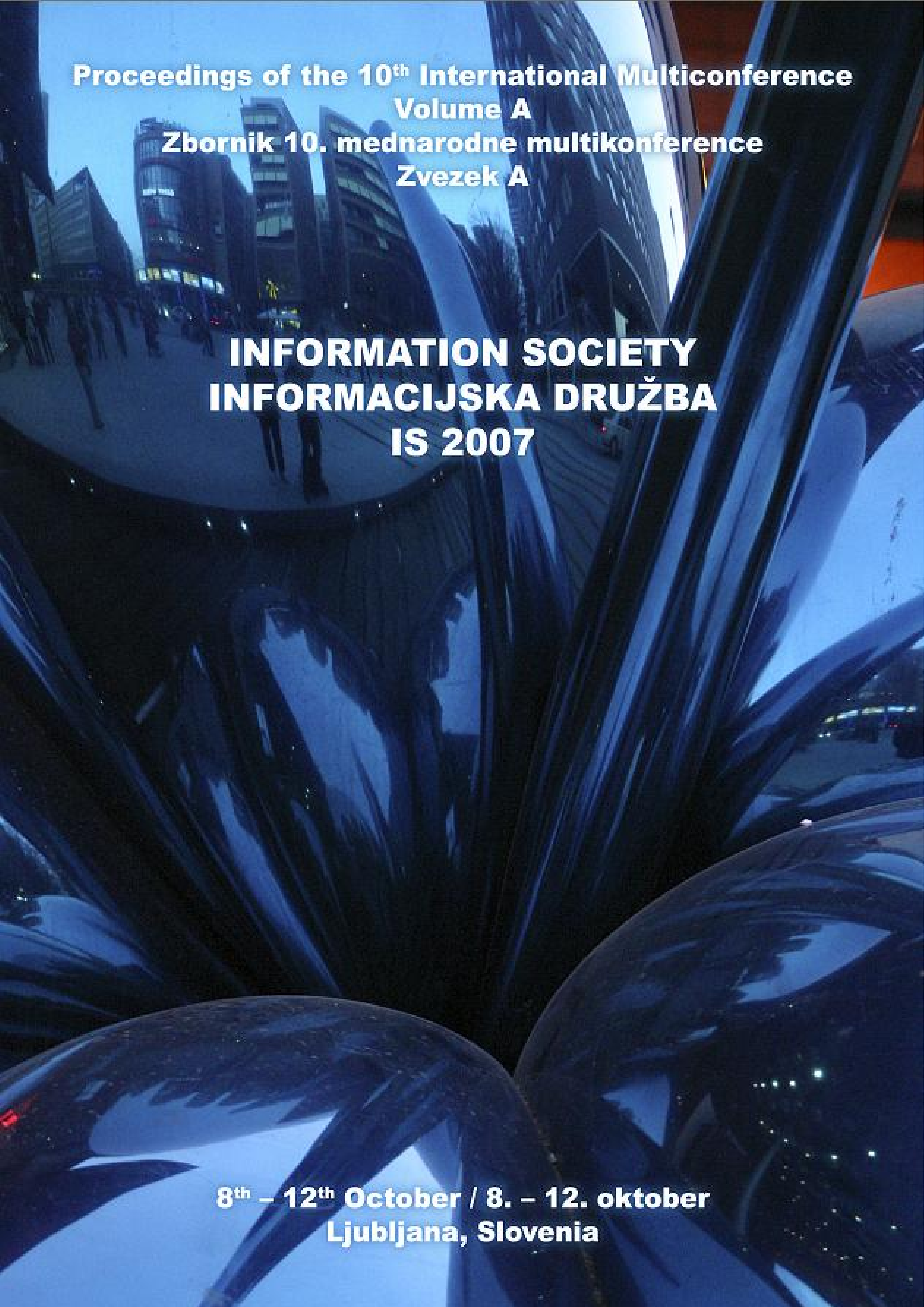


Proceedings of the 10th International Multiconference
Volume A
Zbornik 10. mednarodne multikonference
Zvezek A

INFORMATION SOCIETY
INFORMACIJSKA DRUŽBA
IS 2007

8th – 12th October / 8. – 12. oktober
Ljubljana, Slovenia

Uredniki:

prof. dr. Marko Bohanec
prof. dr. Matjaž Gams

prof. dr. Vladislav Rajkovič
prof. dr. Tanja Urbančič
Mojca Bernik

dr. Dunja Mladenić
Marko Grobelnik

prof. dr. Marjan Heričko

dr. Urban Kordež
prof. dr. Olga Markič

Založnik: Institut »Jožef Stefan«, Ljubljana
Tisk: Birografika BORI d.o.o.
Priprava zbornika: Mitja Lasič
Oblikovanje naslovnice: dr. Damjan Demšar
Tiskano iz predloga avtorjev
Naklada: 100

Ljubljana, oktober 2007

Konferenco IS 2007 sofinancirata
Ministrstvo za visoko šolstvo, znanost in tehnologijo
Institut »Jožef Stefan«

Informacijska družba
ISSN 1581-9973

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

659.2:316.42(063)
659.2:004(063)
004.8(063)

MEDNARODNA multi-konferenca Informacijska družba IS (10 ; 2007 ; Ljubljana)
Zbornik 10. mednarodne multikonference Informacijska družba IS 2007, 8. do 12. oktober 2007 = Proceedings of the 10th International Multiconference Information Society IS 2007, 8th-12th October 2007, Ljubljana, Slovenia / uredili, edited by Marko Bohanec ... [et al.]. - Ljubljana : Institut "Jožef Stefan", 2007. - (Informacijska družba, ISSN 1581-9973)

Vsebina na nasl. str.: Inteligentni sistemi = Intelligent systems ; Vzgoja in izobraževanje v informacijski družbi = Education in information society ; Izkopavanje znanja in podatkovna skladišča = Data-mining and data-warehouses ; Sodelovanje, programi in storitve v informacijski družbi = Collaboration, software and services in information society ; Kognitivne znanosti = Cognitive sciences

