Zbornik 17. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2014

Zvezek H

Proceedings of the 17th International Multiconference

INFORMATION SOCIETY – IS 2014

Volume H

Interakcija človek-računalnik v informacijski družbi
Human-Computer Interaction in Information Society

Uredili / Edited by
Franc Novak, Bojan Blažica, Ciril Bohak, Luka Čehovin

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8. oktober 2014 / October 8th, 2014
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Oblikovanje naslovnice: Vesna Lasič, Mitja Lasič

Ljubljana, oktober 2014

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

004.5(082)(0.034.2)

MEDNARODNA multikonferenca Informacijska družba (17 ; 2014 ; Ljubljana)
Interakcija človek-računalnik v informacijski družbi [Elektronski vir] : zbornik 17. mednarodne multikonference Informacijska družba - IS 2014, 8. oktober 2014, [Ljubljana, Slovenia] : zvezek H = Human-computer interaction in information society : proceedings of the 17th International Multiconference Information Society - IS 2014, October 8th, 2014, Ljubljana, Slovenia : volume H / uredili, edited by Franc Novak ... [et al.]. - El. knjiga. - Ljubljana : Institut Jožef Stefan, 2014

Način dostopa (URL): http://library.ijs.si/Stacks/Proceedings/InformationSociety

ISBN 978-961-264-078-1 (pdf)
1. Gl. stv. nasl. 2. Vzp. stv. nasl. 3. Dodat. nasl. 4. Novak, Franc, 1950-
275928320

PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2014

Multikonferenca Informacijska družba (http://is.ijs.si) s sedemnajsto zaporedno prireditvijo postaja tradicionalna kvalitetna srednjeevropska konferenca na področju informacijske družbe, računalništva in informatike. Informacijska družba, znanje in umetna inteligenca se razvijajo čedalje hitreje. Čedalje več pokazateljev kaže, da prehajamo v naslednje civilizacijsko obdobje. Npr. v nekaterih državah je dovoljena samostojna vožnja inteligentnih avtomobilov, na trgu pa je moč dobiti kar nekaj pogosto prodajanih tipov avtomobilov z avtonomnimi funkcijami kot »lane assist«. Hkrati pa so konflikti sodobne družbe čedalje bolj nerazumljivi.

Letos smo v multikonferenco povezali dvanajst odličnih neodvisnih konferenc in delavnic. Predstavljenih bo okoli 200 referatov, prireditev bodo spremljale okrogle mize, razprave ter posebni dogodki kot svečana podelitev nagrad. Referati so objavljeni v zbornikih multikonference, izbrani prispevki bodo izšli tudi v posebnih številkah dveh znanstvenih revij, od katerih je ena Informatica, ki se ponaša s 37-letno tradicijo odlične evropske znanstvene revije.

Multikonferenco Informacijska družba 2014 sestavljajo naslednje samostojne konference:

- Inteligentni sistemi
- Izkopavanje znanja in podatkovna skladišča
- Sodelovanje, programska oprema in storitve v informacijski družbi
- Soočanje z demografskimi izzivi
- Vzgoja in izobraževanje v informacijski družbi
- Kognitivna znanost
- Robotika
- Jezikovne tehnologije
- Interakcija človek-računalnik v informacijski družbi
- Prva študentska konferenca s področja računalništva
- Okolijska ergonomija in fiziologija
- Delavnica Chiron.

Soorganizatorji in podporniki konference so različne raziskovalne in pedagoške institucije in združenja, med njimi tudi ACM Slovenija, SLAIS in IAS. V imenu organizatorjev konference se želimo posebej zahvaliti 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 2014 bomo drugič podelili nagrado za življenjske dosežke v čast Donalda Michija in Alana Turinga. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe je prejel prof. dr. Janez Grad. Priznanje za dosežek leta je pripadlo dr. Janezu Demšarju. V letu 2014 četrtič podeljujemo nagrado »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono je dobila nerodna izvedba piškotkov, jagodo pa Google Street view, ker je končno posnel Slovenijo. Čestitke nagrajencem!

Niko Zimic, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2014

The Information Society Multiconference (http://is.ijs.si) has become one of the traditional leading conferences in Central Europe devoted to information society. In its 17th year, we deliver a broad range of topics in the open academic environment fostering new ideas which makes our event unique among similar conferences, promoting key visions in interactive, innovative ways. As knowledge progresses even faster, it seems that we are indeed approaching a new civilization era. For example, several countries allow autonomous card driving, and several car models enable autonomous functions such as "lane assist". At the same time, however, it is hard to understand growing conflicts in the human civilization.

The Multiconference is running in parallel sessions with 200 presentations of scientific papers, presented in twelve independent events. The papers are published in the Web conference proceedings, and a selection of them in special issues of two journals. One of them is Informatica with its 37 years of tradition in excellent research publications.

The Information Society 2014 Multiconference consists of the following conferences and workshops:

- Intelligent Systems
- Cognitive Science
- Data Mining and Data Warehouses
- Collaboration, Software and Services in Information Society
- Demographic Challenges
- Robotics
- Language Technologies
- Human-Computer Interaction in Information Society
- Education in Information Society
- 1st Student Computer Science Research Conference
- Environmental Ergonomics and Psysiology
- Chiron Workshop.

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, SLAIS and IAS.

In 2014, the award for life-long outstanding contributions was delivered in memory of Donald Michie and Alan Turing for a second consecutive year. The Programme and Organizing Committees decided to award the Prof. Dr. Janez Grad with the Michie-Turing Award. In addition, a reward for current achievements was pronounced to Prof. Dr. Janez Demšar. The information strawberry is pronounced to Google street view for incorporating Slovenia, while the information lemon goes to cookies for awkward introduction. Congratulations!

On behalf of the conference organizers we would like to thank all participants for their valuable contribution and their interest in this event, and particularly the reviewers for their thorough reviews.

Niko Zimic, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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PREFACE

HUMAN-COMPUTER INTERACTION IN INFORMATION SOCIETY

Human-Computer Interaction in Information Society is a conference organized by the Slovenian HCI community. The Slovenian HCI community is an informal community of Slovenian human-computer interaction researchers that started in 2008 by a group of HCI researchers and enthusiasts from the Faculty of Computer and Information Science, University of Ljubljana, XLAB and the Jožef Stefan Institute. The main idea behind the community is to connect Slovenian researchers interested in HCI in order to exchange ideas, collaborate and accelerate the development of this exciting interdisciplinary field in Slovenia and its surrounding countries.

This is the second event organized by our community. The target audience of the conference are HCI researchers and developers from academia and industry as well as other HCI enthusiasts. The conference will provide the opportunity to share research experience and establish fruitful relationships for future collaboration.

Franc Novak, Bojan Blažica, Ciril Bohak in Luka Čehovin

PREDGOVOR

INTERAKCIJA ČLOVEK-RAČUNALNIK V INFORMACIJSKI DRUŽBI

Interakcija človek–računalnik v informacijski družbi je konferenca, ki jo organizira Slovenska skupnost za proučevanje interakcije človek–računalnik. Omenjena skupnost je nastala v letu 2008 v okviru neformalne povezave raziskovalcev s področja interakcij človek–računalnik na Fakulteti za računalništvo in informatiko Univerze v Ljubljani, XLAB-u in Institutu "Jožef Stefan". Osnovno vodilo je povezati slovenske raziskovalce in razvijalce s tega področja, spodbuditi izmenjavo idej in pospešiti razvoj tega zanimivega interdisciplinarnega področja v Sloveniji in sosednjih državah.

Ta konferenca je že drugo srečanje, ki ga organizira naša skupnost. Ciljni udeleženci konference so raziskovalci s področja interakcij človek-računalnik iz akademskih krogov, industrije ter tudi ostali, ki jih navedena problematika zanima. Konferenca je priložnost za izmenjavo izkušenj in navezavo osebnih stikov za bodoče plodno sodelovanje.

Franc Novak, Bojan Blažica, Ciril Bohak in Luka Čehovin

UX – FROM THEORY TO PRACTICAL APPLICATION

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ABSTRACT

We present the importance and key aspects of the User Experience, Usability and User/Human Centered Design paradigms and approaches. Furthermore, real-life examples are given to illustrate the practical use of these approaches.

There are many definitions of the "user experience", however the common ground to all is the idea, that the focus should be on the user and his/her needs, wishes and expectations, rather than exclusively on the product or service itself. The main goal is that the product or service in question should not only be functional or usable but also easy, intuitive and fun to use and explore. This is closely connected with the term of "cognitive flow".

The definition from The User Experience Professionals Association states the user experience as follows: "User experience (UX) is an approach to product development that incorporates direct user feedback throughout the development cycle (human-centered design) in order to reduce costs and create products and tools that meet user needs and have a high level of usability (are easy to use)." This definition emphasizes the users' role in the process through the User/Human Centered design philosophy. It defines the whole product or service design and development process as a continuous circular process, where user product testing at each phase is very important. In this way problems can be found early on and solved, which allows for a more cost effective approach with a better final product.

Of course, to design something for the "user" one has to know who your users are. To achieve this goal first end target user groups should be defined, and then specific, but single virtual users in a form of personas should be created. Not all users have the same abilities; therefore a special attention should be given to the accessibility issues.

Finally, some general, but golden rules of good design approach exist: the user should always be in control as much as possible, the interface should adapt to the user and reduce the cognitive load as much as possible, the interface should be consistent, and finally, the product or service should be personal and adapt to the users' needs, and be not only functional, but also easy and intuitive to use.

To illustrate these paradigms, five distinct real-life examples are given, how the UX design approach was used to create a more "human" product, service or content. These examples include lessons learnt from a TVWEB project; a national RTV mobile multimedia application; a project for the national Telecom operator with a goal of designing an interface for the e-health portal; UCD approach used for designing the new university multimedia programme; and finally, the World Usability Day conference event in Slovenia.

MULTI-TOUCH SURFACE BASED ON RGBD CAMERA

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ABSTRACT

The popularity of interactive surfaces is increasing because of their natural and intuitive usage. Adding 3D multi-point interaction capabilities to an arbitrary surface creates numerous additional possibilities in fields ranging from marketing to medicine. Interactive tables are nowadays present in numerous museums, schools and companies. With the advent of low-cost RGBD cameras, thee-dimensional surfaces are slowly emerging as well, attracting even more attention. This paper presents an affordable system for 3D human-computer interaction using a RGBD camera that is capable of detecting and tracking user's fingertips in 3D space. The system is evaluated in terms of accuracy, response time, CPU usage, and user experience. The results of the evaluation show that such low-cost systems are already a viable alternative to other multi-touch technologies and also present interesting new ways of interaction with a surface-based interfaces.

1 INTRODUCTION

With the reduction in size and by increasing the computational power that we have witnessed in the past decades, computers have become indispensable and ubiquitous in everyday life. Regardless of all the progress, the methods of human computer interaction most widely used have remained almost unchanged since the 1980s, when a computer mouse became a crucial part of every desktop computer. Despite the technological advancements, the ways of using a computer mouse remained the same, together with all of its shortcomings.

Only in the last decade, new technologies that enable multi-touch interaction and eliminate several limitations of a mouse have become available. Decreasing the production costs of multi-touch screens greatly contributed to their inclusion in practically all new mobile devices and even in the majority of the new laptops. On the other hand, high cost of larger screens limits the technology to smaller portable devices. Bigger multi-touch surfaces have been developed using IR cameras and emitters combined with a projector and utilizing advanced computer vision algorithms. Well known examples are commercial multi-touch table *Samsung SUR40*, with *Microsoft PixelSense* technology [1] and an open-source software package *Community Core Vision (CCV)* [2]. High cost of the

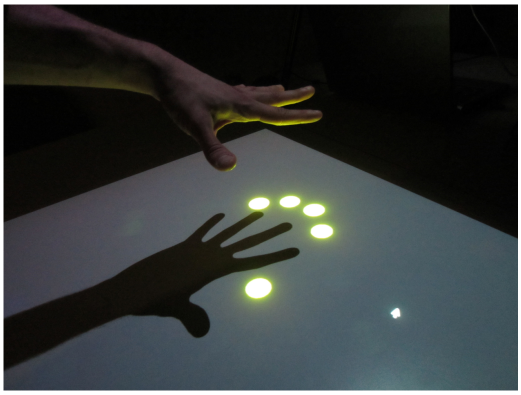

Figure 1: 3D finger interaction

first and a complex construction of the second are the main reasons why they remained limited to large institutions and a handful of HCI enthusiasts. Even though these solutions provide multi-touch interaction, the interaction remains limited to a 2D plane. With the introduction of low-cost depth cameras, such as *Microsoft Kinect* and *Asus Xtion Pro*, HCI researchers have gained a cheap and efficient way of obtaining information that would have otherwise require special controllers or multi-camera systems with complex and extremely sensitive calibration.

The ideas for development of 2D multi-touch surfaces, by observing a small area above the surface were introduced in [14]. Enlarging the observed area above the surface, to enclose the area of the palms enabled [12] to eliminate the majority of false touch detections as well as extract additional information (hand type, finger-hand association, etc.) Portable depth camera and projector were used in [3] to allow the detection on a changing surface in real time. The research has also focused on interaction in 3D space with [5] acquired 3D model of the scene to which touch capabilities were added without restriction of the shape of the scene. [1, 6, 4] went one step forward, providing the user the ability to capture a real object and manipulate with it in virtual world. Latter also studied the 3D interaction by detecting and tracking users fingertips using a specific surface material. Researchers in [9] have developed systems that enable users multi-touch interaction on an arbitrary surface and basic 3D interaction through finger and hand gestures.

