in opis projekta. Opisani so tudi glavni rezultati in cilji projekta, med drugim tudi povečanje kakovosti in varnosti življenja kroničnih bolnikov in daljša oskrba v domačem okolju.

- RRP 6 - Prototipi rešitev: EkoSMART-asistentu lahko postavite vprašanja glede projekta RRP 6. Na spletni strani EkoSMART v ozadju se odpre zavihek "Rešitve" in opis projekta RRP 6. Glavni rezultati in cilji so zagotovitev, vzpostavitev in testiranje prototipov sistemov v ciljnih okoljih, vključno z izvedbami, ki bodo podobne delovanju v realnih okoliščinah.

- Partnerji/inštitucije: Konzorcij programa Ekosmart sestavlja 25 partnerjev z različnih področij delovanja, našteti so na spletni strani v ozadju.
- Program Ekosmart: Na spletni strani EkoSMART v ozadju se odpre zavihek "O projektu", kjer si lahko ogledate splošen opis in namen projekta EkoSMART.

- Prototipi: Povezava na seznam prototipov.

Slika 3. prikazan je EkoSMART-asistent, ki je dostopen na spletni strani [6].

7. ZAKLJUČEK

V prispevku "EMZ in EkoSMART-asistent" je bil v celoti predstavljen program EkoSMART, ki je sestavljen iz 6 raziskovalno-razvojnih projektov, med njimi tudi EMZ (Elektronsko in mobilno zdravje). Glavni namen EMZ je z umetno inteligenco in IKT izboljšati zdravje in kvaliteto življenja ljudem, hkrati pa s programskimi rešitvami razbremeniti zdravstveni sistem. Na Odseku za inteligentne sisteme na Institutu "Jožef Stefan" je bil razvit tudi EkoSMART-asistent s številnimi aplikacijami za lažji dostop do informacij.

8. ZAHVALA

Raziskave in razvoj so bile izvajane v okviru programa EkoSMART in so delno sofinancirane s strani Ministrstva za izobraževanje, znanost in šport ter Evropske unije iz

Evropskega sklada za regionalni razvoj (ESRR). Zahvaljujemo se tudi sodelavcu Alešu Tavčarju, ki je največ prispeval pri programu in vsem ostalim sodelavcem.

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Pregled asistentov IJS E9

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POVZETEK

Asistenti so v zadnjih letih čedalje bolj pogosti in dobrodošli na spletnih straneh. V tem prispevku so opisani asistenti, ki so bili razviti na Odseku za inteligentne sisteme na Institutu »Jožef Stefan«. Zajetih je več asistentov, med drugim asistent IJS, asistent za pametna mesta, asistenta za zdravjem, meta asistent, ki povezuje vse občinske asistente, 3D-asistent in asistent ZDUS.

Ključne besede

Virtualni asistent, asistent IJS, zdravje, pametna mesta, meta asistent, občine.

1. UVOD

Virtualni asistenti so koristni na spletnih straneh, saj nas zelo hitro pripeljejo do željenih odgovorov in nam podajo informacije, ki nas zanimajo. V prispevku je narejen kratek pregled asistentov in opis asistentovih aplikacij, ki so bili razviti na IJS v okviru Odseka za inteligentne sisteme. Razvoj asistentov je bil usmerjen predvsem na točne informacije v povezavi s spletno stranjo v ozadju asistenta. Kot najboljši se je izkazal asistent IJS, zelo pomembni pa so tudi občinski asistenti, ki obiskovalca spletne strani informirajo o dogajanju v občinah. Zanimivi so tudi ostali asistenti, vsi so opisani v 2. poglavju.

2. PREGLED ASISTENTOV

Vsi asistenti so v obliki spletne aplikacije / spletnega agenta, ki se po klicu (kliku) prikaže v obliki okenca. V zgornjem delu je neka slika, povezana s predstavitvijo sistema, nad njo je rob z aplikacijami levo, pomočjo in izhoda desno. Aplikacije zgoraj levo so pomembne, ker povedo, na katere teme se asistent posebej spozna. Če izberemo aplikacijo, asistent najprej pogleda v omenjenem modulu, ali je kje pripravljena primerna aktivnost. Recimo v primeru, da imamo izbrano aplikacijo zaposleni (Slika 1), potem bo sistem iskal najprej po imenih, priimkih in drugih podatkih o zaposlenih in v primeru zadetka prikazal tovrstne odgovore. Če pa isto vprašanje napišemo splošno, potem so moduli enakovredni in lahko sistem najde povsem drug odgovor kot bolj smiseln.

Slika 1. Asistent Robi, ki je na spletnih straneh Instituta "Jožef Stefan" [1].

V sredinsko polje uporabnik vpiše vprašanje in spodaj se pojavi odgovor v obliki spletnega besedila. V ozadju se na spletni strani pojavi zadetek iskalnika, tako da uporabnik vidi odgovor asistenta in iskalnika v ozadju. Četudi asistent nič ne najde, še vedno dobimo odgovor spletnega iskalnika.

Sledi opis asistentov.

2.1 Asistent IJS, Robi

Kratek opis: Asistent Robi odgovarja na vprašanja obiskovalcev IJS in zaposlenih na IJS. Na vprašanja odgovarja v slovenščini, angleščini, francoščini. Zna govoriti slovensko in angleško, zna komunicirati preko robota, npr. Nao, zna izvajati animacije preko robota animirano na zaslonu in dejansko, kadar je fizično priključen na robota.

Aplikacije:

- Zaposleni/imenik: Če vpišete ime ali priimek ali kak drug podatek o zaposlenem, bo Robi poiskal vse zaposlene, ki ustrezajo opisu.
- Prireditve, novice: Robi vam ponudi koledar prireditev, ki vas usmeri na napovednik dogodkov.
- Vprašanja iz podjetij: Robi odpre obrazec, ki je namenjen podjetjem pri navezovanju stikov z IJS.
- Organizacijska struktura IJS: Odpre se spletna stran, kjer najdete organizacijske enote Instituta.

- Zaposlitve, študentsko delo: Robi vas usmeri na objavo prostih delovnih in študentskih mest.
- Raziskovalna oprema: Spisek pomembnejše inštitutske raziskovalne opreme na strani Nanocenter.
- Znotraj hiše, notranji akti in obrazci: Robi v ozadju odpre spletno stran, kjer zaposleni dobijo pomembne informacije. Del informacij je dostopen samo zaposlenim.
- Obvestila vzdrževalcem: Zaposleni lahko preko aplikacije posredujete vzdrževalcem podatke o okvarah na infrastrukturi IJS.
- Počitnice: Robi vas usmeri na počitniške kapacitete, ki jih ima IJS.
- Malica: Robi vas seznani s tedenskim jedilnikom v menzi na IJS.
- Računalniški slovarček: Robi odpre spletno stran z računalniškim slovarčkom.
- Slovarji: Robi vam odpre slovarje v ozadju.
- Vreme: V ozadju se prikaže ARSO petdnevna vremenska napoved.
- Znamenitosti Slovenije: Robi vam pomaga najti željene znamenitosti po Sloveniji.
- Turist: Robi odpre spletno stran e-Turist, s katerim lahko načrtujete izlet.
- 3D IJS: Robi odpre 3D IJS robota, ki zna tudi zaplesati in vas vodi po IJS kot virtualni vodič. Pelje vas do iskane osebe po simuliranem IJS.
- IJS TV, napovednik IJS: V ozadju si lahko ogledate vsebino, ki se predvaja na IJS kanalu, zasedenost predavalnic itd.

2.2 Čakalne vrste

Kratek opis: Asistent Čakalne vrste, dostopen na [2], je namenjen iskanju čakalnih dob za zdravstvene posege pri posameznih ustanovah. Asistent deluje tako, da v iskalno okno vpišemo poseg, ki ga želimo (asistent nam lahko sam ponudi več opcij), nato izberemo, kako hitro potrebujemo poseg in regijo Slovenije, zatem pa nam asistent ponudi vse možne ustanove, pri čemer jih razporedi v vrstnem redu od najkrajše do najdaljše časovne dobe. Asistent izpiše tudi kontaktne podatke od zdravstvenih ustanov, zato se lahko hitro naročimo na željeni poseg [3].

2.3 Stres

Kratek opis: Cilj študentskega projekta OSVET je spletni pogovorni svetovalec za zaznavanje stresa pri uporabnikih in nudenje psihosocialne pomoči preko spleta. V spodnjem okencu vpišemo svojo težavo oz. počutje, virtualni svetovalec pa nam pomaga s svojo bazo podatkov. Če nečesa ne ve, nas prosi, da svojo težavo opišemo kako drugače. Svojo stopnjo stresa lahko ocenimo tudi z uporabo ankete [3].

Slika 2. Spletni pogovorni svetovalec za zaznavanje stresa [4].

2.4 EkoSMART-asistent

Kratek opis: Asistent je namenjen posredovanju informacij o programu pametne specializacije EkoSMART. V trenutni realizaciji odgovarja na vsebinska vprašanja o posameznih projektih, ki so vključeni v program. Posreduje organizacijske podrobnosti in podatke o prototipih produktov, storitvah in izdelkov, ki se razvijajo v okviru programa. V končni različici pa bo asistent omogočal iskanje različnih vrst podatkov v zdravstvenih platformah in razviti integracijski platformi pametnega mesta [3, 5].

Aplikacije:

- Opis: Ekosmart-asistent v ozadju odpre kratek opis projekta Ekosmart.
- Partnerji/ljudje: Aplikacija za pomoč iskanju ljudi zaposlenih na projektu Ekosmart.
- RRP 1 - Zasnova ekosistema pametnega mesta: V ozadju se odpre kratek opis RRP 1.
- RRP 2 - Pametna mobilnost: V ozadju se odpre kratek opis RRP 2.
- RRP 3 - Aktivno življenje in dobro počutje: V ozadju se odpre kratek opis RRP 3.
- RRP 4 - Elektronsko in mobilno zdravstvo: V ozadju se odpre kratek opis RRP 4.
- RRP 5 - Integrirane zdravstvene storitve: V ozadju se odpre kratek opis RRP 5.
- RRP 6 - Prototipi rešitev: V ozadju se odpre kratek opis RRP 6.
- Partnerji/inštitucije: Konzorcij programa Ekosmart sestavlja 25 partnerjev z različnih področij delovanja.
- Program Ekosmart: V ozadju si lahko ogledate opis in namen projekta Ekosmart.
- Prototipi: Povezava na seznam prototipov.

Slika 3. EkoSMART- asistent, dostopen na spletni strani [6].

2.5 Meta asistent

Kratek opis: Meta asistent, imenovan Metka, nam da povezavo na ostale občinske asistente.
V levem zgornjem kotu asistenta so na voljo vse aplikacije, pod njimi lahko izberemo tudi regije in občine [7, 8] za zožitev interakcije.

Aplikacije:

- Splošno: Asistent vam da splošne informacije o občini, občinskem svetu, zaposlenih in zanimivostmi občine.
- Okolje, prostor in komunala: Asistent vam odgovori na vprašanja v zvezi s prometom, okoljem in komunalo.

- Kultura, šport in izobraževanje: Asistent vam odgovori na vprašanja glede kulture, športa in izobraževanja.
- Zdravstvo in sociala: Asistent vam odgovori na vprašanja v zvezi z zdravstvenim domom, zdravniki, oskrbo na domu in socialno službo.
- Zaščita in reševanje: Asistent vam odgovori na vprašanja povezana s civilno zaščito, gasilci, policijo, načrti zaščite in reševanja.
- Vloge in obrazci: Asistent za vas poišče različne vloge in obrazce.
- Kmetijstvo in gospodarstvo: Asistent odgovori na vprašanja glede kmetijstva, gozdarstva, prehrane in gospodarstva.
- Storitve in obrtniki: Asistent odgovori na vprašanja glede storitvenih dejavnosti v občini (npr. seznam trgovin, lokacije bankomatov, kinodvorane, banke, seznam obrtnikov ipd.).
- Turizem: Asistent vam odgovori na vprašanja glede turizma (prenočišča, znamenitosti, turistično informacijski centri).
- Moja občina: Asistent v ozadju odpre spletno stran, kjer si lahko preberete novice, dogodke in zanimivosti posameznih občin.
- Vreme: V ozadju se odpre spletna stran ARSO, kjer lahko vidite petdnevno vremensko napoved.
- Prevajanje: V ozadju se vam prikaže prevajalnik podjetja Amebis, kjer lahko prevajate med slovenščino, nemščino in angleščino.
- Slovarji: V ozadju lahko uporabite slovarje za večje evropske jezike.

Slika 4. Meta asistent, ki je dostopen na [8].

2.6 Občine

Kratek opis: Vsaka izmed 200 občin ima svojega občinskega asistenta, do seznama asistentov lahko dostopate na spletni strani [8], pod zavihkom Občine. Po kliku na "Asistenti za občine" se vam odprejo vse povezave na občinske asistente. Izberemo občino in odpre se nam spletna stran občine in občinski asistent v levem zgornjem kotu. Na Sliki 5 je primer asistenta, ki prikazuje pokrajine. Ponujene aplikacije so pri vseh občinskih asistentih enake.

Slika 5. Povpraševanje je možno po Sloveniji, pokrajinah ali občinah.

Aplikacije:

- Splošno: Asistent vam da splošne informacije o občini, občinskem svetu, zaposlenih in zanimivostmi občine.
- Okolje, prostor in komunala: Asistent vam odgovori na vprašanja v zvezi s prometom, okoljem in komunalo.
- Kultura, šport in izobraževanje: Asistent vam odgovori na vprašanja povezana z različnimi športnimi kot tudi kulturnimi društvi in klubi, izobraževalnimi ustanovami in o prireditvah.
- Zdravstvo in sociala: Kontaktni podatki za prvo pomoč.
- Zaščita in reševanje: Asistent vam odgovori na vprašanja povezana s civilno zaščito, gasilci, policijo, načrti zaščite in reševanja, ravnanjem v primeru naravnih nesreč.
- Vloge in obrazci: Asistent vam lahko poišče različne vloge in obrazce.
- Kmetijstvo in gospodarstvo: Asistent vam odgovori na vprašanja povezana s kmetijstvom, gozdarstvom, prehrano in gospodarstvom na splošno.
- Storitve in obrtniki: Asistent odgovori na vprašanja povezana s storitvenimi dejavnostmi v občini (seznam trgovin, lokacije bankomatov, kinodvorane, banke, seznam obrtnikov, itd.)
- Turizem: Asistent vam nudi koristne informacije glede turizma.
- Novice in prireditve: Na spletni strani v ozadju si lahko ogledate novice in prihajajoče prireditve v občini.
- Moja občina: Spletna storitev Moja občina je namenjena seznanjenju občanov slovenskih občin z novicami.
- Vreme: V ozadju se odpre spletna stran ARSO, kjer si lahko ogledate vremensko napoved.
- Slovenski turizem: V ozadju se odpre spletna stran e-Turist, kjer lahko načrtujete ogled.
- Občinska TV: V ozadju se odpre spletna stran TV IJS.

2.7 3D-asistent

Kratek opis: 3D-asistent je virtualni vodič po IJS. Če ga vprašate, kje je določeni posameznik, vas popelje pred njegova vrata, tako da hodi pred vami v virtualni 3D resničnosti.

3D-asistent omogoča tudi, da vsak zgradi svoj virtualni posnetek resničnega prostora in svojega 3D-asistenta. 3D-asistenti povezujejo številne sisteme, razvite na Odseku za inteligentne sisteme IJS, ki omogočajo virtualno izkušnjo. Uporablja se ga lahko preko spletnega portala, enostavno pa se vzpostavi tudi samostojna aplikacija za pametni telefon Android ali iPhone, računalnik Windows ali Mac. 3D-asistent pride do izraza predvsem pri uporabi v občinskih stavbah, podjetjih, inštitutih, muzejih ali znamenitostih, saj do neke mere nadomešča vodiča ali vratarja.

Slika 6. 3D IJS asistent, ki ga lahko upravljamo s pomočjo tipk: W, A, S, D. Po kliku na robotovo glavo mu lahko zastavimo vprašanje.

Do 3D-asistenta dostopate tako, da v svojem občinskem asistentu kliknete levo zgoraj "Aplikacije" in nato "3D-asistent". Primer zanimivega 3D-asistenta je 3D IJS asistent, ki je prikazan na Sliki 6. Nudi druge funkcije, recimo če kliknete na glavo 3D robota, po želji tudi zapleše [9, 10].

2.8 ZDUS

Kratek opis:
ZDUS (Zveza društev upokojencev Slovenije) ima na svoji spletni strani ZDUS asistenta, imenovanega Zdusko. Le ta vam odgovori na vprašanja, ki mu jih zastavite. V levem zgornjem kotu asistenta pa so na voljo tudi aplikacije, ki jih lahko izberete.

Slika 7. prikazuje ZDUS asistenta, ki je dostopen na spletni strani [11].

Aplikacije:

- Splošno: Na spletni strani v ozadju si lahko preberete splošno o društvu ZDUS.
- Društva: V ozadju lahko vidite vsa društva in klube. Društva so prikazana na zemljevidu, tako da se lažje orientirate.
- Aktivno staranje: V ozadju lahko dobite koristne informacije o aktivnem staranju, vključno s predlogi o tem, katere vaje izvajati.
- Zdravje: V ozadju lahko dobite koristne informacije o zdravju (pomoč pri različnih boleznih, kaj je priporočljivo jesti, zdravilne rastline).
- Bivalna kultura: Na spletni strani v ozadju si lahko preberete več o bivalni kulturi starejših.
- Letovanje: V ozadju lahko dobite informacije o zanimivih izletih in potovanjih.
- Zakonodaja: V ozadju si lahko preberete več o sprejetih zakonih.
- Aktivno državljanstvo: Na spletni strani v ozadju lahko dobite koristne informacije o aktivnem državljanstvu, ki spodbuja, da starejši ostanejo aktivni in avtonomni.
- Informatika: V ozadju lahko dobite koristne informacije o tem kako starejše naučiti uporabe IKT, ki je v današnjem času nujna.
- Medgeneracijsko sodelovanje: V ozadju je opis načinov medgeneracijskega sodelovanja in primeri dobre prakse.
- Slovarji: Zdusko vam pomaga razložiti neznane besede.
- Vreme: V ozadju se vam odpre spletna stran ARSO, kjer lahko vidite vremensko napoved.
- Slovenski turizem: Zdusko vas poveže s spletno stranjo e-Turist, kjer lahko načrtujete svoj ogled Slovenije.

2.9 SVIZ

Kratek opis: Na spletni strani SVIZ (Sindikat vzgoje, izobraževanja, znanosti in kulture Slovenije) je dostopen virtualni asistent, imenovan Svizec. V levem zgornjem kotu lahko izberete aplikacije, v iskalno okno pa vpišete vprašanje.

Slika 8. Asistent SVIZec.

Aplikacije:

- Splošno: Asistent vam odgovori na splošna vprašanja o SVIZu.
- Vreme: V ozadju se odpre spletna stran ARSO, na kateri si lahko ogledate vremensko napoved.
- Prevajanje: V ozadju se pokaže prevajalnik podjetja Amebis, kjer lahko prevajate stavke med slovenščino, nemščino in angleščino.
- Slovarji: V ozadju se odpre slovar za večje evropske jezike.
- Računalniški slovarček: V ozadju se nahaja slovarček računalniških izrazov.
- Matematika / Znanje: Odpre se spletna stran Wolphram Alpha, zmogljivo orodje za reševanje matematičnih, fizikalnih, kemijskih in drugih znanstvenih nalog.
- Počitnice: V ozadju se odpre spletna stran Odpočij.si, kjer lahko najdete počitniški kraj.
- Predpisi in zakoni: Dostopni splošni zakoni na spletni strani v ozadju.

3. ZAKLJUČEK

V prispevku je bil predstavljen pregled večine asistentov, ki so bili razviti na Odseku za inteligentne sisteme Instituta "Jožef Stefan". Skupno jih je med 200 in 300. Kot prvi in najpomembnejši je bil opisan Asistent IJS (2.1.), v nadaljevanju pa še dva, ki sta povezana z zdravjem, to sta Čakalne vrste (2.2.) in Stres (2.3.). Sledijo asistent za pametna mesta EkoSMART-asistent (2.4.), nato pa Meta asistent (2.5.), ki pokriva Občine (2.6.). Sledi bolj zabaven 3D-asistent (2.7.), do katerega lahko dostopamo iz občinskih asistentov. Na koncu je opisan asistent ZDUS (2.8.), ki je v pomoč starejšim.

4. REFERENCE

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Varnostna ura IJS

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POVZETEK

Starejša populacija se vse pogosteje spoprijema s težavami kakovostnega, varnega in samostojnega življenja. Situacija odpira vrata za inovativne rešitve z uporabo umetne inteligence. Na Institutu »Jožef Stefan« na Odseku za inteligentne sisteme že vrsto let razvijamo sisteme za pomoč starejšim. Med njimi je tudi pametna ura, ki omogoča podaljšanje samostojnega življenja, hkrati pa poveča varnost in udobje. Zaradi slednjega je primerna tudi za druge ciljne skupine, kot so odročni delavci, reševalci, raziskovalci, avanturisti ipd. V prispevku je splošno predstavljena najnovejša različica ure, ki je zmožna nenehnega spremljanja uporabnika. Med najpomembnejšimi funkcijami sta zaznavavanje padcev in mirovanja, obenem pa ura vsebuje več kot 15 funkcij, ki so predstavljene v prispevku.

Ključne besede

EMZ, pametna ura, skrb za starejše, aktivno staranje, zaznavanje padcev, zaznavanje mirovanja, srčni utrip.

1. UVOD

Razvoj medicine in izboljšanje življenjskih pogojev sta pripomogla k podaljšani življenjski dobi, a tudi hitrejši tempo življenja ter povečan obseg dela in zmanjšanje rodnosti, zaradi česar se je prebivalstvo začelo starati [1]. Daljše življenje je velik civilizacijski dosežek, eden od ključnih izzivov pa je, kako ohraniti samostojnost in varnost starejših ter kako narediti starost dostojno in prijetno tako za starejše kot njihove sorodnike [2]. S tem namenom je bila razvita pametna ura za starejše. Razvoj pametne ure temelji na večletnem raziskovalnem delu prepoznavanja aktivnosti in padcev ter dolgotrajnega in natančnega testiranja različnih prototipov pri številnih ciljnih uporabnikih [3,4,5]. Končni rezultat je pametna ura, ki uporabniku ne poveča le varnosti, ampak tudi izboljša življenje s številnimi uporabniškimi funkcijami.

Sistem povezuje starejše in njihove skrbnike ter jim pomaga pri komunikaciji in hitri pomoči pri nezgodah. Primeren je za starejše, ki želijo dlje časa bivati v domačem okolju, za živeče v domovih za starejše in za uporabnike, ki delajo na tveganih območjih. V prispevku predstavimo osrednjo komponento našega sistema, pametno uro, ki je namenjena izboljšanju varnosti uporabnika.

2. PAMETNA URA

2.1 Osnovne funkcije

Varnostna pametna ura IJS ima skupaj s komandnim modulom naslednje osnovne funkcije:

1. **Čas in datum:** Na domačem zaslonu vidite čas, datum, signal, baterijo, števec korakov ter način delovanja.
2. **Opomniki:** Opomnike lahko nastavite na spletnem portalu ali jih pošljete preko SMS-a. Lahko so enkratni ali periodični.
3. **Socialni klici (prijatelji):** Če od domačega zaslona s prstom po zaslonu potegnete 2-krat v desno stran, prispete do kontaktov. Pokličete lahko do 4 shranjene številke.
4. **Zunanji klici:** Kdorkoli lahko pokliče na uro in začne pogovor – kot z mobilnim telefonom.
5. **Spremljanje aktivnosti:** Pametna ura spremlja aktivnost uporabnika. Če se nenavadno malo ali preveč giblje, kot se običajno, ura to sporoči skrbniku. Lahko se nastavi, da se sprememba dnevne aktivnosti sporoči na določeno številko.
6. **Geo-lociranje:** Lociranje uporabnika v primeru nevarnosti.
7. **Peskovnik:** Če uporabnik zaide preko določenega območja, ura o tem obvesti skrbnika.
8. **Števec korakov**: Dnevno štetje korakov. Ura nas opomni, če se moramo več gibati ali pa če smo že naredili dovolj korakov v dnevu.
9. **Merjenje srčnega utripa**: Ura meri srčni utrip eno minuto in nato izpiše povprečni utrip.
10. **Avtomatski klic na pomoč v primeru padca**: Pametna ura pokliče skrbnika, če se zgodi padec.
11. **Avtomatski klic na pomoč v primeru mirovanja**: Pametna ura pokliče skrbnika, če uporabnik obmiruje 1-5 min (odvisno od načina delovanja).
12. **Klic na pomoč s pomočjo gumba**: Ročni klic na pomoč, ki ga lahko izvede uporabnik sam, če potrebuje pomoč.
13. **Prekinitev klicanja na pomoč**. Če se sproži klic na pomoč, ga lahko uporabnik prekine.
14. **Nastavljanje ure s komandnim modulom**. Preko komandnega modula je možno nastavljati uro.
15. **Nastavljanje ure**. Uro je možno nastaviti na več načinov delovanja, parametrov itd. Nastavitve je možno doseči na skrit način, da ne bi npr. dementni uporabniki narobe nastavljali ure.
16. **Tovarniške funkcije pametne ure**. Ura predstavlja nekoliko okrnjen mobilni telefon in ima vse osnovne funkcije tovrstnih naprav. Možen je dostop do tovarniških funkcij, vendar na skrit način.

Nekaj teh funkcij je podrobneje opisanih v nadaljevanju.

2.2 Varnost

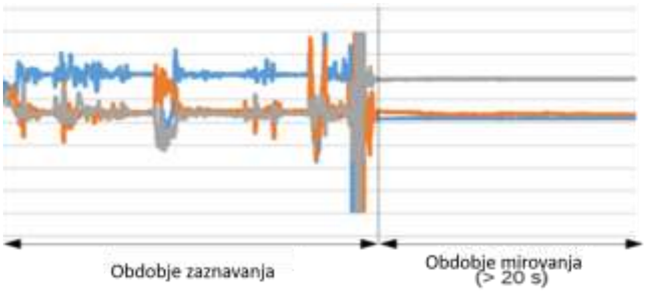
Glavna funkcionalnost in razlog, zakaj si uporabniki sploh želijo takšen sistem, je varnost. En poglavitnih strahov, zakaj se starejši odločijo za zapustitev domačega okolja ter prehod v varovano okolje (dom za ostarele, varovana stanovanja), je ravno strah pred poškodbo in nezmožnostjo klica na pomoč. Žal se dandanes, kljub vsej sodobni tehnologiji, pogosto dogaja, da se starejša oseba poškoduje (pade) v domačem okolju, ni pa zmožna vstati in poklicati na pomoč. Zaradi dolgotrajnega (tudi večdnevnega) ležanja na tleh s poškodbo se zdravstveno stanje izredno poslabša, okrevanje se podaljša, v najhujših primerih pa lahko to privede do smrti.

Sistem je zasnovan tako, da prepoznava določene tipe nevarnosti in samodejno pokliče na pomoč v primeru, da prepozna nevarnost.

2.2.1 Zaznavanje padcev

Zaznavanje padcev temelji na prepoznavanju značilnih pospeškov, ki nastanejo med padanjem in po padanju. Glavni senzor, ki ga za to uporabljamo, je pospeškomer. Z uporabo dodatnih senzorjev, kot so barometer, giroskop in PPG, pa lahko natančnost algoritma še izboljšamo. Žal imajo osnovne (cenejše) ure le pospeškomer, višji cenovni razred pa omogoča dodatne senzorje ter s tem višjo natančnost in manj lažnih alarmov.

Glavna ideja algoritma je prepoznavanje treh obdobij padca; gibanje pred padcem, visok pospešek, ki nakazuje padec in mirovanje po padcu (glej sliko 1). Na ta način lahko prepoznamo vse hujše padce, po katerih je oseba tako poškodovana, da se ne more več premikati (niti poklicati na pomoč). V primeru, da se oseba še lahko premika, predpostavimo, da lahko pokliče na pomoč z uporabo gumba. Na ta način drastično zmanjšamo število lažnih alarmov, obenem pa zagotavljamo visok nivo varnosti.



Slika 1. Prepoznavanje padcev iz pospeškov. Ob padcu nastanejo izstopajoči pospeški, po njem pa se stanje umiri.

2.2.2 Prepoznavanje mirovanja

Pogosto se zgodi, da osebi postane slabo, omedli ipd., a ker ne stoji, pri tem ne pride do padca, zato sistem za prepoznavanje padcev ne sproži alarma. Z namenom, da bi prepoznali takšne težave, smo razvili metodo za prepoznavanje nenavadnega mirovanja. Metoda ves čas spremlja premikanje osebe (zapestja). Ker merimo mikro-gibe, ki so prisotni skorajda vedno, ko je oseba budna (npr. tudi ko tipkamo po tipkovnici), enostavno določimo mejo, ki predstavlja, da je oseba omedlela. Z namenom zmanjševanja lažnih alarmov sistem v takšnem primeru najprej opozori uporabnika z 10-sekundnim vibriranjem. Če je uporabnik priseben, premakne zapestje, kar pomeni, da je vse v redu. V primeru, da se to ne zgodi, sistem sproži alarm.

2.3 Povezljivost

Majhen zaslon na uri onemogoča enostavno upravljanje kompleksnih nastavitev, to je še posebej poudarjeno pri starejših uporabnikih, ki imajo pogosto težave z vidom. Zato smo se odločili, da uro povežemo s spletnim portalom (komandnim modulom), ki omogoča upravljanje ure na daljavo, poročanje o morebitnih alarmih in stanju ure ter enostaven vpogled svojcem ter skrbnikom.

Zaradi boljše pokritosti in zanesljivejšega delovanja je primarni sistem, ki se uporablja za komunikacijo s strežnikom, SMS, naknadno pa smo omogočili tudi uporabo podatkovnega prometa z uporabo REST-protokola.

Zaradi varovanja osebnih podatkov se na strežniku shranjuje le uporabniško ime (ki je poljubno), geslo ter telefonska številka ure, ki je hkrati tudi identifikacija naprave. Uporabnik lahko sam izbira, ali želi določeni osebi (uporabniku, skrbniku) dodeliti vpogled do podatkov. Da pa bi bilo delovanje sistema razširljivo, smo omogočili določene API-klice, ki omogočajo povezljivost z drugimi sistemi. To je predvsem primerno za klicne centre, ki želijo ohraniti svoj obstoječ sistem za prejemanje klicev in hranjenje podatkov ter ga na enostaven način nadgraditi z dodatnimi funkcionalnostmi, ki jih omogoča pametna ura.

3. NAVODILA

Sistem umetne inteligence skuša izvajati nekatere funkcije, ki bi jih skrbnik-človek s pridom uporabljal. Ura poveča varnost starejših, odraslih in otrok ter podaljša samostojnost življenja starejših. Možni so trije načini uporabe:

a) aktivni način, ko se sproži alarm ob vsakem daljšem mirovanju (npr. na izletu, ob zahtevnih hišnih opravilih, za varnostnike, vlakovodje, delavce; trajanje baterije 8 ur),
b) normalni način, ko se sproži alarm ob velikem pospešku in nato mirovanju, tj. padcu (npr. izlet; trajanje baterije 24 ur), in
c) varčni način, ko ura ne zaznava padcev in mirovanja, ampak samo SOS-gumb (trajanje baterije 3 dni).

Video na YouTube: Varnostna ura IJS (https://youtu.be/bokP2_x-Q3s)

Več informacij na spletni strani: http://ura.ijs.si

3.1 Vklop/izklop

1. Za vklop pritisnemo in držimo srednji gumb (slika 2), dokler se na zaslonu ne izpiše »Lemfo 5«, to je znak, da se ura prižiga (ugaša). Po nekaj sekundah bo pametna ura v stanju pripravljenosti in na zaslonu se bo prikazal domači zaslon z uro in dnevom.
2. Za izklop zopet pritisnemo in držimo srednji gumb, dokler se na zaslonu ne pokaže slika 2.

- Če želimo uro ugasniti, pritisnemo modri gumb na zaslonu (glej sliko 2).
- Če želimo uro ponovno zagnati, pritisnemo zeleni gumb na zaslonu (glej sliko 2).
- Na sredini zgoraj je tudi SOS-gumb za ročni alarm.

Slika 2. Pametna ura s prikazanim SOS-gumbom.

3.2 Kako pogledamo čas in datum?

- Po prižigu ure se pokaže domači zaslon. Na sredini zaslona se samodejno izpišejo čas, datum, signal, baterija, dan, števec korakov in način delovanja (glej sliko 3).
- Ura varčuje z energijo, zato se zaslon po nekaj sekundah zatemni. Če je zaslon temen, ga oživimo s pritiskom na srednji gumb.

Slika 3. Domači zaslon pametne ure.

3.3 Polnjenje baterije

Uro polnimo preko magnetnega polnilnika. Kabel za polnjenje ima na eni strani magnet ovalne oblike, ki ga prislonimo na rumene kontakte na zadnji strani ure (glej sliko 4). Na drugi strani kabla je USB-priključek, ki ga vstavimo v adapter, le-tega pa v vtičnico. Ob začetku polnjenja pametne ure zaslišimo zvočni signal, govor in vibriranje, na zaslonu pa se pojavi znak za polnjenje.

Slika 4. Polnjenje pametne ure.

3.4 Prehod med načini delovanja

Način delovanja nastavimo tako, da na domačem zaslonu s prstom potegnemo od desne proti levi. Pojavi se okno »Moduli« in tri možne izbire (kot je opisano na začetku):

a) aktivni način, tu je možnost izbire dveh:
   - zaznavanje padcev
   - zaznavanje mirovanja

b) normalni način

c) varčni način

Izbrati je mogoče eno možnost izmed a), b) in c) s pritiskom znotraj ustreznega kroga.

3.5 Klic prijateljev

Do kontaktov lahko dostopamo tako, da na domačem zaslonu s prstom dvakrat potegnemo z leve proti desni. Pojavi se okno »Kontakti« z vnaprej shranjenimi številkami. Prijatelje pokličemo tako, da držimo prst na željenem kontaktu.

Opomba: Za klice mora biti vstavljena SIM kartica.

3.6 Samodejni klic na pomoč v primeru padca

V primeru, da padete in obmirujete 20 sekund ali eno minuto (se nastavi v »Napredne nastavitve«), bo pametna ura samodejno poklicala na pomoč in bo klicala toliko časa, dokler koga ne prikliče. Navodila za preklic klica so spodaj.

Pomembno: Uro nosite na roki, v roki, v žepu oz. nekje na sebi, da lahko zazna padec.

3.7 Ročni klic na pomoč

Če želimo sami poklicati na pomoč, pritisnemo najprej srednji gumb, da je ura v stanju pripravljenosti, nato pa tri sekunde držimo spodnji gumb. Ura bo poklicala na pomoč, na zaslonu pa se bo pojavila slika 5: »Kličem na pomoč. Pritisni in drži za preklic.«

Če želimo, lahko klic na pomoč prekinemo – glej navodila spodaj.

3.8 Preklic klica na pomoč

Ko ura kliče na pomoč, se na zaslonu pojavi slika 5: »Kličem na pomoč. Pritisni in drži za preklic.« Klic prekličemo tako, da pritisnemo na zaslon in držimo. Barva zaslona se bo spremenila z rdeče na zeleno (slika 5) in klic se bo prekinil.

Slika 5. Prikazan je postopek za sprožitev in preklic klica na pomoč.

3.9 Srčni utrip

Okno za merjenje srčnega utripa se nahaja levo od okna »Domači zaslon«. Ko je na zaslonu izpisan »Domači zaslon«, s prstom po zaslonu potegnemo z leve proti desni, tako da se na zaslonu prikaže slika 6. Za začetek merjenja srčnega utripa pritisnemo in držimo na zaslon. Ura približno 25 sekund meri srčni utrip in ga nato prikaže na sredini zaslona.