ISBN 978-961-6303-94-1
1. Informacijska družba 2. Information society 3. Bohanec, Marko, 1958-
235264512

Zbornik 10. mednarodne multikonference

INFORMACIJSKA DRUŽBA - IS 2007

Zvezek A

Proceedings of the 10th International Multiconference

INFORMATION SOCIETY - IS 2007

Volume A

Inteligentni sistemi
Vzgoja in izobraževanje v informacijski družbi
Izkopavanje znanja in podatkovna skladišča
Sodelovanje, programi in storitve v informacijski družbi
Kognitivne znanosti

Intelligent Systems
Education in Information Society
Data Mining and Data Warehouses (SiKDD 2007)
Collaboration, Software and Services in Information Society
Cognitive Sciences

Uredili / Edited by

Marko Bohanec, Matjaž Gams, Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik, Dunja Mladenić, Marko Grobelnik, Marjan Heričko, Urban Kordeš, Olga Markič

http://is.ijs.si

8. – 12. oktober 2007 / 8th – 12th October 2007
Ljubljana, Slovenia

PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2007

V svojem desetem letu ostaja multikonferenca Informacijska družba 2007 (http://is.ijs.si) ena vodilnih srednjeevropskih konferenc, ki združuje znanstvenike z različnih raziskovalnih področij, povezanih z informacijsko družbo. V letu 2007 smo v multikonferenco povezali šest neodvisnih konferenc. Informacijska družba postaja vedno bolj zapleten socialni, ekonomski in tehnološki sistem, ki je pritegnil pozornost vrste specializiranih konferenc v Sloveniji in Evropi. Naša multikonferenca izstopa po širini in obsegu tem, ki jih obravnava.

Rdeča nit multikonference ostaja sinergija interdisciplinarnih pristopov, ki obravnavajo različne vidike informacijske družbe ter poglabljajo razumevanje informacijskih in komunikacijskih storitev v najširšem pomenu besede. Na multikonferenci predstavljamo, analiziramo in preverjamo nova odkritja in pripravljamo teren za njihovo praktično uporabo, saj je njen osnovni namen promocija raziskovalnih dosežkov in spodbujanje njihovega prenosa v prakso na različnih področjih informacijske družbe tako v Sloveniji kot tujini.
Na multikonferenci, ki bo trajala šest dni, bo na vzporednih konferencah predstavljenih preko 200 referatov, vključevala pa bo tudi okrogle mize in razprave. Referati so objavljeni v zbornikih multikonference, izbrani prispevki pa bodo izšli tudi v dveh posebnih številkah znanstvenih revij, od katerih je ena Informatica, ki se ponaša s 30-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2006 sestavljajo naslednje samostojne konference:

- Inteligentni sistemi
- Vzgoja in izobraževanje v informacijski družb
- Slovenija pred demografskimi izzivi 21. stoletja
- Rudarjenje podatkov in podatkovna skladišča (SiKDD 2007)
- Sodelovanje, programska oprema in storitve v informacijski družbi
- Kognitivne znanosti

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija. Zahvaljujemo se tudi Ministrstvu za visoko šolstvo, znanost in tehnologijo za njihovo sodelovanje in podporo. V imenu organizatorjev konference pa 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 letu 2007 sta se programski in organizacijski odbor odločila, da bosta podelila posebno priznanje Slovencu ali Slovenki za izjemen prispevek k razvoju in promociji informacijske družbe v našem okolju. Z večino glasov je letošnje priznanje pripadlo prof. dr. Ivanu Bratku. Čestitamo!

Viljan Mahnič, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2007

In its 10th year, the Information Society Multiconference (http://is.ijs.si) continues as one of the leading conferences in Central Europe gathering scientific community with a wide range of research interest in information society. In 2007, we organized six independent conferences forming the multiconference. Information society displays a complex interplay of social, economic, and technological issues that attract attention of many scientific events around Europe. The broad range of topics makes our event unique among similar conferences.

The motto of the Multiconference is synergy of different interdisciplinary approaches dealing with the challenges of information society. The major driving forces of the Multiconference are search and demand for new knowledge related to information, communication, and computer services. We present, analyze, and verify new discoveries in order to prepare the ground for their enrichment and development in practice. The main objective of the Multiconference is presentation and promotion of research results, to encourage their practical application in new ICT products and information services in Slovenia and also broader region.
The Multi-Conference is running in parallel sessions for five days with over 150 presentations of scientific papers. The papers are published in the conference proceedings, and in two special journal issues. One of them is Informatica with its 30 years of tradition in excellent research publications.

The Information Society 2007 Multi-Conference consists of the following conferences:

- Intelligent Systems
- Education in Information Society
- Slovenian Demographic Challenges in the 21st Century
- Data Mining and Data Warehouses (SiKDD 2007)
- Collaboration, Software and Services in Information Society
- Cognitive Sciences

The Conference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of ACM. We would like to express our appreciation to the Slovenian Government for cooperation and support, in particular through the Ministry of Higher Education, Science and Technology.

In 2007, the Programme and Organizing Committees decided to award one Slovenian for his/her outstanding contribution to development and promotion of information society in our country. With the majority of votes, this honor went to Prof. Dr. Ivan Bratko. 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 revieewers for their thorough reviews.