The main focus of our work is on increasing robustness and

[1] Microsoft PixelSense: http://www.microsoft.com/en-us/pixelsense/
[2] Community Core Vision: http://ccv.nuigroup.com/

generality of depth-camera based multi-touch systems using systematic evaluation the limits of technology in terms of accuracy, speed, and usability. We present a system that adds full 3D finger interaction capabilities to an arbitrary surface (shown in Figure 1) using depth camera, a projector, and a middle-ware software module that performs finger detection and has been sufficiently optimized that it can be run on a conventional desktop computer (without hardware acceleration). Besides the description of the system and the finger tracking method, a major contribution of this paper is a detailed empirical evaluation in which we highlight the capabilities and limitations of the system. In Section 2 we present the system components. In section 3 we describe the detection and tracking algorithms. In Section 4 we present the evaluation of the system and we conclude the paper with a short summary and ideas for future work in Section 5.

2 SYSTEM OVERVIEW

Our system that is capable of adding 3D multi-touch functionalities to an arbitrary surface using a low-cost depth camera, a projector and an ordinary computer, is shown in Figure 2.

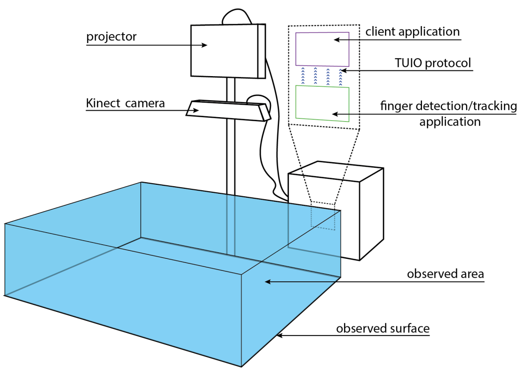

Figure 2: Components of the system

Depth camera acquires 3D information about the scene. In our prototype we use *Microsoft Kinect* camera, due to its low cost and decent support in research community, however, other cameras could be used as well. Microsoft Kinect contains an IR projector and IR camera as well as a RGB camera.

Projector is used to project the target application to the observed surface. In our setup the projector is positioned above the surface and under an oblique angle. We have used a wide lens projector that produces an image of similar size than the area captured by Kinect positioned at a similar distance to the surface.

Surface, to which we intend to add the 3D multi-touch capabilities, can be any planar surface, at any orientation. The only limitation is its material, as Kinect camera does not correctly work with reflective and transparent materials. With additional implementation of an appropriate mapping function, the planar shape limitation could also be waived.

Software of the system can be divided into finger detection and tracking middle-ware that is described in Section 3 and the client target. Fingers detected by the middle-ware are transmitted to the client application using the TUIO protocol [8].

3 FINGER DETECTION AND TRACKING

The process of a precise detection and robust tracking of users fingers is divided into the initialization, that is performed only once, and the detection stage executing constantly.

3.1 Initialization

Initialization of the system consists of building a surface model and calibration of depth camera with the projector. The surface model contains the depth model of the background, a mathematical equation of the observed surface and the information about the borders of the observed area. The depth model is the reference model used to classify pixels as foreground-background in the first step of detection. Each pixel in the depth image is modeled with an independent Gaussian model. By continuously updating the model only with pixel values classified as the background [10], we ensure that the foreground objects (such as users hand) will not be fused with the background, even if they persist at the same location for a longer period of time.

The geometry of the observed planar surface is modeled using mathematical equation of a plane in 3D space robustly estimated using RANSAC [2] method on a point cloud constructed from the depth image. The calibration of the camera and the projector is vital for the correct mapping of any detected finger to the reference frame of the target application. A transformation between both coordinate systems is obtained using barycentric coordinates. To provide the reference points, the observed surface is divided into triangle grid. In the interactive calibration process the user provides the information about the location of reference points in both coordinate systems. After the calibration, every point can be easily transformed to the other coordinate system, by finding the triangle in which it lies and computing the barycentric weights.

3.2 Finger detection and tracking

Every captured depth image is processed with a series of steps to determine the positions of the fingers. First, the background is removed using the background model. Every pixel located below the surface is instantly discarded as are the pixels that fit the depth model of the surface. The remaining regions are split and individually analyzed using the k-curvature algorithm [13] that ensures quick and robust detection of finger candidates. Each point of interaction is computed in 3D space, as the mass center of the elements in an area enclosed by the fingertip contour. Surface touch events are detected by thresholding the distance of the fingers to the surface. These events can then be used to mimic the click action, e.g. simulate a click of a computer mouse. Fingers have to be associated over frames to enable the user interaction using temporal gestures. Tracking of individual fingers is performed using Kalman filter [7] with a nearly-constant-velocity motion model. At every time step the algorithm attempts to associate detected fingertips with the detections from the previous time step. Fingertips which are not associated are considered to be new fingers. The association is done using suboptimal nearest neighbor (SNN) [11] with local optimization of the distances. The locations of the detected fingers are given in the camera coordinate space. They are then transformed to the observed surface space by computing a perpendicular projection to the surface plane. Then the location in the projector space is obtained using the barycentric coordinates provided during the calibration phase.

4 EVALUATION AND DISCUSSION

We evaluated our system in terms of accuracy, response time, and user experience. A desktop computer running Ubuntu 12.04 with Intel Core i5 and 8GB of RAM was used in the evaluation. Kinect and projector were positioned at a height of 0.91 m and 1.23 m and inclination of 15° and 10° respectively. The size of the resulting observed volume was $65 \times 49 \times 31$ cm.

Accuracy: As our main objective is to provide the user with an accurate and responsive system, we can mark a correct detection of a finger only, if the detected point of interest lies on the finger itself. Considering the average width of a finger being between 1.5 and 2 cm, the acceptable detection error is up to 0.5 cm. First we performed a calibration step using 6×5 grid of points. Two evaluation scenarios were then performed. In the first scenario, the error was measured at the center of gravity in each of the triangles, as they represent the average errors. In the second set, the accuracy was measured at 4 randomly selected points in each of the triangles.

Results of the evaluation are summarized in Table 1. Figure 3 shows the location of the evaluated points together with the detected locations in the first as well as the second test set. Dotted lines mark the borders of the calibration triangles, with the calibration points located at their vertices. The distribution of the errors combined for both sets is shown on Figure 4. This experiment shows that the system is sufficiently accurate. The detection error was less than 7 mm in 98% of the points, which still enables a satisfactory interaction with the system.

Responsiveness: The responsiveness of the system is calculated as the elapsed time between the users action and the display of the consequence. The overall delay was estimated empirically, using a camera capable of capturing 60 fps, while the processing time of each frame was computed within the software as the time elapsed between receiving a depth image and sending the positions of fingers to the client application.

The overall response time of the system was on average 120 ms for a single and 125 ms for ten fingers. Processing of a single frame took on average 8 ms, while the displaying time is 1 ms. It is evident that the main source of the delay is the depth image acquisition, which could be shortened by using a faster depth camera. Even though the total response time is relatively big, it was not noticeable in the majority of the applications. The delay only affects the user experience in applications that require quick responses, e.g. real-time games.

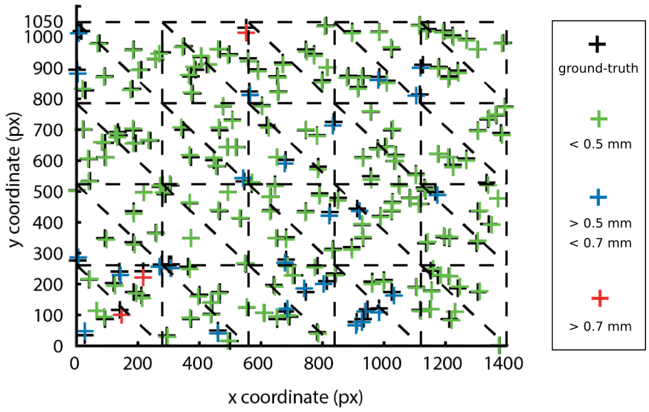

Figure 3: Accuracy evaluation

Number of points	**200**
Points with error $< 5mm$	**169** (**84.5**%)
Points with error $< 7mm$	**196** (**98.0**%)
Avg. error	**3.1mm**
Avg. error on axis x / y	**1.5mm / 2.4mm**
Avg. error in pixels	**6.4px**
Size of pixel	**0.46mm** × **0.49mm**

Table 1: Accuracy evaluation summary

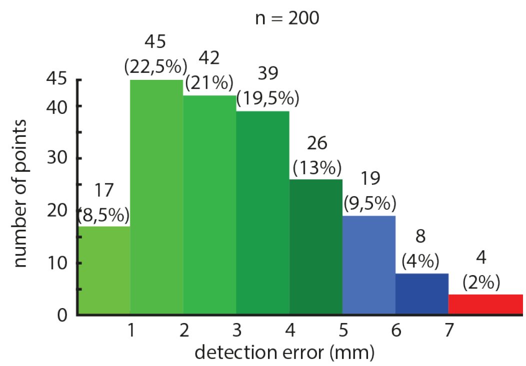

Figure 4: Distribution of errors

Computational performance: To confirm or disprove the hypothesis of an ordinary computer being sufficiently powerful to run our system, we have monitored the CPU usage, while a user was interacting with the system using both hands (10 fingers) for 30 seconds. The average usage of each of the 4 cores was 20%, leaving enough processor power to simultaneously run the client application.

User experience: To the best of our knowledge there does not exist and application that would use 3D information obtained over TUIO protocol, so we have decided to evaluate user experience using applications developed for 2D interactive tables (*Microsoft Touch Pack for Windows 7*) as well as standard TUIO-compatible applications. To observe the interaction in 3D we have designed a simple application that displays circles at the positions of the detected fingers, with the color and size depended on the fingers distance to the observed surface as shown in Figure 1. Although the application is simple it gave us the ability to observe users problems and estimate the robustness of the 3D detection.

Perceived user experience closely resembled the results obtained in the evaluation with accurate detections and barely noticeable delay. Only for applications, where quick responses are necessary (Microsoft Rebound), the delay prevented normal usage. In 3D interaction users faced some problems mainly due to the occlusions occurring among fingers. Occluded fingers, once made visible again, were marked as new fingers instead of being associated with the previous detection a few frames before.

System limitations: Our system can be used under the majority of conditions, with a few exceptions mainly due to the limitations imposed by the hardware components. Near-IR light is used by the Kinect camera, therefore the system is limited to non-reflective and opaque materials and should not be used in the direct sunlight. Maximum dimensions of the observed area are limited to 80×69 cm as the depth sensor is only able to accurately measure distances in the range between 40cm and 90cm. Static placement of the Kinect and projector is also essential for accurate operation of the system.

5 CONCLUSION

We have presented a system for adding 3D multi-touch functionalities to an arbitrary surface using a depth sensing camera using commodity hardware components, such as Kinect camera, a projector, and an ordinary desktop computer. In the presented evaluation we have shown that the system is very accurate. The average measured response time allows normal everyday usage of majority of applications. We have to emphasize that the vast majority of the processing time is the consequence of current hardware limitations.

Our future works includes development of applications exploiting the 3D information. Change of the fingers distance to the surface could be used to manipulate the level of details of information presented, enlarge/shrink an area on the map or in conjunction with graphical applications, set the size or thickness of the tools used. System could also be used in scenarios, where tracking of fingers in 3D could help understanding users motivation better or in sterile environments where frequent disinfection of the tactile surface is required.

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USING KINECT FOR TOUCHLESS INTERACTION WITH EXISTING APPLICATIONS

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ABSTRACT

In this paper we present a system for touchless interface using Kinect sensor. The system can be used for general purpose interaction with existing applications. We show a case study implementation for use with web-browser where user can interact with the content using gestures. We also present implementation of the game that uses presented system for handling interaction with the user. We also present advantages and disadvantages of such framework and give possible solutions for some of the problems.

1 INTRODUCTION

In the recent times there is increasing demand for natural user interaction and consequently there is a need for such systems as well. While there were many implementations of touchless interfaces in the past [1, 4, 5], most of them were implemented for use with dedicated applications in limited environment. In the past there were many different devices used in such setups, in recent time more interfaces are available at consumer affordable prices such as Microsoft Kinect[1] and Leap Motion[2]. While the intended primary use of Kinect was for gaming purposes, many researchers and developers have successfully used it in more general purpose scenarios. Both interaction devices were used as an input in different systems. Use of Kinect is presented in [3], where authors present a web based kiosk system. Leap motion was used as a doodling interface presented in [8].

In our case we present a system for general purpose touchless interface for use with existing applications on Microsoft Windows platform. The rest of the paper is organised as follows: in the following section we present the related work, in Section 3 we present our implementation. In Section 4 we discuss the advantages and disadvantages of our method. In the end in Section 5 we give the conclusions and possible future extensions of presented approach.

[1]http://www.microsoft.com/en-us/kinectforwindows/
[2]https://www.leapmotion.com/

2 RELATED WORK

The idea of controlling Windows applications using the Kinect sensor is not new and there have been many attempts to achieve this functionality. Most solutions are based on Kinect for Windows Software Development Kit, while some of them use open source libraries like OpenNI[3] or OpenKinect[4]. Basically all of the existing solutions were open source projects, developed by individual programmers in their free time. Most common practice is controlling Windows applications by transforming hand movements into movements of the mouse cursor as described in [7]. Limited functionalities of the left and right click are achieved through simple gestures, like raising one hand or pressing towards the screen with the palm of the hand.

Some of the solutions extend the functionality to support a couple of other gestures to control actions like zoom in and zoom out or even drag and drop. Limited gesture recognition is also presented in [6]. While some work quite well, we could not find any of them that are dealing with the issues of controlling the application in harder circumstances, for example in a public place with a lot of people (e.g. expos, conventions and conferences). This means that there can be high level of background noise (in form of people passing by behind the user) as well as occlusions (in form of people passing between the user and the system). That is why we decided to create our own system that implements all of the functions of existing solutions and takes a step further in terms of usability.