Za izhod na »Domači zaslon« s prstom potegnemo po zaslonu od desne proti levi.

Slika 6. Zaslon pred začetkom merjenja srčnega utripa.

4. ZAKLJUČEK

V prispevku je opisana najnovejša različica Varnostne ure IJS. Ura vsebuje več kot 15 funkcij, med katerimi sta najbolj pomembni funkciji za avtomatsko zaznavanje padcev in mirovanja. Pametna ura je bila razvita na podlagi večletnih izkušenj in številnih preizkusov prototipov na različnih stopnjah razvoja z dejanskimi uporabniki, kar je tudi pripeljalo do trenutnega izdelka, ki je že preizkušen in primeren za končne uporabnike. S pomočjo spletnega API-ja je tudi omogočena enostavna integracija v že obstoječe sisteme za e-oskrbo ter pomoč na daljavo, s čimer upamo na hiter in učinkovit prodor na trg, najprej v Sloveniji, nato pa v Evropi.

5. ZAHVALA

Raziskave in razvoj so nastale v okviru programa EkoSMART in so delno sofinancirane s strani Ministrstva za izobraževanje, znanost in šport ter Evropske unije iz Evropskega sklada za regionalni razvoj (ESRR).

Zahvaljujemo se vsem, ki so sodelovali pri razvoju pametne ure: Jani Bizjak, Anton Gradišek, Hristijan Gjoreski, Luka Stepančič, Nejc Mlakar, Nejc Kovač, Tadej Magajna, Kristian Remsak, Samo Remec ter ostali sodelavci odseka E9.

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New HRV biofeedback technique and monitoring its effects in a psychotherapeutic group of coronary patients with SAVVY mini ECG devices installed

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ABSTRACT
In the past years, two techniques for raising heart rate variability (HRV) were presented; 1) resonant breathing with a frequency of 0.1 Hz and 2) rhythmic isometric contraction of skeletal muscles with a frequency of 0.1 Hz. Research has shown greater efficiency for resonant breathing techniques.

In our study, we want to test Combined respiratory and muscular HRV technique, or CBM-HRV, in which muscular and respiratory techniques are combined. For this technique, preliminary experiments have shown greater efficiency, as compared to other techniques, since it has greatest contribution to the increase in HRV. Because the technique is not physical demanding, it could be practiced by patients in the first days after myocardial infarction (MI) in the lying position. In addition, a possibility to use the SAVVY medical device (mini ECG device, developed at the Jožef Stefan Institute) for the purpose of psychophysiological coronary rehabilitation is stressed.

Keywords
Heart rate variability, Biofeedback, Resonant breathing, Rhythmic isometric contraction of skeletal muscles, Combined respiratory and muscular HRV technique, SAVVY medical device

1. INTRODUCTION
There is a worldwide occurring trend of increasing the number of scientific studies on biofeedback training aimed to increase heart rate variability (HRV-BFB) in patients following a heart attack, as well as in other coronary patients, and in patients with some other somatic and psychiatric illnesses [1,2,3]. In the Internal Clinic, UKCL (Ljubljana UMC), at the Department of Cardiac Rehabilitation, we are also preparing a study in cooperation with colleagues from the USA, in which we will investigate the impact of psychophysiological coronary rehabilitation (standard physiotherapeutic rehabilitation + stress management + HRV-BFB) on the reduction of psychogenic and oxidative stress in patients following a heart attack (MI).

2. NEW USE OF THE SAVVY DEVICE
We believe that we should have a possibility to use the SAVVY medical device (mini ECG device, developed at the Jožef Stefan Institute) for the purpose of psychophysiological coronary rehabilitation. With these devices applicated on each patient, we could simultaneously measure heart rate variability (HRV) on the whole group of cardiac patients during psychophysical relaxation exercises and during exercises aimed at increasing the HRV. The next step, however, would be the possibility of lending these devices to patients for home use during a period of three months of coronary rehabilitation. In this way, it would be easier to monitor the progress and cooperation of patients in means of regular practicing of these exercises at home. We believe that this would also increase the motivation of patients to carry out exercises at home. The results of home HRV measurements could be sent by patients to Psychophysiological rehabilitation clinic via e-mail or in some other, even more elegant way- for instance telemetry.

3.1. NEW HRV BIOFEEDBACK TECHNIQE
One of the authors of the HRV biofeedback training, professor Vaschillo E.G., presented two techniques for increasing the heart rate variability: resonant breathing with a frequency of 0.1 Hz and a rhythmic isometric contraction of skeletal muscles with a frequency of 0.1 Hz [4]. In his research, he found that the technique of resonance abdominal breathing with a frequency of 0.1 Hz was more effective than the aforementioned muscles contraction technique. By reviewing professor Vaschillo's article [4], authors Dušan Enova and Tej Enova found that participants in the study of isometric muscular contractions technique did not have a fixed, specific, breathing rhythm during the exercise, but they breathed spontaneously, each with their own rhythm. From the results of one of the participants in the study, it is evident that the latter was breathing with an average rhythm of 0.3 Hz or approx. 18 breaths per minute. Dušan and Tej Enova have, by trials on themselves, came up with biofeedback technique: simultaneous isometric tensioning of the muscles of the crossed lower limbs

in a sitting position, namely for 4 seconds during the inhalation phase; and relaxation of all muscles for 6 seconds in the exhalation phase (the entire respiratory cycle is 10 seconds, 6 breaths per minute, frequency 0.1 Hz). Thus, the respiratory and muscular techniques are combined, both in the rhythm of 0.1 Hz (Combined respiratory and muscular HRV technique or CBM-HRV). It turned out that this new HRV technique is significantly more effective than resonant breathing technique. We are now planning a study to confirm these preliminary results on a sample of young and healthy people. In case of confirmation of this hypothesis, we will use this new HRV technique in the aforementioned planned study at the UKCL Internal Clinic. The technique is not physically demanding and could already be practiced (in the lying position) in the first days after the MI by hospitalized patients.

3.2. PRELIMINARY RESULTS OF THE NEW HRV BIOFEEDBACK TECHNIQUE

Figures 1 to 4 show the results of HRV measurements parameters of the four techniques performed by the author himself in a state after experiencing stress (Saturday, 22.9.2018, in the morning). Measurements were done with the Nexus 10, MindMedia medical device. Results of the combined CBM1 technique (tensioning the leg muscles during the inhalation phase with a rhythm of 0.1 Hz) are presented in the final Figure 4. It is evident that, when practicing this technique, SDNN as a classical measure of heart rate variability, is significantly higher than when practicing other techniques. This technique was performed after a breathing phase of 12 breaths per minute (0.2 Hz). The other two techniques were carried out later.

Duration of each of four measurements presented in Figures 1. to 4. was 3 minutes, but only those intervals without artifacts were counted for calculation.

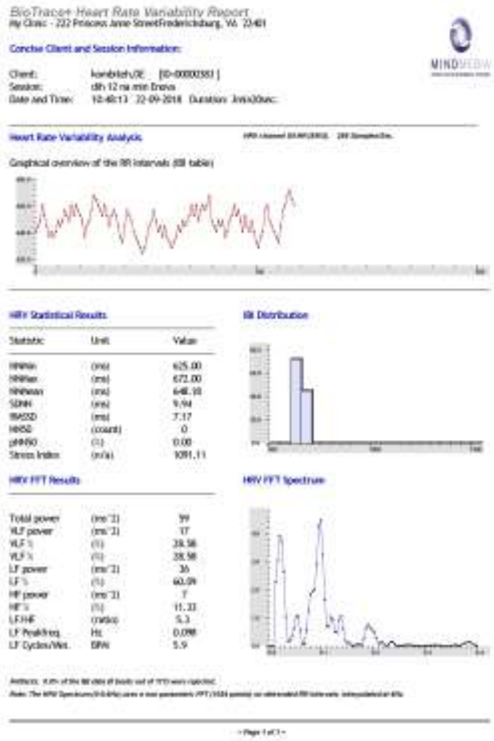

Figure 1. Breathing with a frequency of 0.2 Hz (average breathing 12 breaths per minute). SDNN 9.94; Stress Index 1091.11

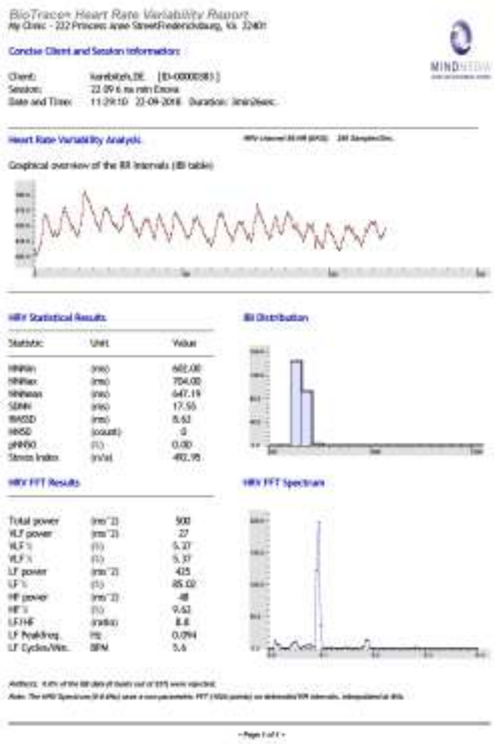

Figure 2. Breathing with a frequency of 0.1 Hz (resonant therapeutic breathing 6 breaths per minute). SDNN 17.55; Stress Index 492.95

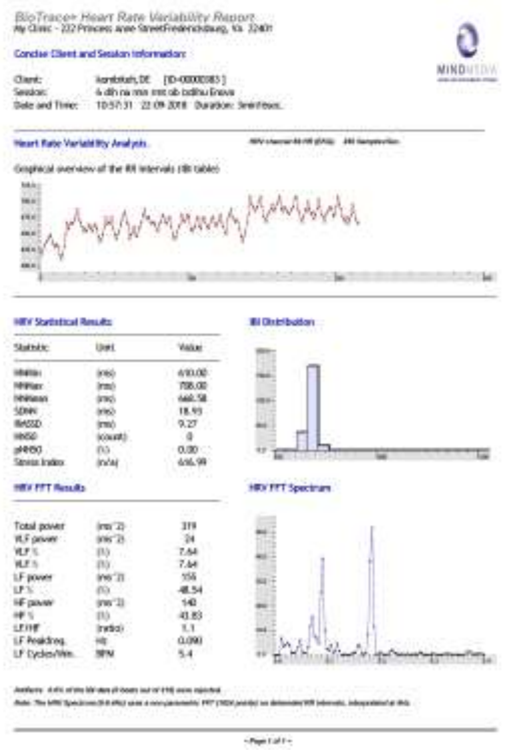

Figure 3. Combined CBM2 technique (tensioning skeletal muscles during the exhalation phase with a 0.1 Hz rhythm). SDNN 18.93; Stress Index 616.99

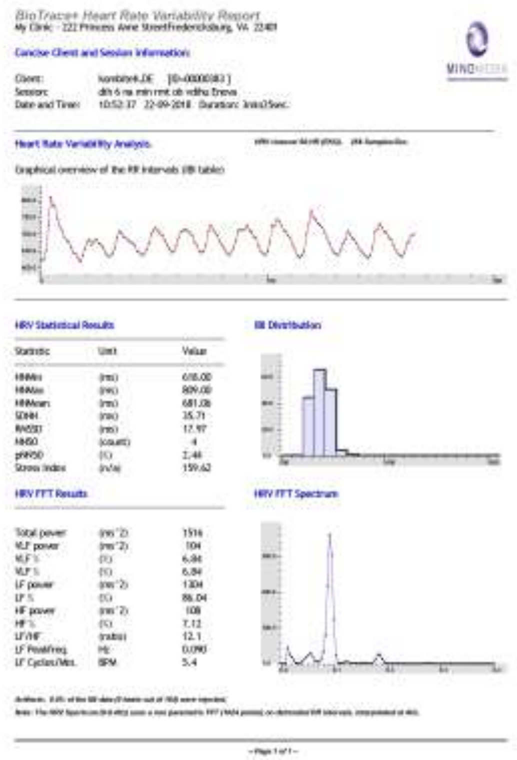

Figure 4. Combined CBM1 technique (tensioning skeletal muscles during the inhalation phase with a rhythm of 0.1 Hz). SDNN 35.71; Stress Index 159.62

3.3.PROPOSED PHYSIOLOGICAL EXPLANATION OF THE COMBINED HRV- BFB TECHNIQUE FUNCTIONING

According to the explanation in professor Vaschillo's article, it is evident that the physiological effect of isometric contractions of skeletal muscles slightly increases the overall body blood pressure. With a delay of about 5 seconds, the heart rate is adjusted after this change of blood pressure [5]. Therefore, it is clear that, by the principle of respiratory sinus arrhythmia (RSA), the heart rate rises slightly during the inhalation phase and slightly decreases during the exhalation phase, and that the amplitude of this variability is maximally increased during breathing with a frequency of 0.1 Hz - there occurs some sort of cardiac-vascular-vegetative nervous system resonance. By tensioning skeletal muscles, blood pressure is slightly increased, after 5 seconds the heart rate is slightly reduced. Within the resonance breathing with 0.1 Hz frequency, the ratio of 4sec / 6 sec was selected between inhalation and exhalation phase. With muscles tensioning for 4 seconds from the start to the end of the inhalation phase (CBM1), and after a time interval of 5 seconds (counted from the start of the inhalation), an additional slight increase in blood pressure in the exhalation phase (lasting 6 seconds) occurs. Consequently, the heart rate frequency in the exhalation phase is further reduced, which leads to a higher amplitude in the curve of heart rate variability. In the opposite case, when using CBM2 combined technique, muscles tensioning is present only in the exhalation phase. As a consequence, there occurs some inhibition of heart frequency variability - thus a lower efficiency of this combined technique in comparison with CBM1. Therefore, we suggest that only CBM1 technique is really more effective.

4.CONCLUSION

In the paper, we presented the possibility of using a new HRV biofeedback technique to increase the heart rate variability, and at the same time suggested that the effects of this technique could be measured with Savvy medical device (mini ECG device, developed at the Jožef Stefan Institute) for the purpose of psychophysiological coronary rehabilitation. It turned out that this new HRV technique is significantly more effective than resonant breathing technique. We are now planning a study to confirm these preliminary results on a sample of young and healthy people.

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The Summoner – "Izbirčnež"

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ABSTRACT

More and more human to human interactions are these days converted into the human to computer interaction. So called agents are replacing human role in serving the users with basic information and executing basic tasks. These interactions are getting better over time, approaching the point where humans cannot make the difference, whether there is a real human or a computer agent (virtual assistant) on the other end of the dialog. Similar to a society of humans, there are also societies of virtual assistants. In this paper we describe a meta-agent, i.e. a meta virtual assistant, that given a question asks a society of virtual assistants and summons the best reply from them all. The "Summoner", as we call our system, is therefore an online service that finds the best answer to the users' question from a predefined list of systems according to the chosen heuristics.

Keywords

best answer, assistant, text distance, intersect, information retrieval

1. INTRODUCTION

Virtual assistants [2] represent a fast developing field with several companies developing at least one of them, e.g. Microsoft, Apple, Google, etc. In Slovenia, Department of intelligent systems of Jožef Stefan Institute developed several hundred virtual assistants [1]. For 220 Slovenian municipalities we managed to design 200 virtual assistants, where the knowledge base was extracted from the municipalities' web pages. 20 municipalities did not have any web page to start with. We call virtual assistants agents and vice versa continuously. Each agent can answer questions for their municipality. If a user wants to know something about Ljubljana, the user needs to find the agent of Ljubljana and ask this agent a specific question. However, the users who don't know which agent to ask have the problem of finding the right agent. We wanted to resolve this gap so that the users could get the most out of the already working 200 agents.

This project had another goal – to combine all of the already working agents into one general agent. Previous experience demonstrated that often some agents find a good reply, but it is hard to predict which one will provide the best one for a particular question. Therefore, dynamic selection from several reply suggestions of different agents is needed. To achieve this, several heuristics had to be applied, tested and improved in order to get the desired performance.

The paper continues with Sections 2 and 3, where the prototypes and "summon" heuristics are described, in Section 4 we describe the agent selection, in Section 5 the user experience is addressed and Section 6 concludes the paper.

2. FIRST PROTOTYPE

The first approach in creating a prototype was to ask all available 200+ agents a given question and then calculate a weight, based on which the Summoner would choose the most suitable answer. The most suitable answer gives the user the most information about the question, or at least guides the user in the right direction, where the answer can be found. The process is presented in Figure 1.

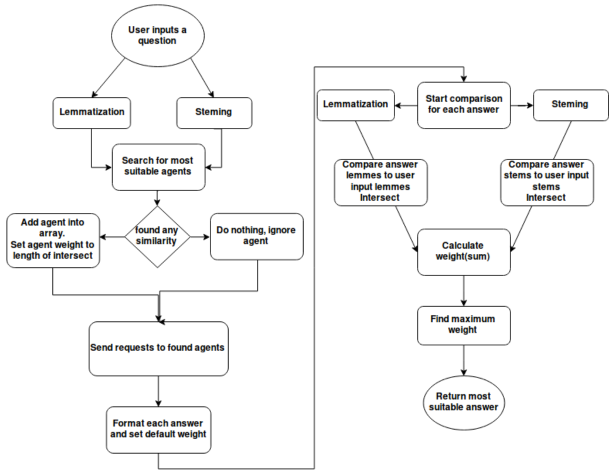


Figure 1: Basic concept flow chart of the Summoner

The user input is processed by removing symbols and stop-words and running it through lemmatization and stemming services. Out of this step three sets of words are created: raw (original), lemmas and stems.

The original question is then sent to each agent according to the municipality agent application programming interface (API) specification. Each agent, when asked, responds with a Javascript object notation (JSON) object with included the answer ID, the answer text and the corresponding link. The link is present if the agent does not find the answer or if the agent wants to display more information about the answer. Each answer is then processed in the same way as the question – removing symbols and stop-words and performing lemmatization and stemming. Each answer is stored in a hash map, where the key is the unformatted answer and value is the score or the weight of the answer.

Only the user input and agent answers are used for calculating answer weight. We use the simple method of word intersection between formatted user input and formatted answer, which are a set of lemmes and stems. The weight is simply the size of the intersect. The answer with the most words that also co-occur in the user input is ranked the highest.

3. SECOND PROTOTYPE

After the testing of the first prototype, it turned out that retrieving answers from all 220 agents took most of the response time. First improvement was to use threads for sending and retrieving questions from all 220 agents. This feature reduced the answer fetch time in average to about a quarter of the original time (Table 1).

Table 1: Use of threads and without threads, when requesting all agents with the same question

	No threads	Threads
Time(s)	201	54

In order to measure the performance of the Summoner, a benchmarking system was set-up, which includes 100 (question, correct answer) pairs. The benchmarking system inserts all 100 questions into the Summoner and compares the obtained answers to the correct ones that were defined manually. Using the prototype described in Section 2, i.e. calculating the size of word intersect, we get 93 of 100 answers right.

In order to improve this score, we included several more complex text distance[1] calculations that compare the user input and the answer. The computed text distance is then used as the weight assigned to each answer. The performance of different text distances was then assessed using the benchmarking system (Table 2).

Table 2: Different text distances used for weight calculation and their performance in the benchmark

Text distance	Jaccard	Sorensen	Bag	Overlap	Overlap, qval is None
Score	91	92	92	93	92

According to the results none of the added text distance metrics improved our score. The best solution for matching user input with answer remained the simplest one – set of the processed words intersection. The response is provided in the JSON format (Figure 2).

```
{"answer": best_answer_formated,
 "data": Izbircnez.data[best_answer],
 "score": Izbircnez.data[best_answer]["weight"],
 "assistant": Izbircnez.data[best_answer]["answerer"],
 "assistant_address": answerer_url,
 "did we ask all:": ask_all,
 "timeout": timeout,
 "number_of_sent_requests": n_agents,
 "number_of_response_ok": n_data,
 "number_of_response_fail": n_agents - n_data}
```

Figure 2: JSON response format

4. AGENT SELECTION

Many of the user questions already have some information about which municipality a question is referring to. So the next improvement idea was to remove the agents that we know will not provide a suitable answer. The question is forwarded to an agent only if the user input has any similarity to the agent title. Doing so reduces the number of suitable agent significantly for almost every question. The similarity is again computed using the text distance calculations, which might help to improve agent selection. After some simple testing we discovered that we had to compare stems and lemmas of both, user input question and agent title too. We also added full match intersect, i.e. set of words intersect without the transformations of stemming and lemmatization. Additionally, we added a function over this weight that takes into account the agent title length. Each agent score is defined as the sum of sizes of intersect (raw, stems and lemmas) each divided by the number of words in the agent title. The final answer score is calculated as the sum of the weights obtained in computing the agent title similarity to the question and agent answer similarity to the user question, where the second weight is computed as described in the first prototype (Figure 3). See Table 3 for benchmark results.

Table 3: Benchmark score after implementing text distances into agent selection

Text distance	Jaro	Stems and lemmas	Stems, lemmas and full match
Score	94	98	97

According to the benchmarking results the best score is obtained when only the agents, whose title similarity to the user question is computed as the interesect of lemmatized and stemmed words, are asked a question. After the agent selection process we get a list of agents that are most suitable for questioning. We identify three typical situations:

1. Only one agent is found. We ask this agent and return the answer.

2. More than one and less than ten agents are found. In this situation only the found agents are queried for the answer. The best answer is chosen according to the heuristic described in Section 2.

3. If more than ten agents are found all the agents are queried for answer. In order to obtain all the answers a special care has to be taken so that the requests to the API are not timed out.

4.1 Response time

[1]https://pypi.org/project/textdistance

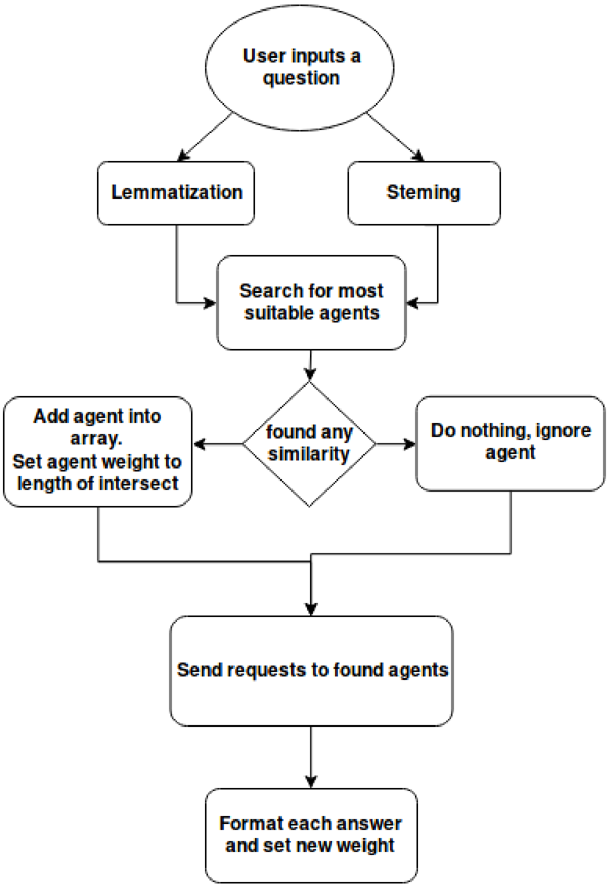


Figure 3: Summoner flowchart after implementing the agent selection

A study[2] shows that when computer program takes more than 0.1 second but less than 1 second to respond, user notices the short delay but stays focused on their current train of thoughts. More than 10 seconds and the flow is broken. Users will often leave the site rather than wait. The goal is to provide the correct answer in less than 10 seconds, however, the response time in cases when all the agents are queried is very long (Table 4).

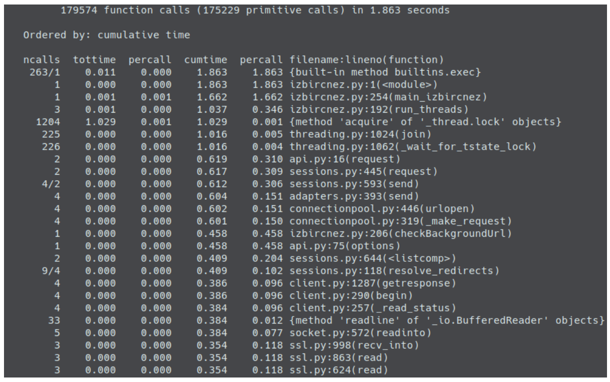
Table 4: Time it takes to return answer in different situations of agent selection

Situation	1 agent selected	2 – 10 agents selected	>10 agents selected
Time(s)	1.1	6.4	54

We ran the profiling of the source code to determine what function or part of the program takes the most time. Evidently, the time to get all the agents to respond takes the most time (Figure 4) – it is the only function that runs in threads.

4.2 The "unknown answer" problem

[2]https://www.nngroup.com/articles/powers-of-10-time-scales-in-ux/



```
       179574 function calls (175229 primitive calls) in 1.863 seconds

   Ordered by: cumulative time

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
    263/1    0.011    0.000    1.863    1.863 {built-in method builtins.exec}
        1    0.000    0.000    1.863    1.863 izbircnez.py:1(<module>)
        1    0.001    0.001    1.662    1.662 izbircnez.py:254(main_izbircnez)
        3    0.001    0.000    1.037    0.346 izbircnez.py:192(run_threads)
     1204    1.029    0.001    1.029    0.001 {method 'acquire' of '_thread.lock' objects}
      225    0.000    0.000    1.016    0.005 threading.py:1024(join)
      226    0.000    0.000    1.016    0.004 threading.py:1062(_wait_for_tstate_lock)
        2    0.000    0.000    0.619    0.310 api.py:16(request)
        2    0.000    0.000    0.617    0.309 sessions.py:445(request)
      4/2    0.000    0.000    0.612    0.306 sessions.py:593(send)
        4    0.000    0.000    0.604    0.151 adapters.py:393(send)
        4    0.000    0.000    0.602    0.151 connectionpool.py:446(urlopen)
        4    0.000    0.000    0.601    0.150 connectionpool.py:319(_make_request)
        1    0.000    0.000    0.458    0.458 izbircnez.py:206(checkBackgroundUrl)
        1    0.000    0.000    0.458    0.458 api.py:75(options)
        2    0.000    0.000    0.409    0.204 sessions.py:644(<listcomp>)
      9/4    0.000    0.000    0.409    0.102 sessions.py:118(resolve_redirects)
        4    0.000    0.000    0.386    0.096 client.py:1287(getresponse)
        4    0.000    0.000    0.386    0.096 client.py:290(begin)
        4    0.000    0.000    0.384    0.096 client.py:257(_read_status)
       33    0.000    0.000    0.384    0.012 {method 'readline' of '_io.BufferedReader' objects}
        5    0.000    0.000    0.384    0.077 socket.py:572(readinto)
        3    0.000    0.000    0.354    0.118 ssl.py:998(recv_into)
        3    0.000    0.000    0.354    0.118 ssl.py:863(read)
        3    0.000    0.000    0.354    0.118 ssl.py:624(read)
```

Figure 4: Profiling sorted by cumulative time

The agent endpoint returns an answer as well as a background website link. This link adds additional information to the answer. If the question is about the mayor of the municipality then the answer contains information about this mayor and the background website gives the user further and more in depth information about the mayor and the municipality.

When investigated, these website links fall in one of three categories. Each of them is treated differently:

- First category. Website is fully working and displaying correct information about the user question. No further processing is made and the link is stored into the response.
- Second category. When checking the website availability, status code 404 is returned. Several municipality website links stored in the virtual assistants' databases are outdated and those pages don't exist anymore. When this happens, link gets parsed and only base of the link is stored into the response, presenting the user the main municipality web page. To test or filter a website link, a request to the municipality website has to be done.
- Third category. The website link is a redirect to najdi.si[3], a Slovenian search engine. This happens when the agent does not have the answer to the given question. By redirecting the user to the search engine, the agent hopes that the user will get the information he is searching for. To overcome this problem, we simply ignore the answers that include search engine results.

5. USER EXPERIENCE

Two main goals of every virtual assistant are to give the user correct answer to his question and to respond as quickly as possible. In order to enable easy user interaction the visual look of the user interface needs to give a user an intuitive way of using the assistant: providing input and answer display fields and the feedback about the state of the system.

We provide a simple user interface (Figure 6). On the bottom of the page there is the user input field, above it are the

[3]https://najdi.si

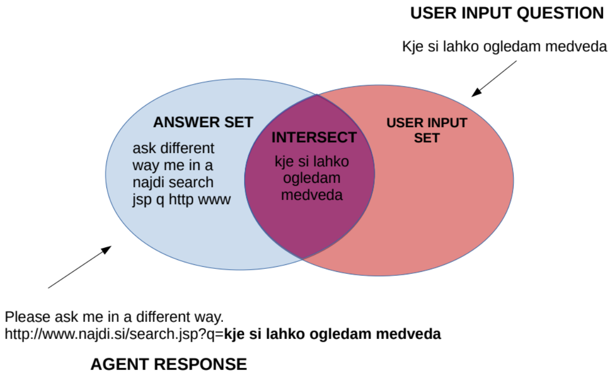


Figure 5: Unknown answer problem visualized

response messages from the system, followed by the system status line and the web page with additional information regarding the system or the website that corresponds to the provided answer.

Figure 6: Summoner web site user interface

As mentioned before, if requests are made to all agents, the long time to retrieve the answer can make the user leave the site, leaving the impression that the system does not work. To give a proper feedback about the state of the system we added an animated status bar, that gives the user visual feedback when the Summoner is processing the input. The animation is a banner above answer display field which uses different colors, depending on the state of the system. Blue animation is displayed when the Summoner is processing the answer and it makes the user feel like the website is thinking. When the answer from the service is retrieved, successful or not, the color changes according to the status. Green marks successful and red unsuccessful response (Figure 7).

6. CONCLUSION

Figure 7: Different system status banners: top – in progress, middle – success, bottom – error

We have developed a meta-assistant that enables choosing the correct answer for a given question, when several answers are provided by the agent society. Development process and system heuristic for choosing the right agent and answer were described together with a short presentation of the web application that enables the user to interact with the Summoner system.

Virtual assistants don't possess true human intelligence, but only try to imitate human interaction and respond to some sort of user request based on some heuristics. Disadvantage of this type of virtual assistants is that they, unlike real artificial intelligence[4], cannot learn on their own. For example, with municipality elections new mayor might be elected. Consequently, a person would need to rewrite some entities of the assistants' knowledge database, which would then enable the Summoner to obtain the correct answer.

Looking forward, this type of virtual assistants is improving with user interaction, since the interactions are stored in the database, a system could be designed in the future that would learn to answer user questions on its own. However, in order to implement such a system, several hundred question-answer pairs have to be obtained first.

Our Summoner has room for improvement, with the first step of improving the underlying agents by decreasing the response time and improving the knowledge base. Future work will also include improving the user experience in using the web application. Additionally, the goal is to provide search across the municipalities in Slovenian, English and German language, enabling wider user base. Further, other publicly available virtual assistants could be included into the agent society, enabling the Summoner to provide the answer to a wider range of questions.

7. ACKNOWLEDGMENTS

The work was co-funded by Cooperation Programme Interreg V-A Slovenia-Austria 2014-2020, project AS-IT-IC.

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Zaznavanje srčnega popuščanja z analizo srčnih tonov

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POVZETEK

Kronično srčno popuščanje je pogosta kronična bolezen predvsem pri starejših od 65 let. Ob poslabšanju zdravstvenega stanja je pogosto potrebna hospitalizacija, zato razvijamo novo telemedicinsko metodo, ki bo na podlagi analize zvoka srčnih tonov sposobna prepoznati poslabšanje stanja in tako preprečiti prepogoste hospitalizacije. V prispevku se osredotočimo na prvi korak te metode, na prepoznavanje zdravih posameznikov in pacientov s poslabšanjem srčnega popuščanja. Metoda je sestavljena iz filtriranja in segmentacije posnetkov, izračuna značilk, gradnje modelov strojnega učenja in združevanja klasifikacijskih algoritmov. Na bazi posnetkov 158 zdravih posameznikov in 40 bolnikov smo dosegli 98,2 % natančnost.

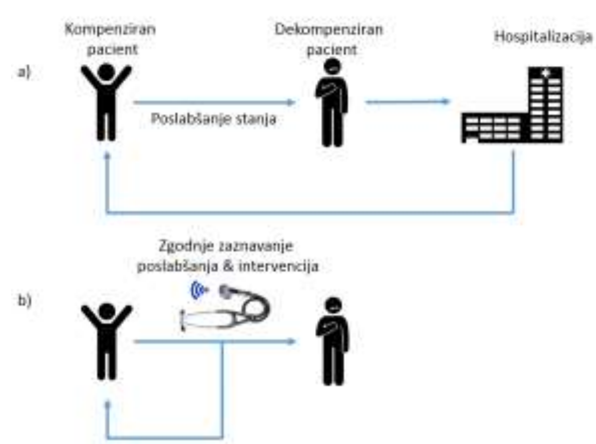
Ključne besede

Srčno popuščanje, analiza zvoka, strojno učenje.

1. UVOD

Kronično srčno popuščanje (angleško: Chronic Heart Failure, CHF) je kronična progresivna bolezen, pri katerem srce ni sposobno črpati dovolj krvi, da bi zadostila potrebam telesa [1]. V razvitem svetu bolezen prizadene 1-2 % splošne populacije in 6-10 % starejših nad 65 let. Glede na trenutno veljavna priporočila Evropskega združenja za kardiologijo srčno popuščanje (SP) diagnosticiramo s pomočjo kliničnega pregleda, z določitvijo nivoja biološkega označevalca SP v krvi (NT-pro BNP ali BNP) ter z ultrazvokom srca. Kljub velikem napredku na področju medikamentozne in nemedikamentozne obravnave kroničnega srčnega popuščanja je prognoza te bolezni še vedno slaba, saj se tudi v zadnjih letih 5-letno preživetje giblje okrog 50 %. Tipično se v kliničnem poteku CHF izmenjujejo obdobja dobrega počutja (tj. kompenzirane faze) in obdobja poslabšanja SP (tj. faze dekompenzacije), kjer bolniki opazijo izrazitejše poslabšanje telesne zmogljivosti, težje dihanje in otekanje v okončine in/ali trebuh. Pogosto je potrebno poslabšanje SP zdraviti hospitalno, saj ti bolniki potrebujejo intravenozna zdravila za učinkovito rekompenzacijo. Zgodnja prepoznava poslabšanja SP pa omogoča, da lahko z ustreznimi terapevtskimi ukrepi (največkrat z omejitvijo vnosa tekočine in povečanjem odmerka zdravil za odvajanje vode) bolniku hospitalizacijo prihranimo. Izkušen zdravnik lahko nastajajoče poslabšanje SP prepozna glede na slabšanje bolnikovega počutja in glede na poslabšanje znakov SP, ki jih lahko ugotovi ob pregledu bolnika. Pri nekaterih bolnikih s poslabšanjem SP lahko pri osluškovanju (fonokardiografija) srčnih tonov opazimo dodatne srčne tone (tipično tretji ton, ki se pojavi 0,1-0,2 s za drugim tonom). Žal slabšanje simptomov in znakov srčnega popuščanja največkrat že pomeni, da gre za polno razvito epizodo poslabšanja SP. V zadnjem času pa ugotavljamo, da se nekateri fiziološki parametri (npr. dodatni srčni toni, porast tlakov v pljučnem krvotoku) pričnejo spreminjati že nekaj tednov preden pride do klinično očitnega poslabšanja SP. Prve analize [2] že kažejo, da zgodnje ugotavljanje spreminjanja teh parametrov pomeni precej učinkovitejšo obravnavo SP, saj je epizod polno razvitega poslabšanja srčnega popuščanja manj, s tem pa je tudi manj potrebe po hospitalni obravnavi teh bolnikov.