Viljan Mahnič, President of the Programme Committee
Matjaž Gams, President of the Organizing Committee

KONFERENČNI ODBORI
CONFERENCE COMMITTIEES

International Programme Committee

Vladimir Bajic, South Africa
Heiner Benking, Germany
Se Woo Cheon, Korea
Howie Firth, UK
Vladimir Fomichov, Russia
Vesna Hljuz Dobric, Croatia
Alfred Inselberg, Izrael
Jay Liebowitz, USA
Huan Liu, Singapore
Henz Martin, Germany
Marcin Paprzycki, USA
Karl Pribram, USA
Claude Sammut, Australia
Jiri Wiedermann, Czech Republic
Xindong Wu, USA
Yiming Ye, USA
Ning Zhong, USA
Wray Buntine, Finland
Bezalel Gavish, USA
Gal A. Kaminka, Israel

Organizational Committee

Prof. dr. Matjaž Gams, chair
Dr. Mitja Luštrek, co-chair
Lili Lasič
Mitja Lasič
Tea Tušar, MSc
Jana Krivec, BSc

Programme Committee

Prof. dr. Viljan Mahnič, chair
Dr. Cene Bavec, co-chair
Dr. Tomaž Kalin, co-chair
Prof. dr. Jozsef Györkös, co-chair
Prof. dr. Tadej Bajd
Jaroslav Berce, MSc
Assist. prof. dr. Mojca Bernik
Prof. dr. Marko Bohanec
Prof. dr. Ivan Bratko
Dr. Andrej Brodnik
Dr. Dušan Caf
Prof. dr. Saša Divjak
Dr. Tomaž Erjavec
Dr. Bogdan Filipič
Prof. dr. Matjaž Gams
Marko Grobelnik
Prof. dr. Nikola Guid
Dr. Marjan Heričko
Prof. dr. Borka Jerman Blažič Džonova
Prof. dr. Gorazd Kandus
Assist. prof. dr. Urban Kordeš
Prof. dr. Marjan Krisper
Andrej Kuščer, MSc
Prof. dr. Jadran Lenarčič
Dr. Borut Likar
Prof. dr. Janez Malačič
Assist. prof. dr. Olga Markič
Dr. Dunja Mladenič
Dr. Franc Novak
Prof. dr. Marjan Pivka
Prof. dr. Vladislav Rajkovič
Dr. Grega Repovš
Prof. dr. Ivan Rozman
Niko Schlamberger, BSc
Prof. dr. Franc Solina
Prof. dr. Stanko Strmčnik
Dr. Tomaž Šef
Dr. Jurij Šilc
Prof. dr. Jurij Tasič
Prof. dr. Denis Trček
Prof. dr. Andrej Ule
Prof. dr. Tanja Urbančič
Prof. dr. Boštjan Vilfan
Prof. dr. David B. Vodušek
Prof. dr. Baldomir Zajc
Prof. dr. Blaž Zupan

KAZALO / TABLE OF CONTENTS

Zbornik 10. mednarodne multikonference

INFORMACIJSKA DRUŽBA - IS 2007

Proceedings of the 10th International Multiconference

INFORMATION SOCIETY - IS 2007

Inteligentni sistemi

Intelligent Systems

Uredila / Edited by

Marko Bohanec, Matjaž Gams

http://is.ijs.si

10. do 11. oktober 2007 / 10 th - 11th October 2007
Ljubljana, Slovenia

Predgovor

Področje inteligentnih sistemov je že prešlo mladostna leta, stabilno in plodovito je že vrsto let. Stalnica je tudi trend: programi čedalje uspešneje opravljajo naloge inteligentnih pomočnikov, hkrati postajajo tudi bistveno bolj komunikativni v smislu govora in mimike. V naše domove prihajajo inteligentni roboti, kot je na primer inteligentni sesalnik, ki so cenovno ugodnejši kot najeta pomoč. Inteligentni sistemi postajajo del naše vsakdanjosti.

Konferenca *Inteligentni sistemi* v letu 2007 ostaja mednarodna in vseslovenska hkrati. Letos posebej izstopajo pristopi, ki temeljijo na uporabi večagentnih algoritmov ter različnih metod analize in vizualizacije podatkov. Predstavljene so tudi konkretne aplikacije na področjih, kot so medicina, okolje, genetika in računalniške igre. Ponovno so posebej razveseljivi prispevki mladih avtorjev, ki se srečujejo s kvalitetnim znanstvenim delom. Večina avtorjev potrjuje, da inteligentni sistemi nudijo pomembne prednosti pri reševanju zahtevnih praktičnih problemov.

Na letošnji konferenci *Inteligentni sistemi 2007* je predstavljenih 26 prispevkov, od tega 15 v angleščini in 11 v slovenščini. Vsi prispevki so bili recenzirani s strani dveh anonimnih recenzentov. Oblikovne pripombe sva prispevala tudi predsednika konference.

Marko Bohanec in Matjaž Gams, predsednika konference

Preface

The area of intelligent systems has matured and become stable, providing useful results for several years. Not only that intelligent systems are becoming more and more advanced intelligent assistants, they are improving their communication skills in terms of speech and expression. Intelligent robots, such as cleaners, enter our homes at affordable costs. Intelligent systems are becoming part of our everyday life.

The conference *Intelligent Systems 2007* remains a national and international event. In this year, the focus is on approaches based in multi-agent algorithms and methods of data analysis and visualisation. Presented are applications in various problem domains, including medicine, environment, genetics and computer games. Particularly promising are contributions of young authors who present interesting practical applications of intelligent systems in different fields. Most of the authors confirm that intelligent systems provide important advantages in the solving of difficult real-life problems.

The proceedings of *Intelligent Systems 2007* includes 26 papers, 15 written in English and 11 in Slovenian. All submitted papers have been reviewed by two reviewers. Some additional suggestions for improvements were also provided by the chairmen of the conference.