3 OUR APPROACH

Our system consists of four main elements:

- PC running Microsoft Windows 7 or above,
- Microsoft Kinect sensor,
- Large computer display or TV screen,
- Software framework.

[3]https://github.com/OpenNI/OpenNI
[4]http://openkinect.org/

The idea is that a person can stand in front of a large screen and control any existing Windows application through touchless interface using Kinect sensor. As it is displayed in the Figure 1, large TV screen is used to display an image from the computer. Kinect sensor is connected directly to the computer and positioned in front of the TV screen. The application was developed using Kinect for Windows SDK, .NET framework and two open source libraries, Coding4fun Kinect Toolkit[5] and InputSimulator[6]. Coding4fun Kinect Toolkit is intended to speed up the process of developing applications for Kinect by replacing repetitive parts of code with short commands. The other used library, InputSimulator, helps with the simulation of mouse and keyboard commands using Win32 SendInput method.

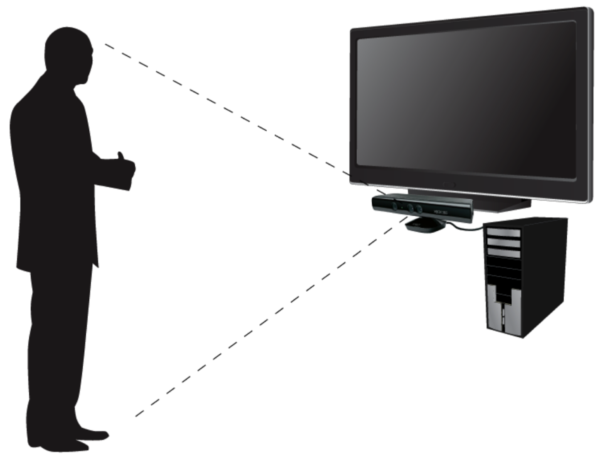

Figure 1: The scheme of our system.

3.1 System outline

When a person steps in front of the Kinect sensor, he or she immediately starts to interact with the computer using the predefined commands. For normal interaction, user has to have both of his palms wide open and facing the sensor. If the user moves his right hand, the mouse cursor on the screen moves accordingly. If he closes and opens the palm of his right hand while keeping the palm of his left hand open, he clicks the object under the mouse cursor. By keeping the right hand palm closed for a longer period of time, the user can perform drag and drop action. If the user closes the palm of his left hand and keeps it closed, he can scroll in any direction just by moving his right hand in desired direction. The distance of the right hand from the starting point translates into the speed of scrolling. If the user wants to zoom in, he needs to close both of his palms simultaneously and, while keeping them closed, pull the hands away from each other. Zooming out can be achieved by doing the opposite action, pulling the hands together. Using this simple commands, user can control and browse through any content on the screen. This is ideal for several cases, like promoting products on conventions, info points, public web browsing and so on.

[5]http://c4fkinect.codeplex.com//

[6]http://inputsimulator.codeplex.com/

3.2 Interaction adaptation

To make the experience of using touchless interface easy for an ordinary user, we had to use different approaches to solve some problems. The commands needed to be simple, logical and very limited, so the user could master them very quickly. Scaling of the moves had to be integrated, because making a lot of repetitive big moves in front of the screen can be tiresome. The hardest part was to find the line where user moves are small enough to be easy and still accurate enough so that he can select the content on the screen without a problem. We got the best ratio of scaling moves through testing different settings on a number of users, which turned out to be about 1:3. Smoothing of users moves also had to be used to improve accuracy and to avoid unwanted random movement of the mouse cursor.

Next step was to make sure that all of the gestures were working as intended and did not collide with each other. The problem appeared when user tried to use zoom in or zoom out gestures. These gestures require that the user closes the palms of both hands at the same time. This turned out to be hard, because if the user closed one palm slightly before the other, different gesture would be triggered, for example mouse click. To avoid this problem, a slight delay was introduced to give the user more time to complete the gesture. Through testing on a number of users we established that a delay of 0.7 seconds is enough to avoid gesture mistakes and still keep the system responsive enough. This was obtained from an user experience evaluation presented in [2].

Because our main goal was to use the system in public places, we had to solve the problem of user recognition and control locking. First generation of Kinect sensor was intended to simultaneously track the skeletons of two persons, while it can recognize up to six persons in his field of view. Our system was designed to allow only one user at a time. We solved this problem by assigning a unique ID to each user in a field of view. Only the first person in the field of view was granted control over the system. As long as the user stayed in the field of view, other users could not take over the control or interfere with it. After the first user was done, he would step aside and the system would grant the control to the next user and so on.

3.3 System structure

Our system consists of several components as presented in Figure 2. Kinect is used as an input that sends the data through the Kinect for Windows SDK. Our application connects to the Kinect Windows SDK and transforms retrieved data into form appropriate for InputSimulator. Input simulator then sends data to the Windows operating system through native Windows input method. Coding4Fun is used for easier implementation of Kinect communication code.

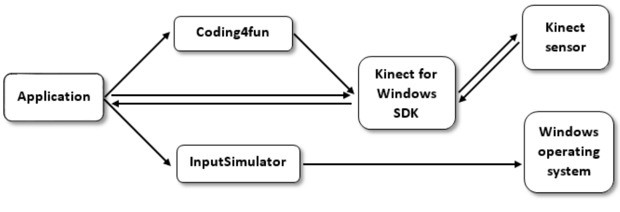

Figure 2: Scheme of system implementation.

3.4 System goals

The main thing that we wanted to achieve was the ability to control any Windows application without communicating with the application. We wanted to develop a system in such a way that the application we control believes it is controlled by a normal mouse and keyboard. This way, there would be no compatibility issues with old or new applications. To get the desired functionality we used existing Windows APIs to inject mouse and keyboard commands into the operating system.

After we implemented user tracking, we used this information to implement another function, automatic program starter. Every time a system detects a new user, it can automatically start any predefined program or open a new website. The idea behind this function is that every time a new user steps in front of a sensor, a so called "welcome" sequence can be started as shown in Figure 3. This way, a new user can be greeted and introduced to all of the functions our system enables him to use.

Figure 3: An example of welcome screen which can be used with our system.

Each of the gestures can be separately turned on or off, so they can be used only if needed. More gestures always means chances for a user to make a mistake.

3.5 System integration

We tested our implementation of touchless interface in a real life situation. An IT company from Slovenia wanted to present itself on an IT conference using touchless interface. The goal was to stand out and attract people passing by. We developed a simple browser based game that was controllable using our touchless interface. The application was developed for general use and can use conventional means of interactions as well (such as mouse and keyboard). The goal was to follow a given path with a mouse cursor from start to finish without touching the borders of the path. To avoid mistakes, all unnecessary gestures were turned off. The game was interesting to play when using our touchless interface because every user first had to learn how to guide the mouse cursor using only his hand and familiarize himself with the responsiveness and accuracy of our system. It turned out that some people had trouble replacing the mouse with a touchless interface while other mastered the game in seconds. It was very obvious that with a bit of training, usefulness and accuracy of our system was good. A screenshot of the application is presented in Figure 4.

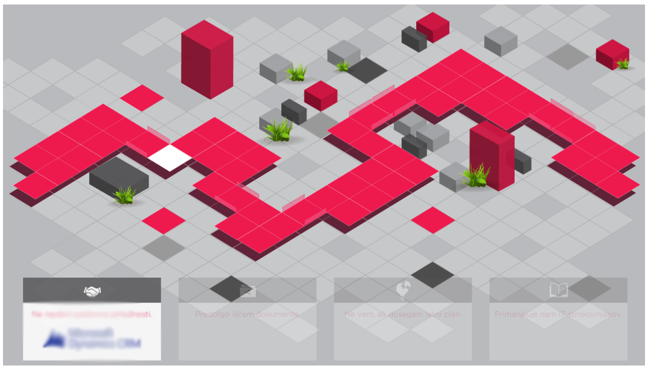

Figure 4: A screenshot of example application that uses our system.

4 DISCUSSION

Even though there are already numerous existing solutions that enable users to control Windows applications using Kinect sensor, our system stands out in a number of ways. It does not only focus on enabling the users to give basic commands using touchless interface but also focuses on dealing with problems of using such an interface in public places. It implements functionalities such as user control locking, gesture recognition delay, user movement scaling, selective gesture enabling/disabling and automatic program starter. It was developed with a specific purpose in mind and therefore concentrates on problems that other applications were not meant to encounter. That is why it deals with the problems better than other similar applications and is usable not just in a lab environment but also in real world situations.

On the other hand, our application is limited to only a few gestures and could be expanded to support other commands. This way, user could control more complicated applications or get desired results faster. By expanding our feature set and improving the quality of already implemented features we could develop a more all-rounded application that would be useful in different situations and for different purposes.

The great advantages of presented system is possibility to use such system with existing windows applications. That can come in handy in many cases where we want to adapt a kiosk system for use with such applications. Using separate hand for pointing and clicking gives user a better accuracy in selecting the correct user interface (UI) elements.

On the other hand use with existing applications is limited to some extent due to the limitation in UI. Usually UI elements are just too small for interaction with such system. There is a possibility of adapting applications for use with presented system. In the conclusion we give possible adaptation of web-based application for easier use with presented system.

Our system was also tested in the real-life situation at a conference, for purposes of obtaining relevant user feedback. Users were participants of IT conference, which means that majority of them had experiences with different ways of interaction. Majority of users gave us positive feedback. During the testing we have realized that one of the main limitations of our system is that it fails in interaction with smaller UI elements, where one has to be very observant to pinpoint the element exactly.

5 CONCLUSION AND FUTURE WORK

In this paper we have presented a system for touchless interaction using Kinect sensor, that allows robust user interaction. The system is developed for Microsoft Windows and allows interaction with native applications. While the idea of such implementation is great, it shows that there are rare applications that allow such interaction due to UI limitations. We have shown that presented system can be used for kiosk-based applications, in our case an interactive game, where user is robustly tracked and the system is not distracted by the actions in the background.

There are several possible extensions of the presented system that would improve its usability. One such extension is implementation of intermediate application for web browsers that would adapt the displayed page for easier interaction with the system. Such application would “snap” cursor to the defined links in the website and emphasize them for easier recognition and interaction. Another extensions of the system is implementation of more gestures, such as right-clicking, onscreen keyboard with auto-completion etc.

The presented system was tested in real-life environment with positive user feedback. We will further develop the system and also perform user experience study to get a relevant feedback from the users.

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AN IMPROVED VISUALIZATION OF LiDAR DATA USING LEVEL OF DETAILS AND WEIGHTED COLOR MAPPING

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ABSTRACT

This paper proposes an improved approach for LiDAR data visualization in terms of rendering quality. The method uses adaptive point-scaling for dealing with variations in data densities, while the contrasts of rendered objects are improved with weighted color mapping. In the former case, points' distances from the observer are used to estimate their optimal rendering sizes. In the latter case, points are colored based on height attributes and increasing visual fidelity a point's color is weighted using that point's intensity information. Common image quality matrices, as well as conducted user study, confirm the improvements of the visualization.

1 INTRODUCTION

Visual analytics of remote sensing data are at the heart of numerous environmental studies. Scientific disciplines like geography [1], biology [2], and ecology [3], are increasingly relying on information gathered by advanced Earth observation systems. These are capable of capturing precise and high-resolution data from vast geographic areas within a short period of time. Light Detection and Ranging (LiDAR) technology in particular, has transformed the traditional approaches to monitoring the Earth's surface with its reliability, great accuracy, and high density of acquired point-clouds. Consequently, the specifics of LiDAR stimulate new visualization techniques capable of clearly exposing the objects contained within these datasets, while overcoming the issues of huge sizes and lack of topology that are inherent with LiDAR point-clouds. In this paper, a new approach to LiDAR data visualization is considered which exploits weighted color mapping for increasing visual contrasts between the contained features. The underlying concepts of the proposed approach are introduced in Section 2. Section 3 explains the proposed method. Discussion and the results are given in Section 4, while Section 5 concludes the paper.

2 RELATED WORK

The majority of real-time visualization techniques use hierarchical space subdivision for efficient scene representation. A method based on recursive data subdivision with a quadtree was presented by Lindstrom et al [4]. They used a hierarchy in which each depth of the tree corresponded to a certain detail level. Therefore, it was easy to combine different detail levels into final data representation. Their system also considered the roughness of the surface and used less details where the topography was smoother. Similar methods have also been developed using Delaunay triangulation for continuous surface Level of Details (LOD) [5].

The concept of using points as rendering primitives for representing an object has been introduced in the pioneering work by Levoy and Whitted [6]. Rusinkiewicz and Levoy [7] developed a point-based rendering system (PBS) named QSplat that was capable to interactively rendering surfaces with large numbers of points in real-time. Their solution was based on a multi-resolution hierarchically bounded sphere for LOD. Recently, Kovač and Žalik [8] developed a two-pass point-based rendering technique that uses elliptical weighed average filtering for solving problems relating to aliasing.

More sophisticated approaches are based on the Human Vision System (HVS) [9], where perceptual metrics like spatial frequency and visual acuity are used to determine visible differences between images. The Just Noticeable-Difference (JND) approach was presented by Cheng et al. [10]. JND uses a perceptual analysis for improving the results of geometric measures for identifying redundant data. A volume-rendering algorithm that follows the user's gaze and smoothly varies the display resolution has been developed by Levoy and Whitaker [11]. Gaze-contingency uses models of human spatial perception and can be applied to geographic data representation.