V zadnjem času smo priče hitremu razvoju telemedicine, ki omogoča spremljanje pacientov na daljavo in tako znatno razbremeni tako pacienta kot tudi zdravstveni sistem. V pričujočem prispevku predstavimo začetke študije, v kateri uporabimo analizo zvoka srčnih tonov za prepoznavanje poslabšanja srčnega popuščanja. Cilj je razviti metodo, s pomočjo katere bo uporabnik lahko sam spremljal svoje zdravstveno stanje. Uporabnik bo občasno z mikrofonom posnel bitje svojega srca, algoritem pa bo ocenil, če se je stanje srčnega popuščanja poslabšalo do te mere, da je potreben posvet z zdravnikom. Dolgoročno bo ta pristop omogočil pravočasno prepoznavanje poslabšanja in posledično zmanjšal število hospitalizacij. Koncept



Slika 1. Shematski prikaz razvoja poslabšanja srčnega popuščanja. V zgornjem primeru mora pacient zaradi poslabšanja v bolnišnico, v spodnjem primeru poslabšanje zaznamo dovolj zgodaj, da lahko z ustrezno intervencijo preprečimo nadaljnjo poslabšanje.

V tej študiji se osredotočimo na prvi korak te metode, tj. na prepoznavanje zdravih posameznikov in dekompenziranih pacientov. Za snemanje srčnih tonov smo uporabili profesionalni digitalni stetoskop, za prepoznavanje pa metodo, ki temelji na strojnem učenju. V nadaljevanju opišemo metodo in trenutne rezultate.

2. MATERIALI IN METODE

2.1 Baza podatkov

V študiji smo zbrali posnetke 158 zdravih posameznikov in 40 posnetkov bolnikov z razvito epizodo srčnega popuščanja (dekompenziranih). V vzorcu zdravih je bilo 104 moških in 54 žensk, povprečna starost 33,2 let. Z izrazom zdravi tu označujemo posameznike, ki niso imeli nobenih medicinskih stanj, ki bi imele za posledico neobičajne srčne tone. V vzorcu bolnih je bilo 22 moških in 18 žensk, povprečna starost 47,7 let. Bolnike smo posneli v bolnišnici med hospitalizacijo.

Za snemanje smo uporabili profesionalni medicinski digitalni stetoskop 3M Littmann Electronic Stethoscope Model 3200. Posnetek, fonokardiogram, je bil vedno sneman na Erbovi točki, nad tretjim medrebrnim prostorom levo od grodnice. Posamezen posnetek je dolg do 30 s, pri nekaterih posameznikih smo posneli več kot en posnetek, da smo povečali količino podatkov v učni množici. Pred začetkom študije smo pridobili pozitivno mnenje Komisije za medicinsko etiko.

2.2 Metoda

Metoda za prepoznavanje bolnikov in zdravih je sestavljena iz treh ključnih korakov, kot prikazuje Slika 2. Prvi korak obsega filtriranje in segmentacijo signala. Za filter je bil izbran nizkopasovni Butterworthov filter s pragom 1 kHz, ta prag je bil izbran na podlagi študije [3], kjer so ugotovili, da večina relevantnih srčnih tonov nastane pod tem frekvenčnim območjem. Signal smo razbili na segmente, dolge 1 s, pri tem so se zaporedni segmenti prekrivali po pol sekunde (segmentacija z drsečim oknom). Nato odstranimo segmente z energijo, manjšo od mediane posameznega posnetka – tako odstranimo segmente, kjer se bitje srca slabo sliši.

V naslednjem koraku iz vsakega segmenta izračunamo vrsto značilk. Pri tem uporabimo odprto knjižnico značilk OpenSmile [4]. Knjižnica vsebuje značilke tako v časovni kot tudi v frekvenčni domeni, skupaj jih je 1582. Po izračunu značilk je tako vsak segment predstavljen z vektorjem 1582 vrednosti, ki jih uporabimo za gradnjo modelov strojnega učenja.

Tretji korak je sestavljen iz treh faz. V prvi fazi zgradimo modele strojnega učenja na podlagi posameznih segmentov. Pri tem testiramo vrsto različnih algoritmov, kot so J48, Naivni Bayes, Random Forest, kNN, SVN in drugi. Tu nas vodi ideja, da se lahko posamezni algoritmi drugače odzivajo na določene strukture v podatkih. V drugi fazi združimo napovedi modelov na posameznih segmentih v napoved na celotnem posnetku. Tu izhajamo iz dejstva, da vsi segmenti istega posnetka pripadajo istemu razredu (zdravi ali bolni). Združevanje poteka z uporabo minimuma, maksimuma in povprečja napovedi modelov na posameznih segmentih. Če denimo uporabljamo pet različnih modelov in vsak posnetek razdelimo na deset segmentov, bo vsak model za vsak segment določil verjetnost, da gre za bolnika. Iz teh verjetnosti izračunamo povprečno vrednost, minimum in maksimum, torej skupno 15 značilk. V tretji fazi poženemo algoritme strojnega učenja na teh 15 značilkah, iz tega dobimo končno odločitev ali gre za zdravega ali za bolnika.

Slika 2. Posamezni koraki metode za prepoznavanje srčnega popuščanja.

3. REZULTATI

Delovanje metode smo preizkusili po načelu »izpusti en posnetek«. To izvedemo tako, da iz baze podatkov izločimo en posnetek, uporabimo preostale posnetke kot učno množico, na kateri naučimo metodo, potem pa jo uporabimo za določitev izločenega posnetka. Postopek ponovimo za vsak posnetek v bazi.

Pri evaluaciji natančnosti algoritma naletimo na manjši problem z interpretacijo. Ker smo uporabili izrazito neuravnotežen vzorec

(158 zdravih in 40 bolnikov, pri tem, da smo pri zdravih pogosto posneli vsaj dva posnetka, da smo povečali učno množico), je večinski razred skoraj 90 % - zanesljivost algoritma, ki je nad 90 %, je tako pravzaprav pričakovana. Tu zato navedemo rezultate, ki smo jih dobili na nekoliko manjšem set podatkov iz prejšnjega koraka te študije [5]. Na množici 99 zdravih in 23 bolnikov, kjer smo imeli večinski razred 81 %, smo dosegli 96 % natančnost. Pri študiji se pokaže, da z uporabo da pristopa s kombinacijo klasifikatorjev vsakič dobimo bistveno boljše klasifikacijske rezultate kot če bi upoštevali samo večinski razred. Če se osredotočimo samo na bolnike, vidimo, da naša metoda pravilno zazna 87 % primerov, pri zdravih pa je ta natančnosti 97 %.

4. ZAKLJUČEK

Predstavili smo metodo za prepoznavanje srčnega popuščanja na podlagi zvoka srčnih tonov. Metoda uporablja kombinacijo algoritmov strojnega učenja in lahko dobro razpoznava med zdravimi posamezniki in bolniki z razvito epizodo srčnega popuščanja. Začetni rezultati so obetavni, seveda pa je za resno oceno potrebno testiranje na večji množici posnetkov. Poleg tega se moramo zavedati, da smo v tej začetni študiji ločevali le med ekstremnima primeroma – med popolnoma zdravimi posamezniki in med hospitaliziranimi pacienti. V nadaljevanju študije načrtujemo analizo posnetkov pacientov z različno izraženimi stopnjami poslabšanja srčnega popuščanja. To nam bo omogočalo, da bomo zaznali poslabšanje in pacienta napotili k zdravniku, še preden bi bila potrebna hospitalizacija. V tej fazi smo za snemanje srčnih tonov uporabili profesionalni stetoskop. Cilj je, da bo pacient lahko za snemanje uporabil mikrofon, ki ga priklopi na telefon, metoda za zaznavanje popuščanja pa bo tekla na telefonu ali v oblaku.

5. ZAHVALA

Raziskave in razvoj so bile izvajane v okviru programa EkoSMART in so delno sofinancirane s strani Ministrstva za izobraževanje, znanost in šport ter Evropske unije iz Evropskega sklada za regionalni razvoj (ESRR). Zahvaljujemo se tudi vsem, ki so sodelovali pri zbiranju posnetkov.

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Elektrokardiografski senzor: uporaba med družinskimi zdravniki

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IZVLEČEK

Motnje ritma so pogosto prisotne pri bolnikih v ambulantah družinske medicine in tako so družinski zdravniki in tudi specialisti drugih kliničnih strok soočeni s problemom, kako obravnavati take bolnike. V Zdravstvenem domu Ljubljana smo pod okriljem Instituta Jožef Stefana v oktobru 2016 začeli s pilotnim sistemom za presejanje bolnikov s sumom na nereden srčni utrip. Z raziskavo smo želeli dobiti vpogled v praktično uporabo elektrokardiografskega senzorja pri bolnikih, obiskovalcih ambulant družinske medicine, ki v anamnezi navajajo motnje srčnega ritma. Ta metoda lahko revolucionizira oskrbo bolnikov s srčno-žilnimi obolenji v domačih ambulantah, nam privarčuje denar in premosti prepad med primarnim in sekundarnim nivojem.

Ključne besede

motnje ritma, EKG senzor, telekardiologija, napotovanje

1. UVOD

Motnja srčnega ritma ali aritmija je vsak ritem, ki ni normalni sinusni ritem z normalnim prevajanjem preko prevajalnega sistema; normalni ritem se torej začne z impulzom v sinoatrialnem vozlu v zgornjem delu desnega atrija, srčni utrip je v normalnem območju, torej od 60 do 100 utripov na minuto, P-valovi so normalni na EKG-posnetku in ritem je stabilen. Motnje ritma so pogosto prisotne pri bolnikih v ambulantah družinske medicine in tako so družinski zdravniki in tudi specialisti drugih kliničnih strok soočeni s problemom, kako obravnavati take bolnike.

Po podatkih Zdravstvenega statističnega letopisa je bilo leta 2014 na primarnem zdravstvu opravljenih 1.229.195 preventivnih in 7.525.179 kurativnih pregledov, kar znaša 596 preventivnih in 3.650 kurativnih obiskov na 1.000 prebivalcev. Tako se Slovenija z 6,5 obiskov pri zdravniku na prebivalca letno uvršča na sredino seznama evropskih držav. Gledano po razlogih za obisk na primarni ravni predstavljajo bolezni srca in ožilja 5,73% vseh obiskov letno, to je 290.086 pregledov, in so na šestem mestu po pojavnosti [1].

Med najbolj pogoste aritmije štejemo: supraventrikularne prezgodnje utripe, ventrikularne prezgodnje utripe, bradikardijo, ventrikularno tahikardijo, atrijsko fibrilacijo in undulacijo, supraventrikularno tahikardijo, avtriventrikularne bloke ali ventrikularno tahikardijo in fibrilacijo. Simptomi določajo, kako je treba k bolniku pristopiti in so lahko odvisni od aritmije same (npr. palpitacije) ali hemodinamskih posledic aritmije (npr. dispneja, vroglavica). Lahko so podobni drugim medicinskim stanjem in vključujejo palpitacije, vrtoglavico, sinkopo, bolečine v prsih in vratu, dispnejo, slabost in anksioznost. Gre pa lahko tudi za posledico nekega srčnega obolenja, kot so kongestivno srčno popuščanje, ishemija ali trombembolični zapleti [2].

Obravnava bolnika z motnjo ritma v ambulanti družinskega zdravnika

Pri obravnavi vsakega bolnika z aritmijo je potrebno odgovoriti na naslednja vprašanja: katera motnja ritma je prisotna; ali ga ta motnja ritma ogroža trenutno in ali ima dolgoročne posledice; ali bolnik motnjo ritma dobro prenaša (kakšni so simptomi in vrednost krvnega tlaka); ali je potrebno takojšnje ukrepanje; ali je potrebna takojšnja hospitalizacija in ali je potreben posvet s specialistom ter če ja, kdaj [3].

Palpitacije so eden najpogostejših problemov bolnikov, ki jih zdravniki na primarni ravni napotujemo h kardiologom; po podatkih študije, ki je zajemala 500 bolnikov, naj bi jih zaradi palpitacij bilo pregledanih 16 % [4]. Vendar pa dejanske motnje ritma najdemo pri manj kot polovici [5]. Palpitacije so senzorni simptom, ki ga spremlja neprijeten občutek močnega, hitrega ali nepravilnega bitja srca; bolniki radi opisujejo, kot da jim razbija v prsih ali v vratu [6]. Diferencialna diagnoza palpitacij je obširna; v študiji, v katero je bilo vključenih 190 bolnikov, so ugotovili vzroke pri 84%. Pri 43% bolnikov je bil vzrok kardialni, pri 31% psihogen in pri 10% mešani vzroki kot tireotoksikoza, uživanje kofeina ali kokaina, anemija in podobno [7].

Da lahko postavimo diagnozo pri bolniku, ki navaja motnje ritma, v praksi uporabimo EKG. Po enkratnem posnetku, ki nujno ne odraža motnje ritma, ki je lahko prehodnega značaja, se poslužujemo bolj kontinuiranih metod. V široki uporabi pri specialistih kardiologih je holter monitoring, kjer gre za 24- ali 48- urno nepretrgano merjenje EKG-ja [8]. V izogib nepotrebnemu napotovanju in zaradi dolgih čakalnih vrst lahko v ambulanti uporabimo osebne prenosne merilnike kot npr. *event loop monitor*, *zio patch* ali implantabilni loop rekorder; gre za manjše prenosne naprave, ki jih ima bolnik nameščene dlje časa [9].

2. RAZISKAVA

Namen, cilji in metode

V Zdravstvenem domu Ljubljana smo pod okriljem Instituta Jožefa Stefana v oktobru 2016 začeli s pilotnim sistemom za presejanje bolnikov s sumom na nereden srčni utrip. Z raziskavo smo želeli dobiti vpogled v praktično uporabo EKG-senzorja (Savvy, [10]) pri bolnikih, obiskovalcih ambulant družinske medicine, ki v anamnezi navajajo motnje srčnega ritma. Pri njih smo želeli ugotoviti uporabnost EKG-senzorja, določiti delež bolnikov, ki v anamnezi navajajo motnje ritma in so le-te objektivno potrjene s pomočjo EKG-senzorja, ugotoviti delež posameznih tipov motenj ritma, ki jih registrira EKG-senzor, ugotoviti skladnost anamnestičnih motenj počutja z dejanskimi motnjami srčnega ritma, ki jih zabeleži EKG-senzor in ugotoviti način ukrepanja zdravnikov glede na izvid EKG-senzorja. Raziskava je prospektivna, tipa primer – kontrola. Vključeni so bili nekateri družinski zdravniki in njihovi bolniki, ki so navajali motnje srčnega ritma in so ob pregledu imeli normalni izvid 12-kanalnega EKG-ja.

Pacienti, ki so sodelovali v raziskavi, so bili izmenoma vključeni v eno od dveh skupin. Prva je bila testna skupina, kjer so bolniki prejeli EKG-senzor in navodila za ravnanje z njim, druga skupina je bila kontrolna, katere bolniki so bili obravnavani brez EKG-senzorja po ustaljeni poti. Vsi v raziskavo vključeni pacienti so prejeli dnevnik opažanj, ki so ga pisali doma in se po 5 do 10 dneh vrnili na kontrolni pregled. Odvisno od situacije je lahko posamezen bolnik ponovil EKG meritve in tako senzor dobil večkrat, a največ trikrat.

Sestavni del EKG-senzorja je bil tudi mobilni telefon, ki pa je bil v raziskavi uporabljen le kot snemalna naprava za EKG. V pripravah na pilotno študijo smo ugotovili, da bo prikaz EKG na zaslonu telefona paciente verjetno preveč motil in smo zato ta prikaz pacientom onemogočili. Sam EKG-senzor Savvy sicer omogoča meritve do 7 dni, telefon pa so bolniki polnili vsako noč, če je meritev trajala več dni.

3. REZULTATI

Od oktobra 2016 do januarja 2018 je bilo v raziskavo vključenih 30 zdravnikov iz ZD Ljubljana in ZD Murska Sobota ter njihovih 110 bolnikov, od katerih je imelo senzor nameščen 100 bolnikov (90.9%), podatki kontrolnih skupin so trenutno na voljo le pri 10 bolnikih. Podatki so bili zbrani od vključenih zdravnikov in njihovih bolnikov.

Zdravnikov, ki so sodelovali, je bilo 30, od tega 23 žensk in 7 moških; 2 sta specializanta družinske medicine, 2 pediatra, ostalo specialisti družinske medicine; povprečna starost je bila 49,18 let, povprečna delovna doba je 22,12 leti. Odgovarjali so na vprašanja o uporabnosti te metode: zadovoljni oziroma zelo zadovoljni z jasnostjo odčitka so bili v 93,5%, z enostavnostjo odčitka v 77,1%, s postavljeno diagnozo v 88,7%; 83,9% jih je odgovorilo, da jim je metoda olajšala oziroma zelo olajšala obravnavo in 83,9% zdravnikov je bilo zadovoljnih oziroma zelo zadovoljnih z uporabo te metode.

Vključenih je bilo 110 bolnikov, od tega je do sedaj zbranih podatkov za 10 kontrolnih bolnikov, ostali podatki so v fazi pridobivanja. Bolniki, ki so bili vključeni v raziskavo, so imeli pri zdravniku normalen posnetek EKG-ja, vseeno pa je obstajal sum na motnjo ritma, bodisi anamnestični (72,2%), klinični (18,7%) ali oba (9,1%). Med bolniki je bilo 71,8% žensk, stari so bili od 18 do 61 let, v povprečju 49,1 let; 41,2% jih je zaposlenih, 28,2% upokojenih, 21,2 % nezaposlenih; 71% jih je nekadilcev, za 58,7% jih je njihov zdravnik opredelil kot tvegane pivce alkohola. Bolniki so kot najpogostejše vzroke za prihod k zdravniku navedli razbijanje srca (45,3%), nato preskakovanje srca (20,3%), ter tiščanje v prsih, bolečina v prsih, omotica in težko dihanje. Bili so tudi povprašani o tem, kako se jim je zdela uporaba te metode: 69,7% se je zdela namestitev enostavna, 68,7% se je zdela uporaba enostavna; 53,5% jih nameščen senzor ni motil, 64,3% ga je z veseljem nosilo in 67,1% jih je ocenilo, da večjih težav s senzorjem niso imeli.

Po odčitku posnetka smo ugotovili, da je vzrok bolnikovim težavam v 39,3% v benignih motnjah ritma, kot prezgodnji utripi, sinusna tahikardija, paroksizmi supraventrikularne tahikardije, v 1% je šlo za paroksizem atrijske fibrilacije, v 13,1 % je šlo za ventrikularne motnje ritma, v 30,3% pa je šlo za anksioznost in panično motnjo. Zdravnikovo naslednje ukrepanje bilo za 63,5% bolnikov nadaljnje opazovanje, 6,7% jih je bilo poslanih na dodatne diagnostične preiskave, 6,7% jih je dobilo novo medikamentozno terapijo; 18,3 % jih je bilo napotenih h kardiologu.

4. ZAKLJUČEK

V pilotni raziskavi pacientov s sumom na nereden srčni utrip se je pokazalo, da so pacienti, ki so uporabljali EKG-senzor, tega dobro sprejeli, saj so ga celo v 64% nosili z veseljem. Zdravniki so bili zadovoljni v še večjem odstotku, saj so v 83% odgovorili, da jim je metoda olajšala oziroma zelo olajšala obravnavo bolnikov. Ker se podatki o kontrolni skupini, ki EKG-senzorja ni imela, še zbirajo, bodo rezultati direktne primerjave med skupinama znani po pridobitvi vseh podatkov. Obširneje o študiji glej v [11].

5. ZAHVALA

Zahvaljujemo se vsem zdravnikom in njihovim bolnikom, ki so sodelovali v naši raziskavi ter marljivemu osebju SIM-centra. Posebna zahvala gre Antoniji Poplas Susič, ki je bila gonilna sila v tem projektu; brez njene pomoči in spodbujanja na večih ravneh nam ne bi uspelo tako uspešno uresničiti zadanih ciljev.

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Ključne besede
pametno zobozdravstvo, pametni ročaj za ščetko, resna igra

1.UVOD

Področje pametnih zobnih ščetk je v zadnjem letu z vidika tehnologij doživelo napredek [1]. Če je še v letu 2016 družina ščetk Oral-B SmartSeries, kot ena najpametnejših, ob povezavi s pametnim telefonom omogočala spremljanje časa, lokacije in pritiska zobne ščetke v ustih, je v začetku 2017 zobna ščetka Kolibree Ara zajem podatkov o čiščenju zob preselila iz pametnega telefona na zobno ščetko, kar je koristno v situacijah, ko pametni telefon ni v dosegu povezave Bluetooth. Podatke zajemajo preko 3D senzorjev, obdelujejo pa jih s pomočjo metod umetne inteligence. Še korak dalje so naredili snovalci ščetke Onvi Prophix, ki za 400USD (skoraj 2-kratnik do sedaj najdražjih pametnih ščetk) ponujajo pametno zobno ščetko s štirimi različnimi nastavki in kamero HD, katera preko aplikacije na pametnem telefonu snema čiščenje zob. Z vidika primerjave s tukaj razvito rešitvijo je zanimiva pametna ščetka Grush. Intelov modul Curie skrbi za zajem podatkov te pametne ščetke, katera s pomočjo pametnega telefona spremeni čiščenje zob v igro za otroke.

V okviru projekta EkoSmart za razliko od zgoraj navedenih pristopov razvijamo pametno okolje za učinkovito ščetkanje in vzdrževanje zobne higiene, ki sestoji iz pametnega držala, resne igre in Kinect aplikacije za spremljanje položaja ščetke.

2.PAMETNO DRŽALO ZA ŠČETKE

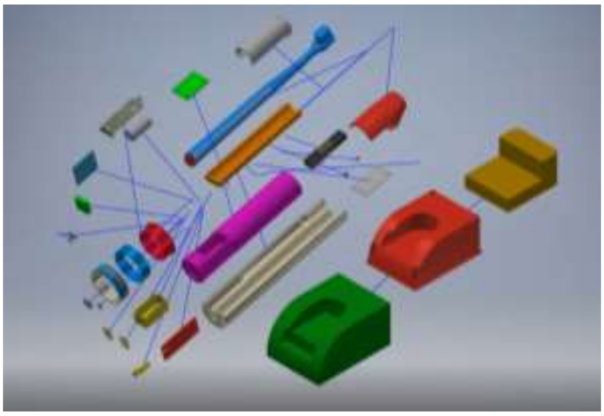
Prototip pametnega držala ščetke (slika 1), omogoča merjenje položaja, pospeškov in pritiska ščetke, s čimer je omogočeno merjenje dodatnih parametrov pravilnega čiščenja zob v primerjavi z že obstoječimi rešitvami. Druga poglavitna razlika med naštetimi pametnimi ščetkami in novo rešitvijo je, da imajo vse naštete komercialno dostopne ščetke glavo na električni pogon, medtem ko rešitev z držalom omogoča uporabo običajne ščetke in s tem povečuje fleksibilnost uporabe in niža ceno uporabe.

Namen pametnega držala za zobne ščetke je zagotoviti instrument za preverjanje pravilnosti čiščenja zob pri otrocih ter učenje le-tega. V ta namen je držalo ščetke opremljeno s senzorji, ki naj omogočajo detekcijo gibanja (pospeškometri) in merjenje pritiska ščetke na zobe. Držalo med čiščenjem javlja podatke na mobilno napravo ali osebni računalnik, od tod pa v oblak, kjer se ti podatki analizirajo in se pridobijo vse relevantne informacije. Za dodatni nadzor pravilnega čiščenja zob pri kliničnih preizkusih, je sistem nadgrajen s sistemom spremljanja položaja uporabnika na osnovi naprave Kinect. Podatki obeh sistemov se združujejo (fuzija podatkov) in omogočajo analizo podatkov na bistveno višji ravni.

Prototip je bil zasnovan na osnovi že izdelanih elektronskih modulov povezanih v celoto znotraj ohišja in vsebuje:

- absolutno orientacijo držala v prostoru (3 osni pospeškometer, absolutno orientacijski senzor v prostoru),

- modul za pretvorbo signala iz merilnih lističev (LOAD CELL),
- Arduino UNO,
- bluetooth modul BlueFruit BLE Shield,
- signalne lučke in vibracijski aktuator,
- akumulator in indukcijski napajalnik,
- tipka za vklop/izklop.



Slika 1. Pametno držalo za zobne ščetke – strukturni prikaz

Delovanje: Mehanski deli, pospeškometer in pretvornik signalov iz merilnih lističev so montirani v preprostem ohišju. Senzorske signale ob uporabi ščetke (pospeški in sila) sprejema Arduino in jih preko protokola Bluetooth BLE (Low Energy) prenaša na mobilne naprave. Svetlobni indikatorji in vibracijski aktuator se uporabljajo za signalizacijo neustrezne uporabe ščetke, signalizacijo vklopa/izklopa in kot indikator napolnjenosti akumulatorja. Držalo je opremljeno tudi z indukcijskim polnilcem, ki se polni preko stojala za ščetko.

Ohišje prototipa je bilo izdelano z metodo 3D tiska.

Držalo podatke senzorjev pretvori v podatke o položaju ščetke v prostoru (Eulerjevi koti). Za določitev začetnega (nultega) položaja ščetke, je predvidena uporaba Kinect naprave v kliničnih eksperimentih in tipka v primeru neodvisnega delovanja držala.

Ker gre za prototip za preverjanje koncepta, bo miniaturizacija potekala v naslednjih fazah. Namesto ločenih vezij se bo uporabilo eno, na novo zasnovano vezje, ki bi primerno tudi za masovno proizvodnjo. Narejena je bila tudi prva študija stroškov za izdelavo držala na osnovi brizgane plastike.

S prototipom smo dosegli potrditev, da je mogoče z razmeroma cenenimi senzorji zajeti dovolj relevantne podatke, iz katerih je mogoče ugotoviti frekvenco ščetkanja ter smer gibanja in silo, s katero ščetka pritiska na zobe in dlesni.

V okviru projekta EkoSMART smo pripravljeno rešitev tudi patentirali. S pomočjo zunanje patentne pisarne je bila oddana prijava patenta, patent pa je že v fazi objave.

V nadaljevanju projekta bo izdelanih deset prototipov držala, ki bodo uporabljeni za klinične teste čiščenja zob z otroki.

3.KINECT APLIKACIJA

Prototip opreme (slika 2) spremljanje položaja ščetke predstavlja naprava Microsoft Kinect for Windows v2 (Kinect), z osebnim računalnikom (Microsoft Windows), z vrati USB (3.0), integrirano tehnologijo Bluetooth Low Energy (BLE ali Bluetooth 4.0) in odjemalsko aplikacijo vrste WPF App (.NET Framework). Slednja skrbi za potrebno sprotno identifikacijo in vizualizacijo pravilnosti položaja dlani desne ali leve roke, ki drži ščetko v ustni votlini, vključno z njeno dopustno (predhodno nastavljivo) oddaljenostjo od obraza osebe, ki meritev izvaja.

Slika 2. Prikaz delovanja Kinect aplikacije

V času umivanja zob zbrani podatki, ki jih senzorji držala zobne ščetke sicer pridobivajo in hranijo povsem avtonomno (tudi v času, ko/če ščetka ni v ustih), so zmeraj ustrezno validirani in za kasnejšo obdelavo zapisani le za čas, ko je ščetkanje zob tudi dejansko potekalo. Na ta način zagotavljamo verodostojnost izmerjenih podatkov, česar sama pametna ščetka ne zmore.

Potrebna oddaljenost obraza osebe, ki ščetkanje izvaja, glede na mesto postavitve Kinect, je med 1,2 in 2,5 m, medtem ko je priporočljiva višina postavitve med 1,0 in 1,8 m.

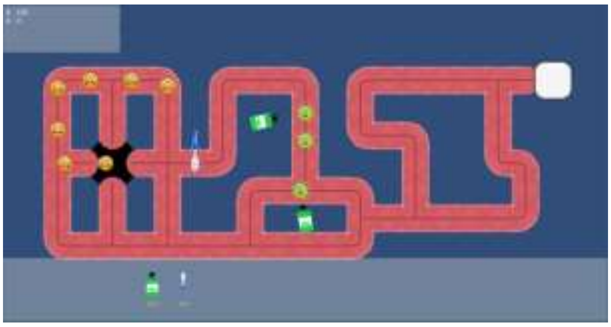
Zaradi preproste prenosljivosti in dobre podprtosti s strani algoritmov za kasnejše obdelave, izmerjene podatke hranimo v formatu JavaScript Object Notation (JSON).

V skladu z določili aktualne uredbe o varstvu osebnih podatkov (GDPR) smo preverjanje identitet oseb (mladostnikov) za katere bo t. i. Longitudinalni management statusa zobovja izvajan, omejili izključno na nivo številk ZZZS. Demografski podatki istih oseb bodo pooblaščenim zdravstvenim delavcem tako dostopni le v povezavi z drugimi zdravstvenimi sistemi na isti Id osnovi.

4.PAMETNA RESNA IGRA

V prvotni fazi razvoja igre smo naredili pregled orodij s katerimi bi jo lahko razvili [2,3]. Tako smo po pregledu ugotovili, da je trenutno eden izmed bolj priljubljenih in prav tako fleksibilnih in stabilnih orodji Unity. Orodje najbolj prepriča z dobro dokumentacijo in neverjetno velikim naborom ličnih iger vseh možnih variant. Prav tako se vse v orodju Unity dela kot objekt kar omogoča hitre spremembe, ki so tako uporabne v sprotnem razvoju, kot v morebitnih nadgradnjah ali spremembah delovanja in izgleda iger.

Pri izbiri tipa iger smo se odločili za tako imenovan »Tower defense«, saj se lahko smisel igre lepo preslika na temo ustne higiene ali bolje rečeno »Ščitenje zob«. V takšnem tipu igre mora igralec namreč trdnjavo braniti pred številnimi skupinami napadalcev s pomočjo postavljanja stolpov. Pri tem je pomembno taktično postavljanje stolpov, saj so surovine omejene in jih je potrebno čim bolj učinkovito porabiti. V našem primeru bo seveda trdnjavo predstavljal zob/zobje, napadalci bodo bakterije, stolpi pa pripomočki za ustno higieno (Slika 3). V igri bo tudi, primerno za otroke, zamenjano uničevanje (ki se lahko interpretira kot ubijanje) bakterij s pretvorbo škodljivih bakterij v pozitivne bakterije, ki se lahko uporabijo za branjenje zob. Prav tako bo s sličicami predstavljeno kako vpliva tip zaužite hrane na število škodljivih bakterij, ki bodo napadale naše zobovje. Za samo motivacijo in omejitev igranja igre bo s pomočjo podatkov pridobljenih s strani pametne ščetke, odvisno od kakovosti umivanja zob, otrok prejel več življenj katera potrebuje za nadaljevanje igranja v kolikor mu jih zmanjka. V primeru zelo dobrega rezultata umivanja zob, dobi otrok dodatno nagrado, ki mu omogoči uporabo predmeta, ki ga v sami igri drugače ne more dobiti. Ta nagrada je predstavljena z jabolkom, ki zmanjša število škodljivih bakterij v naslednjem napadu. Razvili smo tudi model nagrajevanja s točkami na podlagi trajnosti in kakovosti oralne higiene za spletno varianto igre in primerjavo z drugimi igralci, kar bo povečalo motivacijo otrok za ščetkanje zob.



Slika 3. Prikaz resne pametne igre

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Time Series or Relational Database for Edge and IoT

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ABSTRACT
In Fog and Edge computing data management and processing is moving from the Cloud closer to the IoT devices. To perform the work in edge devices, different, more lightweight, small-footprint and specialized tools need to be employed. In this paper we perform a side-by-side comparison of relational and time series databases of their speed and resource consumption. The Results show better performance of time series over relational databases.

Keywords
database, SQL, timeseries, relational, cloud, fog, IoT, edge

1. INTRODUCTION
Nowadays plenty of databases are available for storing actual timestamped data to a database. In the past several years, there are growing appeals for reading and storing data from IoT devices [8]. In the close future, storing and manipulating time series data will play an important role in IoT [1]. A common technique is to gather the data using cloud or fog devices that read IoT sensors [4] and temporarily store it in relational or time series databases. As not all sensor readouts are required to be stored in the Cloud, it is useful to filter and process the sensors on the Edge near them and thus save Cloud resources and bandwidth. To achieve this, one of the most important and desired abilities for Edge devices is to handle volumes of time series data quickly with minimum latency and footprint in order to give the observer results as quickly as possible [11], [9]. IoT devices can rely on different database types behind them and the best choice mostly depends on the type and format of the data that is being stored and on the requirements of the edge device [6]. Among available database types that can be used for IoT devices are NoSQL (e.g. MongoDB) with its subtype time series database (e.g. InfluxDB, Prometheus, TimecaleDB) and relational database (e.g. PostgreSQL, MySQL, MSSQL). Global trends unveil that time series databases are currently the fastest growing database type [7].

This paper explores the efficiency of relational and time series databases on edge devices by measuring and comparing response times and memory footprints of two representatives. From the results a reader can conclude which type of the database is better for a specific edge device or fog-like environment.

The research of the database performance will be further used in a fog-to-cloud application called Smartboat, which is developed as a use case for EU H2020 funded project called mF2C[5]. The application's goal is to establish support for boats that would simplify sailing and detect different types of threats across the sea. The IoT sensors that are installed onto the boats are used to collect certain amount of data, for example they can retrieve the temperature, GPS position, pressure, humidity, they can detect whether doors are open or not, generate flood alarms and so on. Based on that data it is important to take different actions. And since it's important when to take these actions, a database that supports storing and aggregating the data annotated with timestamps is required. Different databases that fulfill the requirements for the project were reviewed in order to select the best one for the use case considering this article. Then a comparison between databases and testing of parameters, most importantly time efficiency and memory footprint, were made.

The paper continues as follows: Section 2 presents the problem, its background and the key parameters to evaluate the database. The experiments and results are presented in Section 3 followed by the discussion and conclusion in the last section.

2. DATA STORAGE IN EDGE DEVICES
Storing data always requires time and has a memory footprint – that means some CPU and memory usage. On top of that there are many performance problems that can arise due to several reasons that are occasionally hard to determine. The following section provides additional information for understanding the problem of storing the data and the problem itself.

2.1 Sensors, edge devices and cloud storage
In a combined fog and cloud environment the processing of data is distributed between edge devices and cloud. Processing in the cloud has no resource restrictions such as opposed to processing at the edge. To provide the best and to the user transparent experience of using cloud and edge environment, the appropriate software has to be applied to each

segment of the fog to cloud hierarchy. A similar stack is presented in Figure 1, which is similar to the one proposed by mF2C project. We focus on data management close to sensors, i.e. edge devices, such as routers or small computers like Raspberry Pi devices that store, filter and transmit data collected from IoT sensors. Beside being able to store and transmit data, edge devices can serve light-weight services and issue notifications based on thresholds. These devices are capable in variety of functions, but do not have an excess of resources, therefore the software needs to be selected carefully.

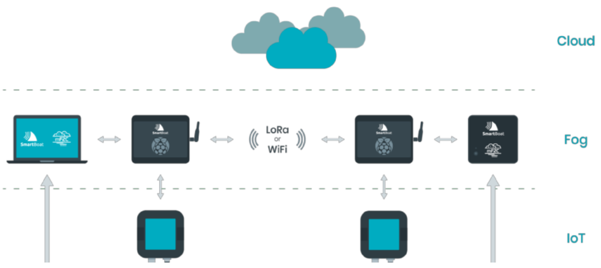

Figure 1: The proposed mF2C architecture.

2.2 The performance degradation issue

From the experience we gained by working on Fog, Edge and IoT use-cases, we found that the relational database, PostgreSQL, can became unstable and an overkill due to the lack of resources. The issue occurs when data is continuously being written into the database for a long period of time. Performance degradation seems to be a common problem in PostgreSQL [10] and sometimes hard or even impossible to solve [3]. For shorter continuous periods of recording (e.g. single day) issue does not manifest due to the small amount of the data and also because the database requires a reasonable amount of RAM. When recording lasts longer (e.g. more than one day) writing becomes slower. To solve the issue different approaches of saving and different databases were taken into consideration.