Marko Bohanec and Matjaž Gams, conference chairs

PROGRAMSKI ODBOR / PROGRAMME COMMITTEE

Dr. Marko Bohanec, *predsednik*
Institut Jožef Stefan

Dr. Matjaž Gams, *predsednik*
Institut Jožef Stefan

Tomaž Banovec, univ. dipl. inž. Geod.
Statistični urad Republike Slovenije

Dr. Cene Bavec
Univerza na Primorskem, Fakulteta za Management Koper; IBM

Dr. Jaro Berce
Univerza v Ljubljani, Fakulteta za družbene vede

Mag. Marko Bonač,
ARNES

Dr. Ivan Bratko
Univerza v Ljubljani, Fakulteta za računalništvo in informatiko, IJS

Dr. Dušan Caf
Telekom Slovenije

Dr. Aleš Dobnikar
Center Vlade RS za informatiko

Dr. Bogdan Filipič
Institut Jožef Stefan

Dr. Nikola Guid
Univerza v Mariboru, Fakulteta za elektrotehniko računalništvo in informatiko

Dr. Borka Jerman Blažič
Institut Jožef Stefan

Dr. Tomaž Kalin
Ministrstvo za informacijsko družbo

Dr. Thiemo Krink
University of Aarhus

Dr. Marjan Krisper
Univerza v Ljubljani, Fakulteta za računalništvo in informatiko

Dr. Marjan Mernik
Univerza v Mariboru, Fakulteta za elektrotehniko računalništvo in informatiko

DEXiTree:
A PROGRAM FOR PRETTY DRAWING OF TREES

Marko Bohanec
Jožef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773309; fax: +386 1 4773315
e-mail: marko.bohanec@ijs.si

ABSTRACT

This paper presents DEXiTree, a computer program for drawing trees. In principle, DEXiTree is aimed at making nice drawings of attribute trees made by DEXi, a computer program for qualitative multi-attribute decision modelling. Apart from that, DEXiTree is quite a general and powerful tree-drawing program that implements four different tree-drawing algorithms (called *Distribute*, *Align*, *Walker*, and *QP*), draws trees in four different directions (top-down, left-right, bottom-up and right-left) and provides an extensive set of parameters for controlling the appearance of trees and their components. DEXiTree's functionality includes loading a decision model from a DEXi file, interactively designing the tree layout, saving and loading the layout using an XML format, and rendering the drawing in two graphic formats: vector and raster.

1 INTRODUCTION

Trees are a common and very important data structure used in computer science. Trees are used to represent hierarchies such as family trees, organization charts, search trees, taxonomies and file hierarchies. Trees are also heavily used in decision support and decision analysis to represent the structure of models such as decision trees and multi-attribute models.

One such a decision-support computer program is DEXi (Bohanec, 2007). DEXi is aimed at the development of qualitative multi-attribute decision models, which are used in complex real-life decision problems to evaluate and analyse decision alternatives. A multi-attribute model is a hierarchical structure that represents the decomposition of decision problem into subproblems, which are smaller, less complex and possibly easier to solve than the complete problem. In practice, it is essential that such trees are properly visualised so that they could be reviewed by and communicated between DEXi users, and ultimately included in various reports, presentations and publications.

This paper presents DEXiTree, a computer program for drawing DEXi trees. The development of DEXiTree has been directly motivated by DEXi, in particular by its current inability to make nice drawings of multi-attribute models. However, the tree-drawing algorithms implemented in DEXiTree are quite general and could be used for drawing other than just DEXi trees. DEXiTree provides a rich set of parameters for an interactive design of the visual appearance of trees and their components: nodes, arcs and text boxes. DEXiTree is implemented in Borland Delphi and runs under Microsoft Windows. It is publicly available and can be downloaded from http://www-ai.ijs.si/MarkoBohanec/dexitree.html.

This paper is structured as follows. Section 2 describes the four tree-drawing algorithms implemented in DEXiTree. Section 3 presents the functionality of DEXiTree, and section 4 concludes the paper.

2 TREE-DRAWING ALGORITHMS

Tree-drawing algorithms have been extensively studied in the context of graph drawing (Di Battista, et al., 1994; 1999). Although trees have a much simpler structure than general graphs, their drawing – and particularly, "nice" drawing – is far from trivial. The tree layout problem is formulated as follows (Kennedy, 1996): given a labelled tree, assign to each node a position on the page to give an aesthetically pleasing rendering of the tree. We assume that nodes at the same depth are positioned on the same line on the page, so the problem reduces to finding a position horizontally for each node.

A common problem with this setup is that it usually requires a lot of width on the page. The challenge is thus to use the width as effectively as possible, that is, to make trees as narrow as possible. However, this should be combined with the requirement for an "aesthetically pleasing" drawing, which is usually defined by a set of *aesthetic rules* that constrain the node positions in a number of ways:

1. Two nodes at the same level should be placed at least a given distance apart.
2. A parent should be centred over its descendants (lower-level nodes, either immediate descendants or terminal nodes).
3. Drawings should be symmetrical with respect to reflection.
4. Identical subtrees should be rendered identically—their position in the larger tree should not affect their appearance.

The most common approach to the layout problem is the following (Kennedy, 1996). First, draw all the subtrees of a node in such a way that none of the rules are broken. Fit these together without changing their shape (otherwise rule 4 is broken), and in such a way that rules 1 and 3 are satisfied. Finally, centre their parent above them (rule 2). Clearly, this is a recursive algorithm that gradually positions nodes and subtrees in the bottom-up direction.

DEXiTree implements four tree-drawing algorithms, three of which are based on the above schema. The fourth algorithm takes a different approach based on constrained optimisation.

2.1 Algorithm *Distribute*

We call *Distribute* the algorithm that is probably the simplest "meaningful" algorithm that obeys all the aesthetic rules. The algorithm positions all terminal nodes horizontally in their left-to-right order, allocating to each terminal node its natural width and separating adjacent terminal nodes with the required separation distance. This positioning does not take into account the actual level of terminal nodes in the tree. After positioning the terminal nodes, their parents are recursively centred on the levels above.

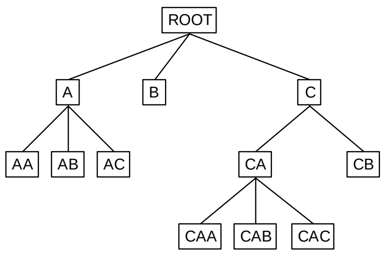


Figure 1: A tree drawn by the *Distribute* algorithm.