3 VISUALIZATION

Visualization of LiDAR data remains a difficult problem, where the main challenges are imposed by huge amounts of topologically unstructured data and variable data-density. Due to limited graphical memory, these datasets cannot be fully processed on graphical processing units (GPU), while data structuring and topology establishing (e.g. triangulation) are ineffective due to additional resources. Consequently, a more intuitive way for LiDAR point-cloud's visualization is to deal with each point as a separate display primitive. Although those implementations using such simple primitives [6] are fast and robust, they produce coarse images i.e. empty gaps between primitives where point den-

sities are not sufficiently high. Therefore, it is necessary to find a balance between technical and perceptual abilities.
In the continuation, a new visualization architecture is described aimed at improving data perception, together with an efficient data organization for real-time rendering.

3.1 Data Management

The basis for fast and effective visualization of point-clouds is hierarchical space partitioning, where data are divided into smaller segments. Since LiDAR data can be considered as 2.5D, a quadtree data structure is applied for this purpose [12]. The quadtree root covers the whole area and its 4 children divide space into equal quadrants. Space subdivision is obtained by inserting point after point into the corresponding node of the quadtree. When a node contains a predetermined maximal number of points, space subdivision is performed by dividing the node into four subnodes and rearranging the content. The space partitioning is constructed during the pre-processing phase. The needed geometry is stored within the graphic memory using vertex buffer objects (VBO), which speeds up the rendering process. This also allows for the maintaining of only point indices and VBO references within the main memory. Rendering points are randomly sampled from the VBO.

3.2 Rendering

In order to achieve real-time visualization, it is necessary to reduce the number of display primitives for rendering. A frustum culling technique is applied on the space subdivision hierarchy to exclude subspaces being outside the viewing frustum. However, this is usually not enough for achieving real-time visualization, and visible points inside the viewing frustum also need to be considered for removal. For this purpose, additional LOD technique is applied for further simplifying the scene. LOD is realized by rendering detailed geometry when the subspace is close to the observer, and a coarser approximation when it is distant or occupies a small screen space. In this way, the rendering workload is significantly reduced. As described by Pečnik et al. [12], the optimal percentage of rendered points L_j for a subspace j can be defined as:

$$L_j = \frac{D_j \cdot (R-1)}{D} + 1 ,$$

where D_j is the distance between the observer and the center of subspace j, D is the average distance for all visible subspaces from the observer and R is the average percentage of rendered points. However, despite its advantages regarding performance LOD also has some significant drawbacks in terms of image quality. Optimizations for improved visual quality are described in the continuation.

Adaptive point-scaling

The main problem when reducing the graphic workload is the scarce density of points, leading to noticeable gaps between them [7]. In order to deal with this issue, a new approach to LOD is proposed here by considering both the sizes of the rendering points in addition to their quantity.
Determination of an adequate point size is of critical importance for avoiding visual gaps within as the image. An illusion of a continuous surface is created if the points are large enough to sufficiently overlap, see Figure 1. Therefore, a point's size is calculated according to the distance of the observer from the subspace. By considering spatial perception, point sizes should be inversely proportional to the distance from the observer, since subspaces further away from the observer occupy a smaller portion of the screen space. Consequently, they can be rendered using smaller points and vice versa. The point size S_j for each subspace is defined by

$$S_j = 1 + \lfloor L_j \cdot \rho \rfloor,$$

where ρ is the average points density of all subspaces.

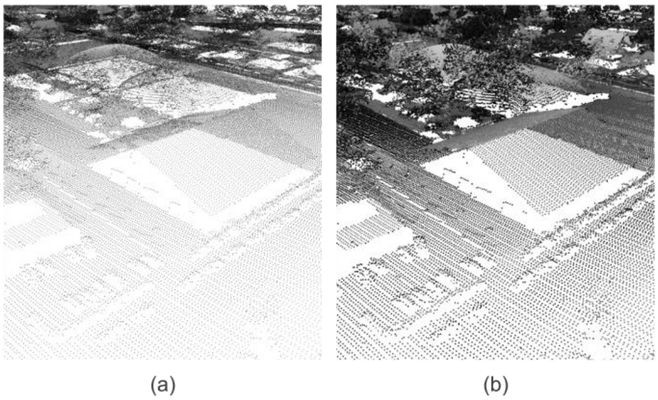

Figure 1: *LiDAR data visualization: rendering without optimization (a), rendering with adaptive points-scaling (b).*

Weighted color mapping

The colors of LiDAR points are typically derived at from the returned laser intensities or airborne image projected onto the point-cloud. These approaches are fine for general data visualization, whereas they fall short regarding the in-depth visual analytics of specific features as they cannot provide adequate contrasts between them. The main reasons for this are the low intensities of points beneath the vegetation and multiple points sharing the same colors, when images are projected on them. Here, we have focused on improving the contrast based on the heights of LiDAR points, i.e. height map visualization.
Typically a height map is visualized by mapping the grayscale pallet between the minimum and maximum height of the targeted data. This limits the visualization, since on most conventional display devices the grayscale pallet has an effective 8-bit range. Therefore LiDAR data can only be effectively visualized for a small height range before visual quantization takes place. In order to improve upon this, this method takes advantage of color perception and the point's returned laser intensities. Though color mapping is not a novel concept and is among other fields used extensively in cartography [13], but has a great impact on visual perception. Because there is no optimal general purpose color map, many application specific color maps exist. Firstly to gener-

ate the point's colors, color mappings are applied to the LiDAR points which are histogram equalized, with regard to their height attributes, ranging between 0 and 1. The equalized height value for point i is used to retrieve the color C_i from the color look-up table (CLUT). The equalization achieves a color merging of outlier points, which are typical in LiDAR data and cause severe extensions of mapping ranges, leading to suppressions of contrast between the majority of points. In this way, more color variety is given to those points with heights at the peaks of the probability density function. The CLUT used is a linear sampling through the HSV color model. The path used is defined by HSV points (200, 1, 1), (140, 1, 1), (60, 0.5, 1) and (30, 0, 1). Only unique 8-bit RGB colors are retained from the sampling process, producing an expanded color pallet, as seen in Figure 2, with over 765 unique colors i.e. over three times that of a grayscale map.

Figure 2: *Generated color mapping with sampling duplicates removed.*

In order to increase visual fidelity, each point's color C_i is weighted with the point's intensity, producing the final color $C_i^{'}$. The point intensities are also histogram equalized, values ranging between 0 and 1. Doing this restores visual cues about dataset structures while still preserving the height map.

4 RESULTS

The visual acuities on 4 different LiDAR datasets were compared according to different terrain-types. The image qualities were evaluated using two different Image Quality Assessments (IQA) algorithms based on Human Visual System (HVS). We calculated the Blind Image Quality Index (BIQI) [14] and Naturalness Image Quality Evaluator (NIQE) [15], on datasets that were rendered with and without both optimizations, separately. Smaller values of the metrics refer to better quality and vice versa. The rendered images can be seen in Figure 3.

The evaluation results are presented in Table 1. The proposed adaptive point-scaling improved the results in all datasets with regards to both IQA metrics. However, when comparing the visual acuities for weighted color mappings, this was found to be problematic since the method focused on height map visualization for which there is no true reference image, i.e. ground truth with which to objectively compare the methods' results. Existing methods such as BIQI and NIQE, which are blind image quality assessment (BIQA) methods, operate on grayscale images. Thus, the used BIQA methods are not appropriate for quantifying the method's image quality, since the RGB to grayscale conversion is subjective. A user survey with 18 participants aged 22 to 47 was conducted, where users were given a set of pair images, grayscale and color heightmaps, and were asked, which one was more suitable for estimating the heights of different objects within the images. Most responded positively to the color images, with a few notable comments. One participant noted that it was much easier to see similar height objects in the color images, due to the relief-like visual cues caused by the color mapping, while another participant was pleased with the improvements in color image when compared to darker regions in grayscale image. The increase in visual fidelity, when the intensity information was included in color mapping, was well accepted. While, with only CLUT many features are masked because contrasts between points are lower and participants perception of heights was worsened. At the time of survey, there were no known issues with participant's color perception, so it was not determined if weighted color mapping is suitable for color blind users.

5 CONCLUSION

This paper proposed a new method for efficient LiDAR data visualization based on LOD. Without reducing the computational efficiency of this approach, we have proposed two improvements on rendering quality by adaptive point sizing and contrast enhancement with weighted color mapping. As confirmed by objective as well as subjective evaluations, the proposed approach improves visual analytics by allowing users to clearly distinguish between rendered objects.

Acknowledgements

This work was supported by the Slovenian Research Agency under Grants J2-5479, and P2-0041. This paper was produced within the framework of the operation entitled ''Centre of Open innovation and Research UM''. The operation is co-funded by the European Regional Development Fund and conducted within the framework of the Operational Programme for Strengthening Regional Development Potentials for the period 2007–2013, development priority 1: ''Competitiveness of companies and research excellence'', priority axis 1.1: ''Encouraging competitive potential of enterprises and research excellence''.

Table 1: *IQA results of adaptive point-scaling and weighted color mapping optimizations.*

Dataset	BIQI			NIQE		
	no optimization	point-scaling	color mapping	no optimization	point-scaling	color mapping
Urban	101.26	75.84	99.02	13.27	9.49	13.71
Roundabout	69.73	65.33	64.87	15.36	12.26	15.11
Mountain	78.59	50.43	80.19	11.35	8.30	12.11
Flat	74.97	30.76	70.49	7.50	7.86	9.58

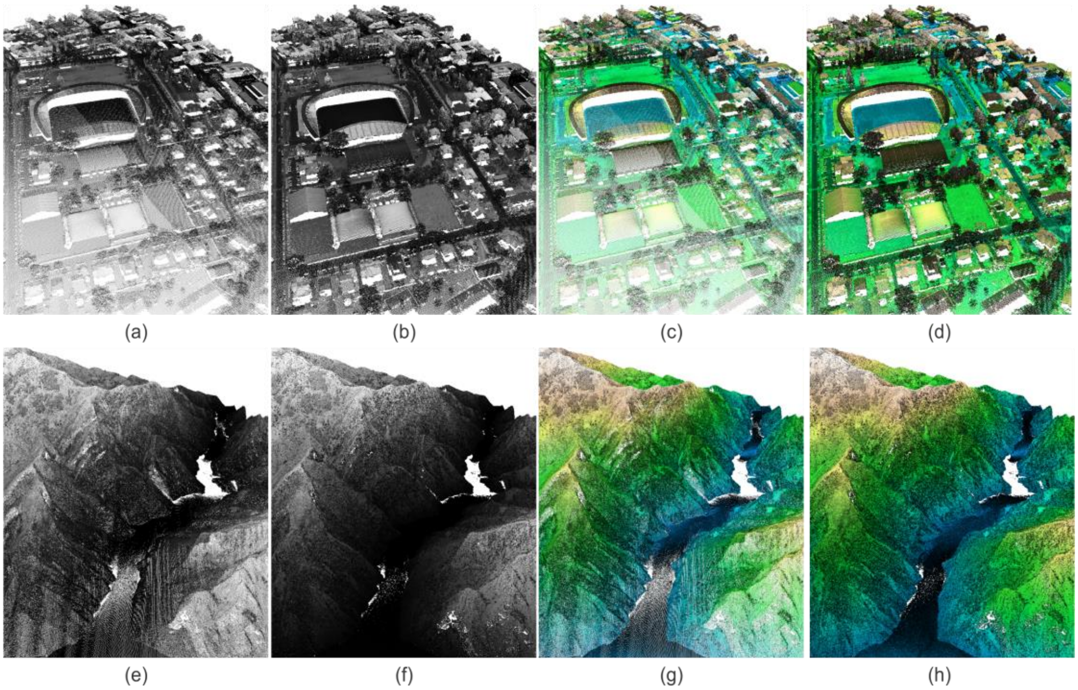

Figure 3: *Evaluation of improved visualization of LiDAR data: urban dataset without optimization (a), with adaptive point-scaling (b), with weighted color mapping (c), with adaptive point-scaling and weighted color mapping (d); mountain dataset without optimization (e), with adaptive point-scaling (f), with weighted color mapping (g), with adaptive point-scaling and weighted color mapping (h).*

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STUDENTS' ACCEPTANCE OF ANIMATED INTERACTIVE PRESENTATION OF SORTING ALGORITHMS

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ABSTRACT

Programming courses are very important and challenging part of computer experts' education process. However, abstract nature of these courses makes them rather difficult for most students. In order to increase students' motivation and level of comprehension regarding programming an approach that includes less abstract presentation of programming concepts using visualization techniques is proposed and implemented through the tool SortExpert that is designed to help the students to cope in a more suitable and easier way with various sorting algorithms. Discussion about the effectiveness of existing visualization tools and research about the evaluation and acceptance of SortExpert are also presented.

1 INTRODUCTION

Programming as a profession is in high demand and this fact puts a lot of importance on the education of young computer experts and programmers. Understanding programming concepts and paradigms is a challenging task for most of undergraduate students that are in many cases seeing computer code for the first time. Abstract computer code format and syntax is not always the best way to make students understand programming principles, program constructs and data structures.

In order to increase students' motivation and to increase the number of students that successfully finish programming courses with sufficient understanding of algorithmic approach and various data structures, an approach that includes students as an active part of educational process through interaction with learning software that enables animated presentation of targeted concepts and structures as well as their mutual comparison is researched and discussed.