2.3 Benefits of using relational or time series databases and their comparison

2.3.1 Criteria for filtering the databases

Before performing the evaluation of the databases, a selection of the testing candidates was required, one from each type of database. Our methodology preferred databases with better support for the following attributes:

Supported platforms Applications should run on all major platforms like Linux, Windows and macOS, therefore we required to be sure that there will not be any complication for the applications to use the database.

Official Docker support Docker, currently the most popular container technology for Linux that allows creating and packaging an application along with all its dependencies, was also very important for the implementation of the services in our project.

Rapsberry Pi Our project was focused and prototyped around the Raspberry Pi, therefore the options that include this were preferred.

Supported languages More supported languages are a plus, but our main focus was on Java and Python support.

Data types The support or special/faster handling of floats and timestamps was considered as a better option.

License An open-source solution is preferred due to better flexibility and potential costs if the databases would run on a large amount of edge devices.

All databases, relational and time series, were evaluated by those parameters and the best candidates of each type were selected for the testing phase. The attributes for databases are collected in the Table 1.

2.3.2 Relational database selection process

We chose PostgreSQL as the initial relational database for our endeavors because of its standards compliance, it offering a native JSON object storage which we aspired to use elsewhere in the application and because it was easily integrated into other frameworks already in use. Other databases may also be appropriate for this purpose, however PostgreSQL proved to be the most compatible choice at that point in development. The key parameters of our comparison, based on two comparative sources [12, 2] are shown in Table 1.

2.3.3 Time series database selection process

These days, time series data applications such as sensors used in IoT analytics, are growing rapidly due to their simplicity and SQL based query language. For the comparison we have chosen 8 time series databases (Table 1) and finally selected InfluxDB as the best candidate mainly because of official Raspberry Pi Docker support. Other databases were not selected because they did not fulfill expectations regarding Docker or Raspberry Pi support (OpenTSDB, TimescaleDB), a proprietary license (Kdb+), low data type flexibility (Prometheus, RRDtool) and a lack of Java support (Graphite, Druid).

3. EXPERIMENT AND RESULTS

3.1 The test between time series and relational databases

The performance was evaluated by integration of InfluxDB into our application and comparing it with the performance of PostgreSQL.

3.2 Measurement environments

The databases could be manipulated through their own terminal clients or by libraries that provide support for different programming languages. To eliminate the probability of poorly written library or additional latencies based on the language overhead, the tests were performed in both environments – through a Java program and through the terminal with official client. According to the presented limitations, the following tests were performed: reading and writing to the InfluxDB and PostgreSQL databases using different methods like Java, bash console, reading from file and so on. So we tested the database and created a table (Table 2) showing first stage results for measuring time taken for writing and reading. All times presented in the table are for writing ten million records to database or for retrieving one million lines from the base.

Table 1: Relational and time series database feature comparison table

	Database	Supported platforms	Official Raspberry Pi Docker support	Number of supported languages	Python and Java support	Written in	Supported data types	License	Release year
RELATIONAL	OracleDB	Linux, Windows, OS X, Solaris etc.	Yes	24	Yes	C and C++	Int, float, bool, string, date etc	Proprietary	1979
	MySQL	Linux, WIndows, OS X, Solaris etc.	Yes	19	Yes	C and C++	Int, float, bool, string, date etc	GPLv2 or proprietary	1995
	Microsoft SQL Server	Linux, WIndows, OS X, Solaris	Yes	11	Yes	C++	Int, float, bool, string, date etc	Proprietary	1989
	PostgreSQL	Linux, WIndows, OS X, Solaris etc.	Yes	9	Yes	C	Int, float, bool, string, date etc.	PostgreSQL License	1989
TIME SERIES	InfluxDB	Linux, OS X	Yes	16	Yes	Go	Int64, float64, bool, string	MIT	2013
	Prometheus	Linux, Windows	No	8	Yes	Go	Only numeric data (float64)	Apache 2.0	2015
	Kdb+	Linux, Windows, OS X, Solaris	No	10	Yes	Q	Int, float, bool, string	Proprietary	2000
	OpenTSDB	Linux, Windows	No	6	Yes	Java	numeric data for metrics, strings for tags	LGPL	2011
	RRDtool	Linux, HP-UX	No	9	Yes	C	Only numeric data	GPLv2 and FLOSS	1999
	TimescaleDB	Linux, Windows, OS X	No	8	Yes	C	Int, float, bool, string, date etc.	Apache 2.0	2017
	Graphite	Linux, Unix	No	2	Only Python	Python	Only numeric data	Apache 2.0	2006
	Druid	Linux, OS X, Unix	No	7	Only Python	Java	Numeric and strings	Apache 2.0	2012

Table 2: Time taken table with first-stage results.

Testing type	InfluxDB [s]	PostgreSQL [s]
Writing to database using CLI terminal	71	256
Writing to database in Java from file generated in bash	556	652
Writing randomly generated lines to database in Java	562	678
Writing randomly generated lines to database in Java structured with 3 classes and one interface	576	673
Reading from the database in Java	5.58	8.35
Reading from the database in Java using mappers	8.20	/

3.3 IoT characteristics for databases

IoT devices, especially sensors, usually have the ability of gathering the data accompanied by data analysis to detect anomalies. Those devices write to database in bursts and are often operating on a lot of data.

3.4 The experiment metrics

The metric chosen for performing the experiment is speed, measuring the time for writing a million rows to the database in chunks of 15 points, which appears to be a common request on an Edge device connected around a dozen IoT devices.

3.5 The results

The results in Figure 2 present a comparison between InfluxDB and PostgreSQL. The x-axis shows the consecutive block number of 15 records and the y-axis shows time required to save the block. While the results are dispersed a trend curve showing the expected time taken is added to the graph. The plots present three cases. From the PostgreSQL plot (Figure 2) below we can see that most of the blocks of fifteen records take 5–8 milliseconds to be stored in database, which means that time is constant most of the time with some deviations that are occurring periodically. Most of the data in InfluxDB (Figure 2) is stored to database very quickly and it takes between 0–1 milliseconds. There are also some deviations of records that take around 50 milliseconds to be stored to database. The curve that shows the average time taken to write to database is also more diverse than in PostgreSQL plot. To perform thorough testing an InfluxDB faster batching was enabled to be included into the evaluation. The threshold for storing was set to 10000 points per batch or every 200 milliseconds. The result was lower times for writing and faster program execution. However, comparing InfluxDB results with and without faster batching (Figure 2) showed similar performance. The results undoubtedly show advantage of InfluxDB over the PostreSQL focusing on time consumption. PostgreSQL has less variance in time taken for transaction, but nevertheless InfluxDB is better in the average case.

Table 3: Time for writing million lines to database

Database	Time taken [s]
InfluxDB	58.92580
InfluxDBFasterBatching	5.25127
PostgreSQL	300.48325

3.5.1 *Database setup times and resource consumption*

Beside runtime performance, setup time and resource consumption were measured. The database setup times, including connecting to the database and building tables and indexes is significantly faster with InfluxDB, which is evident in Table 3. The resource consumption comparison was performed by writing and querying data for PostgreSQL and InfluxDB via CLI (Command Line Interface). 100000 records were written to database using CLI and then retrieved back. The results of this test are presented in Table 4, where it is evident that InfluxDB uses less storage, prepares database

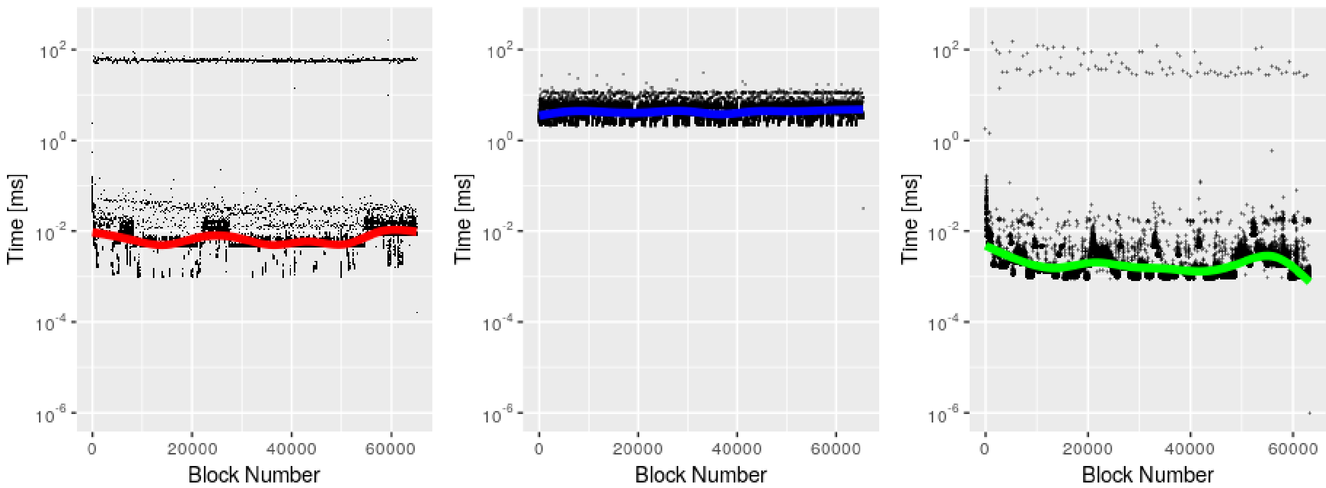

Figure 2: Plots for InfluxDB and PostgreSQL and InfluxDB faster batching.

faster, a query takes only 30 % of time. It seems that RAM and CPU consumption is higher for InfluxDB.

Table 4: Different test methods performed in CLI

	InfluxDB	PostgreSQL
Writing time	0.694 s	223.374 s
Query time	1.492 s	5.617 s
Database size	5.5 MB	15 MB
Memory usage	63.98 MB	20.53 MB
CPU usage	107 %	98.3 %

4. CONCLUSION

This paper presented the approach towards comparing relational and time series databases including comparing characteristics and performance. We explored several time series databases and their use related to the Cloud, sensors and IoT. The results indicates why time series database can be a better solution when it comes to storing IoT-generated data. We concluded that InfluxDB is a more suitable option for handling data gathered from IoT sensors and is also significantly faster in comparison to a relational database.

5. ACKNOWLEDGMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730929.

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Spletni obrazec in REST API za naročanje receptov

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POVZETEK

Razvili smo rešitev za elektronsko naročanje receptov za stalne terapije. Zasnovana je kot *Representational State Transfer* (REST) *Application Programming Interface* (API) vmesnik, pred katerim se nahaja grafični uporabniški vmesnik (*angl. Graphical User Interface – GUI*) v obliki preproste spletne aplikacije za naročanje zdravil. Za komunikacijo (tj. pošiljanje naročil) smo izdelali ogrodje za posredovanje sporočil (routing) prek treh kanalov: elektronske pošte (e-mail), platforme za avtomatizacijo marketinških opravil (Mautic) in prek REST API klica (za npr. klic vmesnika platforme Think!EHR).

Ključne besede

spletno naročanje, elektronski recept, REST API vmesnik

1. UVOD

Naročanje receptov pri splošnem zdravniku je vsaj za stalne terapije, tj. ponavljajoče se že predpisane recepte, zgolj administrativno opravilo. Pacient mora telefonirati v ambulanto, kar ponavadi traja dolgo zaradi zasedenih telefonskih zvez, nato pa zgolj posredovati potrebo po podaljšanju recepta, ki ga prek sistema e-Recept izvede zdravnik na osnovi že postavljenih diagnoz in prejšnjih izdaj zdravil. Gre za postopek, ki jemlje dosti časa vsem udeleženim, zaradi preprostosti pa bi ga lahko poenostavili z uporabo digitalnih rešitev.

2. REŠITEV

Če želimo postopek digitalizirati, lahko to storimo tako, da del procesa (tj. sporočanje prek telefona ali osebno) pretvorimo v izpolnjevanje spletnega obrazca, ki ga nato zdravnik prejme v svoj zdravstveni informacijski sistem. Zato smo pričeli z zasnovo ogrodja za spletno naročanje receptov stalnih terapij. Najprej smo definirali podatkovni model, ki bo implementiran v obliki podatkovne baze za hrambo naročil receptov. Nato smo rešitev razdelili na zaledni del (*angl. backend*), ki je navzven dostopen prek *Representational State Transfer* (REST) *Application Programming Interface* (API) vmesnika, in grafični uporabniški vmesnik (*angl. Graphical User Interface – GUI),* ki omogoča pacientom uporabo rešitve v obliki spletne aplikacije.

3. REST API VMESNIK

Zaledni sistem (*angl. backend*) smo zasnovali kot ogrodje (framework), ki izpostavlja REST API vmesnike za izvedbo vseh podprocesov, povezanih s procesom spletnega naročanja. Pripravili smo vse potrebne posamezne REST API vmesnike (Tabela 1) ter ustrezne razporejevalnike (*cronjob-driven scheduler*) opravil (naročila, pacienti, predlogi novih ambulant, stanja ambulant). Izdelali smo HTML predloge in vsebinska sporočila, ki se v okviru e-mail sporočil posredujejo ob različnih dogodkih v procesu (oddaja naročila, obvestila ambulanti in pacientu, potrditve in zavrnitve naročil, preklici, preusmeritve v drugo ambulanto,…). Izdelali smo ogrodje za posredovanje sporočil (routing) prek treh kanalov: elektronske pošte (e-mail), platforme za avtomatizacijo marketinških opravil (Mautic [1]) in prek REST API klica (za npr. klic vmesnika platforme Think!EHR [2]). Sistem smo opremili s sinhronizatorjem podatkov iz centralne baze zdravil (CBZ) ter implementirali predpomnjenje (caching) seznama.

Tabela 1. Nabor klicev REST API vmesnika in njihove metode

API klic	Metoda
order	GET
order/new	POST
order/status	GET
order/last	GET
patient	GET
patient/confirm	GET
patient/register	POST
service	GET
service/drugs	GET
ward	GET
ward/search	GET
ward/suggest	POST
ward/register	POST
ward/login	POST
ward/login/forgotten	GET
	POST
ward/edit	POST
ward/edit/status	POST
ward/edit/forwarding	POST
	DELETE
ward/edit/forwarding/apply	POST
cron	GET
ward/confirm	POST
ward/authorize	POST
ward/disable	POST

4. SPLETNI OBRAZEC (GUI)

Nazadnje smo razvili še spletni grafični uporabniški vmesnik (GUI), ki je bil implementiran v HTML/JS/CSS tehnologiji z uporabo AngularJS ogrodja [3] (Slika 1). Izdelali smo posamezne podsklope GUI (uporabniški vmesnik, registracija, potrditveni pogled, administracijski vmesnik) in ustrezne komunikacijske vmesnike za povezovanje z vsemi razvitimi REST API vmesniki posameznih podsklopov (naročila, pacienti, storitve, ambulante, predlogi, zdravila). GUI smo optimizirali tudi za mobilni prikaz (responsiveness).

5. PREIZKUŠANJE

Vse razvite REST API vmesnike iz nabora smo preizkusili na način funkcionalnega testiranja: definirali smo nabor pozitivnih in negativnih vhodnih podatkov ter preizkušali odzive posameznih API vmesnikov nanje. S preizkušanjem smo potrdili pravilno delovanje razvite spletne rešitve za naročanje receptov.

6. NADALJNJE DELO

Za potrebe povezovanja rešitve v platformo EkoSmart bo potrebno dodatno preizkušanje komunikacijskega vmesnika za pošiljanje sporočil prek REST API klica v platformo Think!EHR [2].

Slika 1. Grafični uporabniški vmesnik za naročanje receptov.

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Postopki in priporočila za izgradnjo govorne zbirke za potrebe sinteze slovenskega govora

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POVZETEK

V članku predstavljamo raziskave in razvoj postopkov izgradnje govorne zbirke za potrebe sinteze slovenskega govora z vidika pridobivanja govornih posnetkov in določanja optimalnih snemalnih pogojev.

Za potrebe sinteze govora predlagamo govorno zbirko z branim govorom. Na podlagi analize izkušenj in praks pri gradnji obstoječe zbirke, uporabljene v sistemu eBralec, podajamo priporočila za razvoj nove zbirke s primarno podporo HMM-sintezi in sodobnejši WaveNet-sintezi z možnostjo preproste prilagoditve na korpusno sintezo.

Ključne besede

Govorna zbirka, govorni bralnik besedil, sinteza slovenskega govora.

1. UVOD

Govorne zbirke vsebujejo računalniško berljive posnetke govora in priložene podatke z opisom posnetega govora (govorni dejavniki, dejavniki govorcev, zapisi in označitve posnetega govora) [1, 2]. Takšne zbirke so nepogrešljive pri raziskovalno-razvojnem delu na področju govornih tehnologij in predstavljajo pomemben člen osnovne infrastrukture za razvoj govornih tehnologij za posamezno jezikovno področje [3].

Razlikujemo med dvema vrstama govornih zbirk:

- brani govor: med drugim vključuje izvlečke iz knjig, radijske novice, sezname besed in zaporedja števk …
- spontani govor: vključuje dialog (med dvema ali več osebami), pripovedovanje (npr. raznih zgodb), opise (npr. poti na zemljevidu), dogovarjanje (npr. glede termina sestanka) ipd.

Za potrebe sinteze govora predlagamo govorno zbirko z branim govorom. Takšen govor ustreza najpogostejšim oblikam rabe sintetizatorjev govora. Poleg tega je lažje izdelati transkripcijo takšnega govora. Snemanje je bolj nadzorovano in predvidljivo. Pri spontanem govoru je govorno zbirko težko fonetično in prozodično uravnotežiti.

Najpomembnejši preostali dejavniki, ki jih je potrebno upoštevati pri snovanju govorne zbirke za potrebe sinteze govora so: izbira vsebine posnetkov, izbira govorcev, snemanje govorne zbirke in označevanje posnetkov.

Izbira velikosti govorne zbirke je posledica kompromisa med želenim številom variacij glasov oz. njihovim pokritjem na eni strani ter časom in stroški, vezanimi na razvoj, na drugi strani. Upoštevati je treba tudi čas za kasnejše preiskovanje govorne zbirke in potreben prostor za njeno hranjenje.

2. ANALIZA IZKUŠENJ IN PRAKS

Govorna zbirka, uporabljena v sistemu eBralec [4], je bila v osnovi zasnovana za korpusno sintezo govora. Vsebina besedila za snemanje je bila pridobljena s statistično obdelavo vseh besednih korpusov, s katerimi smo razpolagali, brez kakšne posebne vnaprejšnje selekcije. Določila se je pogostost posameznih glasov in glasovnih nizov v besedilu. V zbirko so bili vključeni vsi stavki (povedni, velelni, vprašalni ipd.), in sicer glede na statistično zastopanost v besednem korpusu.

Pri izbiri povedi se je težilo k temu, da so bile le-te *fonetično* čim bolj *bogate*, da so zagotavljale vse možne difone in da je vsaka dodatna poved doprinesla čim več novih polifonov (trifonov, štirifonov ipd.). Dolžine izbranih stavkov naj bi čim bolj ustrezale statistični porazdelitvi dolžin stavkov iz besednega korpusa.

Osnovni statistični podatki govorne zbirke eBralca so podani v tabeli 1.

Velikost besednega korpusa	7.145.345 povedi 77 milijonov besed
Obseg govorne zbirke	**4.000 povedi** (46.785 besed)
Število različnih difonov	1.883
Število različnih trifonov (št. kombinacij v korpusu)	21.369 (24.702)

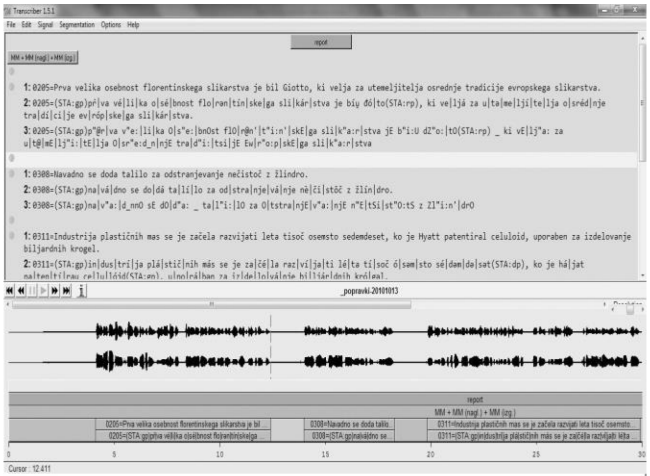
Tabela 1: *Statistični podatki o govorni zbirki sistema eBralec.*

Snemanje govorne zbirke je potekalo v studiu RTV Slovenija ob prisotnosti izkušenega tonskega tehnika. Med 10 profesionalnimi govorci smo izbrali najustreznejši moški in ženski glas. Med branjem besedila so govorci imeli nameščene elektrode Laryngographa, s katerimi smo spremljali nihanje glasilk za lažje kasnejše označevanje period govornega signala.

Samo snemanje je zaradi obsežnosti besedila, ki ga je bilo potrebno prebrati, trajalo več mesecev. Pri tem smo skušali zagotoviti, da so nastavitve opreme ves čas ostale čim bolj nespremenjene. To ni bilo najlažje, saj je bila oprema v studiu že precej stara, studio je bil konstantno v uporabi, konfiguracija prostora pa se je prilagajala trenutnim potrebam RTV Slovenija. Pred vsakim snemanjem je govorec poslušal svoje predhodne posnetke, s čimer se je skušalo zagotoviti čim bolj enak način govora, z enako intonacijo ipd.

Zbirka sintetizatorja eBralec je bila označena na treh nivojih: grafemski zapis besedila, fonetični zapis prebranega govora z mejami posameznih fonemov, oznake period zvenečih glasov.

Govorna zbirka oz. njen fonetični prepis se je popravljal s programom Transcriber (Slika 1). Govorci vseh besed niso izgovorili tako, kot smo pričakovali oz. tako, kot bi jih izgovoril sam sintetizator govora. Zato je bilo potrebno fonetični zapis uskladiti z dejansko prebranim.



Slika 1. Postopek popravljanja fonetičnih oznak v govorni zbirki eBralca.

Največje izrazite identificirane pomanjkljivosti govorne zbirke eBralca so naslednje:

- prevelika osredotočenost na čim večje število različnih polifonov (npr. štirifonov, petfonov ipd.),
- stavki omejenih dolžin znotraj vnaprej določenih intervalov ne pokrivajo dovolj vseh situacij, s katerimi se srečamo med dejansko sintezo,
- premalo vprašalnih in velelnih povedi,
- vsebina govorne zbirke ni bila povezana z najbolj pogostimi vsebinami besedil, ki se sintetizirajo v praksi oz. z najpogostejšimi aplikacijami rabe sintetizatorjev govora,
- govorna zbirka je brez posebnih prozodijskih oznak, označena sta dva nivoja (grafemski in prozodični),
- sploh niso oz. pomanjkljivo so označeni razni dogodki, povezani z govorilnimi organi, kot so tlesk, zapora, odpora, pripora, pridih,
- govorna zbirka ne vsebuje posebej posnetih števk, števil, števnikov, ideogramov, aktualnih slovenskih in pogostih tujih imen, priimkov, krajev, imen ulic ipd., prav tako ni podprto črkovanje (razumljivo črkovanje je v nekaterih aplikacijah in za posebne skupine uporabnikov še posebnega pomena; npr. slepi in slabovidni uporabniki, uporaba v bralnikih zaslona),
- predvsem ženski glas ni najbolj »posrečeno« izbran za potrebe sinteze slovenskega govora,
- oddaljenost govorca od mikrofona ni bila najbolj ustrezna; prevelik razpon med konicami signala in preostalim delom onemogoča večjo glasnost sintetiziranega govora,
- pri snemanju ni bil pred mikrofon postavljen ustrezen filter, ki bi zadušil neželene zvoke; npr. razne tleske,
- premajhna pozornost pri zagotavljanju enakih snemalnih pogojev med posameznimi seansami snemanja.

Pri izgradnji nove govorne zbirke bo na podlagi preteklih izkušenj treba več pozornosti nameniti:

- večji prozodični pestrosti posnetega besedila, ki bo pokrivala najrazličnejše situacije rabe sintetizatorja govora, besedilo mora vsebovati tudi zelo kratke in zelo dolge povedi,
- poleg najpogostejših besed je treba »pokriti« tudi različne prozodične kontekste, v katerih se te besede običajno pojavljajo,
- čim bolj se skušamo izogibati besedam, ki niso vsebovane v slovarjih izgovarjav, s katerimi razpolaga projektna skupina, saj je zanje potrebno ročno zagotoviti pravilen fonetični prepis,
- v besedilo je priporočljivo vključiti pogoste leksikalne termine oz. pogoste besede, kot so denimo telefonske številke, ekonomsko terminologijo (bančništvo), različne valute, terminologijo s področja računalništva in interneta, medicine, pogosta lastna imena, nekatera tuja imena in izraze, glavne in vrstilne števnike, črkovanje, značilne jedi, turistične znamenitosti, lahko tudi države in njihova glavna mesta; pri tem stavke, ki pokrivajo te termine, kreiramo sami,
- v zadnjem času je pomembno, da govorna zbirka pokriva še različne situacije, ki nastopajo v dialogu (aplikacije dialoga in simultanega prevajanja; npr. raba v virtualnih asistentih),
- večji zastopanosti raznovrstnih povedi, predvsem vprašalnih in velelnih (pogostost teh povedi mora biti večja, kot je v samem besedilnem korpusu, iz katerega se zajema besedilo za branje),
- besedilo naj zajema različne zvrsti novic, razne napovedi (npr. vremenske napovedi) in podajanje informacij (npr. stanje na cestah, borzne informacije) ter navodil (npr. napotki za vožnjo),
- bolj podrobno označevanje govorne zbirke, ki naj vsebuje tudi prozodijske oznake in razne dogodke, vezane na govorne organe,
- izbiri ustreznega ženskega glasu – ta naj bo nekoliko nižji in bolj aspiriran (povprečna osnovna frekvenca naj bo nižja kot pri aktualnem ženskem glasu),
- zagotavljanju enakih snemalnih pogojev med posameznimi sejami snemanja,
- obseg govornega korpusa naj bo večji od obstoječega.

3. PRIPOROČILA ZA VSEBINO BRANIH BESEDIL

Umetno generirani govor mora zveneti naravno in biti prijeten za poslušanje. Pomembne so tudi nastavitve za hitrost branja in jakost zvoka ter možnost uporabe različnih glasov.

Izbor vsebine posnetkov oz. branih besedil govorne zbirke za sintezo govora poteka v več korakih [5]:

- ustvari se obsežna tekstovna zbirka besedil, ki pokriva različne zvrsti (dnevni časopisi, revije, leposlovje ipd.),
- tokenizacija – iz zbirke besedil se odstranijo vse oznake, vezane na oblikovno podobo (glava besedila, tabele ipd.),
- okrajšave, števila ipd. se pretvorijo v polno besedno obliko (normalizacija besedil),
- besedila se pretvorijo v predvideni fonetični prepis (grafemsko-fonemska pretvorba),
- optimizira se obseg zbirke glede na vnaprej pripravljene kriterije (metoda požrešnega iskanja); doseči želimo statistično ustrezno vzorčenje izbranega področja govorjenega jezika.

Izbira povedi ne sme potekati naključno, pač pa mora biti skrbno načrtovana [6]. Priporočamo, da se za čim optimalnejšo izbiro povedi uporabi naslednji postek, ki ga sestavlja več korakov:

1. *Statistična obdelava besedil:*
    - Statistično obdelamo celoten besedni korpus in določimo pogostost pojavljanja posameznih glasov in glasovnih nizov v besedilu.
    - Vključimo vse stavke (povedne, velelne, vprašalne itd.) in izdelamo statistiko posameznih vrst povedi oz. stavkov.

2. *Izdelava spiska glasovnih nizov z oceno zaželenosti posameznega niza:*
   - V spisek vključimo nabor vseh teoretično možnih kombinacij difonov.
   - V spisek vključimo vse trifone, štirifone in (po potrebi) ostale zaželene (najpogostejše) polifone, na katere smo naleteli pri statistični obdelavi besedil.
   - Utež oz. ocena zaželenosti niza je odvisna od pogostosti njegovega pojavljanja v besedilu.
3. *Postopek izbire povedi:*
   - Ocenimo doprinos glasovnih nizov za vsako poved iz tekstovnega korpusa.
   - Doprinos povedi je enak vsoti vseh ocen zaželenosti nizov (iz spiska), ki se v povedi pojavijo.
   - Doprinos posamezne povedi normiramo z dolžino povedi (št. besed v povedi ali št. fonemov v povedi).
   - Določimo takšno utež, da bodo dolžine izbranih stavkov čim bolj ustrezale statistični porazdelitvi dolžin stavkov iz korpusa.
   - Izberemo poved z najvišjim normiranim doprinosom.
   - Iz spiska odstranimo vse glasovne nize, ki jih izbrana poved vsebuje.
   - Ponovno ocenimo vsako poved in izberemo najboljšo (glede na novi spisek, v katerem so izločeni tisti glasovni nizi, ki smo jih že pokrili) ter popravimo spisek.
   - Postopek ponavljamo, dokler ne izberemo želenega števila povedi.
4. *Ovrednotenje rezultatov:*
   - Vsakih 1000 povedi izdelamo statistiko difonov, trifonov, štirifonov in drugih polifonov, ki jih že pokrivamo (gre za glasovne nize, ki smo jih do takrat že izločili iz zgoraj omenjenega spiska).
5. *Dodatne izboljšave algoritma:*
   - Ker mora zbirka vsebovati vse možne kombinacije difonov, algoritem popravimo tako, da difone dodatno utežimo glede na ostale polifone. Na takšen način bo algoritem na začetku dajal prednost povedim, ki bodo pokrile čim več novih difonov. Predvidoma se vsi difoni pokrijejo že po ca. 100 stavkih.
   - Pri trifonih in štirifonih upoštevamo pri robnih glasovih tudi podatek o glasovni skupini, ki ji pripadajo (npr. štirifon "krak" ne bo doprinesel prav dosti novega v našo zbirko, če ta že vsebuje štirifon "krat"; zato oceno koristnosti takega štirifona popravimo navzdol). To lahko naredimo preprosto tako, da v spisek vnesemo dodatne nize skupaj z njihovimi frekvencami pojavljanja v korpusu (primer takega štirifona: "k"+"r"+"a"+"pripornik").
   - Algoritem z različnim uteževanjem izboljšamo tako, da končni nabor vsebuje različne povedi (povedne, vprašalne, velelne, enostavne, sestavljene, naštevanje itd.). Tako lahko isti korpus učinkovito uporabimo tudi za generiranje prozodičnih parametrov pri sintezi govora.

Fonetični prepis besedila se izvede z modulom za grafemsko-fonemsko pretvorbo, s katerim razpolagajo projektni partnerji.

Posnetih naj bo več 10 (do 50) ur govora. Prva ura posnetkov naj bo označena na zgoraj opisani način (čim boljša fonetična uravnoteženost). Besedilo za preostale posnetke do 10 ur se izbere tako, da so stavki čim bolj pestri in zajemajo različne prozodične variante. Na takšen način dobimo dovolj učnega gradiva za pravilno nastavljanje prozodičnih parametrov sintetizatorja. Razliko do preostanka polnega obsega govorne zbirke se zapolni z branjem različnih zvrsti besedil, za katere se predvideva, da se bo sintetizator govora najpogosteje uporabljal. Tako se sintetizator govora še posebej prilagodi izbranim domenam, za katere prebrani umetni govor potem zveni še posebej naravno in ga »na hitro« skoraj več ni moč ločiti od človeškega govora.

Za izbor fonetično in prozodično uravnoteženega besedila predlagamo uporabo besedilnega korpusa Gigafida , ki vsebuje 1,2 milijarde besed v slovenskem jeziku.

4. PRIPOROČILA ZA IZBIRO GOVORCEV

Posname naj se vsaj 10 različnih govorcev. Te krajše posnetke (nekaj sto stavkov z dobrim pokritjem difonov) se nato strojno označi in preizkusi na aktualnem sintetizatorju govora. Po možnosti se izvede tudi anketa med več poslušalci glede naravnosti in razumljivosti govora, pa tudi glede subjektivne ocene, kateri glas se jim preprosto zdi najprijetnejši za poslušanje.

Dobro je, da je glas takšen, da se v postopku sinteze mesta »lepljenja« čim manj opazijo oz. slušno zaznajo. Pri izbiri govorca je potrebno upoštevati tudi njegovo sposobnost sledenja napotkom, potrebne ponovitve med snemanjem, čas snemanja ipd. Potrebujemo vsaj en moški in en ženski glas. Smotrno je, da sintetizator govora razpolaga s po dvema glasovoma za vsak spol.

Pomembno je, da se kandidate vnaprej seznani z namenom snemanja in možne uporabe tako pridobljenih glasov. Pred snemanjem morajo izbrani govorci podpisati pogodbo oz. privolilo, da dovolijo rabo posnetkov za potrebe sinteze govora.

DEJAVNIKI GOVORCEV

Pri izbiri govorcev moramo upoštevati nekatere značilnosti, ki so povezane z njihovim govorom. Pri tem razlikujemo med [7]:

- prehodnimi značilnostmi oz. tranzienti in
- trajnimi značilnostmi.

Prehodne značilnosti so morebitne psihološke in fiziološke motnje (npr. počutje, bolezen, psihično stanje).

Med trajne značilnosti pa uvrščamo fiziološke in anatomske značilnosti (npr. spol, starost, težo, okvare na govorilih, kadilske in pivske navade) ter geografske in socialno-jezikovne vplive na govor (izobrazbo in poklic govorcev, narodnostno-narečno področje trenutnega in morebitnega predhodnega bivališča govorcev, narodnostno-narečno področje govorčevih staršev).

GOVORNI DEJAVNIKI

Med govorne dejavnike uvrščamo prozodijske značilnosti govora, ki se nanašajo na trenutno razpoloženje govorca ter njegov pristop k tvorjenju govornih posnetkov [7]. Posneti govor lahko tako označimo za hiter, počasen, napet, sproščen, odrezav, natančen, površen ipd.

V praksi se izkaže, da so nekateri glasovi preprosto bolj primerni za izdelavo sintetizatorjev govora kot drugi. Pri tem je zelo težko vnaprej napovedati, ali je nek glas primeren ali ne, pri tem ni splošno veljavnih pravil.

5. PRIPOROČILA ZA SNEMANJE GOVORNE ZBIRKE

Besedilo, ki vsebuje vsa želena zaporedja alofonov, je najpriporočljiveje prebrati naenkrat. Zelo pomembno je namreč, da govorec skozi vso besedilo govori na enak način, z enakim glasom, z enako intonacijo, skratka z enakimi parametri govora.

Snemanje besedila po kosih v daljšem časovnem obdobju je manj priporočljivo, saj se govorcu lahko glas zaradi različnih zunanjih vzrokov (vreme, drugačne nastavitve pri snemanju, spremenjen spekter in intenziteta motenj iz okolice) ali notranjih vzrokov (razpoloženje, bolezen) spremeni, govorna zbirka pa ni v celoti posneta, kar oteži kvalitetno sintezo govora.

Snemanje govornega gradiva naj poteka ob prisotnosti izkušenega snemalnega operaterja z namenom, da se preprečijo neustrezne izgovarjave besed in napake pri snemanju govora. Govorcu je potrebno pred snemalnimi sejami podati ustrezna navodila in ga zaprositi, da povedi prebira razločno in enakomerno hitro. Med branjem besedila imajo govorci nameščene elektrode laringografa, s katerimi se spremlja nihanje glasilk zaradi lažjega kasnejšega označevanja osnovnih period govornega signala.

Samo snemanje celotne govorne zbirke zaradi obsežnosti besedila, ki ga je treba prebrati, navadno traja več mesecev. Pri tem morajo nastavitve snemalne opreme ves čas ostati nespremenjene. Pred vsakim snemanjem naj govorec posluša svoje predhodne posnetke, s čimer se skuša zagotoviti čim bolj enoten način govora med posameznimi snemalnimi sejami. Na začetku snemanja posamezne seje naj govorec prebere nekaj vnaprej določenih fiksnih stavkov, ki omogočajo primerjavo glasnosti in višine govora med posameznimi snemalnimi sejami.