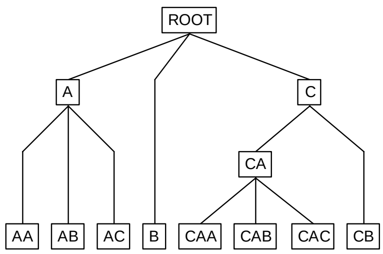


Figure 2: The same tree drawn by *Align*.

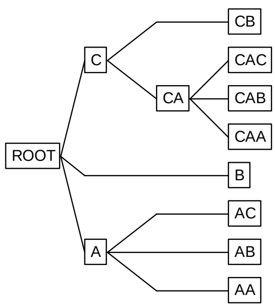


Figure 3: A left-to-right orientation drawn by *Align*.

Figure 1 reveals an obvious disadvantage of *Distribute*: ineffective use of horizontal space. There are too large gaps between the subtrees A and B, B and C, and CA and CB. All these subtrees could have been brought together. This issue is addressed by the algorithm *Walker* (section 2.3). Nevertheless, *Distribute* provides a good basic positioning for a useful variation of the algorithm, called *Align*.

2.2 Algorithm *Align*

The *Align* algorithm is essentially the same as *Distribute*, except that all terminal nodes are brought to the same level at the bottom of the tree (Figure 2). Although this rendition violates rule 4, it has a practical value. Namely, in DEXi, terminal nodes represent input attributes of a multi-attribute model, so it makes sense that they are grouped together and shown at a same level. Also, *Align* is great for drawing trees that are oriented from left (root) to right (terminal nodes), or vice versa. In this case, each terminal node occupies one "line" in the drawing, producing a nice and highly readable layout (Figure 3).

2.3 Algorithm *Walker*

The third algorithm has been originally proposed by Walker (1990). Basically, it is similar to *Distribute*, but it additionally takes into account two important issues:

- Better use of horizontal space, which is achieved by moving subtrees closer together wherever possible (see the subtrees CA and CB, and A and C in Figure 4).
- Handling "orphans", that is, single nodes or small subtrees surrounded by large subtrees and thus having a lot of free space around them (B in Figure 4). These are centred or distributed so as to satisfy rule 3.

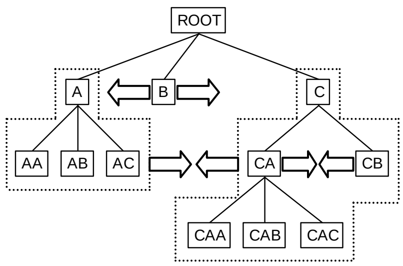


Figure 4: Tree-adjustment operations of *Walker*.

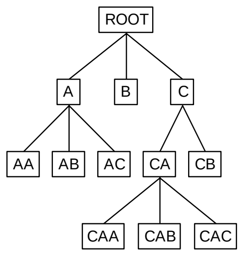


Figure 5: The tree drawn by *Walker*.

The result of these operations performed on our sample tree is shown in Figure 5. Now, the tree is narrower and uses the horizontal space very efficiently.

Walker is one of the best general-purpose tree-drawing algorithms. Its drawings satisfy all the four aesthetic rules. The algorithm is also very efficient: an improved version of the algorithm, proposed by Buchheim, et al. (2002), runs in linear time with respect to the number of nodes.

2.4 Algorithm *QP*

The fourth algorithm takes a different approach and draws trees simulating a physical system composed of wires, pearls and springs. Imagine that nodes are pearls (of appropriate width), sliding on horizontal wires, which represent tree levels. Suppose that pearls are equipped with appropriate "bumpers" so that they always stay sufficiently apart. Finally, let parents and their children be connected by springs. The idea is to construct such a tool, release the pearls ... and see what happens. Eventually, the system will position itself into some, hopefully nice, tree structure.

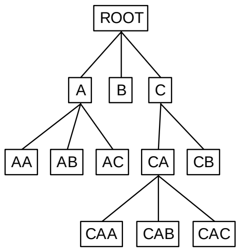


Figure 6: The tree drawn by the *QP* algorithm.

Recently, such approach has been studied for drawing general graphs (Dwyer, et al., 2006). Here, we present our own problem formulation for trees.

Let x_a and y_a denote horizontal and vertical coordinates, respectively, of the centre of some node a. Let the node p be a parent of c. Then, p and c are connected by a spring, whose elastic potential energy E_{pc} is proportional to the squared distance between p and c:

$$E_{pc} \propto d_{pc}^2 = (x_p - x_c)^2 + (y_p - y_c)^2$$

The system will self-organise itself so that the total elastic potential energy E of all springs will be minimal. We assume that the distances between two adjacent tree levels (y_p–y_c) are all equal and constant, so we may discard them from the minimization. The goal is then to minimise the total $E = \Sigma E_{pc}$, which is proportional to

$$\sum_{\forall p,c:\, p \text{ is parent of } c} (x_p - x_c)^2$$

This minimization is subject to constraints: two adjacent pearls placed on a single wire must be separated with at least the node separation distance s. Thus, each pair of adjacent nodes a and b, where a is positioned to the left of b, should satisfy the condition

$$x_b \geq x_a + \tfrac{1}{2} w_a + s + \tfrac{1}{2} w_b$$

where w_a and w_b denote the widths of the respective nodes.

Finally, to guarantee a unique solution, the x coordinate of the root of tree should be set to some constant, typically 0.

In this way, the tree-positioning problem is formulated as a constrained optimisation problem. More precisely, because the objective function is quadratic, this is a quadratic programming (QP) problem (hence the name of the algorithm). In DEXiTree, we use a QP solver based on the Goldfarb-Idnani method (Goldfarb, Idnani, 1983) and adapted from a publicly available Fortran source code of P. Spelluci.

Interestingly, the *QP* algorithm produces very nice and very compact trees, which look "natural" and balanced, even though they generally violate aesthetic rules 2 and 4 (Figure 6). Breaking these rules typically allows *QP* to use horizontal space even better than *Walker*.