2 STUDENTS AND PROGRAMMING

Programming is a fundamental part of all computer science studies and curricula [8] and its importance in modern business world cannot be overstated. However, many authors agree that to learn how to program is a very difficult and challenging task [1, 9, 14, 7, 11]. Students tend to spend a lot of time and effort on grasping pure syntax of programming languages which leaves them with rather little time for understanding the main concepts that lie beneath the written syntax. This fact asks for means to increase the speed with which students are able to fully understand a particular algorithm or data structure. Nevertheless, most of programming classes still use mainly traditional way of teaching [10], omitting high-tech visual techniques. Visualization and SortExpert tool are one step in the direction of changing this kind of state in programming education.

3 VISUALIZATION IN PROGRAMMING COURSES

Adoption of visualization as well as willingness and ability of professors to make this kind of materials available is of vital importance. Research has also shown that passive graphical representation is not sufficient for proper understanding [13], so it can be stated that an interaction between students and visualization tools is also of great importance [12].

There are many existing visualization tools such as [16]: BALSA-II, XTANGO, JHAVE, BlueJ, Jeliot, TRAKLA2, ALVIS and ViLLE. Studies however still show variations in results of using these kind of tools [3] which indicates that there still remains a need for new concepts and improvement.

All this points in the direction of creating visualization models that would be complex and high-tech but would also include some form of interaction with the students. Interaction and customization of visualization model would support constructivism learning theory in which students are creators of their knowledge based on their existing knowledge and new presented paradigms [2]. It can be concluded that it is generally indicated that visualization is beneficial for students [15].

4 SORTEXPERT

SortExpert enables students to visually observe the whole process of sorting for some particular sorting algorithm. Sorting algorithms have been chosen because of their complexity and many problems that students have reported regarding this area of programming. SortExpert is aimed at providing students with visual representation of sorting algorithms that are dynamic is their nature and require more effort to be understood properly than programming concepts than can be presented in purely static way. In SortExpert every step is animated and students are able to experience the sorting process in much more vivid and clear way than by presentation which uses just static images. Since most of students are visually oriented the pure usage of graphics makes them more focused and more willing to deal with sorting algorithms.

SortExpert's design is simple and minimalistic with clear and intuitive navigation and options providing students with environment that enables them to focus on sorting animations. This is one of important characteristics that frequently lacks in many visualization tools. Another advantage of SortExpert is its interaction component which is an essential part of SortExpert that is aimed to further increase the focus and motivation of students to learn sorting algorithms. SortExpert supports several well-known sorting algorithms that are commonly found in programming courses: Bubble sort, Heap sort, Insertion sort, Merge sort, Quick sort, Selection sort and Shell sort.

When SortExpert is launched an initial set of numbers is displayed as a general set to be sorted. This set of numbers is also visualized through graphical representation. Students are able to select which sorting algorithm will be applied to generated set of numbers. Generated set of numbers can be changed by generating new set in one of four modes: random numbers (generates the set of some random numbers), reversed order (generates the set of numbers that are initially sorted in decreasing order), almost sorted (generates the set of numbers that are almost sorted) and few unique sets (several chosen examples of various sets of numbers). There is also possibility of changing the speed of sorting animation in order to see particular steps more accurately and possibility to pause the animation process. After the animation of selected sorting algorithm is done, in the details section at the bottom of the screen the students are able to see how many comparisons and how many replacements have occurred during the sorting process so they are able to quickly determine the complexity of particular sorting algorithm. All described features are shown in Figure 1.

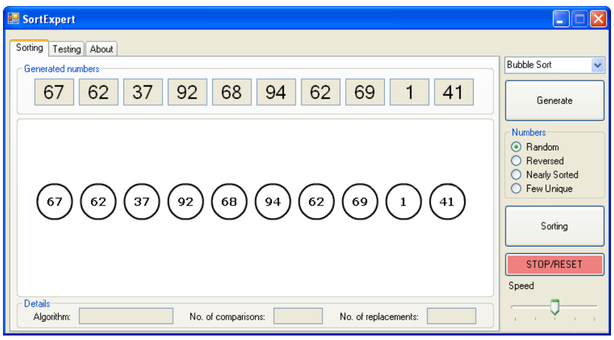

Figure 1: *Features of SortExpert*

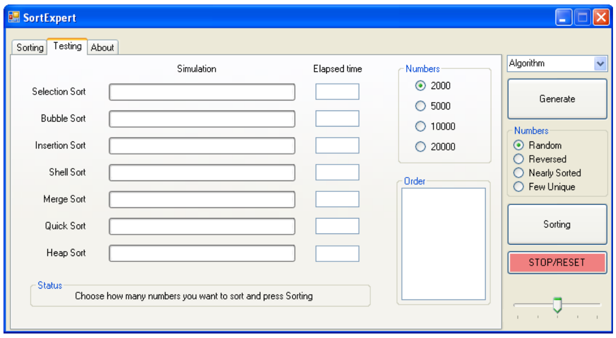

Figure 2: *Comparison of several sorting algorithms*

Along with the possibility of animated presentation of sorting algorithms, SortExpert also gives the possibility of comparison of several sorting algorithms using array of several possible lengths. Students are able to choose the number of elements to generate in an array and then they can compare sorting speeds in order to see which sorting algorithm was the most efficient (see Figure 2).

SortExpert provides a focused tool that has clean design that is intuitive and easy to use. User interface of SortExpert is composed of two main parts that are divided into two sections (Sorting and Testing) using tab control. Sorting tab is arranged is such a way that numeric array elements are vertically aligned with their graphical representations and the area around this representation contains a lot of free space which creates the minimalistic effect and enables easier focus on animation process. All necessary options are vertically ordered in the right part of the screen to be non-intrusive and easy to apply.

Testing tab consists of all supported sorting algorithms which are sorted vertically. Speed animation and elapsed sorting time are located along every sorting algorithm which enables students to clearly see the speed of every algorithm and to quickly conclude which algorithm is more suitable for array of chosen length. All array options are vertical aligned in the right part of the Testing tab in minimalistic way in order to enable quick change of array length and to show the final order of tested sorting algorithms.

5 SORTEXPERT EVALUATION

In order to evaluate acceptance of SortExpert tool a research was conducted on 182 information science students using TAM (Technology Acceptance Model) [6]. The research was conducted using an online questionnaire that was designed to measure the following aspects: perceived usefulness (U), perceived ease of use (E), attitude towards using (A), and behavioral intention to use (BI). Before the questionnaire was given the students were introduced to SortExpert during one lesson. Likert scale was used in all given questions (1-strongly disagree, 5-strongly agree). Cronbach's alpha coefficient values for every of 4 stated groups of questions were above 0.8 which shows sufficient internal consistency of designed questionnaire [4, 5]. The results of conducted questionnaire are given in Table 1.

Questionnaire item	Mean	Std. dev.
Perceived Usefulness (Cronbach's α = 0.825)		
SortExpert helps me in understanding sorting algorithms	4.730	0.493
SortExpert makes learning sorting algorithms easier	4.736	0.478
Using SortExpert makes learning of sorting algorithms quicker than by using textbooks	4.770	0.472
Using SortExpert enables me to learn sorting algorithms in a way that is more suitable for me than classic school presentations that are mostly based on text	4.713	0.512
I am able to understand sorting algorithms much more clearly by using SortExpert than by using classic textbook presentations	4.632	0.528
SortExpert increases my productivity in studying programming	4.431	0.730
SortExpert reduces time I spend learning sorting algorithms	4.701	0.559
SortExpert improves the quality of my knowledge about sorting algorithms	4.534	0.652
SortExpert gives me better insight into functioning of sorting algorithms than classic school presentations	4.615	0.657
Interaction and visual nature of SortExpert increase my motivation for learning programming	4.161	0.902
Perceived Ease of Use (Cronbach's α = 0.821)		
Using SortExpert is easy for me	4.598	0.624
I found SortExpert's interface to be intuitive and comprehensive	4.557	0.656
It is easy for me to remember how to work with SortExpert	4.649	0.565
I have no problems in using SortExpert	4.534	0.654
I think that learning how to work with SortExpert is easy	4.621	0.602
Attitude Towards Using (Cronbach's α = 0.840)		
I think that SortExpert is very useful in learning programming	4.684	0.555
I find that using SortExpert is helpful in clarifying sorting algorithms	4.747	0.496
I think that usage of SortExpert would be beneficial in programming courses	4.695	0.591
I think that SortExpert would enhance students' understanding and comprehension of sorting algorithms	4.764	0.499
Behavioral Intention to Use (Cronbach's α = 0.856)		
I plan to use SortExpert for learning of sorting algorithms	4.236	0.969
I intent to use SortExpert as a learning tool in my programming courses	4.305	0.867
When needed, I will use SortExpert to recall the concepts of sorting algorithms	4.431	0.745
When needed, I will use SortExpert for explaining sorting algorithms to others	4.178	0.981
I would recommend using SortExpert to all students	4.747	0.572

Table 1: *Questionnaire items*

The results in Table 1 show that students find SortExpert useful and easy to use. The results also show that students find SortExpert to be useful and beneficial in learning sorting algorithms. The usage of SortExpert also positively affects the motivation of students to learn programming. 93.40% of students gave answers 5 – Strongly agree or 4 – Mostly agree on the questionnaire item "SortExpert helps me in understanding sorting algorithms". 87.36% of students gave the same answers on the questionnaire item "SortExpert improves the quality of my knowledge about sorting algorithms". 88.46% of students gave answers 5 – Strongly agree or 4 – Mostly agree on the questionnaire item "Using SortExpert is easy for me". The same answers have been given by 91.20% of students on the questionnaire item "I think that SortExpert is very useful in learning programming" and by 91.75% of students on the questionnaire item "I would recommend using SortExpert to all students". According to presented results it can be concluded that students have positive attitude towards using SortExpert and that they find it to be beneficial and useful regarding their present and future learning of sorting algorithms. Simple interface, animation and interaction makes SortExpert usable educational tool for all students that captures their attention and makes them more focused.

5.1 Evaluation of SortExpert's effectiveness

In order to provide more objective conclusion about the usefulness of SortExpert, additional research has been conducted in a form of tests that have been given to students designed to test their knowledge about insertion sort. The same test was given to students after presenting them with insertion sorting algorithm in a traditional textbook way and after using SortExpert and graphical representation. Both tests consisted of 5 questions which were graded with either 0 or 1 point. The results of the test gave 415 points (45.60% accuracy) for the first test and 659 points (72.41% accuracy) for the second test which is increase of 244 correct answers or 59.79% after using SortExpert and visual presentation of insertion sorting algorithm. Stated data shows that SortExpert and graphical representation of sorting algorithms subjectively and objectively are beneficial for students in terms of easier learning and comprehension and increased level of retained knowledge.

6 CONCLUSION

Programming experts are in high demand and this makes their education more important than ever. However, students tend to find programming courses rather difficult because of their abstract nature. In order to make programming courses easier to understand and to increase students' motivation to learn programming an approach that includes visualization techniques and interaction between the students and visualization tool has been proposed. In order to evaluate such approach a tool called SortExpert that enables visualization of sorting algorithms has been developed and evaluated.

Evaluation has been conducted among 182 information science students and the results have shown that students perceive SortExpert tool as useful and easy to use which consequently results in positive attitude towards SortExpert tool and in positive behavioral intention to use this tool. SortExpert's interface simplicity combined with speed-adaptable animation and interaction has proven to be an efficient mean that increases students' focus and makes overall learning process more interesting and more understandable. Usage of SortExpert brings sorting closer to students in a way that is intuitive and comprehensive which helps to decrease students' fear of programming and increases their motivation to learn. Adding new concepts and constructs to SortExpert and further research about effects of visualization will be main part of future work.

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USE OF UX AND HCI TOOLS AMONG START-UPS

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ABSTRACT

Today, User Experience (UX) and Human-Computer Interaction (HCI) tools can provide a competitive advantage that might be key of a company's business success or failure. In this paper, the awareness and use of these tools among start-ups is examined with a survey. The results hint that there is lots of room for improvement in terms of raising awareness and adoption of tools that help companies deliver better experiences through their products.

1 INTRODUCTION

Small and Medium sized Enterprises (SMEs), and start-ups as a sub-group, play an important role in the economy [1]. Their business success is determined by various factors: access to financing, ease of administration defined by (local) regulations, and the product/service itself. Differentiating from the competition can be done on technical capabilities or features, price and the experience the product/service offers to the user or customer.

The annual report on European SMEs [2] highlights the importance of small firms (SMEs, start-ups) for economic growth: "*Being and staying small in size does not, however, mean that these firms are unimportant for macroeconomic growth. Due to their large numbers, they provided more than 66% of the total jobs in the EU in 2012. New businesses can also generate important impulses for economic growth and the SME sector has to be regarded as a particular seedbed for further start-ups and for a culture of entrepreneurship*," and "*Since nearly all new firms start from a very small size – often just the founder with no dependent employees – new business formation directly contributes to the SME sector. Moreover, the great majority of new businesses stay micro-businesses for the whole period of their existence. Only very few exceptional start-ups become larger firms.*"

How to successfully compete and survive? Jim Shamlin argues that "*user experience is becoming the primary means of competition, and involves a sustainable competitive advantage over its competitors*."[1] Furthermore, he talks about a new era of competition, which is based on UX. In contrast to buying a product/service because it is the only one and later because it is better (for a specific need or purpose), UX based competition strives towards creating a relationship with the customer over time, based on how he feels during the whole life-cycle of the product/service (e.g. buying, using). This point of view is echoed by Erik Flowers: "*This is what makes businesses successful in the modern age. The age of features is dead. The age of experience has arrived. Look at the top performing companies in the world – all are focused on experience. It is proven. It is quantifiable. Parity on widgets, patents, technological capability has been reached. People demand a higher order experience.*" It is important to have "*a cohesive flow of how we handle designing things. Not just what we see on the screen, but the design of the whole experience. What a user ends up feeling and thinking in their mind cannot be designed, that is the experience that manifests. But the tools and methods we use to set it all up is what brings us as close as we can to setting up that happy journey.*"[2]

Due to the importance of both start-ups in the economy and UX and *HCI tools* and *methods* in start-ups, we examine in this paper how these tools are used. In other words, this paper is focused on the question if HCI/UX tools are being used, whereas related work is mostly focus on how a specific tool is used [3-5]. What follows is a brief description of the tools taken into consideration and the results of a survey about the awareness and use of these tools.