Med snemanjem govora je priporočljivo preverjati, ali govorec ustrezno izgovarja predloženo besedilo. To lahko storimo s prisotnostjo druge osebe med snemanjem ali pa poskušamo v snemalni postopek vgraditi določeno samodejno preverjanje.

Govor snemamo preko mikrofona v digitalni obliki, po navadi kar na namenski računalnik v studiu. Potrebujemo še ustrezno mešalno mizo, zaslon in slušalke (preko katerih govorec prejema navodila in posluša povratni govor). Posnetke govora shranimo v digitalni obliki na trajne računalniške pomnilniške medije.

Med posameznimi sejami nastavitev ne spreminjamo (uporabljamo vnapej preddefinirane nastavitve opreme). Ustreznost govornih parametrov lahko preverjamo z ustreznimi merilci (npr. Bruel & Kjaer 2230 Sound Level Meter).

Govor se snema z več različnimi mikrofoni in pod različnimi koti (npr. Studio Projects T3 Dual Triode). Pred mikrofoni je primeren filter (angl. »anti-pop filter«), ki zaduši razne poke, tleske ipd.

Zaželeno je, da imamo nameščeno tudi spletno kamero in ogledalo. S tem se govorcu pomaga, da ohranja konstantno razdaljo do mikrofona (tudi med različnimi seansami snemanja).

Oseba, ki snemanje nadzoruje, lahko preveri položaj govorca pred vsako snemalno sejo in jo primerja s položaji v predhodnih sejah. Majhno ogledalo (na steni) govorcu omogoča ohranjati primerno razdaljo tekom same snemalne seje. Govorce se zaprosi, da periodično preverjajo položaj svojega obraza v ogledalu [8].

Priporočamo frekvenco snemanja 44,1 kHz in 24-bitno vzorčenje govornega signala.

Ker je pri snemanju pomembno, da govorec ni preveč utrujen, predlagamo 10-minutno snemanje znotraj pol urnega intervala. Posamezna seja naj traja dve uri; znotraj tega časa je možno posneti 40 minut govornega materiala (v štirih sejah). Vsak govorec naj opravi le eno dveurno sejo na dan. Za 50 ur posnetkov tako potrebujemo 75 sej oz. 150 ur časa.

Razlike pri pogojih snemanja med različnimi sejami je možno detektirati s primerjavo povprečnih vrednosti MFCC parametrov posameznih izgovarjav [9].

Med posameznimi sejami preverimo predhodne posnetke. Morebitne napake zaradi neenakih snemalnih pogojev, napačnih izgovarjav, različne hitrosti govora ipd. popravimo ob snemanju naslednje seje.

6. OZNAČEVANJE GOVORNIH POSNETKOV

Predlagamo, da se uporabi tri nivoje anotacij oz. prepisov govorjenega besedila: grafemski prepis, fonetični prepis in prozodijske oznake.

Ker je ročna segmentacija govora na fonetičnem nivoju naporna in dolgotrajna, pri tem uporabljamo vsaj delno avtomatizirane postopke, ki so bolj učinkoviti, če vnaprej poznamo grafemski prepis govorjenega gradiva.

Avtomatskim metodam in postopkom po potrebi sledi »ročno« popravljanje oznak, kar je ne glede na hiter razvoj tehnologije še vedno zelo zamudno.

7. ZAKLJUČEK

Pri razvoju metod in priporočil za izgradnjo govorne zbirke CityVOICE smo posebno pozornost namenili določanju optimalnih pogojev za snemanje govornih zbirk, določanju optimalnih fonetično in drugače uravnoteženih vsebin za snemanje govornih zbirk ter rešitvam za iskanje optimalnih govorcev.

8. ZAHVALA

Operacijo CityVOICE sofinancirata Republika Slovenija in Evropska unija iz Evropskega sklada za regionalni razvoj, in sicer v okviru »Operativnega programa za izvajanje evropske kohezijske politike v obdobju 2014-2020«.

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Telemetric ECG monitoring during physical activity in field tests

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ABSTRACT
In this paper we show how it is possible to measure ECG signal with telemetric ECG body-sensor during physical activity in regular conditions. Based on previous studies we choose position and type of fixation for sensor. Participant made three different tests, first test was shuttle run test where speed of running was increased every minute, second test was Cooper 2400 m test, and third test was 100 m maximal sprint. We measure ECG signal in all three tests and analyse it with special software for Holter analysis.

Keywords
ECG body sensors, Shuttle run, Cooper 2400 m, 100 m sprint, Healthcare.

1. INTRODUCTION
Nowadays sudden cardiac death presents extremely high risk for sudden death of professional sportsmen and recreational athletes. Cardiovascular disease causes more than 90 % of sudden deaths during physical activity [1]. Two France studies reported a daily incidence of 3 sudden deaths and 4 myocardial infarctions during physical activity in the general population [2,3]. Studies from USA shows sudden cardiac death incidence between sportsmen in high schools and colleagues is 1:200.000 per year [4,5,6], while European studies shows that incidence is even higher, 1-1,6:100.000 [7,8]. Considering the fact that 55-80 % of the athletes who died of sudden cardiac death had no prior symptoms of heart disease [9], the question is what else should be done for the prevention of sudden cardiac death, and to detect the people who has increased risk of sudden cardiac death.

Telemetric ECG body sensor used in this paper was already used in previous pilot studies made during light physical activity [10], and in maximal laboratory exercise stress test (EST) [11]. Since an EST with ECG monitoring is usually performed in laboratory conditions, our goal is to determine whether it is possible to measure an ECG during regular sport activities, because it will offer a significant advantage for the prevention of cardiovascular accidents [12].

Aim of this study was to evaluate body-sensor ECG signals during three different field tests, and to analyse the quality of the recorded ECG signal. Next aim was to determine if different types of sensor fixation influenced the ECG signal. The use of a telemetric ECG during physical activity could be very beneficial for medical doctors and sports scientists, and the most of all for professional and recreational athletes.

2. MATERIAL AND METHODS
2.1 Study Population
In this study was included one participant, age 24 years. He was a student at the Faculty of Sport and Physical Education at the University of Belgrade. He was healthy and without known previous cardiac problems. Before the tests the study purpose, and its protocol were explained to him, and he signed consent for participation in the study.

2.2 Experimental Setup
ECG measurements during the field tests were made with wireless ECG body sensors Savvy (Saving d.o.o., Ljubljana, Slovenia) [13], which is a certified medical device, described in detail in the study of Trobec et al. [14]. The body sensor is light and non-obstructive for users, which allows long-term exercise ECG measurements. The sensor is fixed on the body via two self-adhesive skin electrodes. An Android application, MobECG, which runs on a smartphone, captures and displays the measured data and saves it in the smartphone's memory for further processing.

Figure 1. Sensor position and type of sensor fixation in the first test (left-hand) and in the second test (right-hand).

The sensor position should be close to the heart to obtain appropriate amplitude of ECG signal. In addition, its position should avoid large muscles, due to the signals from the electrical muscular activity (EMG) that could disturb the ECG [14,15]. In this study was used position Left Inferior (LI), shown as most adequate in previous study [11]. In the LI position the sensor electrodes are at the positions V1 and V2 of standard precordial leads, and the sensor is translated by approximately 10 cm, below the xiphoid, where the influence of muscular disturbances is expected to be minimal (see Figure 1). The ECG electrodes were positioned 5 cm apart [16]. Before the positioning, we cleaned the skin of the subjects with diluted ethanol.

The participant made six tests, two shuttle run, two Cooper 2400 m, and two 100 m sprint test. In the first test the ECG body sensor were fixed with self-adhesive medical Omniplast 2,5 cm tape (Paul Hartmann AG, Heidenheim, Germany), specially designed to fix Holter electrodes. Both parts of the sensors were fixed together with one, approximately 40-cm-long strip of tape. In the second test sensor were fixed with standard Polar belt made for measurements of the heart rate (HR) with Polar system.

The measured ECG data were continuously stored in the mobile-phone memory and transferred to the personal computer. The ECG analysis were made with medically certified Holter interpretation software QuickReader® AFT-1000 (Holter Supplies, Paris, France).

2.3 Measurement Protocol

Every test was made in a separate day, except 100 m sprints where both tests were made in the same day, with 30 min pause in between tests. Before performing the tests, the electrodes and sensors were positioned at the LI position and fastened with self-adhesive tape. After that the participant sat down and waited for 5 minutes, while the ECG was recorded. After 5 minutes the participant started with the test. When the test was finished the participant sat down and rested for 5 minutes, while the ECG was still recording. The next day the participant took part in a second test. In the second test sensors were fixed with Polar belt. The ECG recording protocol was the same as on the previous day. The next type of test, under the same protocol, were performed in the next 2 days. The study was conducted in accordance with the ethical standards of the Faculty of Sport and Physical Education (IRB approval No. 02-1359/18-2), University of Belgrade, and the Helsinki Declaration.

3. RESULTS

In the first shuttle run test participant successfully made 11 minutes of the test (11/2) with the maximal heart rate (HR) 196 beats per minute (bpm), while in second test he successfully made 10 minutes of the test (10/10) with the maximal HR 192 bpm. In the first Cooper test he run 11:49 minute, with the maximal HR 192 bpm, and in the second test he run 13:10 min, with the maximal HR 193 bpm. In the 100 m sprint test he run 13:45 sec in the first test, with maximal HR 172 bpm, while in second test he run 13:84 sec, with the maximal HR 179 bpm.

Analyse of the signal show that ECG signal was of adequate quality in both shuttle run tests, while in Cooper and in 100 m sprint test signal was of adequate quality only in second test when sensor was fixed with a Polar belt. An example of screenshot of a typical HR signal in bpm, and correct QRS complex detection of a signal which is of adequate quality for interpretation and for further analysis is shown in Figure 2.

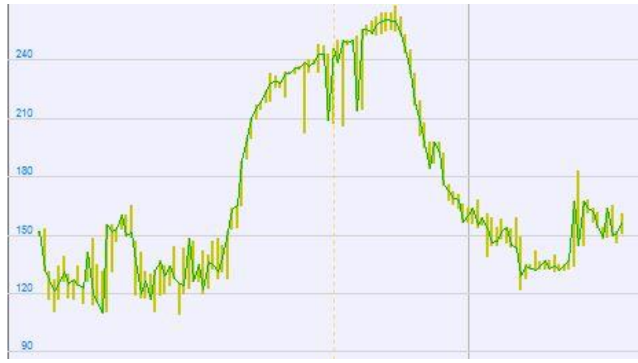

Figure 2. An example of adequate quality signal.

An example of screenshot of a signal which is not of adequate quality for interpretation and for further analysis is shown in Figure 3.

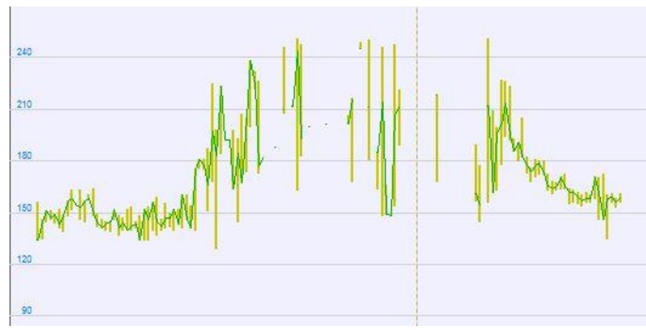

Figure 3. An example of a signal which cannot be interpreted.

The computerized heart-rate analysis was successful for most of the time during both shuttle run tests and during Cooper and 100 m tests when sensor was fixed with Polar belt. During the visual inspection we also found erroneously detected QRS complexes, using the Holter interpretation software, often because of the excessive artefacts that come from the intense activity (right-hand part of Figure 4).

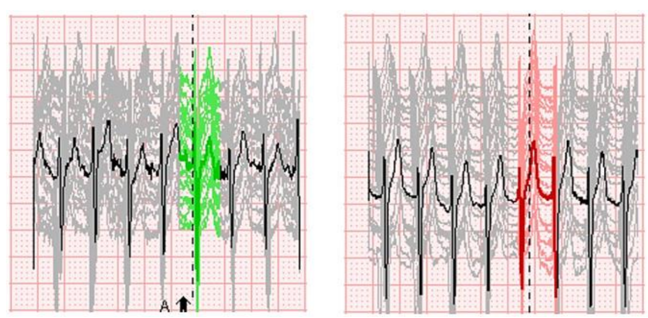

Figure 4. Visualization of the detected heart beats using the Holter interpretation software QR. The correctly interpreted QRS complexes are shown in the left-hand panel. An example of the erroneously interpreted QRS complexes is shown in the right-hand panel.

4. DISCUSSION

This paper show that a wireless ECG body sensor can be used for non-obstructive measurements of an ECG during some regular physical activities. The aim of this study was to check if wireless ECG body sensors can be used during field tests. The results show that the type of fixation and the type of test influence the results. When sensor was fixed with Polar belt signal was of adequate quality during entire test, but when sensor was fixed with Omniplast tape the signal was of adequate quality only in shuttle run test, when the speed of running starts with 8.5 km/h and increases 0.5 km/h every minute, while in tests when speed of running was constantly high the signal was not acceptable. In that case maximal speed of running in shuttle run test was between 13.5 and 14.0 km/h, and this was very similar to previous laboratory study which confirm that ECG signal on a treadmill was of adequate quality for speeds of running up to 13.5 km/h.

The diagnostic ability of the ECG body sensor, used in this study, has been compared in various previous pilot studies with other similar devices [14] and with standard 12-lead ECG [14,17]. Previous studies shown that ECG body sensor, even so simple, can also detect most of the arrhythmic events, e.g., atrial or ventricular fibrillation, exstrasystole, tachycardias, bradycardias, etc. The analysed measurement methodology can provide basic information about the heart rhythm's status. In the case of any detected abnormality the users can be directed to further diagnostics with a standard stress test and medical personnel.

5. CONCLUSION

The presented results are a motivation for further study, where more participants will be included. With such a telemetric approach it might be possible, to the best of our knowledge for the first time, to routinely measure ECG signals in real conditions, e.g., when users are running in nature, during a significant activity. In the presented paper an appropriate method of sensor fixation was found; however, to confirm this conclusion study should be extended, and heterogenous group of participants, e.g., male and female, should be included.

6. ACKNOWLEDGMENTS

This paper was supported by Slovenian Research Agency under the Grant P2-0095.

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POVZETEK

Inteligentni pogovorni svetovalci olajšajo uporabnikom iskanje informacij in komunikacijo z informacijskimi sistemi, saj omogočajo dostop do ogromne količine informacij na semantičnem spletu z uporabo naravnega jezika in s poizvedovanjem po strukturiranih podatkih, glede na uporabniške poizvedbe. Učinkovitost tovrstnih sistemov se je občutno povečala z razvojem semantičnega spleta, ki je v zadnjih letih pripeljal do velike količine podatkov objavljenih na spletu na podlagi povezanih podatkovnih načel, kar olajša avtomatsko obdelavo podatkov. V tem prispevku predstavimo inteligentni sistem, ki je sposoben razumevanja vprašanj uporabnikov in lahko posreduje podatke ter informacije iz obstoječih spletnih servisov ter podatkovnih virov.

Ključne besede

pogovorni svetovalci, procesiranje naravnega jezika, think!EHR

1. UVOD

Eno bolj dinamičnih področij raziskav je danes interakcija med človekom in računalnikom z razvojem inteligentnih sistemov ali aplikacij, ki so sposobni komuniciranja v naravnem jeziku in upravljanja z obširnimi bazami znanj [1]. Take sisteme pogosto imenujemo pogovorni svetovalci ali virtualni agenti. Takšni agenti so sposobni posredovati celovito znanje o določenih domenah, kar olajša dostop do ogromnih količin podatkov, ki obstajajo na svetovnem spletu. Svetovalci so v zadnjih letih postali izredno uporabno orodje, ki uporabnikom omogoča iskanje informacij hitreje in natančneje. Podjetja, kot so Google, Microsoft ali Apple, nudijo splošne pomočnike, ki uporabnikom pomagajo najti restavracije ali trgovine blizu njihove lokacije, upravljati svoj telefon ali nuditi računalniško podprto podporo za programske pakete. V prihodnosti bodo programski paketi in spletne platforme, v določeni obliki, vsebovale pogovorne svetovalce, ki bodo uporabnikom svetovale in pomagale pri uporabi programske rešitve.

Na področju procesiranja naravnega jezike se je v zadnjem času razvilo precej orodij (spletnih storitev), ki omogočajo procesiranje tekstovnega vnosa, določanje namena uporabnika in tudi luščenje vrednosti določenih, v naprej definiranih parametrov. Izmed teh so najbolj poznane DialogFlow [2] in Rasa [3]. Prvi je Googlov sistem, ki deluje v oblaku in uporabniki dostopajo do funkcionalnosti preko REST vmesnika. Rasa pa je odprtokodna rešitev, ki omogoča namestitev na lastnem strežniškem sistemu.

Kombinacija spletnih ali mobilnih aplikacij, oblačnih sistemov za procesiranje naravnega jezika in zalednih funkcionalnosti, ki omogočajo pridobivanje podatkov iz podatkovnih baz, semantično anotiranih podatkov na spletu ali spletnih platform, omogoča razvoj uporabnih in naprednih aplikacij za komunikacijo z uporabnikom.

V pričujočem prispevku predstavimo sistem za procesiranje vprašanj uporabnikov in naprednega posredovanja informacij. Delovanje pogovornega svetovalca demonstriramo na dveh domenah. Posredovanje informacij o čakalnih dobah za posamezne posege in poizvedovanje po platformi Think!EHR.

2. ZASNOVA SISTEMA

Splošna arhitektura predlaganega sistema je sestavljena iz štirih glavnih komponent:

- spletnega vmesnika za zajem uporabniških poizvedb,
- pogovornega agenta znotraj sistema DialogFlow,
- zalednega mehanizema, ki procesira zahtevke iz DialogFlow agenta,
- univerzalnega vmesnika za dostop do podatkovnih zbirk.

Spletni vmesnik je implementiran v obliki pogovornega okna (angl. chat), kjer se vprašanja in odgovori izmenično prikazujejo (glej Slika 4). Vmesniku so dodani tudi izbirni gumbi, kar olajša uporabniku interakcijo, saj mu ni potrebno pisati in lahko izbere želeno opcijo (glej Slika 4). Aplikacija je implementirana v html jeziku, z uporabo jquery komponent za dinamično spreminjanje vsebine in prikazovanje kompleksnejših elementov. Zaledni del, ki procesira vnose uporabnika pa je implementiran v spletnem ogrodju Django.

Za učinkovito procesiranje naravnega jezika je bilo uporabljeno orodje DialogFlow. Gre za spletno storitev, ki jo podpira Google in se izvaja na Googlovi oblačni infrastrukturi in omogoča uporabo orodij za procesiranje in razumevanje vprašanj, postavljenih v naravnem jeziku. Vnos, ki se ga želi analizirati se iz zalednega dela posreduje DialogFlow servisu preko ustreznih knjižnic. Za posamezno domensko področje (baza znanja svetovalca) se ustvari agent, ki ga s posredovanjem množice učnih primerov naučimo razločevati med nameni uporabnika. Za vsak namen, ki ga definiramo, vnesemo večje število vprašanj in prepustimo sistemu, da zgradi odločitveni model. Na podoben način je mogoče iz teksta, ki ga uporabnik vnese, izluščiti vrednosti za različne parametre, ki jih predhodno definiramo (datumi, kraji, imena ipd.).

Rezultat procesiranja v DialogFlow agentu je JSON objekt, ki vsebuje klasifikacijo uporabniškega vnosa v enega od definiranih razredov (angl. intents) in seznam morebitnih vrednosti parametrov, ki jih je sistem izluščil. To prejme zaledni del (implementiran v Djangu) in na podlagi procesiranja JSON objekta določi nadaljnji potek. Ta lahko vsebuje že ustrezni odgovor, ki ga sistem nato vrne spletnemu vmesniku in ga prikaže v pogovornem oknu. Mehanizem pa lahko določi, da je potrebno pridobiti odgovor ali podatke iz zunanjih virov ali podatkovnih baz.

Zahtevo se nato pošlje do ustreznega vmesnika, ki je sposoben komunicirati z zunanjim virom znanja. Ta pretvori JSON podatke v zahtevek, ki ga zunanja podatkovna zbirka, aplikacija ali platforma razume. Običajno se generira REST zahtevek.

3. ČAKALNE VRSTE

Definirani inteligentni sistem smo najprej aplicirali na domeno svetovanja o čakalnih vrstah za zdravstvene storitve.

3.1 Implementacija

Aplikacija uporablja generičnega svetovalca, ki smo ga predstavili v prejšnjem razdelku. Ustvariti smo morali DialogFlow agenta in ga naučiti razpoznavati ustrezne zahtevke uporabnikov. Iz vprašanj uporabnika agent poskuša pridobiti tri vrste podatkov: poseg, nujnost napotnice in regijo posega. Agenta smo naučili tako, da smo mu podali večje število primerov vprašanj za različne kombinacije parametrov.

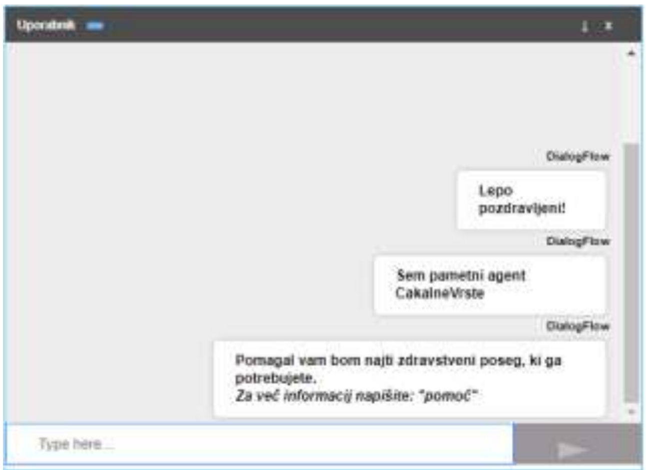
Uporabnik lahko povpraša po posegih na različne načine in v različnih sklonih. Zato smo pri iskanju ustreznih posegov uporabili tudi algoritem za indeksiranje nizov. V primeru, da DialogFlow agent ne najde natančnega zadetka za poseg, se izvede delno iskanje po indeksiranih posegih in metoda vrne seznam posegov, z izračunanimi verjetnostmi. Nekaj najverjetnejših posegov se ponudi uporabniku v izbiro preko izbirnih gumbov.

Primer uporabe sistema je zaporedje vnosov, ki podajo informacijo o čakalnih dobah za določen poseg v določeni regiji. Uporabnik najprej poda poseg za katerega se zanima. Svetovalec nato poskuša pridobiti manjkajoče podatke, ki jih potrebuje za pridobitev informacij o čakalnih dobah. Najprej uporabniku prikaže izbirne gumbe z nujnostjo napotnice. V naslednjem koraku uporabnik izbere regijo, kjer želi izvesti poseg. V primeru, da uporabnik že v osnovnem zahtevku poda vse potrebne informacije, se ta dva koraka izpustijo. Primer takega vprašanja je: »Pod nujno iščem zobarja na štajerskem«.

Podatke o čakalnih dobah pa zaledni del pridobi iz spletnega servisa [4], kamor se pošlje http POST zahtevek, odgovor se procesira in informacije o ustanovah in ustreznih čakalnih dobah shrani v strukturiran JSON objekt.

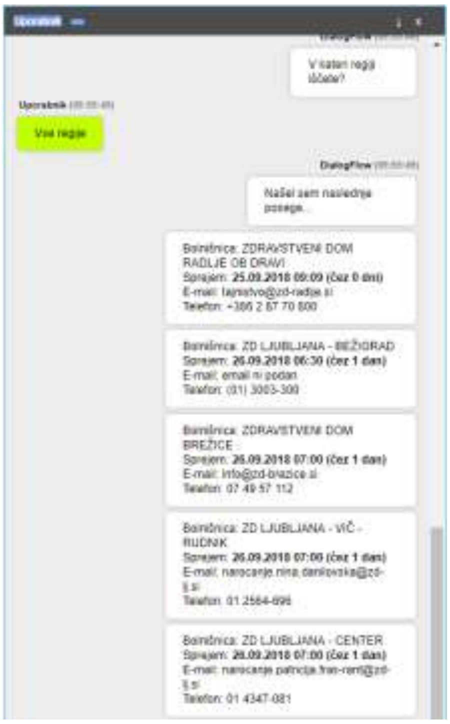
3.2 Primeri uporabe

V tej sekciji predstavimo nekaj primerov uporabe aplikacije za posredovanje informacije o čakalnih dobah. Slika 1 prikazuje začetni pogled spletne aplikacije. Ob zagonu vmesnika se prikažejo pozdravni nagovori, kjer se pogovorni svetovalec predstavi in uporabnika obvesti, da z ključno besedo »pomoč« lahko pridobi več informacij in prejme dodatna navodila. Uporabnik vnaša vprašanja in zahteve v spodnje vnosno polje.



Slika 1: Začetni pogled svetovalca za posredovanje informacij o čakalnih vrstah.

Odgovori sistema se prikažejo na desni strani in so osenčeni s sivo barvo. Vnosi uporabnika pa se prikažejo na levi strani in so osenčeni s svetlo zeleno barvo. Svetovalec najprej poskuša razbrati iz vnosov uporabnika za kateri zdravstveni poseg se zanima. To je realizirano s kombiniranjem algoritma za indeksiranje in klasifikacijo z DialogFlow agentom. V primeru, ko svetovalec ni prepričan o posegu, uporabniku vrne množico elementov, za katere je določil najvišjo verjetnost ujemanja. Ti so prikazani v obliki gumbov, katere lahko uporabnik izbere (glej Slika 4).



Slika 2: Prikaz rezultatov poizvedovanja za zobozdravstveni pregled.

V naslednjem koraku uporabnik preko vnosnih gumbov izbere nujnost napotnice in regijo, v kateri želi opraviti poseg. Sistem nato pošlje poizvedovanje na spletni servis za razbrane parametre in pridobi čakalne dobe za različne zdravstvene ustanove. Uporabniku se prikaže 5 ustanov, kjer je čakalna doba najkrajša. Vsaki ustanovi je pripisan naslov in kontaktni podatki. Primer izpisa je prikazan na Sliki 2.

4. THINK!EHR SVETOVALEC

Naslednja domena kjer smo preizkusili pogovornega svetovalca je poizvedovanje po Think!EHR platformi. V tej aplikaciji se mora uporabnik najprej prijaviti. Svetovalec loči med dvema vlogama: zdravnik in pacient. Na podlagi vloge svetovalec posreduje različne tipe in obseg podatkov iz Think!EHR platforme.

4.1 Implementacija

Pri implementaciji aplikacije smo ponovno uporabili generičnega svetovalca, ki smo ga prilagodili glede na specifike domene.

Think!EHR platforma je namenjena zdravstvenim delavcem in vsebuje različne podatke o pacientih: osebni podatki, relacije med pacienti, rezultati analiz ipd. Zdravnik lahko pregleduje zgolj podatke svojih pacientov, določena oseba pa zgolj svoje podatke in meritve. Zaradi te logične razdelitve smo spletnemu vmesniku dodali možnost prijave (glej Slika 3), kjer se lahko prijavijo zdravniki ali pacienti in tako se določi uporabniku vloga. Na podlagi tega se nato uporabniku omogoči različna poizvedovanja in prikaz različnih tipov in obsega podatkov.

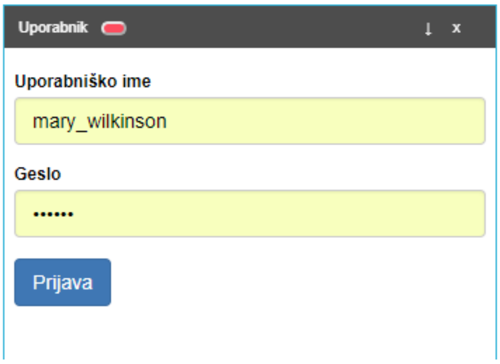
Za pregledovanje meritev smo spletnemu vmesniku dodali grafični prikaz v ozadju pogovornega svetovalca (glej Slika 5). Ta omogoča prikaz poljubnih podatkov v meritvah na preglednejši način.

Na novo smo generirali DialogFlow agenta in ga naučili razpoznavati različne zahtevke, ki jih uporabnik lahko posreduje. Agent načeloma lahko iz teksta izlušči imena, različne nazive meritev in datume.

Pridobivanje podatkov pa je realizirano preko REST vmesnika ehrscape platforme [5]. Določene podatke smo lahko pridobili preko osnovnih API klicev, za kompleksnejše poizvedbe pa smo uporabili AQL jezik, ki omogoča poizvedovanje po EHR zapisih.

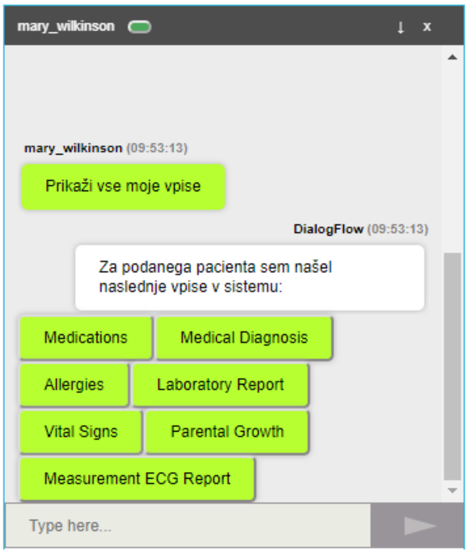
4.2 Primeri uporabe

Pogovornemu svetovalcu je dodano prijavno okno, kjer se mora uporabnik prijaviti, da lahko dostopa do podatkov v platformi (glej Slika 3). S prijavo se uporabniku določi ena od dveh možnih vlog: zdravnik ali pacient. Glede na to se prilagodi funkcionalnosti sistema in nabor možnih poizvedovanj po platformi.



Slika 3: Prijavni obrazec svetovalca. S prijavo se določi vlogo in funkcionalnosti.

Uspešno prijavljena oseba (pacient) lahko pregleduje vse svoje zapise, ki so shranjeni v platformi Think!EHR. Slika 4 prikazuje posredovani seznam zapisov, ki so zabeleženi za določeno osebo. S klikom na gumb se izbere posamezno meritev.

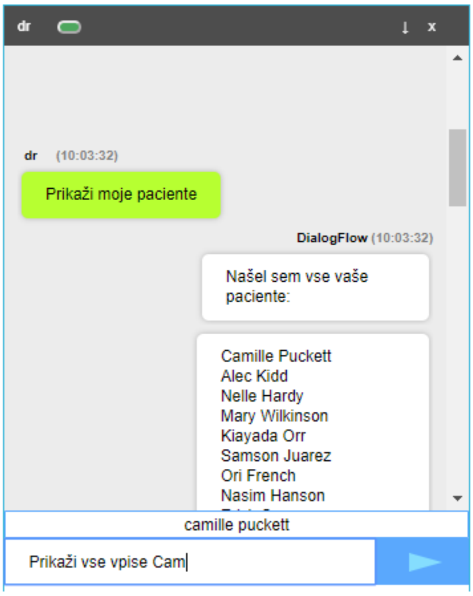


Slika 4: Pregled vseh vrst zapisov v Think!EHR za vlogo pacient.

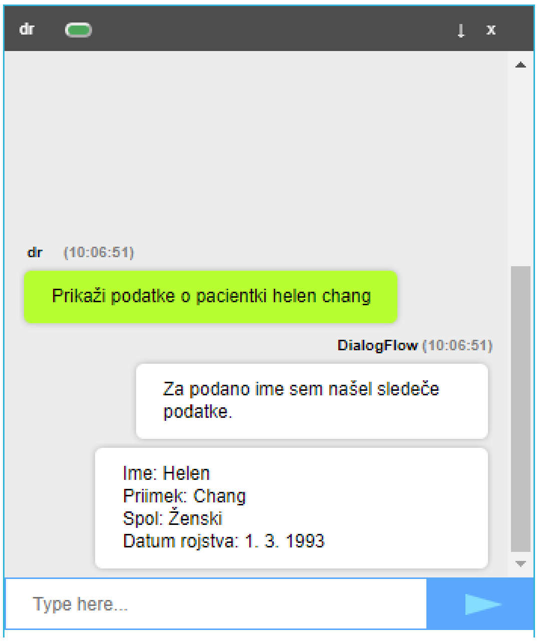
Posamezni sklopi meritev za izbrani vnos se prikažejo na strani v ozadju (glej Slika 5). Posamezne meritve so časovno urejene in grafično prikazane. Uporabnik lahko poljubno vklaplja ali izklaplja prikaz posameznih meritev znotraj sklopa.

Slika 5: Grafični prikaz posamezne vrste meritev za vlogo pacienta

Druga vloga, ki jo lahko uporabnik zavzame je zdravnik. V tem primeru lahko prijavljeni uporabnik dostopa do seznama svojih pacientov (glej Slika 6) in pregleduje osebne podatke o posameznem pacientu (glej Slika 7). Vnosnemu polju je dodana tudi funkcionalnost iskanja in avtomatske dopolnitve znakovnega niza (angl. autocomplete), ki olajša vnašanje imen pacientov določenega zdravnika. Uporabniški vlogi zdravnik je omogočena polna funkcionalnost sistema in dostop do vseh različnih poizvedb, ki jih platforma podpira. Kot v prejšnjem primeru lahko pridobi osebne podatke o svojih pacientih, išče podatke o sorodstvenih vezeh ter njihove vnesene informacije in pregleduje vse sklope meritev, laboratorijskih izvidov, napotnice, lekarniške recepte, alergije itd. Za posamezne sklope meritve in laboratorijske izvide mu je omogočen grafičen prikaz posameznih komponent v času, kot je prikazano na Sliki 5.



Slika 6: Prikaz vseh pacientov, ki so dodeljeni prijavljenemu zdravniku.



Slika 7: Prikaz podatkov o posameznem pacientu za vlogo zdravnik.

5. ZAKLJUČEK

V pričujočem prispevku smo predstavili koncept splošnega sistema pogovornega svetovalca, ki omogoča komunikacijo v naravnem jeziku in ga je mogoče uporabljati na različnih domenah. Svetovalec lahko uporablja statično bazo znanja v obliki vprašanja–odgovor, ali želene informacije/podatke pridobi iz zunanjih virov. To pa so lahko podatkovne baze, internetni viri, spletni servisi, platforme itd. Sistem je sestavljen iz štirih glavnih komponent. Spletni vmesnik omogoča interakcijo z uporabnikom preko tekstovnega vnosa ali izbirnih gumbov. Sistem za procesiranje naravnega jezika kombinira metode iskanja po indeksiranih tekstovnih nizih in razpoznavanje namena uporabnika z uporabo storitve DialogFlow. Zaledni del prejema rezultate analize teksta, ki ga uporabnik vnese preko spletnega vmesnika in na podlagi pridobljenih vrednosti parametrov določi ustrezni vir za pridobivanje zahtevanega podatka. Zadnja komponenta sistema pa je množica vmesnikov za komunikacijo z zunanjimi viri podatkov. Vsi vmesniki prejemajo zahtevke iz zalednega dela na enoten način, njihova vloga pa je transformacija splošnega zahtevka v obliko, ki jo razume zunanji servis. V večini primerov gre za definiranje REST zahtevka, ki se nato posreduje ustreznemu cilju.

Sistem smo demonstrirali na dveh domenah. Implementirali smo svetovalca za posredovanje informacij o čakalnih dobah za posamezne posege in za pridobivanje podatkov iz zdravstvene platforme Think!EHR. Predstavili smo primere uporabe za obe aplikaciji in različne vloge uporabnika. Predstavljeni sistem ima velik potencial za integracijo v različne produkte podjetij, saj olajša interakcijo in izboljša uporabniško izkušnjo pri uporabi produkta ali storitve podjetja.