3 DEXiTree FUNCTIONALITY

DEXiTree is an interactive Windows program facilitating:

1. Loading a DEXi model from a DEXi (.dxi) file.
2. Interactive design of the drawing (Figure 7) by:
   - choosing between the four algorithms,
   - selecting the drawing direction (section 3.1),
   - modifying drawing parameters (section 3.2).
3. Save the drawing to a file, or copy the drawing to clipboard for transferring it to other programs.

Drawings are rendered in two graphic formats:

- Windows Enhanced Metafile (.emf), which is a vector graphic format, and
- Windows Bitmap (.bmp), a raster graphic format.

In addition, DEXiTree uses its own XML-based ".dxt" file format for storing the current tree structure and drawing parameters. DEXiTree can both load and save these files.

3.1 Tree-Drawing Directions

DEXiTree can draw trees in four different directions: Top-Down, Left-Right, Bottom-Up and Right-Left. The Top-Down direction makes a usual placement so that the root of the tree is shown at the top and subtrees branch downwards. The other three directions respectively correspond to 90-degree counter-clockwise rotations of the tree structure. Displayed text, however, is never rotated.

3.2 Tree-Drawing Parameters

On the right-hand side of its main window (Figure 7), DEXiTree offers an extensive set of parameters for controlling the appearance of trees and their graphical components. In most cases, DEXiTree immediately responds to a parameter change and redisplays the current tree. Parameters are conveniently grouped on two pages, **Tree** and **Node** (Figure 7).

The **Tree** page contains parameters that affect the placement of the tree as a whole:

- horizontal and vertical stretching of the drawing,
- picture borders,
- separation of two adjacent nodes, levels and node boxes,
- parent alignment,
- tree mirroring, and
- background colour of the whole drawing.

The **Node** page controls the display of tree nodes. The user can set drawing parameters individually for each node or collectively for a group of nodes: all nodes, terminal nodes, or internal nodes in the tree.

Node has two subpages, **Graphic** and **Text**. The former defines graphical properties for displaying tree nodes, such as the minimum and maximum dimensions of the node, its shape, colour, line and fill, vertical alignment of nodes, and positioning of the incoming and outgoing arcs. The **Text** page controls the display of text within nodes: internal text borders, text wrapping, clipping and trimming, line spacing for multi-line text, text positioning within a node, and specifying text font.

6 CONCLUSION

DEXiTree is a small, convenient and publicly available software tool that provides four state-of-the-art tree-drawing algorithms. Basically, it is aimed at drawing DEXi multi-attribute trees, but can also be used to draw other types of trees. DEXiTree is highly interactive and responds immediately to parameter changes. Parameter defaults have been designed so that it is easy to produce a useful drawing without too much effort, but the extensive set of parameters allows an advanced user to control almost any aspect of the graphic output. We believe that DEXiTree has also an educational value for the study of tree-drawing algorithms.

Currently, DEXiTree does not offer any tree-editing capabilities and leaves this task to DEXi. In the future, this might be alleviated by an integration of DEXi and DEXiTree. Also, it is likely that DEXiTree will be extended with some other types of tree-drawing layouts, such as radial, indented or cascade.

References

Di Battista, G., Eades, P., Tamassia, R., Tollis, I.G.: Algorithms for Drawing Graphs: an Annotated Bibliography. *Computational Geometry: Theory and Applications* 4, 235–282, 1994.

Di Battista, G., Eades, P., Tamassia, R., Tollis, I.G.: *Graph Drawing: Algorithms for the Visualization of Graphs*, Prentice-Hall, 1999.

Bohanec, M.: *DEXi: Program for Multi-Attribute Decision Making, User's Manual, Version 2.00*. IJS Report DP-9596, Jožef Stefan Institute, Ljubljana, 2007. http://www-ai.ijs.si/MarkoBohanec/dexi.html

Buchheim, C., Jünger, M., Leipert, S.: Improving Walker's algorithm to run in linear time. *Lecture Notes In Computer Science* 2528, Revised Papers from the 10th International Symposium on Graph Drawing, Springer-Verlag, 344–353, 2002.

Dwyer, T., Koren, Y., Marriott, K.: Drawing directed graphs using quadratic programming. *IEEE Transactions on Visualization and Computer Graphics* 12(4), 2006.

Goldfarb, D., Idnani, A.: A numerically stable dual method for solving strictly convex quadratic programs. *Mathematical Programming* 27, 1–33, 1983.

Kennedy, A.J.: Drawing Trees. *Journal of Functional Programming* 6(3), 527–534, 1996.

Walker, J.Q. II: A node-positioning algorithm for general trees. *Software—Practice and Experience* 20(7), 685–705, 1990.