2 SURVEY AND RESULTS

The set of 15 tools and methods taken into consideration in this study was adopted by the usability.gov [6] portal, along with the descriptions in this paper: contextual interview, focus groups, on-line surveys, standard usability questionnaires, heuristic evaluation, first click testing, eye-tracking, mobile device testing, wireframing, card sorting, prototyping, personas, task analysis, individual interviews, and diary study.

The survey focused on the use of these tools among start-ups. The survey was conducted on-line, after entering some background data, respondents were asked to '*rate the following terms based on how much you use them in your*

[1] http://www.uxbrainstorm.org/user-experience-as-competitive-advantage/

[2] http://www.helloerik.com/view-on-ux

work.' The answers were provided on a scale from 1 to 4, namely 1-never heard of, 2-heard of, but never used, 3-used a few times, 4-use regularly. In total 23 people involved in start-ups responded, aged from 21 to 38 (28 average), 2 females and 21 males, on average involved in 3 startups in the last 3 years. 9 were Slovenian, 7 Italian, 2 Romanian, 2 Polish, 1 Czech, 1 Bolgarian and 1 Ukrainian. Their background covered business, design, technical and marketing skills.

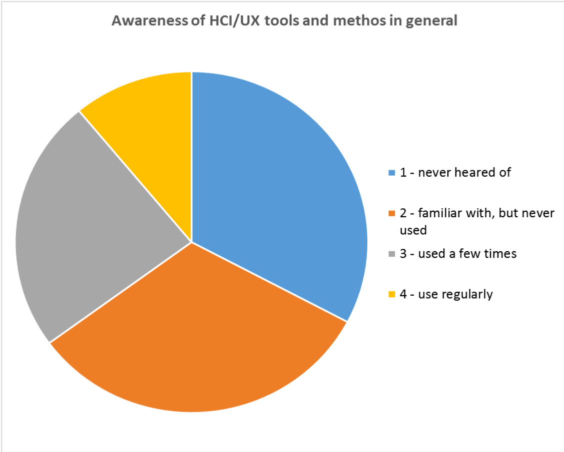

Figure 1: General overview of awareness of UX/HCI tools and methods.

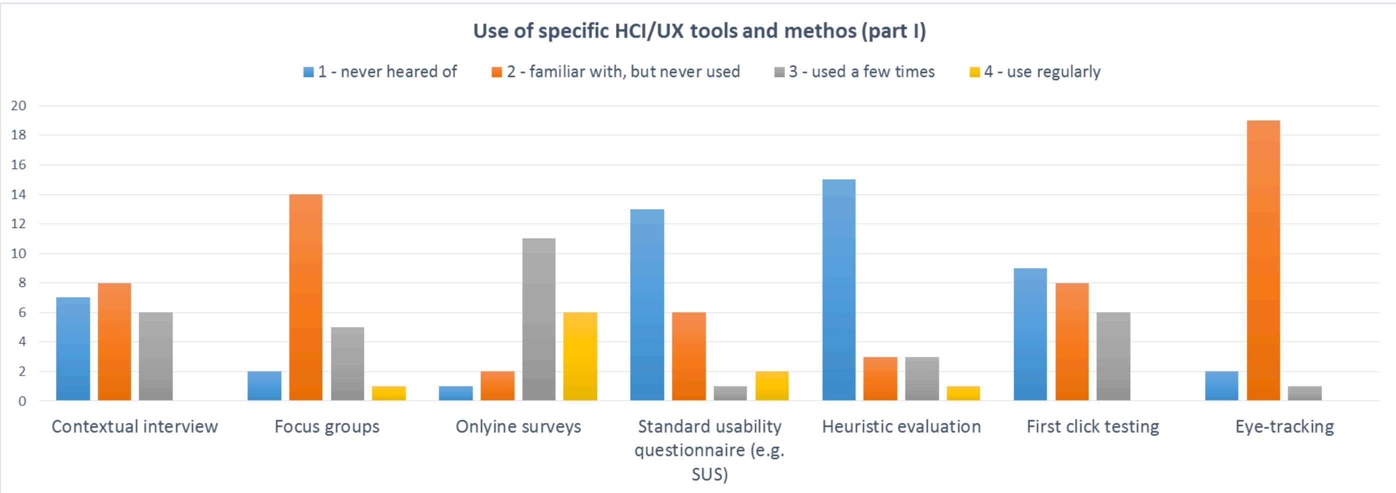

Figure 2: Awareness and use of specific UX/HCI tools among start-ups, first part.

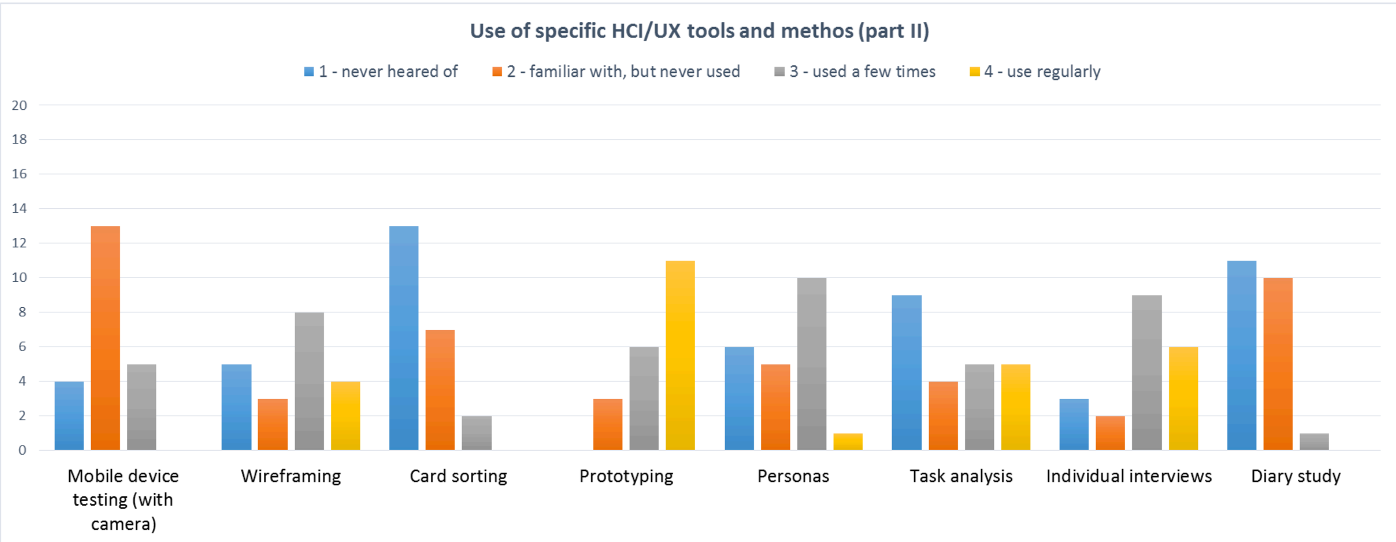

Figure 3: Awareness and use of specific UX/HCI tools among start-ups, second part.

Contextual interview: During these interviews, researchers watch and listen as users work in the user's own environment, as opposed to being in a lab. Contextual interviews tend to be more natural and sometimes more realistic as a result. They are also usually less formal than lab tests and do not use tasks or scripts.

Focus groups: A focus group is a moderated discussion that typically involves 5 to 10 participants. Through a focus group, you can learn about users' attitudes, beliefs, desires, and reactions to concepts. Focus groups differ from usability testing or contextual interviews in the kind of information they produce in two ways: (a) in a typical focus group, participants talk. During the focus group users tell you about their experiences or expectations but you do not get to verify or observe these experiences and (b) in a typical usability test or contextual interview, users act. As a result, you are able to watch (and listen to) them and draw conclusions from that.

On-line surveys: An on-line survey is a structured questionnaire that your target audience completes over the Internet generally through a filling out a form. On-line surveys can vary in length and format. The data is stored in a database and the survey tool generally provides some level of analysis of the data in addition to review by a trained expert. Unlike traditional surveys, on-line surveys offer companies a way to collect information from a broad audience for very little cost. When conducting an on-line survey, you have an opportunity to learn who your users are, what your users want to accomplish, and what information your users are looking for.

Standard usability questionnaires (e.g. SUS): A standardized questionnaires have gone through the process of psychometric validation. They have several advantages over ad-hoc questionnaires: reliability, validity, sensitivity, objectivity, quantification, economy, communication, and norms[3]. An example is the System Usability Scale (SUS), which provides a "quick and dirty", reliable tool for measuring usability. It consists of a 10-item questionnaire with five response options for respondents; from Strongly agree to Strongly disagree. Originally created by John Brooke in 1986, it allows you to evaluate a wide variety of products and services, including hardware, software, mobile devices, websites and applications.

Heuristic evaluation: In a heuristic evaluation, usability experts review your product's interface and compare it against accepted usability principles. Nielsen's heuristics are: Visibility of system status, Match between system and the real world, User control and freedom, Consistency and standards, Error prevention, Recognition rather than recall, Flexibility and efficiency of use, Aesthetic and minimalist design, Help users recognize, diagnose, and recover from errors, Help and documentation. The analysis results in a list of potential usability issues.

First click testing: First Click Testing examines what a test participant would click on first on the interface in order to complete their intended task. It can be performed on a functioning website, a prototype or a wireframe. First Click Testing allows you to evaluate the effectiveness of the linking structure of your site, including the navigation, to see if users how to get around the site and complete their intended task.

Eye-tracking: Eye tracking involves measuring either where the eye is focused or the motion of the eye as an individual views a web page. It discloses the following information: where they are looking, how long they are looking, how their focus moves from item to item, what parts of the interface they miss, and how parts of the interface effects attention.

Mobile device testing: Testing mobile devices such as phones, tablets, and eReaders requires special equipment and methodology. Since traditional desktop screen-capture software cannot adequately capture touch interactions, usability practitioners have been using strategically placed cameras to record usability test interactions on these mobile devices.

Wireframing: A wireframe is a two-dimensional illustration of a page's interface that specifically focuses on space allocation and prioritization of content, functionalities available, and intended behaviors. For these reasons, wireframes typically do not include any styling, color, or graphics. Wireframes also help establish relationships between various templates.

Card sorting: Card sorting is a method used to help design or evaluate the information architecture of a site. In a card sorting session, participants organize topics into categories that make sense to them and they may also help you label these groups. To conduct a card sort, you can use actual cards, pieces of paper, or one of several online card-sorting software tools. It helps understand users' expectations and understanding of topics.

Prototyping: A prototype is a draft version of a product that allows you to explore your ideas and show the intention behind a feature or the overall design concept to users before investing time and money into development. A prototype can be anything from paper drawings (low-fidelity) to something that allows click-through of a few pieces of content to a fully functioning site (high fidelity).

Personas: Personas are reliable and realistic representations of your key audience segments for reference. These representations should be based on

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[3] http://www.measuringusability.com/blog/standardized-usability.php

qualitative and some quantitative user research and web analytics. Effective personas: represent a major user group, express and focus on the major needs and expectations of the most important user groups, give a clear picture of the user's expectations, aid in uncovering universal features and functionality, describe real people with backgrounds, goals, and values.

Task analysis: Task analysis is the process of learning about ordinary users by observing them in action to understand in detail how they perform their tasks and achieve their intended goals. Tasks analysis helps identify the tasks that your website and applications must support and can also help you refine or re-define your site's navigation or search by determining the appropriate content scope.

Individual interviews: In individual interviews, an interviewer talks with one user for 30 minutes to an hour. Individual interviews allow you to probe their attitudes, beliefs, desires, and experiences to get a deeper understanding of the users who come to your site. You can also ask them to rate or rank choices for site content. These interviews can take place face-to-face, by phone or video conference, or via instant messaging system.

Diary study: Diary Study is a longitudinal technique used in User Experience Research primarily to capture data from participants as they live through certain experiences. There are two types of diary studies: (a) elicitation studies where participants capture media that are then used as prompts for discussion in interviews. The method is a way to trigger the participant's memory. (b) Feedback studies where participants answer predefined questions about events. This is a way of getting immediate answers from the participants.

3 DISCUSSION

Generally speaking, we can say that the results are not encouraging and call for improvement. Figure 1 shows that 35% of the listed tools are used regularly or have at least been tried out by start-ups. This leaves almost two thirds of the UX/HCI tool-set unexplored and unused. One the one hand, we could argue that people with non-designer roles don't need to use these tools on a regular basis, but on the other hand, they should at least be aware of them, given that work in a start-up is often done also outside one's field of expertise. Additionally, some doubt can be shed on the correctness of the results as it is highly improbable that someone never heard of on-line surveys.

More specifically, we can conclude that the most widely used tools are: task analysis, individual interviews, prototyping, wireframing, and on-line surveys, while diary studies, card sorting, first click testing, heuristic evaluation, standardized usability questionnaires, and contextual interviews are rarely used or even unknown.

For a more in-depth analysis on which tools are used by people with different backgrounds or nationalities more data is need.