ZAHVALA

Raziskave in razvoj so nastale v okviru programa EkoSMART in so delno sofinancirane s strani Ministrstva za izobraževanje, znanost in šport in Evropske unije iz Evropskega sklada za regionalni razvoj (ESRR).

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The potential of Blockchain technology in health monitoring

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ABSTRACT
This paper is an overview of available technologies for a practical implementation of a system that would facilitate large scale sensor networks with some unique required features. It outlines some special features and benefits of decentralized systems and explores the possibilities of applying them in building and health monitoring. Arguably, the adoption of Internet of Things systems suffers from a trade-off between privacy, usability and availability. While these systems can solve a variety of problems by acquiring enormous amounts of data, they pose security and privacy concerns. We identify these trade-offs and the unique properties needed to resolve them in an effort to find the most suitable technology for a demonstration implementation.

Categories and Subject Descriptors
C.2.4 [**Distributed Systems**]: decentralized systems; E.3 [**DATA ENCRYPTION**]: Public-private key encryption

General Terms
Application

Keywords
DLT, Blockchain, Sensor network, Structural health monitoring

1. INTRODUCTION
Storing and processing data has become very important. Technological advances in hardware have enabled high capacity storage and data processing. In recent years, the ideology of an information society where information becomes a financial instrument has matured substantially in both the private and public sectors. Small and large companies have built business models monetizing information obtained from processing data. The ability to extrapolate a deeper understanding of data has been a focus in academic research for years. Previously, however, scientists, research institutions and governments have relied solely on a system of self-regulation based on shared ethical principles and generally accepted research practices to ensure integrity in the research process. Due to an increase in provable reports of private and public entities sharing and processing user data without consent, awareness amongst the general public has increased substantially. Regulation has tightened following the data protection movement and increased public awareness, which is reflected by recent developments of the GDPR in Europe and the battle for net neutrality internationally. While these regulatory frameworks are still in their infancy, overcoming the clear barrier of storing and processing data privately and securely must be carried out in a way that does not impact the progress of research and innovation.

Structural health monitoring of buildings is important in damage detection [6], [7] [3] and [4]. More specifically, damage to building components or systems may be observed as changes in materials or the geometrical properties of a system. Additionally, a building's health can be assessed by monitoring and detecting damage over time. It is also important to provide an explanation as to why the damage occurred. With the developments and progress in readily available and affordable sensors, data collection has become more widespread. Storing and processing sensor data in a functioning building can also reveal sensitive and personal information about building users. While this poses a privacy and security risk, it supports an emerging and discovering field of research: discovering behavioral patterns in building usage and user health monitoring. Besides monitoring the user's health, there is a growing need to design and implement smart solutions for buildings, focused on elderly people. These are just examples a few amongst many use cases where storing and processing building and user data can be beneficial.

Logging data-points from a large quantity of sensors and storing it safely is predominately and engineering task. However, exploring architectural patterns and design principles is important to study the security and availability of data. Generally, such systems are implemented as centralized databases handling data integrity and storage, while peripheral devices are connected to the database directly through any medium of digital communication. However, centralized systems inherently represent a single point of failure. Another downside is that these systems require users to trust a central entity by losing control over their data and transparency. A broader view of these problems lies in the nature of digital information. If digital information is passed to someone, the owner loses control as the information can be copied or altered. In other words, as soon as access is granted, the data can be copied, processed and shared without the user's consent or knowledge. Public-private key encryption techniques solve this but again require users to trust a central authority issuing certificates (certificate authority) and the underlying implementation of software that facilitates the service. Ideally, a system for storing and processing data would be transparent, trustless and could uniquely identify digital information.

Designing a system where data can be safely stored and processed without the possibility of copying or sharing (without consent) is challenging. In this paper we explore the potential of distributed ledger technology (DLT) with a specifically designed architecture that aims to solve the aforementioned problems of centralized systems while still maintaining the same functionality, availability and security.

2. REAL WORLD IMPLEMENTATION

This review and research of existing DLTs is inspired by a project at the InnoRenew CoE. The research institute focuses on sustainable building with renewable materials, human health in the built environment and ICT integration buildings, manufacturing and products. A new building will be constructed to house the InnoRenew CoE staff and research facilities. In addition to its primary function, it is also a demonstration project for sustainable building with wood and it will include various sensors that will give more insight into how materials and components perform, how spaces are used and the overall health and performance of the building. A sensor network of this scale requires careful examination to identify the appropriate technology and implementation constraints. One of the key attributes of sensor networks is to store sensitive data, including user data, while having the ability to process and analyse data for research purposes. The unique properties of DLTs and distributed computing could meet those requirements and at the same time maintain a high level of security, availability and scalability. In chapter 3 we identify the properties required and review existing platforms that would potentially be suitable for real-world implementation.

3. REVIEW

In this chapter we review various existing DLTs that enable storing, analyzing and processing data in a completely trustless way. We structure this chapter so that it provides some background on DLTs. We then explore some important features of Blockchain technology, a type of DLT, describe some of their unique features and explain the functionality they provide to our system [1], [2].

3.1 DLTs and Blockchain

Interest in distributed ledger technology has spiked significantly in recent years. This is mostly due to a few successful implementations. DLTs are systems that maintain a distributed database. In such a system, there is no central entity that administers or controls the state of the network. The absence of a central server or entity requires a peer-to-peer network of nodes that form a distributed system. In general, each node keeps the current state of the ledger. Any change in the state of the ledger is propagated to all nodes. To ensure replication, a consensus algorithm is needed. The algorithm's properties are predominantly inherited by the specific implementation. However, they in general address the following problems.

- All nodes controlling an instance of the ledger need to come to an agreement on the order of transactions and commit the transactions to the ledger in that order.
- Decide on the state of the ledger when two or more conflicting states are being propagated through the network
- Secure the protocol against deliberate or accidental malicious actors.

One of the most well-known protocols that has addressed those issues is Bitcoin, a type of DLT called a Blockchain. There are now many variations of the protocol experimenting with different consensus algorithms that provide interesting properties. A Blockchain is simply a distributed and decentralized database that has mathematically provable properties addressing the problems mentioned above. These properties make it suitable for maintaining a digital currency or value transfer. The Bitcoin protocol enables participants in the network to transact with one another using Bitcoin as a digital currency. The consensus algorithm, usually refereed to as Proof of Work, solves the aforementioned problems. Private-public key encryption is used for security and it has some interesting and unique properties, which we address later. Another successful implementation of a Blockchain is Ethereum, which added support for Smart Contracts (SC). SCs are in essence programs that can be executed in a distributed system. The result of the computation is decided through the consensus protocol. These programs have the ability to send transactions and store data. Lately, most research and innovation related to consensus algorithms and distributed system shifted focus to explore Blockchain technology. Arguably, the interest spiked due to an abundance of investments and business opportunities in this emerging technology. Due to the rapid expansion of DLT, different protocol implementations and use cases, a careful review is needed to choose a suitable platform.

Our review includes DLT systems specifically designed to tackle the Internet of Things (IoT) systems. The desired functionalities required are:

- Storing large amounts of uniquely identifiable data in a trustless way. Successful implementations of DLT such as Bitcoin have the ability to uniquely identify digital data by unique fingerprints. This is achieved through public private key encryption, which has been used for years. However, in a completely trustless distributed and decentralized system such as Bitcoin, this can be achieved without trusting a centralized entity. A Bitcoin must and can be uniquely identified, otherwise participants in the network could create new Bitcoin by simply copying the digital fingerprint of another. This can be translated to any data which would in turn prevent copying and manipulating data.

- Security is an important issue in centralized systems. Storing sensitive data in a central server inherently creates a single point of failure. A compromised central database can be fatal for any centralized system. Decentralized implementation of DLT can solve this by having all nodes in the system keeping a copy of the current state of the database. In such systems, there is no central entity that malicious actors could attack, instead the whole system must be attacked. This would require malicious actors to convince participants in the network to change the state of the database through consensus. The details of the different types of attack vectors is outside the scope of this paper, but has been studied extensively.

- Data processing is the most important functionality the system must provide. DLT implementations have achieved this by introducing SCs. SCs are computer programs that can be executed by nodes in a distributed system. Through consensus protocols, the network comes to an agreement of what the output of the program is. The output can be included in the ledger. This important feature can facilitate programs that process data without the need for the author to ever access data. Instead, a SC is granted access to the data and writes the output to the ledger.

- Transparency has been an ever growing problem in information systems. Even though some systems claim to be transparent about how and which data they process, policing this is infeasible due to the nature of digital data. A distributed system can provide maximum transparency. All transactions and SCs included in a distributed ledger can be transparent as all nodes keep a copy of the current state of the ledger. Any instance of a ledger can be queried for information about the current state of the system and the entire history of transactions and SC executions (computation results are stored as a transaction).

In the following subsections we review popular existing implementations of DLT and identify subsets of the required properties they provide. We focus on public permissionless Blockchains that at least have a semi-working product. There are many other projects working on DLTs to support smart buildings, health monitoring and sensor networks but are currently not ready for production use.

3.2 IOTA

IOTA is one of the most popular projects aiming to solve problems in IoT and create a machine to machine economy. However, unlike many other DLT implementation, IOTA is not a Blockchain. Consequently, the consensus protocol is somewhat unique. IOTA is implemented as a directed acyclic graph refereed to as the Tangle. The construction of the graph is done by having transactions be vertexes and edges be confirmations of transactions. In a Tangle, each new, unconfirmed transaction must confirm two other unconfirmed transactions. The confirmation creates an edge connecting the current transactions with two others [5]. Arguably, the choice of transactions to confirm is very important to prevent transaction starvation and avoid latency. With this data structure, IOTA eliminates the need for miners and special nodes that confirm transactions. We do not go into details about the cryptography and transaction confirmation but one important aspect is that it does not require a lot of resources and can be done by most devices. This enables the IOTA network to process transactions without fees as there is no need to incentivise specially designed nodes to provide security to the network. Additionally, the scalability of the network is ensured as having more transactions on the network consequently means more transactions are confirmed. This makes IOTA the perfect candidate for creating a decentralized sensor network where sensors log data in a form of a transaction. However, IOTA has received some criticism about the possibility of centralizing the network which has not been addressed yet. Another downside is the lack of SCs support, which prevents execution of programs in a distributed and trustless system.

3.3 Ethereum

Ethereum is a unique platform which enables developers to implement their own protocol on top of Ethereum's protocol with the use of Turing-complete SCs. The network is a variation of Bitcoin's network using proof-of-work as to reach consensus [8]. Miners race to solve a problem, which involves guessing the result of a problem with some accuracy. In general the actual problem and the solution is not important. The properties of such problems are. In a proof of work model, the problem being solved has to be hard, while checking if the found solution is correct is trivial. Since the only way to find the result is to check all possibilities in a brute-force manner, finding the result is also proof that a lot of computational power (work) was put into finding the result. Every time such the result is found by a miner, the network checks if the result is correct. If a winning node is found, it gets to include the next block in the chain of blocks. There are a lot of specifics to each implementation of Proof of Work, but in general, the system is secure because trying to cheat it would potentially result in a huge financial loss (electricity and equipment used to mine). Ethereum builds on Bitcoins idea by adding SC support. The ability for actors within a trustless network to execute programs opens up a world of possibilities which are still being explored. However, due to the Poof of Work based consensus, blocks get added to the network realistically slowly. Additionally, transactions and SC executions are not free, as miners have to be payed a reward for executing them. Hence, large scale sensor networks cannot be built on top of Ethereum due to the financial impact and slow transaction speed. Ethereum plans to update in the coming years, migrating from the PoW consensus to a proof of stake, where instead of mining, validator nodes will validate transactions. To ensure security of the network, validators will have to stake coins, which can be taken from them by the network, should they provably act against the network. Eliminating the need for miners would decrease block-time and allow the network to overcome it's current scalability issues.

3.4 VeChain

VeChain is a Blockchain based DLT that digitalizes real assets that can be uniquely identified and tracked. The most promising application is arguably supply chain management and verifiability of real assets. VeChain also supports authorization based digital assets, which simply means ownership of digital assets (and, consequently, real assets) can be represented. This is done with the help of SCs that link a digital asset to an account. Whoever owns the private key to the account, owns the digital asset. The processing of transactions and execution of SCs is done by delegates. VeChain is built as a delegated proof of stake (DPOS) system where delegates using the network are granted the right to run a node. The consensus algorithm, named Proof of Authority, grants stakeholders the right to run a node if they maintain a minimum balance of VET tokens (VeChain's native currency) to engage in protocol governance. The network is not completely trustless as users and applications must trust the majority of delegates to act in the favor of the network. In general, this is solved by choosing delegates that would oppose one another rather than work together. The details of SC support are still not known, which makes VeChain unsuitable for real life implementation at the time of writing.

4. CONCLUSION

The paper presents an overview of the existing DLT technologies that could be potentially used as an aggregation platform for personally identifiable data in the context of building monitoring and ambient assisted living. The challenges that we face and try to address with the platform are:

- fault tolerance (the platform should detect faulty sensors),
- security issues detection and prevention,
- data security (platform should act as a safe storage network),
- data anonymity and privacy
- data availability and transparency

Selected technologies will be used in a real-life pilot implementation: the new Innorenew CoE building that will incorporate sensors monitoring building parameters and health parameters of the employees. The pilot represents a true engineering challenge (mounting thousands of specialized and multi-purpose sensors with the accompanying equipment), but the true challenge lies in devising, implementing and testing a platform based on DLT that will address the monitoring and analytical needs as well as the security and privacy concerns. The building is in the last preparation stages and is scheduled to be built in the next year and a half, the sensor network will be partly built into the building so we expect the full implementation of the presented setting to be fully functional in the months following the inauguration of the building.

5. ACKNOWLEDGEMENTS

Authors Tošić and Burnard gratefully acknowledge the European Commission for funding the InnoRenew CoE project (Grant Agreement No. 739574) under the H2020 Widespread-Teaming programme.

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Prenos projekta “Asistent IJS” na Python 3.6

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POVZETEK

V prispevku si bomo ogledali, kako smo prenesli kodo projekta “Asistent IJS” (asistent) iz programskega jezika *Python 2.7* v *Python 3.6* in opravili nekaj drugih popravkov. Prenos v novo verzijo je bil potreben zaradi ohranitve tehnične podpore programskemu jeziku.

Ključne besede

asistent, avtomatično odgovarjanje, *Py2to3*

1. UVOD

Asistent je projekt, katerega začetki segajo v leto 2013. Dostop do uporabniškega vmesnika projekta se nahaja na spletni strani *https://www.ijs.si*. Asistent je orodje za izbiro najustreznejšega odgovora na zastavljeno vprašanje v zvezi z Institutom “Jožef Stefan” (IJS). Projekt je podrobno opisan v [1]. Trenutno delujoča različica asistenta je napisana v programskem jeziku *Python 2.7*. Ker je projekt dolgoročne narave, smo se odločili, da opravimo prenos kode projekta na verzijo *Python 3.6*, kateri je zagotovljena nadaljna tehnična podpora.

2. STRUKTURA PROJEKTA

Asistent je spletna aplikacija, razdeljena na jedro in več med seboj neodvisnih modulov. Vsak od modulov je odgovoren za vprašanja z določenega področja ali za določen vidik delovanja asistenta. Navzven je asistent spletni servis, ki prejme vprašanje uporabnika in vrne odgovor. Poleg te osnovne funkcije nudi asistent še uporabniški vmesnik za uporabnike in administratorje.

2.1 Moduli

Glavna uporaba asistenta je, da uporabnik vnese vprašanje in pritisne tipko *Enter*. Ob tem se vsak modul odzove s klicem funkcije, ki poišče najboljši odgovor v modulu in ga doda v izbor vseh odgovorov. Odgovori so sestavljeni iz besedila odgovora, uteži odgovora, morebitne povezave na spletno stran v ozadju, informacije o tem, kateremu modulu pripadajo in morebitne pripadajoče geste asistenta. Utež odgovora je merilo njegove kvalitete. Primeri modulov so:

- modul *static_answer_kb* za statična vprašanja iz baze podatkov (pripona *kb* je okrajšava za ang. *knowledge base*),
- modul *ijs_contacts_kb* za informacije o zaposlenih na IJS,
- modul *slovenia_info_kb* za glavne informacije o Sloveniji,
- modul *dont_know_kb* za nedefinirane odgovore,
- modul *qa* za izbiro najboljšega odgovora izmed vseh odgovorov, ki so jih v izbor dodali ostali moduli.

3. PRENOS PROJEKTA

Prenos kode asistenta na verzijo programskega jezika *Python 3.6* je potreben, ker bo v letu 2020 ukinjena podpora za *Python 2.7*, projekt asistent pa je dolgoročnejši projekt. Naloge smo se lotili s pomočjo knjižnice *Py2to3*, ki pregleda datoteke s kodo in avtomatično vnese popravke. Naštejmo nekaj razlik med verzijama programskega jezika, ki jih knjižnica *Py2to3* upošteva. V *Python 3.6*

- je ukinjena uporaba značke `'u'` za *unicode* nize,
- branje vrednosti slovarja vrne generator namesto seznama,
- imamo drugačno notacijo za prestrezanje napak,
- se je knjižnica *urllib* razdelila na dve knjižnici: *urllib.request* in *urllib.error*.

Med asistentovimi moduli ni neposredne komunikacije, zato smo lahko prenašali vsak modul posebej. Do komentiranih delov kode in blokov kode, ki so bili shranjeni v podatkovnih bazah asistenta, knjižnica *Py2to3* ni imela dostopa, zato smo jih morali prenesti ročno.

4. DRUGE SPREMEMBE

Izkoristili smo priložnost, da uvedemo še nekaj drugih sprememb asistentove kode:

- popravek prijave administratorja,
- dodajanje dokumentacijskih komentarjev,
- pisanje testnih primerov.

5. ZAKLJUČEK

Na projektu asistent ostaja veliko možnosti za stilistično izboljšavo kode in za izboljšanje načina izbire pravega odgovora. Morda je najbolj očitna pomanjkljivost v statičnosti izbire odgovorov. Vzorci za iskanje odgovorov so določeni, izven njih pa asistent nima dobrega odgovora.

Prenesena koda se v času pisanja tega prispevka nahaja v ločenem repozitoriju. V bližnji prihodnosti bo postavljena v produkcijo.

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Časovna sinhronizacija brezžičnih EKG senzorjev

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POVZETEK
V prispevku opišemo in ovrednotimo na Institutu »Jožef Stefan« razvito metodo za sinhronizacijo brezžičnih EKG senzorjev. Sinhronizacija je nujen pogoj, če želimo iz istočasnih meritev več senzorjev, opravljenih na eni osebi, sintetizirati standardni 12-kanalni EKG. Rezultati kažejo, da je metoda uspešna in torej omogoča tovrstno sintezo.

Ključne besede
EKG senzor, sinhronizacija, linearna regresija, 12-kanalni EKG.

1. UVOD
Merjenje EKG signalov se je od začetka 20. stoletja do danes močno razvilo in se je uveljavilo v obliki standardnega 12-kanalnega EKG. Poleg klasičnih stacionarnih večkanalnih EKG sistemov [1] so v uporabi tudi prenosni monitorji (tipični predstavnik je Holterjev monitor), ki že od leta 1960 omogočajo dolgotrajno (okvirno en cel dan) spremljanje EKG [2].

Tehnološki napredek je pozneje omogočil, da so prenosne naprave postajale vse manjše in so za snemanje visokokakovostnih EKG signalov uporabile manjše, a še zadostno število elektrod. Prenos posnetkov lahko poteka preko brezžičnega kanala do vozlišča z dostopom do Interneta. Opisana konfiguracija omogoča zagotavljanje širokega spektra mobilnih zdravstvenih storitev, od spremljanja bolnikov v bolnišnicah [3], oddaljenega spremljanja bolnikov [4][5] in oddaljene medicinske podpore do športa, rekreacije in zabave.

Na Institutu »Jožef Stefan« je bila razvita večfunkcionalna senzorska naprava EKG, ki je del mHealth platforme [6]. Naprava obsega analogni EKG senzor, mikrokontroler in radijski oddajnik Bluetooth Low Energy (BLE). Ima zelo nizko procesorsko zmogljivost in nima zmogljivosti shranjevanja, zaradi česar je majhna in energetsko učinkovita. Nosi se jo na prsih, kjer meri EKG in ga v realnem času brezžično pošilja na pametni telefon.

Enostavnost naprave po eni strani omogoča, da je majhna, nemoteča in kot taka lahko nosljiva v vsakodnevnih dejavnostih, po drugi strani pa zaradi svoje enostavnosti prelaga več tehnoloških izzivov na stran pametnega telefona oziroma druge naprave, ki služijo urejanju prejetih podatkov v koherentno meritev. Glavni izziv je celovitost podatkov, ki je lahko ogrožena zaradi netočne ure na strani senzorja, naključnih zakasnitev v prenosu, ki so posledica brezžičnega protokola, in po naših izkušnjah tudi zaradi nihanja urnega takta na pametnem telefonu.

Izziv je potrebno obravnavati že na ravni enega samega EKG senzorja [7]. Naša motivacija pa je, da sistem razvijemo do te stopnje, da pravilno združimo meritve iz več EKG senzorjev, ki merijo srčno aktivnost istega človeka in so priključeni na isti pametni telefon. Cilj takega združevanja je pridobiti zmožnost sinteze klasičnega 12-kanalnega EKG, ki bi bil tako dosegljiv tudi z vzporedno uporabo več neodvisnih brezžičnih senzorjev hkrati. Motivacija temelji na že predlaganih metodologijah, ki potrjujejo, da je sinteza iz treh vzporednih diferencialnih meritev EKG mogoča [8].

Cilj tega prispevka je na kratko predstaviti novo metodologijo, ki smo jo razvili za dosego natančne sinhronizacije več EKG signalov, merjenih z brezžičnimi senzorji. Natančna sinhronizacija predstavlja nujen pogoj za uspešno sintezo 12-kanalnega EKG. Čeprav je bila metoda razvita s specifičnim namenom sinhronizacije senzorjev EKG pa deluje v splošnem za vse vrste meritev z visoko vzorčno frekvenco, kjer imajo posamezne merilne naprave samostojne nesinhronizirane ure.

2. SINHRONIZACIJSKI ALGORITEM
Predlagani algoritem poskuša sinhronizirati prejete vzorce tako, da doseže pravilno reprodukcijo časovnih trenutkov, pri katerih so bili vzorci dejansko vzeti. Ura vozlišča, t.j. pametnega telefona, služi kot referenca.

Na vhodu algoritem dobi vzorce, označene s številko števca in časovnim žigom. Števec je monotono naraščajoče število, ki ga vodi senzor. Predpostavljamo, da so števci pravilni in da so bili predhodno že opravljeni morebitni popravki preliva (angl. overflow), ki so nujni zaradi omejene preciznosti števil, s katerimi števce shranjujemo oziroma prenašamo. Časovne žige zapiše vozlišče v času sprejema na aplikacijskem nivoju (ker se le-to ne zgodi na nivoju gonilnikov, do katerih uporabniške aplikacije nimajo dostopa). Na voljo so torej naslednji podatki: *cnt_sensor (n)* in *t_hub (n)* za *n ε [1, N]*, kjer je *N* število poslanih podatkovnih paketov.

Na izhodu algoritem določi nove, popravljene časovne žige, označene kot *t_new (n)*.

Algoritem se izvaja v štirih korakih:

1. Razčlemba meritev.

2. Linearna regresija s filtriranjem paketov.

3. Odprava nezveznosti.

4. Določitev časa vzorčenja.

Korak 1: Razčlemba meritev. V tem koraku želimo razdeliti meritve v dobre in slabe bloke, kjer imajo slednji težko nadomestljive pomanjkljivosti, kot so večja izguba paketov, daljši premor v prenosu paketov ali močno zapozneli paketi. Vse od naštetih pomanjkljivosti je mogoče prepoznati le z analizo časov prejetih paketov, to je iz daljše časovne razlike med zaporednimi prejetimi paketi.

Druga naloga tega koraka je frekvenčna razčlemba, ki dobre bloke nadalje razdeli na manjše bloke vnaprej določene največje dolžine. Motivacija je izboljšati natančnost ocenjevanja frekvenc vzorčenja, ki bo potekala v naslednjem koraku, saj lahko le-ta med samo meritvijo opazno niha.

Korak 2. Linearna regresija s filtriranjem paketov. Na vsakem posameznem dobrem bloku opravi algoritem postopek enostavne linearne regresije. Postopek je iterativen in ob vsaki iteraciji je po postopku linearne regresije določena linearna funkcija, ki ima najmanjšo vsoto kvadratnih razlik do pripadajočih vzorcev.

Na koncu vsake ponovitve se izvaja filtriranje paketov. Njegov namen je odstraniti manj zanesljive pakete z veliko zamudo. Vsi paketi, katerih vrednost je nižja od vrednosti določene z regresijsko funkcijo, se odstranijo pred izvedbo naslednjega ponovitvenega koraka.

Po končanem iterativnem procesu določitve linearne funkcije se opravi zadnja naloga tega koraka – določanje začetne vrednosti. Ta je določena glede na vzorec z največjo (pozitivno) napako med preostalimi vzorci. Z drugimi besedami, začetna vrednost je nastavljena po najzgodnejšem vzorcu glede na linearno funkcijo. Postopek zagotavlja, da so ocenjeni časovni žigi nižji ali enaki izmerjenim časovnim žigom, saj vemo, da izmerjeni časi ne morejo biti nižji od dejanskega časa vzorčenja.

Korak 3. Odprava nezveznosti. Da bi odpravili nezveznosti med deli funkcije, ki jih lahko med bloki dobimo po 2. koraku, v 3. koraku konsolidiramo meje blokov.

Glede na postopek 2. koraka slabi bloki vedno ležijo le ob dobrih blokih, dobri bloki pa so lahko bodisi zraven dobrih bodisi zraven slabih blokov. Zato je meja med dvema sosednjima blokoma, t.j. zadnjim paketom enega bloka in hkrati prvim paketom drugega bloka, lahko bodisi med dobrim in slabim blokom bodisi med dvema dobrima blokoma.

Konsolidacija poteka tako, da za vse možne primere velja eno od dveh pravil, kot sledi.

- Pravilo 1. Če leva stran nima ocenjenega časa (slab blok), se zadnji točki v njenem območju dodeli vrednost prve točke desnega območja.

- Pravilo 2. Če desna stran nima ocenjenega časa (slab blok), potem se prvi točki v njenem območju dodeli vrednost zadnje točke levega območja.

Če imata obe strani čas ocenjen (dva dobra bloka), se uporablja pravilo 2.

Korak 4. Določitev časa vzorčenja. V zadnjem koraku se ocenjene frekvence vzorčenja, določene na vsakem od signalnih blokov, uporabijo za izračun vzorčnega časa vseh paketov. Za vsak paket je čas vzorčenja določen kot:

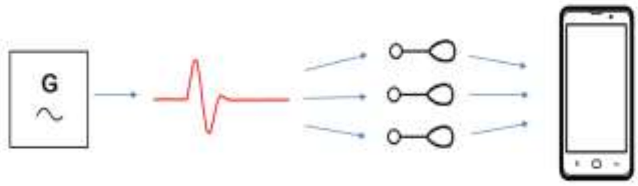
$$t_{new}(n) = \frac{cnt\,(n) - cnt_0}{f(t)},$$

kjer je *cnt(n)* vrednost števca za ta paket, medtem ko sta cnt_0 in *f(t)* začetna vrednost in nagib (smerni koeficient) paketnega bloka.

3. VREDNOTENJE ALGORITMA

Algoritem smo ovrednotili v laboratorijskem okolju z umetnim signalom EKG, generiranim z napravo, izvedeno na razvojnem modulu Arduino. Simulirani signal (stilizirani QRS kompleks iz realnega EKGja) ima obliko, podobno eni periodi sinusnega vala, ki ji sledi enosmerni signal. Opisani vzorec se ponavlja periodično enkrat na sekundo. V eksperimentu uporabljeni senzorji EKG so merili signal s približno frekvenco vzorčenja 125 Hz. Vsi senzorji so povezani z enim samim vozliščem (Android-napravo) prek radijskega protokola Bluetooth LE. Konfiguracija je prikazana na sliki 1.

Vsak od signalov, prejetih na pametnem telefonu, je podvržen procesu sinhronizacije. Rezultat sinhronizacije nato primerjamo medsebojno, glede na absolutne časovne razlike, izračunane z iskanjem vrhov treh signalov in primerjavo njihovih časov. Vrhove signalov poiščemo z uporabo kvadratne interpolacije, kar zmanjša napako algoritma za iskanje vrhov. Dobljeni rezultat je funkcija časa in služi kot metrika za oceno uspešnosti sinhronizacije.

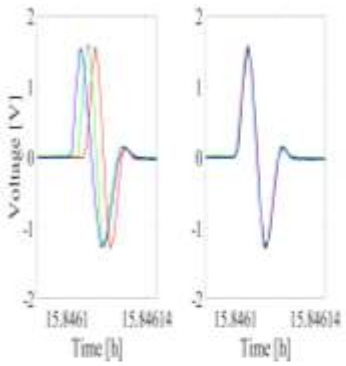


Slika 1. Shema istočasnega merjenja umetnega signala EKG s 3 senzorji.

3.1 Rezultati

Rezultati analize kažejo, da v primeru, ko meritve niso sinhronizirane, povprečna časovna razlika merjenih vrhov znaša 12,7 ms s standardnim odklonom 10,2 ms. Vrednosti se znatno znižajo, ko se uporabi sinhronizacijski algoritem. Srednja vrednost je v tem primeru le 0,49 ms, standardni odmik pa 0,39 ms.

Za ponazoritev so prikazani povprečni primeri izmerjenih generiranih signalov EKG na sliki 2. Časovne razlike med vrhom v nesinhroniziranem primeru so 12,9 ms in 13,3 ms za zeleno-modri in zeleno-rdeči par, medtem ko je zakasnitev med vrhovi za modro-rdeči par 26,2 ms, kar presega napako treh vzorčnih obdobij. Po drugi strani so pari sinhroniziranih signalov vizualno skoraj popolnoma poravnani, njihova časovna razlika je med 0,2 ms in 0,6 ms.



Slika 2. Del generiranega EKG signala, merjenega s tremi senzorji. Levi graf: nesinhroniziran primer. Desni graf: sinhroniziran primer.

4. ZAKLJUČEK

Postopek sinhronizacije brezžičnih senzorjev mora biti sistematičen in mora ustrezno rešiti dve glavni vprašanji, (i) negotovost in zakasnitve na komunikacijskem kanalu ter (ii) nihanje ure (takta) senzorjev in pametnega telefona.

V članku predlagana metoda problem rešuje učinkovito in natančno. Rezultati kažejo na to, da bi s takšno sinhronizacijo zagotovili vse pogoje za potrebe pravilne sinteze 12-kanalnega EKG iz signalov, merjenih vzporedno z več samostojnimi brezžičnimi senzorji.

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Integration of Oncology Information System with Proton Therapy Software and Think!EHR Platform

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ABSTRACT

Proton therapy uses a beam of high-energy protons accelerated in a particle accelerator to treat cancer. Treatment plans are created for each patient individually and are uploaded to the Oncology Information System (OIS). The OIS forwards this information to the Proton Therapy (PT) software system. When the treatment is complete, a treatment report is generated detailing treatment specific information. The PT system uploads this report to the OIS. To connect the OIS to an external platform such as the Think!EHR [2] it is critical for the PT system to be able to communicate with the external API of the platform. This article describes the design of a Oncology Information System simulator and the integration of the Think!EHR platform, into a PT software system using the EHR service software component.

Keywords

oncology information system, proton therapy, DICOM, OIS simulator, Think!EHR, EHR service

1. INTRODUCTION

Cosylab provides system integration and customer-adapted products and solutions covering the complete area of control systems and instrumentation. We specialize in accelerators both for scientific research and particle therapy, especially in the area of Proton Therapy machines.

A complete Proton Therapy software system is composed of a Motion Control System (MCS), a Treatment Control System (TCS) and a System of Safety (SOS). The MCS controls movements of the patient couch, the gantry (for directing the beam to the patient), the X-ray imaging system (for patient scanning) and the translation slides (for inserting patient specific devices). The TCS controls the accelerator that accelerates protons to a certain energy, it checks the delivered dose and manages the data storage that stores patient and machine related data. The SOS controls a set of PLCs (programmable logic controllers) connected to multiple PT hardware components and room sensors. The SOS regularly checks the status of these components and reports issues to the TCS.

2. ONCOLOGY INFORMATION SYSTEM

Cosylab is a partner in the Ekosmart project in the domain of IoT health platforms. We analysed the architecture, data structure and communication standards of an Oncology Information System (OIS) and its integration with a proton therapy system and the Think!EHR platform. The role of an OIS is to delegate and manage the workflow of a PT system. This is done through task assignments and progress reporting. Within the study of the OIS system architecture we laid out a basic treatment plan with a specified data structure, defined the patient registration procedure and created the final treatment report.

We defined the acquisition, processing and final display of patient data in a graphical interface. The processing and structure of imaging data for medical software is described by the international DICOM standard [1] (Figure 1).

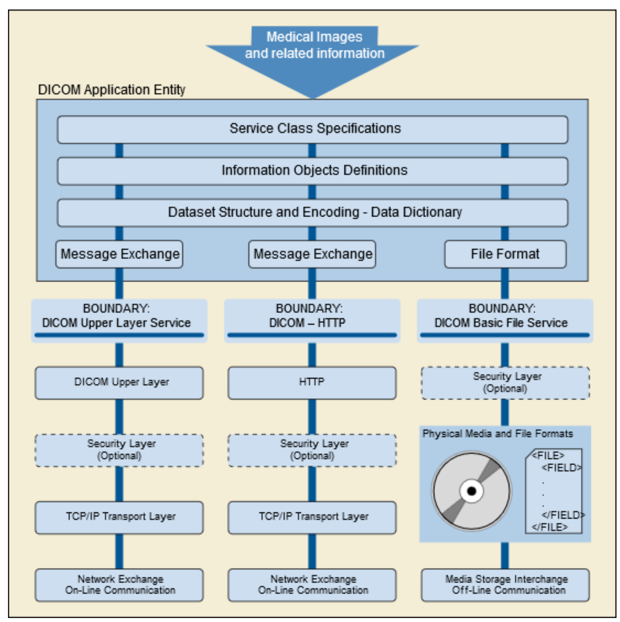

Figure 1: General DICOM communication model [1]

3. OIS SIMULATOR

An important research field in our work is the architectural design of an OIS simulator, which is adaptable and can be used to mimic an OIS system. We laid out the design of OIS simulator (OISSIM) and specified the compliance of the simulator to the DICOM standard. The primary goal of OISSIM is to simulate an OIS that is being used at a hospital and provide a controlled environment where OIS-dependent applications such as the software used in proton treatment can be tested. The client can request a list of tasks, decide to perform one or several of them and report back on the status of the performed tasks (Figure 2). With such a simulator, proton therapy software can already be tested during its development phase.

OISSIM supported functionalities:

- **worklist retrieval**: an AE can retrieve a worklist, i.e. list of UPSs, by sending a C-FIND request to the simulator. The OIS simulator then processes the request and returns the UPSs specified by the query.
- **claim UPS**: before the AE can perform work on behalf of a UPS it has to claim it, i.e. the AE commits to performing the work specified by the UPS. This is done by sending an N-ACTION request to move the UPS state from "SCHEDULED" to "IN PROGRESS".
- **update UPS**: the AE can modify the attributes of the UPS by sending an N-SET request with new values.
- **close UPS**: after work on the UPS is completed, the AE has to close the UPS. This is done by sending an N-ACTION request to move the state of the UPS from "IN PROGRESS" to "COMPLETED" or "CANCELED".