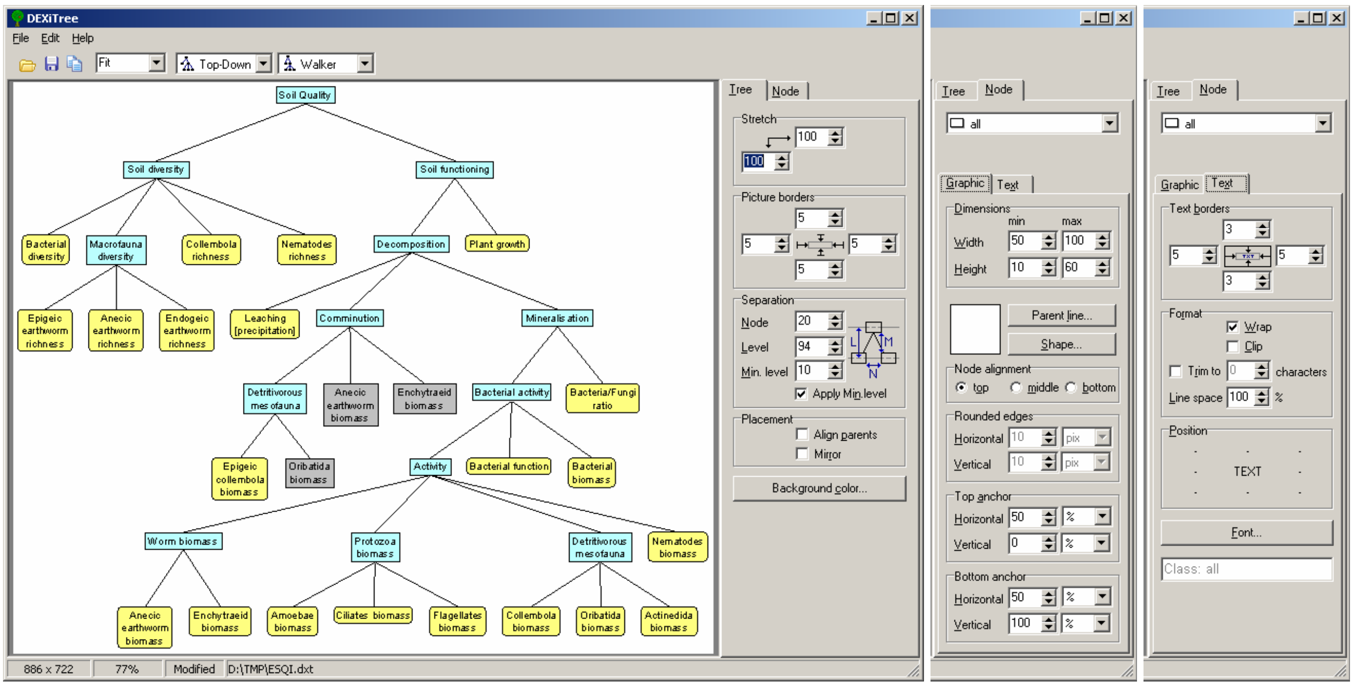


Figure 7: DEXiTree user interface: tree display (left) and tree-drawing parameters (right).

COOPERATIVE MULTIAGENT NEGOTIATION BASED ON THE AGGREGATION/DISAGGREGATION ANALYSIS

Andrej Bregar, József Györkös, Matjaž B. Jurič
Faculty of Electrical Engineering and Computer Science
University of Maribor
Smetanova ulica 17, 2000 Maribor, Slovenia
Tel: +386 2 2207352; fax: +386 2 2207272
e-mail: andrej.bregar@uni-mb.si

ABSTRACT

An approach to multiagent negotiation that is based on the aggregation/disaggregation decision analysis is introduced. Several key issues are addressed, pertaining to the integral negotiation mechanism, convergent consensus seeking protocol, agent architecture, preference elicitation, robustness, visualisation, data interchange and knowledge extraction. In addition, the role of aggregation/disaggregation analysis in automated negotiation processes is discussed.

1 INTRODUCTION

Most decision support and negotiation systems are based on mathematical models [12, 15]. These systems aim at solving semistructured problems by applying various methods from the domain of multiple criteria decision analysis [16], which aggregate values of preferential parameters to deal with one of common problematics – choosing, ranking, classifying or sorting alternatives. A necessary prerequisite for reaching a rational decision is to elicit correct inputs from the decision-maker, which means that a complex preference structure has to be accurately captured. However, this requirement is not realistic in many problem situations. It has been proven that unexperienced people and people under time or knowledge constraints have difficulties in formalizing judgements [5]. It is more convenient for them to directly express decisions instead of providing exact values of formal parametrs. For this reason, traditional preference elicitation techniques can be supplemented or even substituted with the disaggregation approach [1, 7]. Its purpose is to infer optimal parameters of the multiple criteria aggregation model by analysing global preference structures of the decision-maker. Parameters are hence obtained from a set of referential alternatives that are evaluated according to any of four possible problematics.

Preference elicitation becomes considerably more difficult in negotiation processes, in which autonomous agents and/or decision-makers communicate in order to reach a common goal [3, 9, 13]. Because negotiation processes are dynamic, preferences of individual group members should not remain constant, but must iteratively adapt to the collective opinion. Consequently, several requirements have to be considered:

- preference specification must be incremental;
- partial preferential information is initially provided by the decision-makers/agents, while holistic information is obtained during the negotiation process with regard to evaluated alternatives and the efficiency of reaching an agreement;
- the decision-makers/agents have to continuously learn and revise their preferential structures;
- it is impossible to specify credible preferences before the negotiation process starts;
- the negotiation mechanism has to be able to direct the decision-makers/agents towards reaching a consensus, and has to adjust parameter values in accordance with individual and collective assessments of alternatives.

Two similar approaches exist that can, at least to a certain extent, satisfy these requirements – machine learning and the aggregation/disaggregation analysis. However, the first does not enable constructive learning and does not provide an analytically useful representation of the decision model, while the latter has not been applied to agent negotiations yet, and has been integrated into only a few group decision-making methods [4, 10, 11]. The aim of this paper is thus to introduce a cooperative multiagent negotiation mechanism, which is based on the aggregation/disaggregation paradigm and extends an existing consensus seeking procedure [1, 2].

2 NEGOTIATION MECHANISM

The outline of the negotiation mechanism is presented on Figure 1. Although it presumes the participation of decision-makers, their role is reduced to the specification of initial demands and constraints according to which agents search for the optimal feasible solution by defending their personal interests. Once the initial preferences of decision-makers are set, agents can autonomously collaborate and automatically reach a common decision. This means that the mechanism has the following properties [1]: autonomous guidance of the negotiation process with the purpose of eliminating the need for a human moderator who is potentially biased in favour of his own beliefs or against the judgements of group members; conflict resolution; convergence of opinions; low cognitive load on the basis of problem localization [2], disaggregation analysis, extraction of information from XML documents, and specification of standard relative magnitudes of model parameters that are set as approximations of preferences and relieve decision-makers from providing exact inputs at the starting stage of the analysis; thoroughness of analysis; high level of imprecision; high robustness and accuracy; ability of learning; and ability of (a)synchronous interaction.