4 CONCLUSION & FUTURE WORK

A general conclusion is that UX/HCI tools and methods are not as widely known and used as they could be. Given the role that user experience has on modern products and services in the economy, it is important to raise awareness of this discipline. UX is part of the broader field of human-computer interaction and as such it should find more place in HCI curricula across universities (in both technical and non-technical programs). It is also the role of local HCI communities to raise awareness and increase knowledge about these tools by providing on-line resources (educational materials and services, for example ready to use templates for standardized usability questionnaires) and seminars on the topic. For starters, spreading the results of this survey among start-ups would raise awareness of the problem, while the brief descriptions of tools and methods in this paper provide an entry point for those seeking a solution.

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DECISION SUPPORT IN EMERGENCY CALL SERVICE

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ABSTRACT

The emergency call service (telephone number 113) in Slovenia yearly receives more than half million calls. The communication between the caller and the policeman receiving the call is occasionally error prone due to stress and related conditions. From the above it is clear that a reliable operation of communication infrastructure and human resources is a prerequisite for efficient performance In this paper we explore possible ways of improving the emergency call service by providing decision support to the officer who receives the calls and dispatches a patrol to the place of the event.

1 INTRODUCTION

When accepting a call, the police officer writes down the received information using the computer program called Event log of Operation communication centre (ELOCC). The recorded information is then processed by another police officer who faces the following dilemma:

1. How urgent is this event in comparison with others which are already in process or are on standby for dispatch?
2. How many police officers are required for solving the event?

The emergency call service (telephone number 113) in Slovenia yearly receives more than half million calls. In order to handle such a great amount of information and react efficiently to specific circumstances of each individual call highly skilled personnel is required. The user interface of the ELOCC provides means for storing information required for further activities of the centre. The user interface in the current version serves its duty but could be improved by providing additional features such as context-aware forms and decision support. Some initial results of our usability testig of alternative ways of recording information of a call have been reported in [1]. In this paper we explore the possibility of including some kind of decision support to help the officer in disapatch phase.

Currently ELOCC does not have any decision support. The first decision about the priority of an event is made by a police officer in the acceptance phase. He can optionally mark an event as urgent (Figure 1). In 2012, the emergency telephone number 113 has received 496.432 calls to all operation communication centres (OCC) in Slovenia, among them 194.135 calls that needed a police intervention on a place of the event and 9.317 of these calls have been classified as urgent. [2]

Urgent events are all events where eminent danger to a human life or property exists. The crime is still in progress or perpetrators are preparing to do it.

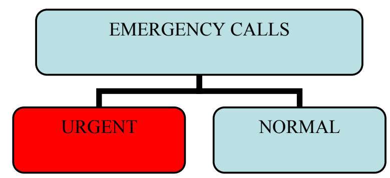

Figure 1. Emergency calls

In our work toward providing some decision support to ELOCC we followed the principles of Multi-Attribute Utility Theory (MAUT) [3]. The model is created in Microsoft Excel and has been developed in conformance with the recommendations presented in [4]. According to [3], the decision support is a part of decision making process. A decision is defined as the choice of one among a number of alternatives. Decision making refers to whole process of making the choice, which includes:

- assessing the problem,
- collecting and verifying information,
- identifying alternatives,
- anticipating consequences of decisions,
- making the choice using sound and logical judgment based on available information,
- informing others of decision and rationale,
- evaluating decisions.

Numerous papers related to the emergency call number 911 in North America as well as papers describing emergency service in other countries have been published. Most of them focus on emergency service infrastructure and management issues, while reports dealing with the problems of processing the incoming calls are relatively few. In [5], local expertise at an emergency call centre is described. The paper is primarily focused on how to combine the knowledge and expertise of the involved personnel in a time effective way. In [6], a case study of design for a police emergency-response system is reported.

The lesson learned of not undertaking a user-centered design process described in the paper gives additional motivation to our work. Higher level emergency operation strategies and solutions are reported in [7], [8]. Decision support issues are described in [9], [10]. However, due to considerable differences in practice they could only serve to some extend as guidelines and not as complete solutions.

2 DEFINING ATTRIBUTES OF THE MAUT MODEL

The process of defining the attributes of the MAUT model implicitly affects the priority of human life. The decree published in Uradni list Republike Slovenije No.63/2013 defines the role of police when protecting certain people and places. The decree gives priority to the life of the president and other people who are mentioned in this decree over the life of an ordinary resident. Implementation in practice is, of course, another story. The police law [11] article 4 defines police tasks in protecting life, personal security and property. In accordance with it we identify the following questions which represent the attributes of our model.

1. Is there endangered life or property?
2. Is the influence on life or propertyof the event in question increasing?
3. Whose life is endangered? (police officer, medical rescue, fire fighter, child, VIP, weak person, etc.)
4. Is there anybody injured?
5. How many people are injured?
6. What kind of injures do they have?
7. Is there anybody dead at the place of event?
8. How many persons are dead?
9. What kind of property is endangered? (national importance, cultural, protected property, etc.)
10. What kind of event has happened? (alarm, murder, other kind of crime, offence, etc.)
11. Will immediate arrival of police secure life of persons or property?
12. Is there some other service more competent to handle this event and is it available?
13. Is the reported event still in progress?
14. Are the perpetrators on the run and must be immediately captured?
15. Are the perpetrators still at the place of the event and are still treating life or property?

In the MAUT model, a weight from 1 to 10 is assigned to each attribute in the preference metric chart. Furthermore, a basic function of usefulness is defined for each attribute. As shown in Figure 2, the function of usefulness of the attributes 1, 2, 4, 7, 11, 12, 13, 14 and 15 has only two values (yes and no). Atribures 3, 5, 6, 8, 9 and 10 have multiple values corresponding to the fact that the related question has multiple possible answers. As an example, the function of usefulness of the attribute 3 is shown in Figure 3.

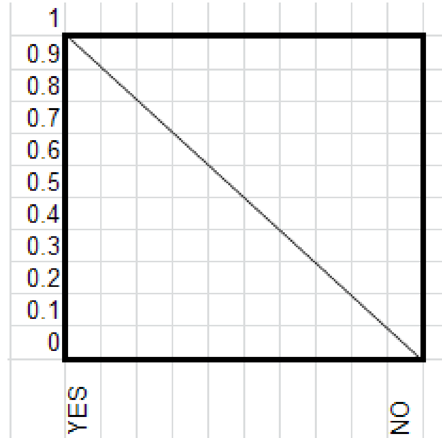

Figure 2: Basic function of usefulness for attributes 1, 2, 4, 7, 11, 12, 13, 14 and 15

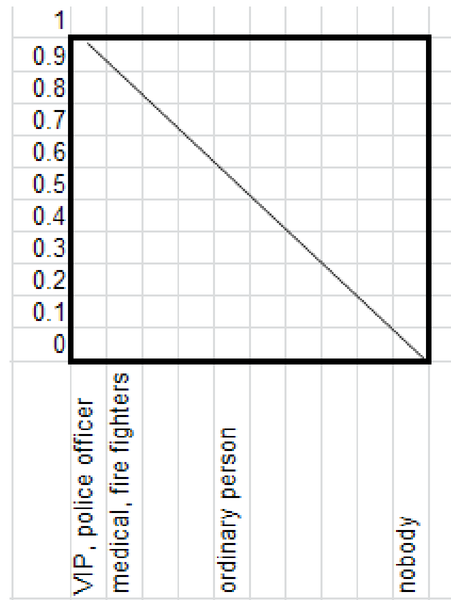

Figure 3: Basic function of usefulness for attribute 3

In order to reduce the number of possible outcomes and consequently to reduce the complexity of the computations we aggregate the attributes into six categories:

- life (attributes 1, 2, 3)
- injuries (attributes 4, 5, 6)
- death (attributes 7, 8)
- event 1 (attributes 10 and 11)
- event 2 (attributes 12 and 13)
- perpetrators (attributes 14 and 15)

In the next step we further aggregate the above categories into the final three:

- life,

- injuries and death,
- event and property.

The resulting model is shown in Figure 4.

3 SCENARIOS AND MODEL CHECKING

In order to evaluate the model we applied a number of scenarios which can happen in real life:
- Murder, Perpetrator has killed his neighbor and called to police to report himself. The crime has ended and there is no other influence.
- Shooting where police officer on duty is involved while he tried to solve the event reported by the urgency call. Nobody is injured at the moment. Attack is still happening.
- Shooting where a non-police person is involved and is calling the police. Nobody is injured at the moment. Attack is still happening.
- Traffic accident on a freeway, with one dead person, many injured (unknown stage of injuries) and leaking dangerous substance. It is a great danger of exposition and for other people to crash into these cars.
- Fight among six people and near is a crowd of hundred people which are hostile to police. Nobody is injured, event is still happening.
- Verbal fight between two neighbors. Nobody injured, event is still happening. They can move to house and end the verbal fight.
- Stolen license plate from a car a few hours ago. The event has ended, nobody is endangered.
- The calling person discovered that somebody has stolen a wallet. Event has ended, nobody is endangered.

The first five events would be classified as urgent, the

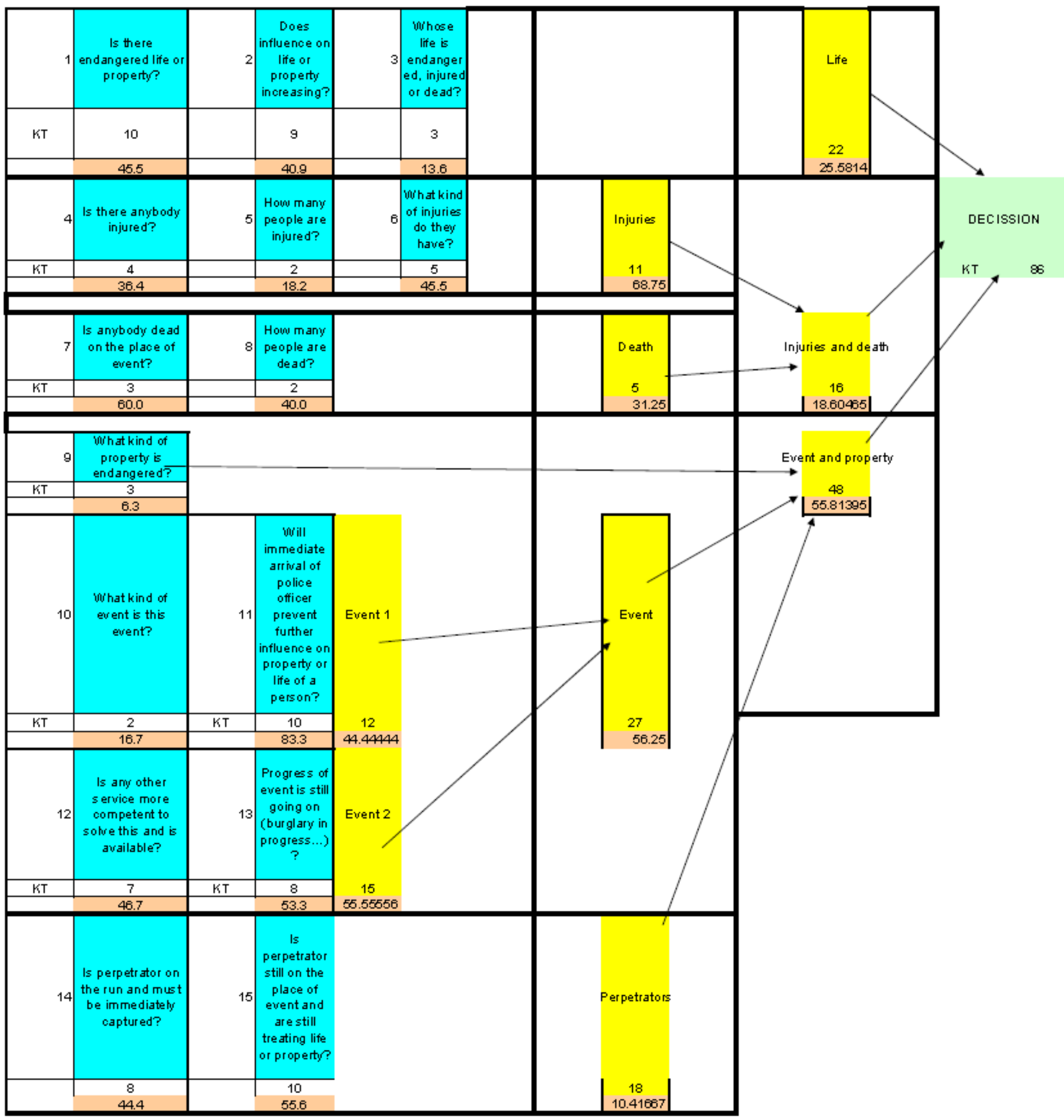

Figure 4: Model structure

last three are normal events and police presence is not immediately required. The question is, to which event a priority should be given in the case that all of them are present at the same time.

Table 1 shows the grades of the events computed using the MAUT model. The resulting priorities of the events corresponding to the computed grades are also shown.

We can see that the most important scenario is a traffic accident, as it should be. We intentionally give in scenario injured people and dangerous substances, which can lead even to greater danger for other people.

The second priority is given to shooting on police officer and third to shooting on a non-police person. We might agree with a result, because the life of a person who is helping others and is in a given situation more important for further solving of the event than some other person.

The fight among six people is on the forth place and before a murder. We again agree with this. Both cases are important, but on the place of event of a murder the police presence can not do anything, except to arrest a perpetrator. But on the place of a fight the police presence can stop the fight and prevent even something worst to happen

Verbal fight is on the sixth place, before stolen license plates and valet, which is again correct. We can see that is a big difference between murder with 0,42 point and verbal fight with 0,181 point.

Finally, the two thefts are placed with 0,097 point. From legal point of view, both thefts are having the same legal categorization.