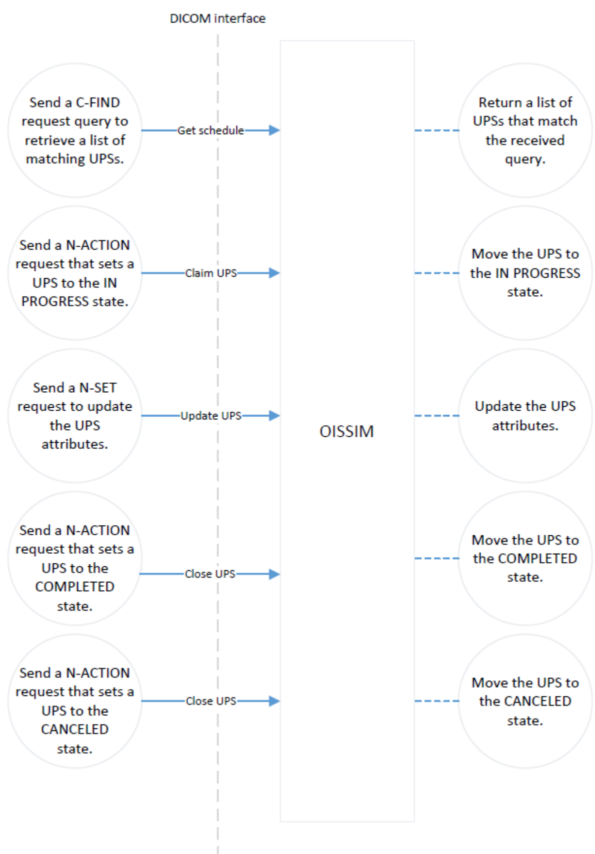

Figure 2: OISSIM application data flow

4. EHR SERVICE

As part of the RRP6 Ekosmart project section (testing and validation of prototypes) we are developing the EHR service component that integrates into a PT software system and is able to pass data from the proton treatment system to the Thin!EHR platform based on the OpenEHR standard. With this component we establish a data flow from the OIS to the Think!EHR platform [2] via a PT software system.

In collaboration with Marand we analysed the data structure and communication protocol of the Think!EHR platform and a specific OpenEHR data model was created to accommodate data generated by the OIS. We analysed the communication standard the platform uses and took this into account in the development of the EHR service. The service reads data from the external control system (ECS), which handles communication between the PT software system and externally connected systems, e.g. the OIS. The Data Distribution Service (DDS) protocol is used in all communication. Once the EHR service connects to the ECS service, algorithms for filtering out patient data are used to retrieve targeted information. We also defined a template data set that should be uploaded to the Think!EHR platform. A basic workflow of the EHR service is shown in Figure 3.

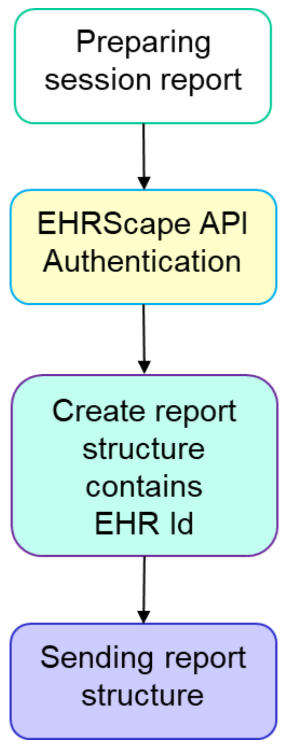

Figure 3: 4-step EHR workflow

5. ACKNOWLEDGMENTS

The work was carried out in the framework of the EkoSmart programme, which is partially financed by the Republic of Slovenia – Ministry of Education, Science and Sport and the European Union – European Regional Development Fund.

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Training of precise movements in 3D or 2D for persons with Parkinson's disease?

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ABSTRACT
The 10Cubes for training and assessment of precise movements with upper extremities has been developed for 3D virtual reality. The system comprises of an infrared stereo camera for hand/finger movements detection and a 3D head mounted device.

In the small scale study 13 persons with Parkinson's disease participated. The participants were randomized into 2 groups; one using a laptop and the other using a 3D head mounted device. The 2-week protocol with 10 sessions, each lasting for 30 min revealed that participants improved some functions by clinical means besides the successful game performance. The kinematics of the hand movements and the outcomes of the clinical test Box & blocks improved for both groups.

1. INTRODUCTION
Parkinson's disease (PD) is a progressive degenerative disease of the extrapyramidal system [1]. The disease often affects people at the age between 35 and 60 years. The following disorders can be observed: rigidity of muscles, slowness of movements (bradykinesia), tremor and various abnormal uncontrolled movements (dyskinesia). Physiotherapy at all stages may help to maintain certain level of quality of life without changing the dosage of medicine. However, only some reports support the statements on successfulness of physiotherapy [2] [3].

In the study we hypothesized that persons with PD can improve their fine motor skills using the 10Cubes3D application regardless of the type of the visual equipment.

2. METHODOLOGY
Virtual environment (VE) for pinch and grip was created in Unity3D (Unity Technologies, CA, USA). The dedicated space with simulated grass floor was limited with hidden walls and a model of a treasure box. In the middle of the dedicated space 10 cubes with the same physical model, size, virtual weight, bounce stiffness, material, etc., were placed. The goal of the task was to grab and put all the cubes into the treasure box, one-by-one with the virtual hand. The virtual hand was a VR avatar presentation of the participant's hand that was tracked in real-time by a mini camera (Leap Motion Controller, Leap Motion Inc., CA, USA). The camera tracked hand and fingers position, both required for construction of the 3D VR hand motion (Fig. 1) and the participant can view his/her hand in the VE. We designed an environment for left and right handed participants; the right handed grabbed the cube with the right hand and put it in the box on the left side of the VE and vice-versa for the left handed participants. The software for the assessment and control was written in C# using Leap Motion libraries. We designed the VE for the use with LCD screen/laptop and with the 3D goggles (Oculus Rift CV1, Oculus VR, LCC, USA).

Figure 1. 10Cubes 3D: What are the advantages of the 3D virtual exergaming for persons with PD at home based physiotherapy or telerehabilitation?

In the study 13 persons with Parkinson's disease were involved (67y, 7y after the first symptoms). The participants were randomized into 2 groups; one using the Oculus Rift 3D (5 males, 2 females) and the other using a laptop (4 males, 2 females). The study was approved by local ethics committee and all participants gave a written consent. We examined the kinematics of the hand movement [4] and the changes in the clinical test Box & blocks.

3. RESULTS
The participants demonstrated higher score at Box & Blocks clinical test in both groups (4/2, 4/3):

BBT	**affected**	**non-affected**
LCD	4/2/0	5/1/0
3D	4/3/0	4/1/2

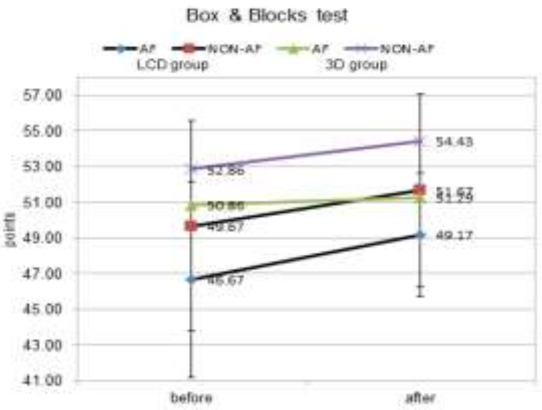

Figure 2. The mean Box & blocks score improved (more boxes collected, more points) for both groups of participants for affected and non-affected hand.

The kinematic analysis demonstrated that the laptop group gradually performed faster, more efficient (inserted more cubes) with less tremor after the training and the 3D group was indeed more successful in speed performance and efficiency, but with significantly more attempts and higher tremor.

4. DISCUSSION

In the preliminary study with only few participants with Parkinson's disease we cannot confirm any major differences between the two applied approaches. Both groups performed well, improved their functional pick and place tasks in the virtual environment and in the real environment as demonstrated by the clinical test. During the task we recorded several unsuccessful trials like misplacement of the cube, cubes falling out of the hand, causing tremendous hand tremor and other measurable components supported by literature [6].

Even if we did not confirm the superiority of the 3D technology over 2D, we would assume that the virtual cube game has enormously increased motivation and thus the participation of the subjects. The motivation of the participant can play an important role [6].

5. ACKNOWLEDGMENTS

The authors would like to acknowledge the financial support to the Republic of Slovenia and the European Union under the European Regional Development Fund (EkoSMART) and Slovenian Research Agency (project MIO-A J2-7357, program P2-0228).

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Forecasting the physical fitness and all-cause mortality based of schoolchildren's fitness measurements

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ABSTRACT

The focus of medicine is steadily shifting from curing the sick to preventive measures. In order to assist the policy makers in making the right decisions that would lead to a healthier population, there is an increasing need to develop models that can forecast the state of the population in the future, check what measures are effective and what policies synchronize. In order to track these changes, predict the state of the population in the future, and thus make informed decisions, the CrowdHEALTH platform is developed. The SLOfit use case takes the information collected from a large population of school children and aggregates this to provide information on the future health of the population that is just now finishing school.

Keywords

obesity, fitness, exercise, machine learning

1. INTRODUCTION

The focus of medicine is steadily shifting from curing the sick to preventive measures[8]. With people's growing desire to increase their lifespan and health, there is an ever greater push for the policy makers to provide ways for people to increase or maintain their fitness. In order to forecast what the population health will be in the years to come, research looks to the machine learning algorithms that can generate models predicting the trends in specific populations. The focus of the CrowdHEALTH (CH) project is to gather this kind of information in a consistent way across multiple data sources and generate models that can be used to predict what the effects of implementing health policies will be on a population.

SLOFit is a large study on physical fitness that includes data collected from Slovenian schoolchildren for over 40 years, and is used to chart global health trends in the population. This data set was used as the basis for our modeling so that we could predict the state of the population in the future (when they are grown) and calculate what the associated risks for mortality will be in the future. In the course of the project we investigated several models that can be used to predict the state of the population and, as expected, the prediction of fitness for children based on previous years is quite hard. Several approaches were evaluated, but at this time linear regression seems to provide the best results, although research on creating better models is still ongoing. Since data on the health risks for the subjects in the SLOFit dataset is not available, we use risk calculation based on the literature to calculate general mortality models based on certain fitness indicators. As the data stored in the system and its applications is complex, the standard used must enable flexible storage of information. The CH infrastructure uses Fast Healthcare Interoperability Resources (FHIR) [3] as the standard for data storage, meaning that all data can be queried in a similar manner, and if the appropriate information is available, compared and forecasts generated.

The rest of the paper is organized as follows. Section 2 provides an overview of the SLOFit data set. Section 3 provides the information on the architecture of the Forecasting Analytical tool and places it in the context of the CH system. Section 4 discusses the forecasting algorithm. Section 5 provides the outline of the Risk assessment and finally Section 6 discusses the results.

2. SLOFIT DATASET

SLOfit is a massive cohort study of physical fitness of Slovenian schoolchildren. Every April, almost all elementary and high school students undergo measurements of 3 anthropometric tests (height, weight, triceps skinfold) and 8 motoric tests, aimed at monitoring different components of physical fitness (such as cardiorespiratory fitness, muscular fitness, explosivity, agility, coordination, etc.) The SLOfit study has been ongoing on the national level since 1987 and serves as the scientific backbone for most of policies related to physical education in schools and enhancing of physical fitness in schoolchildren. To date, the SLOfit database includes over 7 million sets of measurements for over 1 million children, being one of the largest cross-sectional and cohort databases of physical and motor development in the world.

In our study on forecasting of physical fitness, a subset of the SLOfit data was used, encompassing the data from aproximately 2000 children from the age of 6 to 18. In the analysis, the data was anonymized, retaining only the municipality-level data in order to be able to create policies on regional level. When assessing risks, we focus on a subset of SLOfit parameters that are directly connected to the risks we are interested in. Height and weight are used to calculate the body-mass-index (BMI), which is used to determine whether a person is overweight (obesity) or underweight. 30 s sit-up results are used as a proxy for muscular fitness (MF), while the 600 m run results are indicative of cardiorespiratory fitness (CRF). In the risk analysis, we are currently focusing on all-case early mortality risks while risks for developing cardiovascular diseases (CVD) or diabetes are planned to be looked at in future.

3. ARCHITECTURE OVERVIEW

The data in the CH project is stored following an extension of the FHIR standard, where each measurement is stored as an observation that includes all the meta-data of the measurement, such as when it was taken, by whom, what are the units of the measurement, etc. The current architecture of the CH system is demonstrated in Figure 1. This enables the overall system to be extended in the future with custom tools.

The data is stored in LeanXcale (LXC) [1], a flexible, ultra-scalable database with analytical capabilities. In order that the information of different types can be stored, a specialized schema was developed. The part that is pertinent to our work was the addition of a new Person class - Student, to differentiate it from Patient that is the general subject in FHIR. Additionally, the metadata for schools, municipalities and regions were added. The 11 standard anthropometric and motoric tests were also codified in the system so that they can be easily accessed. In order to speed up the queries, the Forecasting module we developed includes a small internal database that caches the data. This is facilitated by SQLite with schema that mimics the data stored in LXC system - i.e., the region, municipality, school, student and observation classes that include most of the data stored in the LXC system. This provides faster look-up times and simplifies some filtering, as SQLite can be tightly coupled with the Django service.

Django is a framework that enables the creation of web APIs in Python. It consists of three main parts. Django Models are mapped directly to supported databases, allowing for fast and efficient filtering and querying of the system. The developer can specify the DB schema and provide rules to check if the values are correct, serialize the data and link the tables in several ways. Djanogo Models are specification that maps directly to the DB schema, that the Framework actually creates for itself, and also handles creation of queries to the system. The Django Views are where the processing of the data happens. Each request can be handled here and responded to accordingly. Django Templates are the presentation layer of the system, but are not used in the current implementation as this is handled by outside systems.

4. FORECASTING

The task of the forecasting algorithm is to predict a particular SLOfit parameter (height, weight, sit-ups, 600 m run) at the age of 18, based on the data from previous years and knowing the general population trends.

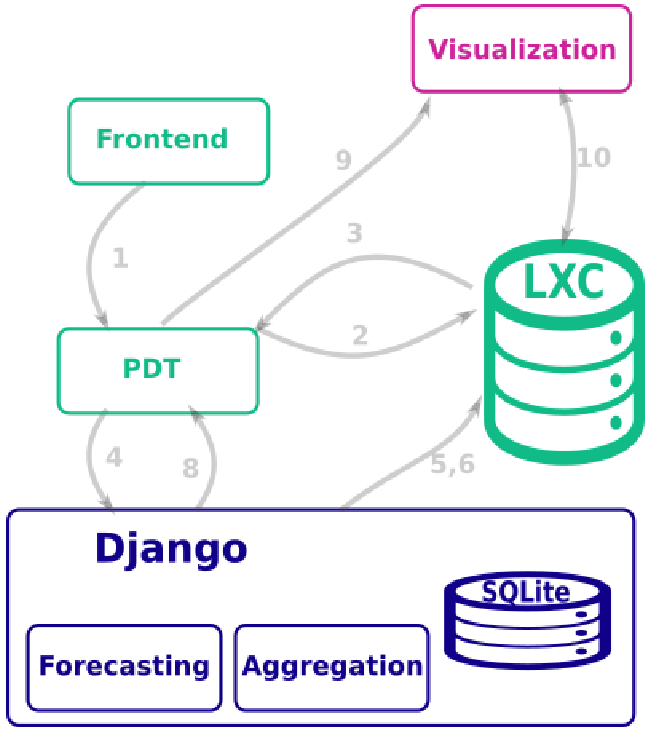

Figure 1: The architecture and flow of the application.

As the starting point, we defined two baseline forecasting approaches. The first one, called baseline percentiles, uses the percentile method: if an individual is in the n-th percentile at the age of 13, we assume he would be in the same percentile at the age of 18. The second baseline model, called baseline average growth, uses the current value and adds the average growth values for each year until the age of 18.

More advanced approaches use machine learning. To improve the prediction accuracy, we generated additional features, such as average, maximum and minimum year growth, standard deviations, data percentiles and peak height velocity - PHV (the year with the maximum growth). Since PHV was not notated in data, we had to estimate it. We manually annotated it for the small amount of children and then trained a prediction model for PHV on this data. We used this model to predict PHV on all other data. These predictions are not 100 % accurate, but this information as an input for predicting e.g. height improves predictions as will be seen in the results.

Next, we built a model for each year up to which we have available data. For example, the model for the age of 13 takes the measurements from ages 6 to 13 and forecasts the value at the age of 18. Since we have data from 6 to 18 years, we build 12 models for each SLOfit parameter.

Additionally, we enriched each SLOfit parameter data with additional data from another parameter. For predicting the height, we also used weight, for predicting weight, we also used height, for predicting sit-ups we also used results from the 600 m run, and when predicting the 600 m run, we also used data from the 60 m run.

Several machine-learning algorithms were tested on the data set of 2000 children introduced in Section 2. To evaluate and compared them, the average absolute error was calculated for each years' predictions and then the average error over all the years. This average error over all the years for predicting the height is presented in Table 1.

Table 1: Comparing algorithms when predicting height.

Method	Average error [mm]
Baseline percentiles	36.0
Baseline average growth	34.3
Linear regression	27.5
Decision tree	38.9
Logistic regression	41.2
SVM	52.3

As we see, the best results were obtained using a linear regression model. Very similar results were obtained also when predicting other SLOfit parameters. The average errors for each year for linear regression and baseline models are shown in Figures 2–5. We see that predicting the values at the age of 18 is a hard problem, so the errors start to decline just a few years before this age.

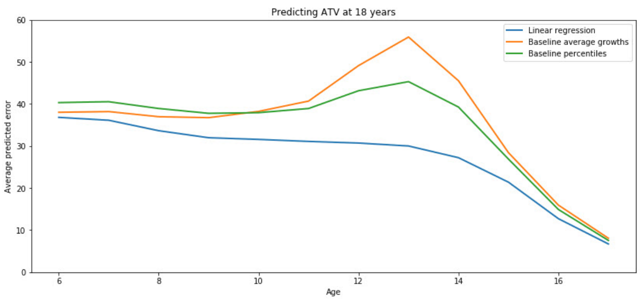

Figure 2: Prediction error for each year when predicting height at the age of 18.

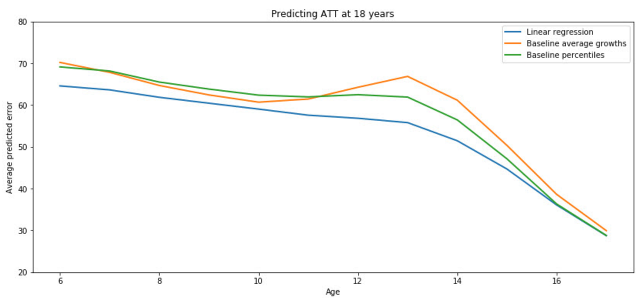

Figure 3: Prediction error for each year when predicting weight at the age of 18.

4.1 Forecasting the population based on collected measurements

Forecasting of SLOfit parameters takes place at the level of an individual. The available measurements of a person are

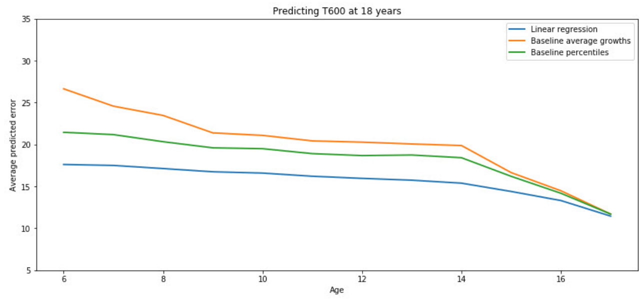

Figure 4: Prediction error for each year when predicting time running 600 meters at the age of 18.

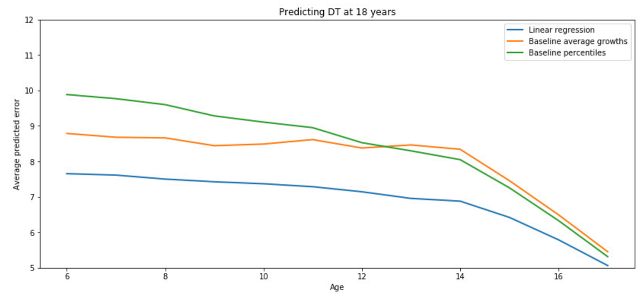

Figure 5: Prediction error for each year when predicting sit-ups at the age of 18.

taken from the database and using an appropriate model, predictions at the age of 18 – we assume the person will be fully developed by this age – are generated. Models are generated for each SLOfit parameter and as such need to be run separately for each prediction we want to generate.

As the overall goal of the system is to generate the predictions for a group of people, not just for an individual, the result should be a cross-section of the population based on a filter that is applied. The filter is usually the mean for the population, but other options are also available, for instance quartiles or median. The system automatically takes the information for the available children based on the region where they are from, and generates forecasts for each child. This can require the system to generate multiple forecasts for each individual, for instance height and weight if the desired outcome of the analysis is the BMI. Due to the nature of the system the result of this operation is stored in the database and must be retrieved from there. The aggregator then takes this information and generates reports that can be visualized by the CH systems.

5. RISK ASSESSMENT

In order to asses the risks for mortality, a stochastic model was generated that describes how BMI, CRF (approximated by 600 m run) and MF (approximated by sit-ups in 30 s) influence mortality. The influence is based on several published studies [2, 4, 5, 7] that relate fitness indicators to all-cause mortality. Table 4 shows how less-than-ideal values of different parameters increase the probability of mortality [6]. In the case of BMI, it is not surprising that this happens if the individual is overweight. But low BMI is also a risk as it signals other difficulties of the person. The risk for obese

Table 2: The risk increases for certain calculated metrics.

BMI (kg/m2)	15-18.5	18.5-20	20-22.5	22.5-25	25-27.5
Risk increase(%)	82	44	2	ref.	7
BMI (kg/m2)	27.5-30	30-35	35-40	40-60	
Risk increase(%)	27	66	166	335	
CRF (600m run)	Q1 (high)	Q2	Q3	Q4	Q5 (low)
Risk increase (%)	ref.	28	59	78	85
MF (30s sit-u ps)	Q1 (high)	Q2	Q3	Q4 (low)	
Risk increase (%)	ref.	61	32	172	

people rises quite drastically, since increased weight prevents a person from exercising, further decreasing fitness and increasing the risk for comorbidities of physical or psychological nature. Low CRF and MF have similar consequences, increasing the risk to one's health. While these factors are certainly correlated there is at this time no quantitative data to what extent the correlation should be taken into account. There is also no concrete information how fitness at the end of schooling predicts the fitness of individuals during the rest of their life, as they can at any time decide to change their lifestyle. However, since the change can be for the better or worse, we assume it stays the same, which is probably not far from the truth for the whole population.

6. CONCLUSIONS AND FURTHER WORK

Predicting the state of the population and the associated risks for them in the future is an important goal if we want to provide good advice to individuals and people that are directly or indirectly given charge over them. While children are the focus of the current work, the implications are broader. The same approaches could be used on the adult population, predicting their physical fitness and assessing their risks during their lifetime.

In the future work of the project we plan to increase the predictive power of the models by using more data and more advanced machine-learning methods. Risk assessment will be augmented by additional studies from the literature. We would also like to base it on our own data, but it is doubtful we will be able to obtain appropriate data, since most schoolchildren in the SLOfit dataset do not yet suffer from many serious health problems, and relating their fitness with medical data is problematic for privacy reasons.

Perhaps the greater advancement will be achieved by modeling the impact of various health policies and interventions – for instance, what happens if an additional hour of physical education is instituted at a school.

7. ACKNOWLEDGMENTS

Funding: This work was supported by the European Union's Horizon 2020 research and innovation program [grant agreement No 727560 (CrowdHEALTH)].

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Zapestnica za pomoč starejšim

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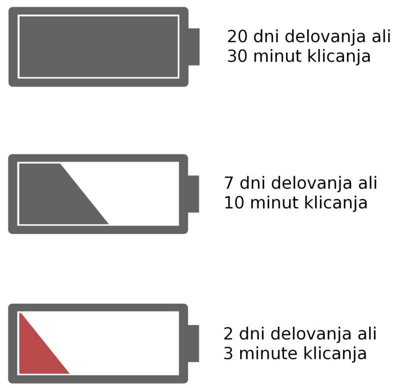
POVZETEK
Da bi starejšim približali sodobno tehnologijo je to potrebno, prilagoditi njihovim potrebam in željam ter jo narediti intuitivno za uporabo. Intuitivnost uporabe lahko dosežemo tako, da uorabnik ne potrebuje nobene dodatne akcije za izvedbo novih funkcionalnosti. Primer takšne funkcionalnosti je detekcija padcev, pri čemer uporabnik ne potrebuje ročno prožiti alarma, ampak se ta samodejno proži ob padcu. Kljub enostavnosti uporabe pa je potrebno zagotoviti, da bo zapestnica vedno na zapestju, s čimer omogočimo večjo varnost uporabnika. V tem delu so predstavljeni rezultati testov in analiz.

Ključne besede
detekcija padcev, zapestnica, starejši

1. UVOD
Da bo razvita zapestnica primerna za končne uporabnike, mora izpolnjevati uporabnikova pričakovanja, saj lahko v nasprotnem primeru določena pomanjkljivost privede do slabe uporabniške izkušnje in posledično do neuporabe zapestnice ter nezadovoljstva uporabnika. Da bi dosegli čim boljšo uporabniško izkušnjo, smo izvedli raziskave na področjih, kot so: avtonomija, polnjenje, ohišje, detekcija padcev in lokalizacija. V nadaljevanju so predstavljene ugotovitve raziskav.

2. ANALIZE
Analize so bile izvedene s pomočjo intervjujev 10 ljudi povprečne starosti 63 let, pri čemer nekateri samostojno prebivajo v lastnih domovih, drugi prebivajo skupaj z družino ali v varovanih domovih. V nadaljevanju so predstavljeni rezultati analiz.

2.1 Avtonomija
Zaradi narave naprave je potrebno v napravi ohraniti dovolj energije, da je ob klicu na pomoč mogoče izvesti klic ter omogočiti vsaj 5-minutni pogovor z klicanim. V nasprotnem primeru se lahko zgodi, da klica ni mogoče izvesti, zaradi česar v času, ko je akumulator skoraj prazen, uporabnik ni varovan, čeprav se tega morda ne zaveda. V analizi smo želeli izvedeti, kolikšna je minimalna oz. željena avtonomnost naprave, v kateri je uporabnik varovan. Mnenja vprašanih so se precej razlikovala, in sicer od enega tedna do enega meseca. Čim daljša avtonomija za uporabnika pomeni manj skrbi in več svobode, medtem ko krajša avtonomija pomeni dodatno nalogo, ki jo lahko pozabijo. Nekateri (40%) so polnjenje povezovali tudi z mobilnim telefonom, za katerega pravijo, da ga velikokrat pozabijo napolniti.



Slika 1: Razpoložjivost baterije.

2.2 Polnjenje
Vprašanim smo predstavili dva načina polnjenja: žično in brezžično. Vsi uporabniki so bili že seznanjeni z žičnim polnjenjem, medtem ko so le nekateri (20%) poznali brezžično polnjenje. Vsi vprašani so bili mnenja, da je brezžično polnjenje enostavnejše in uporabniku bolj prijazno, medtem ko je žično polnjenje lahko zelo zahtevno za starejše. Težave, ki so jih navedli pri žičnem polnjenju je majhnost in krhkost priključkov, ki jih je težko videti, kaj šele pravilno priključiti. Pri brezžičnem polnjenju uporabniki niso imeli težav, čeprav jo je večina vprašanih prvič videla. Nekateri (20%) bi bili pripravljeni tudi pogosteje polniti zapestnico, ki bi omogočala brezžično polnjenje.

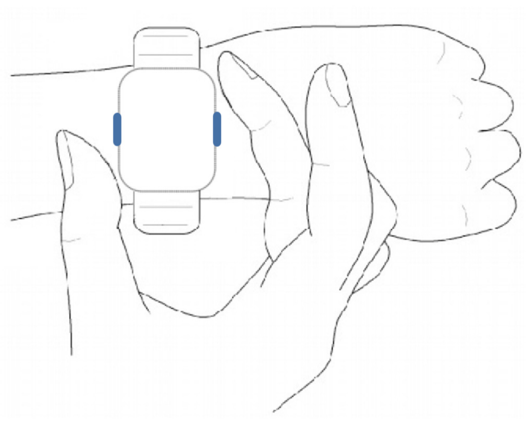
Slika 2: Primeri brezžičnega polnjenja.

2.3 Ohišje

Ohišje naprave je lahko velikokrat ključni faktor nakupa posamezne naprave, pri čemer ni pomembna le oblika, temveč tudi funkcionalnost ohišja [1]. Po vprašanju kakšno ohišje bi si želeli, so nekateri odgovorili, da bi bilo enako uri, ki jo nosijo, drugi so želeli čim manjšo in takšno, ki ne bode preveč v oči. Več kot polovica vprašanih (60%) bi imela rajši zapestnico, ki ima tudi ekran z uro ali celo uro z kazalci. So se pa skoraj vsi vprašani (90%) strinjali s tem, da je zelo dobro, če bi bila zapestnica vodoodporna, s čimer jim ne bi bilo potrebno skrbeti, kdaj jo nosijo ter je poleg tega ne bi mogli pozabiti namestiti na roko.

2.4 Ročno proženje alarma

Razvita zapestnica omogoča klic na pomoč ob kliku na gumb (na trgu obstajajo podobni produkti [2, 3, 4, 5, 6]), kar omogoča uporabniku, da je vedno varovan in lahko pomoč hitro in enostavno pokliče, ne glede na situacijo. Vprašani so se strinjali, da je to uporabna funkcionalnost ter bi jo vsi uporabljali. Udeležene v intervjuju smo povprašali po dogodkih, ob katerih bi to funkcionalnost uporabili in ali se jim je kdaj pripetilo, da pomoči ne bi mogli sami poklicati s pomočjo zapestnice. Navedli so nekaj primerov, v katerih bi bilo klicanje na pomoč oteženo oz. zakasnjeno (npr. ukleščena roka pod telesom, šok zaradi padca, izguba zavesti), v nekaterih okoliščinah mogoče celo nemogoče (npr. možganska kap).



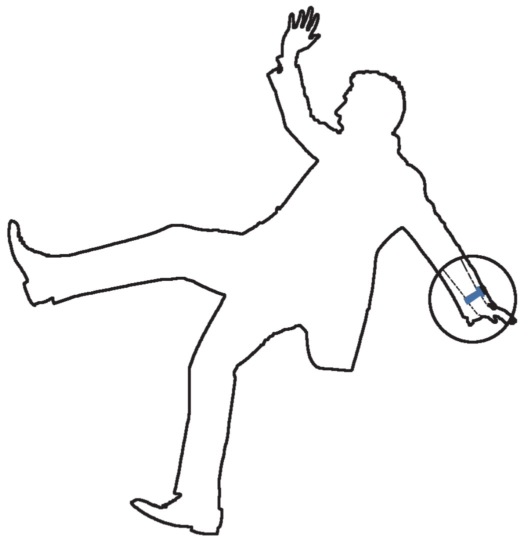
Slika 3: Ročno proženje alarma.

2.5 Detekcija padcev

Pomembna funkcionalnost zapestnice je samodejna detekcija padcev. Želeli smo izvedeti, ali je ta funkcionalnost zanimiva za potencialne uporabnike. Vsi vprašani so bili mnenja, da je to zelo uporabna funkcija. V nadaljevanju smo želeli ugotoviti, koliko udobja so uporabniki pripravljeni žrtvovati za to funkcionalnost. Tukaj so se mnenja uporabnikov zelo razlikovala. Nekaterim (30%) ne bi bilo moteče, če bi detekcija enkrat na dan napačno zaznala padec, v kolikor bi v primeru pravega padca ta bil pravilno zaznan. Drugi vprašani (70%) bi želeli bolj natančen algoritem, drugače te funkcionalnosti najverjetneje ne bi uporabljali.

2.6 Lokalizacija

Potencialne uporabnike smo spraševali, ali so pripravljeni deliti svojo lokacijo za namene hitrejšega posredovanja v primeru klica na pomoč. Vsi vprašani so bili istega mnenja, da



Slika 4: Samodejna detekcija padcev.

je posredovanje lokacije, ki omogoča hitrejše posredovanje koristna in jih ne bi motila.

3. ZAKLJUČEK

Pridobljeni podatki o potencialnih uporabnikovih željah in pričakovanjih ter o njihovih izkušnjah so pomembni vhodni podatki pri načrtovanju zapestnice. Na podlagi pridobljenih podatkov lahko sklenemo, da je zapestnica zelo zaželena ter bo olajšala življenja uporabnikov, kar je glavni cilj ravzoja. Trenutna omejitev je le detekcija padcev, ki še ne ustreza pričakovanjem vprašanih. Drugi izziv, s katerim se v razvoju še nismo soočili je razvoj ohišja, ki bo tako po funkcionalnosti kot tudi po izgledu prilagojen starejšim.

4. ZAHVALE

Raziskava je bila izvedena v okviru projekta "Ekosistem Pametnega mesta (EkoSmart)" in je sofinancirana s strani Republike Slovenije in Ministrstva za izobraževanje, znanost in šport ter Evropske unije iz Evropskega sklada za regionalni razvoj (ESRR).

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A Protocol for Joint Acquisition of Heterogeneous Resources

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ABSTRACT
This article presents a protocol for multiple agents to jointly acquire a number of heterogeneous resources. The protocol allows the agents to negotiate the amount of resources bought based on their individual needs and budget constraints. It also ensures that the price of the purchased resources is fairy distributed among all the buyers, and that risk averse agents will not try to gain an advantage by being untruthful.

Keywords
smart city, protocol, heterogeneous resources, negotiations

1. INTRODUCTION
As buying in bulk is usually more advantageous then buying smaller amounts of resources, it is natural that agents in a smart city would organise together to acquire resources as a group in larger quantities to benefit from that. This however produces a need for an established protocol that is capable of determining the amounts of resources to order, as well as a way to fairly distribute the price tag for the purchase among the buyers. This article presents a protocol that aims at solving both of these issues. Finally, by producing a protocol that is fully automatic and capable of providing real time decisions on the bought resource bundles, this protocol also makes it possible for the agents to strategize when they buy different resources, based on their current prices. While the language of the article will be limited to a setting where smart houses jointly acquire resources, the presented protocol is applicable in other areas within and outside of the smart city setting.

The protocol presented here is applicable in a scenario where each of the agents looking to acquire some amount of resources has different levels of satisfaction, that can be satisfied by different bundles of resources. Each agent needs to have a way to decide how much it is prepared to pay for satisfying each of those levels of satisfaction. A possible setting where the levels of satisfaction correspond to the number and kind of home appliances to be turned on, which in turn corresponds to the agent's electricity consumption is presented in [3]. In fact the protocol presented here builds upon the protocol described in [3] without some of the limitations introduced in that article: the cost function need not be convex, and it does not have to be a weighted sum of the costs of individual resources. This has its drawbacks, as our protocol needs more information from each of the participating smart home agents and also does not have a mechanism for rewarding agents with a smaller consumption.

2. NOTATION CONVENTIONS AND DEFINITIONS
The actors in the protocol are the consumer agents and a coordinator agent whose role is to collect the needs of the consumers and then inform them of the prices associated with their purchases. Let us use n to denote the total number of consumer agents, and N to denote the set of all consumer agents. We will use the letter c to refer to a consumer agent; in particular let $c_i, i = 1, \ldots, n$ denote the i-th consumer agent. We will describe the resources being bought using the notation $r_i, r = 1, \ldots, m$ where m is the total number of available resources, and denote the set of all resources by M. Finally we will also need a way to express the cost of a bundle.