TABLE I
EVALUATION OF SCENARIOS

Scenario	Grade	Result
1. Murder	0,420	**5**
2. Shooting on police	0,628	**2**
3. Shooting on person	0,610	**3**
4. Fight 6 people	0,597	**4**
5. Traffic accident	0,630	**1**
6. Verbal fight	0,181	**6**
7. Stolen license plate	0,097	**7, 8**
8. Stolen valet	0,097	**7, 8**

5 CONCLUSION

As demonstrated, the developed MAUT model assigns reasonable priorities to the events and might prove to be a useful support in the police dispatch in the case of simultaneous events. A possible application could be as an interactive remainder, which would help the police officer in the acceptance phase to lead conversation and to determine the priority of the event. Its implementation and integration with the existing ELOOC in practice is, however, still an open issue. Any change of such a system obviously requires thorough analysis and preparation. Elaborated case studies nevertheless show that improvements are possible and they can serve as a basis for future strategic decisions.

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MOBILE AND RESPONSIVE WEB APPLICATIONS

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ABSTRACT

Web technology has been a major factor of globalization for years. Modern technology has enabled web applications to be more complex because of greater data transfer speeds. Web quality is something that has come to focus as well as usability as one of its major aspects. Mobile applications have become popular since smartphones have gained greater hardware possibilities. The question that has presented itself is whether web technology can be as good as native mobile technology. The discussion about these two technologies is presented in this paper along with the research about the current popularity and utilization of responsive mobile websites.

1 INTRODUCTION

Web technology has been stable and reliable factor in globalization and communication for years. Rapid development of web technology has brought a wide variety of possibilities and web applications today are able to resemble classic desktop applications in great deal. With increase of data transfer speeds greater design possibilities have been enabled and usability has come to focus.

With the development of smartphones market and advancement in possibilities of mobile operating systems, the mobile applications have become more and more popular. Web technology has responded with responsive web design and rapid advancement in possibilities to mimic mobile applications. The question that has emerged is whether to develop native mobile or web applications and can web applications' interfaces really resemble mobile applications in satisfactory way.

2 USABILITY OF WEBSITES

Globalization as a worldwide trend is closely connected to Internet and development of web technologies. Web as a global media has become one of the most important factors of successful advertisement and other business activities. One of important questions that has been researched is the question about the quality of websites. This quality has been observed through several dimensions: design, content, entertainment, ease of use, reliability, interactivity, security and privacy. [8].

In the past years there was a lot of talk about optimization of websites because of lower data transfer speeds but today with greater speeds of data transfer there are other aspects that deserve more attention such as usability and design of user interfaces.

Many different definitions of usability can be found [4]. ISO 9241 defines usability as: The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [6]. No matter what definition is observed, they all have user at the center of their focus and satisfaction of the user as the main criteria. There are many recommendations on what should be considered to achieve usable design. One of these recommendations proposes the following three principles [5]:

- Early focus on users and tasks
- Empirical measurement
- Iterative design

Early focus on users and tasks presumes a user-centered design in which the user with his expectations is early involved in the development process. Empirical measurement and iterative design mean that developer should test and measure the effectiveness and efficiency of his solution until all issues are resolved.

3 INTERFACE DESIGN AND USABILITY

Another already mentioned aspect that deserves attention is user interface design. User interface includes several elements: navigation, site organization, searching ease, user-controlled navigation, links, cross-platform design, writing style, and multimedia capabilities [8].

Although websites are popular and in mass usage, a lot of them are not well designed [1]. The reason for this could be found in education system in which students of computer science are trained mostly in HTML techniques and modern website design techniques [1], which is not enough to achieve proper design quality and usability. In order to design usable websites one has to understand the site's audience, category, content, usability goals, and how to measure to achieve these goals [1].

It can simply be said that user interface design should answer the questions of who, how and for what purpose will use the interface.

4 RESPONSIVE WEB ON MOBILE PLATFORMS

One of mentioned elements of website usability is cross-platform design. This means that website should be equally usable on different operation systems, different browsers but also different screen sizes and resolutions. The ability of website to adapt to different screen resolutions is today named with the term responsive web or responsive design. In earlier years the term responsive in the context of websites denoted the speed in which the website worked in the terms of human satisfaction [7]. Today, this term has shifted and its primary meaning is the ability of website to adapt its size to the available screen real estate.

This focus on websites' responsiveness is greatly boosted by another rather new industry and that is the one that deals with smartphones and mobile applications. The biggest jump in mobile applications popularity which led to exponential growth of its market was made after the Apple AppStore was launched in 2008. Mobile applications interface was somewhat different from the ones of websites and it was based on widgets, touch, physical motion, and keyboards (physical and virtual) instead on well-known WIMP (Windows, Icons, Menus, Pointer) style [9]. Smaller screens brought many restrictions and design of mobile applications was simplified and minimized in great amount providing the users with quick and simple means to accomplish desired tasks, omitting many functionalities and options that were standard in familiar web applications.

Mobile applications' user interfaces have common elements with web applications, but they are often redesigned to include only the most commonly used functionalities and to make the most out of rather small screens of smartphones as well as to utilize the mobile user interface paradigm which includes various user inputs as well as motion and location information [9].

Web technology has taken into consideration the rising popularity of mobile platforms and it has incorporated another aspect and that is so called responsive web or responsive web design. This kind of design enables website or web application to rewrap, reorder and to adapt to different screen sizes and resolutions rather than having separate mobile version of the same site or application.

In this way developer is able to design a web that will look good on all platforms and which will be more detailed on traditional monitors and more minimalistic and simple on mobile devices which is closer to mobile design paradigm. In time this same technology started to be used to create mobile web applications which are designed to resemble native mobile applications and to serve as a substitution for them. So when confronted with the need to create an application for smartphone and mobile platform, developer can choose to develop in native, web or hybrid technology.

5 RESPONSIVE WEB OR NATIVE APPLICATIONS

The main question remains whether to develop a native or mobile web applications. Native mobile applications enable the developer to make the most out of platform's technology and possibilities but on the other hand developing mobile applications is costly and time consuming process for several reasons: fragmentation, the web, control, and consumer expectations [3].

Fragmentation in mobile world is apparent. There are dozens of platforms, taking into consideration all possible variations, and developing an application which will work equally on all platforms is a very troublesome task. Web technologies are developing rapidly and web is still the area that has the most rapid expansion. Development of additional possibilities and technologies in this areas makes websites and web applications more and more capable to completely resemble native mobile applications. Web is still the only market where developer has all the control over distribution of his product to the users. Control in the area of mobile applications deployment is largely in the hand of third parties. Also, customers expect for all applications to just work fine. This is not the case in many usages of mobile applications on many devices which have problems in rendering mobile applications' interfaces or in not having enough power for fluent mobile applications performance.

All mentioned aspects are not so prominent in the case of web technologies which offer developer possibility to develop everything just once in one technology (cross-platform development) and everything else is just a matter of browsers which are today mostly compliant to new standards and thus have little problems in rendering and executing web applications. This kind of development obviously saves money and time. Another technology that boosts the usage of web mobile applications are responsive CSS frameworks such as Twitter Bootstrap [13], Foundation, Skeleton, HTML5 Boilerplate, HTML KickStart and others [15] which support easier and quicker development of web applications that have the ability to adapt to various screen sizes which is suitable approach for usage on smartphones.

The most commonly mentioned disadvantages of cross-platform development are the speed and inability to utilize the full potential of mobile hardware possibilities. For example, JavaScript code in mobile websites that are fully cross-platform oriented runs sandboxed in WebView which is one of the components that is known to be rather slow. Another problem that is associated with cross-platform development is inexistence of plugins for all needed purposes and a problem with performance when a larger amount of graphics is used. There is also a problem of getting just the right look and feel of mobile applications UI and this is the reason that some developers use the combination of cross-platform core that interacts with native view which results in better looking applications but this approach frequently lacks clear procedures and documentation that describes this kind of interaction.

Research results show that developers feel that there is no universal solution and that all possible approaches (native, web-based or hybrid) are suitable depending on particular application and its demands [14]. Research results also show that web and hybrid approaches are gaining popularity

among developers and that web technology (HTML5 and JavaScript) is developers top choice for building cross-platform applications [14].
The biggest problem for web applications was inability to utilize some features of smartphones' hardware but this is now also starting to be possible as web technology advances. One example of this is project PhoneGap [2] which uses mobile browser which can be instantized programmatically and from this mobile browser instance it is possible to call native code from JavaScript [2]. PhoneGap enables developers to use JavaScript, HTML and CSS to develop their mobile applications and it also enables developers to use advanced mobile hardware features such as accelerometer, geolocation and camera. PhoneGap has been purchased by Adobe in 2011 [10]. Beside PhoneGap that is probably the most popular and awarded cross-platform development framework there are also several other well-known alternatives. Appcelerator Titanium [12] is very popular development environment that is Eclipse-based and that provides a single codebase mobile applications development using JavaScript. The great advantage of this platform is that it supports the usage of native UI components which increases performance of developed mobile applications. MoSync [12] is also Eclipse-like and it provides options of developing mobile applications in either C/C++ or JavaScript/HTML5 codebase. RhoMobile Suite [11] supports development of mobile applications in HTML, CSS, JavaScript and Ruby. Adobe AIR [16] uses HTML, JavaScript, Adobe Flash and Flex as well as ActionScript in order to provide means of building rich mobile applications. Other alternatives for cross-platform development include Xamarin [16] which is C# based, jQuery Mobile [10] and Sencha Touch [10] which are a HTML5-based frameworks that provide means for development of native-like web applications, Corona [12] that uses Lua programming language and Telerik AppBuilder [16] which uses HTML5, CSS and JavaScript codebase. Taking this into consideration and rapid advancement of web technology it can be presumed that in some point it will be possible to completely mimic mobile applications by using web applications and that native mobile application will be absolutely necessary just in some cases such as for example mobile games [3] which require full utilization of smartphone's hardware.

6 RESPONSIVE WEB DESIGN USAGE

Today, responsive web design can be used for one of the following purposes:

- To adapt web design to different monitors and resolutions
- To adapt web design to mobile browsers
- To emulate mobile applications

Currently, the most utilization of responsive design is still in the first two cases. One question that is interesting to answer is whether users actually use responsive features of websites. In the first case it is obvious that users use these features because of different monitor sizes although in this case web design can be fixed according to smallest monitor and resolution that is currently used and this is mostly the case. As already mentioned the third case is still not so common and will be interesting topic for further research but the second case is actual and the question that can be asked is whether users use responsive feature of web design in the way that they use mobile versions of websites or web applications rather that full sites and pinch-to-zoom gestures. The answer to this question shows whether current design and philosophy of mobile websites is sufficient for average visitor or it needs further design alterations.
To answer this question an international research has been conducted on 87 random smartphone users that were approached and asked to answer several questions regarding their mobile web browsing habits. All users that didn't use smartphones were not considered. The research was conducted in Croatia and Slovenia. 54 participants from Croatia and 33 from Slovenia participated in the research. Likert scale was used in all questions (1-strongly disagree, 5-strongly agree). 62 participants were under 40 years old, 48 participants were men and 39 were women. Questionnaire items and results are given in Table 1.

Questionnaire item	Mean	Std. dev.
When I visit websites I immediately switch to full site if mobile version is loaded	3,871	0,749
I prefer mobile versions of websites over full sites	2,028	0,587
Mobile websites are easier to use and I prefer to use them over full sites	2,214	0,423
Full sites are better because of more information that can be seen at once	4,068	0,824
I don't use mobile versions of websites because they lack information and features comparing to full sites	3,687	0,642
I find mobile versions of websites easier to use because of no need to increase or decrease content	1,842	0,481
I would use mobile websites more often if they were richer in content	2,785	0,398
I prefer increasing/decreasing the content in full sites over the need to scroll in their mobile versions	3,414	0,751
I can access information more quickly in full sites than in mobile versions	4,257	0,543

Table 1: *Questionnaire items and results*

The results in Table 1 show that the mobile versions of websites is not something that most of visitors use. According to the research results, the reasons of this can be found in less amount of information that are usually provided in mobile versions and in longer time needed to find information by scrolling than by increasing/decreasing the content. It can be presumed that older population would prefer more simple mobile interfaces with initially enlarged content over full sites as well as more simple navigation of mobile websites which includes only scrolling through the content. This presumption is also supported by research results. Younger population with good eyesight and more dynamic way of living is more keen to use full sites and see all information at once in order to quickly enlarge or choose the content of interest.

Mobile versions of websites and web applications as well as responsive web design is something that is changing the web reality. It also enables web applications to be used on a mobile devices in almost native way and it is something that will probably be seen more and more often. At a present level of usage however, the responsive web that brings mobile versions of websites and web applications is a feature that is not used by majority of users which shows that there is a room for improvement. According to the research results it can be presumed that with further improvement and richer web mobile user interfaces that will be both richer in content and design elements that will resemble native mobile applications in a greater amount, more and more mobile websites will be in mainstream usage as they will provide equivalent experience compared to their full websites counterparts. Web technologies and responsive web is developing rapidly and more and more features can be expected in the near future.

7 CONCLUSION

Web technology has been used for years. With resolution of data transfer issues and various needs for optimization of websites and web applications the usability and interface design has come into focus. Along with web technology, development of more capable smartphone mobile platforms has produced its own mobile applications which have rapidly become very popular. Web technology has responded with responsive web and various possibilities to make web applications that are similar to native mobile applications. With this rapid development of web technology there is even greater meaning of the question whether developers should develop native or web mobile applications. In this paper both alternatives have been discussed along with the research that has shown that web technology in mobile world is promising but at the present moment there is still room for improvement and the majority of user still do not use mobile websites in their everyday usage. Further research about the factors that influence the amount of mobile web applications usage and further comparison of mobile and web technology and their possibilities will be a part of future work.

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