Definition 1. *Let $\mathbb{R}_+$ be the set of all non negative real numbers. A function $C : \mathbb{R}_+^m \to \mathbb{R}_+$ is a cost function when it is continuous, increasing in the sense, that for any two $a, b \in \mathbb{R}_+^m$ such that $a <_m b$, it follows that $C(a) < C(b)$, where we are using $<_m$ to denote the relation of dominance and $C(0) = 0$.*

Definition 2. *We say that a is dominated by b that is, for each $i = 1, \ldots, m$, the i-th component of a is smaller then or equal to the i-th component of b, with at least one component of a being strictly smaller.*

We will be using the letter q when referring to resource bundles and add an index when that resource bundle belongs to a consumer, so q_i is a resource bundle requested by consumer c_i. Resource bundles are equated with points in $\mathbb{R}_+^m$, and

$$E_C(q) = \{s \in \mathbb{R}_+^m; C(s) = C(q)\}$$

will be used to denote the subspace of $\mathbb{R}_+^m$ where the cost function C has value $C(q)$.

Definition 3. *A path p_f is the image of a continuous function $f : [0,1) \to \mathbb{R}_+^m$, such that $f(0) = 0 \in \mathbb{R}_+^m$. We say that the path p_f is increasing, when for each $a, b \in [0,1)$ such that $a < b$ $f(a) <_m f(b)$. A path is unbounded when for every $q \in \mathbb{R}_+^m$ there exists an $x \in [0,1)$, such that $q <_m f(x)$.*

Let p_f be some increasing unbounded path and C a cost function. Then the composition of C and f $h : [0,1) \to \mathbb{R}_+; h = C \circ f$ is a continuous and increasing (let $a, b \in [0,1)$ and $a < b$ then $f(a) <_m f(b)$ because p_f is increasing and thus $h(a) < h(b)$ because C is increasing by definition 1) function. Now, say that there is a $q \in \mathbb{R}_+^m$ such that $C(q)$ is not in the image of h. Because p_f is unbounded there must exist an $x \in [0,1)$ such that $q <_m f(x)$, which means that $C(q) < C(f(x)) = h(x)$. Because h is continuous and 0 is in its image, this means that $C(q)$ is also in the image of h. Thus $C(q)$ is in the image of h of every $q \in \mathbb{R}_+^m$. Because h is increasing it is injective. We have thus proven the following theorem:

Theorem 1. *Let p_f be an increasing unbounded path. Then for any $q \in \mathbb{R}_+^m$, $p(f)$ intersects $E_C(q)$ exactly once.*

We will use the notation $p_i(q)$ to mean the intersection between the unbounded path constructed from the list of bundles corresponding to the levels of satisfaction of user c_i and the set $E_C(q)$. We will use $o : N \to \mathbb{N}$ to denote the ordering of users based on the price of their current consumption, in other words $o(c_i) < o(c_j)$ means that $C(q_i) < C(q_j)$ where we use q_j to denote the bundle requested by consumer c_j

3. PROTOCOL DESCRIPTION

The protocol starts when the coordinator agent sends a request to all of the participating consumer agents. Each of the consumer agents is required to respond with a list of resource bundles corresponding to their satisfaction levels and ordered by their values. From here on, the protocol is a series of rounds where the coordinator agent computes the price to be paid by each of the consumer agents for their most expensive bundle. The consumers then respond with a yes or no, based on whether they find the price acceptable. If the price is not acceptable, the most expensive bundle for the consumer is removed from its list and a new round is started. If a consumer's list is empty, it is understood that the agent is happy with paying 0 for receiving 0 resources. The protocol terminates when all consumer agents agree with the price they are paying (obviously, it does terminate, since for every round in which some agents do not agree to the price, the total length of all the bundle lists is shortened).

A full description of the algorithm is given by:

1. The coordinator requests a list of resource bundles from each consumer.

2. Each consumer responds with a sorted list of vectors

$$V_i = \left(q_i^l\right)_{l=1,\ldots,u_i}$$

such that

$$q_i^{l+1} \leq_m q_i^l$$

for each $l = 1, \ldots, u_i - 1$. Each one of the vectors q_i^l represents the resource consumption of consumer c_i for a different level of satisfaction. No two bundles requested by the same consumer may have the same price. That is $C(q_i^l) \neq C(q_i^k)$ for any k, l in $1, \ldots, u_i$.

3. The coordinator computes a payment proposal for each of the consumers using the following formula:

$$x_{o(i)} = \sum_{k=1}^{o(i)} \frac{C(Q_k) - C(Q_{k-1})}{n+1-k} \tag{1}$$

where

$$Q_k = \sum_{\{c_i \in N | o(i) > o(k)\}} p_i\left(V_k[0]\right)$$

for every $k \in N$ and $Q_0 = 0$ and $V_k[0]$ is the first element of the bundles vector belonging to consumer c_k. When a consumer c_i has no resource bundle in $E_C(V_k[0])$, the value of $p_i(V_k[0])$, is produced by finding the intersection between $E_C(V_k[0])$ and an unbounded increasing path that is initially constructed for each user based on the list of bundles as reported in step 2. The method of its construction is described in subsection 3.1.

4. The coordinator informs each consumer c_i of their price x_i for their current comfort level.

5. Those consumers who find the price acceptable send a confirmation to the coordinator. If that covers all users, the process terminates.

6. For every consumer c_i who did not agree with the price, the coordinator pops the first element from V_i, and the protocol restarts from point 3.

3.1 Constructing Paths

The formula used to compute the individual payments for the consumer agents is the path serial rule as described in [2]. As its name suggests, it uses the serial cost sharing rule from [1] to produce a fair cost allocation between the consumer agents. The serial cost sharing rule works by saying that the consumer agent with the smallest demand should pay a proportion of the cost incurred by his demand. That is

$$\frac{C(nq_1)}{n},$$

where we are using the same conventions as before, except that now q is a number and the users are already sorted. The second user has to pay his proportionate share of the cost incurred by the smallest demand as well as his proportional share of the cost assigned to the difference between his demand and that of the first user. And so on for the rest of them, each covering their proportional share of all the cost differences up to the level of their own demand. The last user covers the remaining difference alone. So each user has to pay

$$x_j = \sum_{k=1}^{j} \frac{C((n-k)q_k) - C((n-k+1)q_{k-1})}{n-k+1}.$$

In order to generalise this to multiple dimensions it is necessary to find a way to represent the amounts requested by other consumers on the same price level as that of the current consumer, so that a fair proportion can be found. It is shown in [2] that in order to achieve that in a manner that preserves the nice properties of the serial rule, it is enough for each consumer to be assigned any increasing path from 0 to their bundle vector and then use the intersection of that path with the price level.

We have decided to use paths that are piecewise linear. They start at 0, and then go in straight lines from one bundle to the next. Since we never need to find an intersection of a consumer's path with a price level above his most pricey bundle, the path from there on does not really matter. In order to make it unbounded in the sense of definition 3 we can set ti to a straight line going in the direction of a vector whose coordinates are all 1. Theorem 1 then guarantees the existence of all the required $p_i(q_k)$ for computing the price allocations for individual consumer agents.

4. PROPERTIES OF THE PROTOCOL

Since the final prices payed by the consumers are computed using the "path serial rule" that is described in [2] they have all of the properties brought by the rule. Those properties are:

1. Equal treatment of equivalent demands (E)
2. The serial principle (S)

The first of these properties means that for any two consumers c_i, c_j whose demands q_i, q_j in the final round of the protocol were equally priced, pay the same amount of money. Property 2 means that the amount payed by consumer c_i is the same no matter how big the demand of any other consumer c_j as long as $C(q_j) > C(q_i)$ and that q_j stays on the same path.

The original path serial rule has a third property called ordinality which states that the payments allotted to the consumer agents do not change under arbitrary change of units for measuring resource quantities, as long as the paths used to compute the payments are transformed along with the rest. This would not do here, because the paths are always piecewise linear functions that go between the points in the consumers' demand lists. However, if we restrict ourselves to linear bijective transformations, that will map line segments to line segments, this property is still true. Since changing measurement units is usually a linear transformation this property that is usually called scale invariance (I) covers most if not all cases where ordinality would be needed in an actual application of the protocol.

4.1 Proofs of the Path Serial Rule Properties

Proving the first two properties, (E) and (S) is as simple as observing that the sum from equation (1) is exactly the same for all users whose demands are equally costly, which proves (E) and that since only intersections of paths with the $E_C(q)$ subspaces are present in the terms of the sum from equation (1), when referring to costlier demands than that of the consumer whose payment we are computing, changing the size of those costlier demands does indeed have no bearing on the price payed by the given user, which proves (S).

In order to show property (I), let us call the linear transformation used to change the scales f. Because it is linear it has an inverse f^{-1}. Let C' be the equivalent cost function of C on the transformed space. The function C' must assign the same value to the same actual amount of resources as C. So we must have that for any q in the original space $C'(f(q)) = C(q)$. If a path intersects $E_C(q)$ in a point s, then $f(s)$ is on the transformed path, but it is also in $E_{C'}(f(q))$, meaning that $f(s)$ is the intersection of the transformed path with $E_{C'}(f(q))$. This means that the terms in the sum of equation (1) all stay exactly the same and (I) holds as well.

5. CONCLUSIONS

We have shown a possible protocol for joint acquisition of heterogeneous resources by any number of consumer agents. It inherits the properties that make it fair from the path serial rule. We believe that it might be an interesting exercise to try finding path constructions, that would add additional properties to the protocol, such as guaranteeing that a price once agreed upon never changes in the future, or that consumers with cheaper demands would enjoy additional benefits. If they exist, that is.

6. ACKNOWLEDGMENTS

The research presented in this article was done as part of the Ekosmart project, which is financed by the Slovenian Ministry of Education, Science and Sport, and the European Regional Development Fund.

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Sistem za podporo odločanju zdravniku

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ABSTRACT
Sistemi za podporo pri odločanju zahtevajo nekoliko specifično arhitekturo, ki vključuje poseben gradnik. Le-ta ima običajno dodatno zalogo podatkov, ki mu omogočajo, da ob upoštevanju ostalih zdravstvenih podatkov pripravi zdravniku ostale podatke kot na primer statistične podatke o stanju pacienta ali o klinični poti zdravljene bolezni.

V prisoevku opisujemo takšno arhitekturo, ki bo črpala podatke iz glavnega medicinskega repozitorija (na primer sistema FHIR ali sistema z opisi kliničnih poti in podobno). Obdelane podatke gradnik lokalno obdela in njihov izvleček hrani ter ga predstavi zdravniku, ko slednji obranava pacienta.

Arhitekturo smo prototipno implementirali v okviru sistema Vitaly.

Categories and Subject Descriptors
C [**e**]: lostna oskrba v bolnišnici

Keywords
pomoč pri odločitvah v zdravstvu, CDS, CDSS, FHIR, Vitaly

1. UVOD
Poslanstvo sistemov, ki jih poznamo pod skupnim imenom e-zdravje, je izboljšati zdravje ljudi z uporabniku prijaznimi programskimi rešitvami, ki močno poenostavljajo sodelovanje na področju zdravstvenih storitev.

Zdravstvo je ena od redkih panog, v kateri tehnološke rešitve še vedno ne prinašajo optimalnih rezultatov. Razlogov je več:

- Podatki v zdravstvenih ustanovah so večinoma otoki informacij brez možnosti izmenjave le-teh z drugimi ustanovami.
- Informacije so še vedno v nestandardni, tiskani in nestrukturirani obliki ter pogosto niso na voljo, ko se jih potrebuje.
- Zdravstveni strokovnjaki z uporabo neoptimalnih in neprijaznih rešitev dragocen čas posvečajo administraciji namesto pacientom.
- Pacient kot subjekt in uporabnik zdravstvenih storitev nima možnosti dostopa do optimalnih zdravstvenih storitev ter prav tako nima možnosti enostavnega in prijaznega dostopa do svojih informacij.

Podjetje Parsek si je zadalo ob tem dva cilja – interoperabilnost ter uporabniku prijazni in smiselni digitalni uporabniški vmesniki z dobro premišljenimi delovnimi postopki (*workflow*). Interoperabilnost dosega z uporabo standardov v zdravstveni informatiki [1]. V njihovem sistemu se podatki izmenjujejo z HL7 sporočili in dokumenti, delovni postopki pa z realizacijo specifikacij profilov IHE. Uporabniški vmesniki so rezultat *Human-centered design* (HCD) procesa načrtovanja in izvedbe, pri kateri so sodelovali zdravstveni strokovnjaki s posameznih področjih. Rešitve so načrtovane za končne uporabnike za njihove potrebe. S tovrstnim načinom razvoja je omogočen velikemu številu ljudi dostop do optimalne zdravstvene storitve. V tem digitalno spremenjenem okolju se informacije zlahka delijo med strokovnjaki in bolniki ter vsakemu posamezniku nudijo najboljšo razpoložljivo zdravstveno storitev.

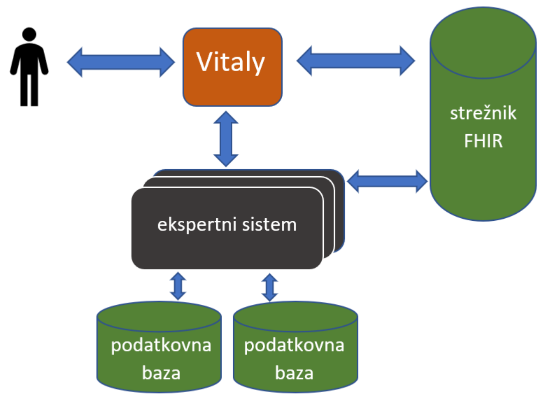
1.1 Sistem Vitaly
Platforma Vitaly in rešitve zgrajene nad njo prinašajo celovit vpogled v zdravstveno stanje pacienta, omogočajo digitalizacijo zdravstvenih storitev ter sodelovanje med zdravstvenimi strokovnjaki in pacienti. Poleg tega prinašajo kontekst, ki je zelo pomemben, in predstavlja dodano vrednost v nasprotju z enostavnim deljenjem in prikazom podatkov.

Vitaly rešitve, povezane na zdravstvene sisteme z uporabo interoperabilnih rešitev, ponujajo zdravstvenim ustanovam možnost, da pacientu omogočijo enostaven dostop do zdravstvenega kartona (*Electronic Health Record*) in zdravstvenih dokumentov ter omogočajo ponujanje zdravstvenih storitev. Po drugi strani lahko pacient upravlja z osebnim zdravstvenim zapisom, ki ga deli z zdravstvenimi strokovnjaki, in dostopa do storitev na enostaven način. Na ta način vsi prispevajo k celovitejši sliki o pacientu, delujejo preventivno in skrajšajo čas, potreben za zdravstveno oskrbo. Podatki so na voljo tudi, ko je pacient na videz zdrav in ne samo, ko potrebuje zdravstveno ukrepanje. Ko imajo deležniki enkrat dostop do zdravstvenih podatkov, digitalizacija procesov v zdravstvu postaja uresničljiva oziroma bolj optimalna. Digitalizacija procesov znotraj zdravstvene ustanove, zdravstvena oskrba na daljavo, sodelovanje oddaljenih zdravstvenih strokovnjakov z uporabo ustreznih tehnologij tako zagotavlja pravočasno, optimalno in najboljšo storitev za pacienta.

V nadaljevanju prispevka najprej opišemo arhitekturo in v njej implementiranih dveh različnih rešitev. Prva je podpora pri predpisovanju zdravil v okviru klinične poti in druga predstavalja podporo pri diagnosticiranju pacienta.

2. ARHITEKTURA

Arhitektura sistema, opisanega v nadaljevanju, je primer razširitve že obstoječega sistema Vitaly. Arhitektura razširitve je sestavljena iz štirih delov, kakor je prikazano na sliki 1. Jedro predstavlja modularni ekspertni sistem, ki vsebuje ra-



Slika 1: Arhitektura razširitev sistema Vitaly.

zlične funkcionalnosti. Tako sistem Vitaly, kot ekspertni sistem črpata podatke s strežnika FHIR [6]. Ta se uporablja za vnašanje in dostopanje do medicinskih podatkov. Tretja komponenta sistema so baze podatkov, ki jih ekspertni sistem potrebuje za svoje delovanje. Zaradi različnih funkcionalnosti sistema, dostopa do različnih podatkovnih baz. Primer take baze je baza opisov kliničnih poti vključno s kontraindikacijami posameznih zdravilnih učinkovin, ali po boleznih razvrščene vrednosti meritev telesnih značilnosti. Zadnji del sistema predstavlja uporabnik, ki do sistema dostopa preko uporabniškega vmesnika, katerega vključuje že obstoječ sistem Vitaly, in skrbi za vnos novih podatkov in uporabo funkcionalnosti sistema.

V obstoječo arhitekturo lahko vključimo različne module ekspertnega sistema. Dva primera takšnih razširitev sta podpora zdravniku pri predpisovanju zdravil na klinični poti in sistem za podporo zdravniku pri diagnosticiranju bolnikov.

2.1 Predpisovanje zdravil na klinični poti

Klinična pot predstavlja natančen, vnaprej zapisan protokol vseh aktivnosti med obravnavo določenega zdravstvenega stanja [5]. Med te aktivnosti spada tudi predpisovanje zdravil. Ko zdravnik ve, katero zdravilo želi predpisati pacientu, mora pri tem preveriti, če morebiti obstajajo kontraindikacije. To so kriteriji za odložitev medicinskih ukrepov (uporabe določenega zdravila, medicinskega pripomočka ali postopka zdravljenja) zaradi stanja bolnika, dejavnikov ali drugih okoliščin. Kontraindikacijo za uporabo določenega medicinskega ukrepa lahko na primer predstavljajo sočasne bolezni, alergije, določen genotip, predhodni neželeni učinki zdravila ali skupine zdravil, starost, spol, predispozicije [8]. Da zmanjšamo število napačno predpisanih zdravil, lahko zdravniku ponudimo pomoč v obliki modula ekspertnega sistema, ki bo skrbel za preverjanje kontraindikacij pri predpisu zdravila pacientu.

Sistem je zgrajen po principu, ki temelji na predhodnem znanju in ne vključuje umetne inteligence, ampak upošteva vnaprej podana pravila za odločanje klinične poti. Bazo znanja predstavlja podatkovna baza, kjer so navedene kontraindikacije posameznih zdravilnih učinkovin.

Ko želi zdravnik pacientu predpisati zdravilo, se v sistem pošljejo podatki o pacientovi identifikacijski številki strežnika *fhir* ter šifra zdravila, ki je bilo predpisano. S pomočjo teh dveh podatkov sistem pridobi vse kontraindikacije zdravilnih učinkovin, ki jih zdravilo vsebuje, iz baze znanja ter pacientove medicinske podatke s strežnika FHIR. Zgodi se primerjava teh dveh skupin podatkov in če so najdene skupne točke, zdravnik dobi obvestilo, da pri predpisu tega zdravila obstaja nevarnost, da pride do zdravstvenih zapletov. Gre torej za funkcionalnost, ki zdravniku ne predlaga določenih rešitev, temveč preprečuje morebitne napake.

Pri implementaciji testnega sistema smo se omejili na eno zdravilno učinkovino, in sicer klozapin, ki se uporablja pri zdravljenju psihoz. Izkazalo se je, da se kontraindikacije med seboj precej razlikujejo in da če primerjamo na primer kontraindikaciji bolezen paralitični ileus in nezmožnost opravljanja rednih preiskav krvi vidimo, da pri prvi lahko pri preverjanju kontraindikacij preprosto iščemo po imenu bolezenskega stanja oziroma še boljše po njegovi šifri, ki ni vezana na jezik, ki ga uporabljamo. V drugem primeru ne gre za bolezensko stanje ali zdravilno učinkovino in je preverjanje po pacientovem zdravstvenem kartonu bolj zapleteno. Testni sistem, ki smo ga postavili, deluje za prvi primer in izkazalo se je, da v primeru najdenih kontraindikacij dobimo ustrezno obvestilo. Če bi želeli sistem nadgraditi ter ga uporabljati v praksi, bi bilo potrebno povezati naš sistem z eno izmed že obstoječih baz kontraindikacij, kjer bi imeli podatke za vse zdravilne učinkovine, obenem pa bi morali imeti za vse tipe kontraindikacij šifre, po katerih bi lahko iskali znotraj elektronskega zdravstvenega kartona.

V Sloveniji za enkrat v državnih bolnicah zdravniki nimajo na voljo tovrstnega sistema, se je pa pojavil korak naprej pri farmacevtih, ki pred izdajanjem zdravila preverijo, če obstajajo kontraindikacije med zdravili, ki so bili pacientu predpisani.

2.2 Diagnosticiranje bolnikov

Drugi primer modularnega ekspertnega sistema temelji na osnovi statistične obdelave medicinskih podatkov, ki s pomočjo znanj iz velike količine podatkov pomaga zdravstvenim uslužbencem pri diagnosticiranju bolnikov in boljšemu razumevanju delovanja bolezni. V medicini obstaja že kar nekaj podjetij, ki se ukvarjajo z razvojem tovrstnih sistemov. Nekatera med njimi so Lumiata [3], Infermedica [9] in Health Catalyst [10]. Vsako podjetje ima svojevrstno arhitekturo sistema in tako svoje prednosti. Mi smo se po drugi strani osredotočili na preprostost uporabe, preglednost, povečljivost in odzivnost.

Modul ekspertnega sistema je sestavljen iz dveh glavnih delov, in sicer strukturiranja medicinskih podatkov v obliko pripravljeno na hitro obdelavo in statistična analiza. Sistem črpa medicinske podatke o boleznih in bolnikih iz strežnikov FHIR. Strežnike FHIR smo izbrali zato, ker zagotavljajo strukturirano shranjevanje medicinskih podatkov. Po prenosu podatke preoblikujemo, da so pripravljeni za nadaljnjo statistično obdelavo.

Drugi del modula ekspertnega sistema je statistična obdelava podatkov. V sistem je mogoče vgraditi različne algoritme statistične obdelave. V našem primeru smo uporabili ROC analizo in analizo iskanja pomembnih telesnih značilnosti pri nastanku bolezni s pomočjo p-vrednosti.

ROC analizo smo uporabili na tipih podatkov, ki imajo neomejeno zalogo vrednosti [4]. Z njegovo pomočjo lahko uporabnik najde tiste telesne značilnosti, ki so pri določeni bolezni najbolj izrazite. Rezultati analize so v uporabniškem vmesniku prikazani v pregledni tabeli. Telesne značilnosti na levi so urejene po vrednostih AUC na desni, od največje do najmanjše, kot je prikazano na primeru na sliki 2.

Drugi primer statistične analize je iskanje p-vrednosti [7], do katere smo prišli s pomočjo različnih testov. Podatke o bolezni smo glede na tip telesne značilnosti razvrstili na kategorične in skalarne. Na vrednostih skalarnih telesnih značilnostih, katerih porazdelitev je normalna smo izvedli T-test, sicer pa Mann Whitneyev U test. Na kategoričnih spremenljivkah smo izvedli Chi kvadrat test, razen v primeru, ko je imela telesna značilnost le 2 različne možni vrednosti smo uporabili Fisherjev natančni test. Primer takšne značilnosti bi bil spol, katerega vrednost sta lahko moški ali ženska. Vsi štirje testi se uporabljajo za računanje p-vrednosti, ki nam pove pomembnost telesne značilnosti pri diagnosticiranju bolezni. Telesne značilnosti, katerih p-vrednost je manjša, so pri diagnosticiranju bolezni bolj pomembni. Rezultati analize so v uporabniškem vmesniku razvrščeni naraščajoče po p-vrednostih na desni, kot je razvidno iz primera na sliki 3. Opisana primera statistične obdelave podatkov sta prikaz zmožnosti delovanja arhitekture. Tovrstni ekspertni sistem lahko uporabniku omogoči lažje razumevanje bolezni in posledično diagnosticiranje pacienta, s pomočjo že obstoječih medicinskih podatkov. Njegov cilj je uporaba v zdravstvenih institucijah, kot pomočnik zdravniku pri diagnosticiranju bolnika. Zdravnik lahko za bolezen, katero sumi da jo bolnik ima, vnese v sistem. Ta mu prikaže telesne značilnosti, ki so bile pri bolnikih z enako boleznijo izrazite. S pomočjo sistema torej lahko zdravnik preveri, če je bila njegova diagnoza pravilna.

3. ZAKLJUčEK

V prispevku smo predstavili prototip arhitekture, ki omogoča nadgradnjo zdravstvenega sistema z dodatnimi moduli za pomoč pri odločanju zdravniku. Namen implementirane izvedbe je zgolj prikaz prototipnega delovanja. V naslednjem koraku je potrebno uporabiti višjo stopnjio abstrakcije arhitekture, ki bo omogočala po eni strani preprostejšo razširitev na različne kliničnih poti, oziroma na upiorabo različnih podatkov pri diagnosticiranju pacientov. Po drugi strani pa je potrebno samo arhitekturo abstrahirati tako, da se za modeliranje uporabi jezik BPML, kot je opisano v [2]. S pomočjo takšne abstrakcije bo sistem preprosteje razširljiv in nadgradljiv.

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Atribut	Youdenov rez	Specifičnost	Senzitivnost	AUC
Ocenjena hitrost glomerularne filtracije	57.380	0.409	1.000	0.749
Hemoglobin A1c	6.600	0.930	0.463	0.657
Višina	169.963	0.646	0.756	0.638
Holesterol	238.912	0.959	0.293	0.612
Liposukcijski holesterol z nizko gostoto	101.274	0.569	0.634	0.607
Glukoza	113.617	0.832	0.439	0.606
Teža	60.964	0.393	1.000	0.602

Slika 2: Tabela z rezultati ROC analize.

Atribut	Tip	Zdravi	Št. zdravih	Bolanih	Št. bolanih	P vrednost
Kreatin	skalar	1.63±1.08	684	1.04±0.38	41	0.000b
Razmerje mikroalbumina kreatinina	skalar	118.94±97.40	304	7.68±5.33	41	0.000b
Ocenjena hitrost glomerularne filtracije	skalar	74.83±47.95	535	117.13±29.92	41	0.000b
Hemoglobin A1c	skalar	4.92±2.03	697	6.62±1.39	41	0.000b
Višina	skalar	148.40±38.99	1862	170.53±5.75	41	0.001b

Slika 3: Tabela analize p-vrednosti.

Razvoj intervencij za srčne bolnike in bolnike z motnjami gibanja

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POVZETEK

Države razvitega sveta se soočajo s spremembami v demografski sliki z izrazitim staranjem prebivalcev ob hkratni nizki rodnosti. Tako se povečuje število starejših prebivalcev, sočasno pa se zmanjšuje število delovno aktivnega prebivalstva. S staranjem se povečuje delež ljudi z nenalezljivi kroničnimi boleznimi (NKB), ki so razlog za 71% vseh smrti [1]. Prav dolgotrajno zdravljenje bolnikov z NKB predstavlja največji delež sredstev zdravstvenega sistema in se zaradi omenjenih razlogov izrazito povečuje. Preventivno delovanje, zgodnje odkrivanje in cenovno učinkovito zdravljenje pacientov z NKB bo ključno za obvladovanje stroškov pri tem pa so lahko IKT v veliko pomoč. Aktivno vključevanje pacientov v proces zdravstvene oskrbe skupaj z uporabo sodobnih tehnologij omogoča učinkovitejše modele zdravstvene oskrbe.

V projektu EkoSmart se bo v kliničnem okolju testiralo spletno-mobilne rešitve za vnos in spremljanje podatkov bolnikov za potrebe znanstveno-raziskovalnega dela. Tako bomo v sodelovanju Univerzitetnega kliničnega centra Ljubljana (UKCL), Medicinske fakultete (MF) in Fakultete za računalništvo in informatiko (FRI) Univerze v Ljubljani (UL) razvili pilotni sistem za spremljanje kliničnih parametrov pri srčnih bolnikih v postoperativni fazi. Sisem bo predvidoma omogočal medsebojno primerjavo različnih senzorjev in s tem njihovo klinično validacijo.

Ključne besede

EkoSmart, e-zdravje, Parkinsonova bolezen, srčno-žilne bolezni, nenalezljive kronične bolezni, interoperabilnost

1. IZHODIŠČA

Staranje prebivalstva je v t.i. zahodnem svetu izrazito prisotno v zadnjem desetletju in je posledica nizke rodnost in daljše življenjske dobe. Delež starejših od 65 let naj bi se do leta 2040 povečal sedanjih 19% na 27% celotnega prebivalstva [1]. Ob povečevanju števila starejših prebivalcev se sočasno povečuje tudi število bolnikov z NKB, ki že danes predstavljajo kar 71% vseh smrti [2]. Pri tem je pomembno dejstvo, da so srčno-žilne bolezni (srčni infarkt, možganska kap), rakava obolenja, diabetes in respiratorne bolezni (KOPB, astma) povzročitelj več kot 80% t.i. prezgodnjih smrti v starosti od 30 do 69 let [3].

Dolgotrajna finančna vzdržnost zdravstvenega sistema z obvladovanjem stroškov NKB bo v prihodnje ključna za učinkovito zdravljenje. K temu lahko ključno pripomore vpeljava IKT v procese zdravstvene oskrbe.

V okviru projekta EkoSmart se razvijajo nove intervencijena področjih postoperativnega spremljanja srčnih bolnikov in oseb z motnjami gibanja. Del sistemov bo tudi avtomatizirano pošiljanje podatkov v nacionalno informacijsko hrbtenico in posledično dostopnost avtoriziranim uporabnikom.

1.1 Tehnologija

V slovenskem zdravstvenem sistemu se še vedno večinoma uporablja ročno opravljanje diagnostičnih meritev z vpisovanjem podatkov v fizične zdravstvene kartone v posameznih zdravstvenih ustanovah. Tako ni (avtomatiziranega) prenosa administrativnih in kliničnih podatkov o posameznem pacientu med različnimi zdravstvenimi ustanovami oz. delavci.

Tehnologija že dlje časa omogoča (avtomatizirano) elektronsko beleženje podatkov, kar je časovno bistveno hitrejše in cenovno učinkovito, podatki pa so na zahtevo avtorizirane osebe dostopni praktično kjerkoli in kadarkoli. Smiselna uporaba obstoječe tehnologije v (prilagojenih) kliničih poteh bi lahko pomembno vplivala na boljšo učinkovitost zdravstvene oskrbe.

1.2 Izmenljivost informacij

Uporaba IKT orodij omogoča hitro in zanesljivo (avtomatizirano) pridobivanje kliničnih in ostalih podatkov oz. informacij ključnih za boljšo (indiviualizirano) zdravstveno obravnavo pacientov. Čeprav so posamezne informacije o pacientu s pomočjo omenjene tehnologije za diagnostiko (in spremljanje terapije) uporabne obstaja t.i. »ozko grlo« zaradi lokalne hrambe podatkov, ki niso na voljo ostalim deležnikom; pri tem pa je prav interoperabilnost ključna za učinkovitost IKT podprtih intervencij [4].

V projektu EkoSmart bomo posamezne podatke pridobljene v procesu zdravstvene oskrbe pošiljali v nacionalno bazo pri NIJZ; s čimer bodo podatki na voljo pacientom in ostalim zaintereiranim/avtoriziranim uporabnikom.

1.3 Boljša zdravstvena oskrba

Osnovni namen novih IKT storitev je v boljši zdravstveni oskrbi pacientov. Njihova uporaba naj zdravstvenim delavcem omogoča natančnejši in hitrejši vpogled v zdravstveno stanje posameznih pacientov in uspešnost posameznih metod zdravljenja.

Pri tem je ključno zadovoljevanje pričakovanj in potreb zdravnikov, medicinskih sester, bolnikov in njihovih svojce, kar bi moralo biti vodilo pri izdelavi tovrstnih sistemov.

1.4 Finančna učinkovitost

Cilj, ki ga zasleduje IKT podprta zdravstvena oskrba je učinkovitejše in cenejše zdravljenje bolnikov. Hitro naraščujoči stroški zdravljenja bolnikov z NKB tako predstavljajo poglavitni razlog za pravilno in finančno učinkovito načrtovanje razvoja in vpeljave spremenjenih (IKT podprtih) zdravstvenih intervencij.

1.5 Izkušnje iz slovenskega prostora

V Sloveniji se je v preteklih letih že testno izvajala vpeljava novih intervencij z uporabo IKT storitev na področju oskrbe bolnikov z NKB. Tako je bila npr. razvita in klinično validirana IKT podprta oskrba za paciente z depresijo [5], kasneje pa na enotni informacijski platformi za diabetike [6], astmatike [7] in osebe s prekomerno telesno težo. Ob tem je bila predstavljena/dokazana tudi finančna učinkovitost tovrstnih intervencij na primeru depresije [8].

2. RAZVOJ IN VALIDACIJA NOVIH INTERVENCIJ

2.1 Orodje za zdravnike-raziskovalce

Spletno-mobilni aplikaciji sta v fazi razvoja oz. beta testiranja.

in izvedbi kliničnih študij na področjih obravnave novonastale atrijske fibrilacije po operacijah na srcu, izdelave aktivnih registrov za zdravljenje atrijskih fibrilacij in za obravnavo bolnikov z motnjami gibanja, ki so vključeni v kontinuirane oblike zdravljenja. Delo je razdeljeno v dva sklopa, obravnava atrijske fibrilacije (AF) in motenj gibanja (PAR). Oba projekta sta primera izvedbe aktivnega registra s pripadajočo klinično študijo.

2.2 Postoperativno spremljanje srčnih bolnikov (AF)

Spremljanje srčnih bolnikov v postoperativni fazi je izrazito pomembno zaradi pojava morebitnih zapletov, med drugim tudi atrijske fibrilacije. Z uporabo prenosne EKG naprav, ki je cenovno relativno ugodna, se lahko doseže učinkovitejši nadzor nad zdravstvenim stanjem bolniki in pravočasno prepreči postoperativne, pogostno smrtno nevarne, zaplete.

Pri projektu AF skupina zdravnikov v sodelovanju z razvojno ekipo na Fakulteti za računalništvo in informatiko skrbi za tehnične vidike razvoja spletno mobilnega okolja (web aplikacija). Sočasno je v procesu izdelave tudi nabor potrebnih arhetipov v formatu OpenEHR za potrebna področja. Pripravila se je klinična intervencija za (post)operativno spremljanje bolnikov z atrijsko fibrilacijo, že izvedla pa se je pilotna klinična študija glede uporabnosti vključitve senzorja Savvy EKG kot telemonitoringa v okviru klinične intervencije. V študijo je bilo v pilotnem delu vključenih okoli 40 bolnikov z Kliničnega oddelka za kardiovaskularno kirurgijo UKCL.

2.3 Vodenje bolnikov z motnjami gibanja (PAR)

Število bolnikov z nevrodegenerativnimi boleznimi je v izrazitem porastu, tako naj bi se število bolnikov s Parkinsonovo bolezenijo od 2010 do leta 2040 podvojilo, pri tem pa so ocenjeni letni stroški pacienta približno 20.000 Eur [9].

Pri projektu PAR se izdeluje tako nove, kot tudi dopoljuje že obstoječe gradnike OpenEHR. Za izvedbo projekta se bo uporabilo periferni senzor motoričnih simptomov parkinsonove bolezni, ki bo vključen v klinično intervenco (sensor gibanja proizvajalca PKG). V okviru projekta se opravlja tudi raziskovalno delo na implementaciji principov zaprte terapevtske zanke, pri kateri meritve trenutnega stanja centralnega ali perifernega živčevja v realnem času vplivajo na modulacijo terapije. Med rezultati omenjenega raziskovalnega dela so deloma že razvite naslednje programske aplikacije:

- palMEP, C++ knjižnica in GUI za avtomatsko in ročno preprocesiranje in analizo TMS-EMG podatkov;

- palEEG, optimizirana C++/Matlab knjižnica in GUI za časovno-frekvenčno dekompozicijo, analizo in vizualno reprezentacijo EEG podatkov, z delno implementacijo računsko zahtevnih algoritmov v NVIDIA CUDA arhitekturi za časovno občutljive analize v realnem času pri eksperimentih z uporabo zaprtih zank;

- palPULSER, C++ knjižnica in GUI za mikrosekundno natančnost kontrole trigerjev pri CED 1401 družini AD pretvornikov v TMS-EEG okolju; 4) palNAV, aplikacija za MRI vodeno nevronavigacijo v realnem času v TMS okolju, z delno C++ implementacijo

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