The disaggregation analysis is used to set parameter values according to evaluated alternatives. Its benefits are:

- The decision-maker is not required to specify initial parameter values. Instead, he is given an opportunity to provide global judgements on a set of alternatives with regard to which he can firmly state his preferences.
- By calculating the degrees of agreement among agents, the negotiation mechanism can determine the direction towards which the common opinion leans. It can then reevaluate unrobustly assessed conflicting alternatives and accordingly adjust preferential parameters in order to iteratively reach uniformity on individuals' views.
- A context for constructive learning is provided through which the perception of the problem can be improved.

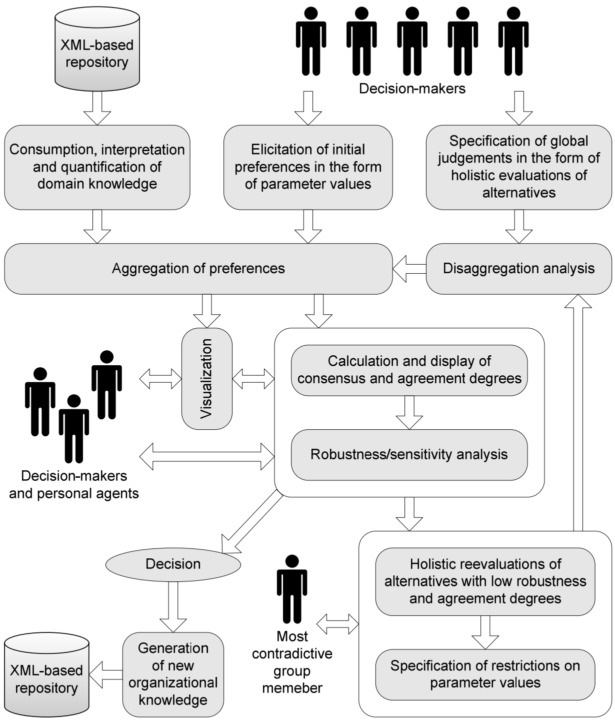


Figure 1: *Negotiation mechanism.*

3 AGENT ARCHITECTURE

The agent negotiation architecture is shown on Figure 3. The central role is given to the analytical and mediation agent. It is responsible for preference aggregation on the individual level; calculation of consensus, agreement, compromise and robustness degrees; adjustment of preferential parameters; negotiation process directing; and accessing the XML-based repository. It communicates with personal agents that are not mutually connected. Each corresponds to a single decision-maker from whom it receives preferential information and requests, and in the name of whom it negotiates.

The centralized architecture has several advantages. As it is far less complex than existing solutions [3], it simplifies the collaboration by eliminating the need for an agent to inform all others about its activities. The number of required inter-agent interactions is therefore decreased. In addition, only the analytical agent must implement the decision-making logic, and has to access the repository. Personal agents are hence thin clients. They merely offer the user interface to decision-makers and ensure that their expectations are met.

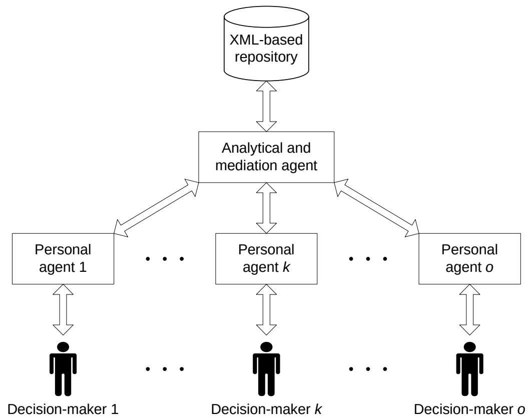


Figure 2: *Agent architecture.*

4 PREFERENCE ELICITATION

The analytical and mediation agent eliminates the need for a moderator. Moreover, the activity of each decision-maker is reduced, so that his only mandatory task is to parameterize the behaviour of its personal agent by specifying the initial values of preferential parameters and permissible deviations that may not be exceeded in the parameter inference process. If preferences are modelled in the form of pseudo-criteria [2], it is possible to elicit this information in several ways:

- by providing holistic evaluations that are transformed into parameters with the disaggregation analysis;
- by setting the exact initial values and the exact lower respectively upper bounds of parameters;
- by determining only the exact lower and upper bounds of allowed intervals, in which case the central points of intervals are taken as the initial parameter values;
- by specifying approximate linguistic modifiers of pre-determined threshold magnitudes.

In the last case, the magnitudes of preferential thresholds are expressed with decibels [14]. The decibel is a dimensionless quantity without any physical units, so it is appropriate for criteria modelling within a wide range of decision problems. It can prevent subjectiveness in judgements, and thereby also potentialy irrational comprehension of imprecision and uncertainty. By extending the concepts of Rogers and Bruen, the magnitudes are predefined as $q_j=\Omega\cdot 2\,\text{dB}$, $p_j=\Omega\cdot 5\,\text{dB}$, $u_j=\Omega\cdot 10\,\text{dB}$ and $v_j=\Omega\cdot 15\,\text{dB}$, where q_j, p_j, u_j and v_j are the indifference, preference, discordance and veto thresholds, respectively, and $\Omega\in\{0.2, 0.4, 0.6, 0.8, 1\}$ is a numerical modifier obtained with a direct transformation of a linguistic influence level $\varsigma\in$ {very weak, weak, moderate, strong, very strong}. Different degrees of influence may be chosen for various thresholds by the decision-maker. He has to specify the initial as well as the lower and upper bound modifiers. Based on these values, the initial, minimal and maximal threshold magnitudes are computed relative to the reference profiles b_j. The j-th indifference threshold is set to:

$$q_j = b_j \cdot \left(e^Q - 1\right), \text{ where } Q = \left(2 \cdot \Omega_j\right) / \left(10 \cdot \log_{10} e\right).$$

Analogously, all other magnitudes are calculated. It is the role of the personal agent to ensure that the decision-maker's requirements are fulfiled. The latter is given the opportunity to revise his preferences in each iteration of the negotiation process. However, he is not obliged to that, because agents are able to proceed without any human interaction.

5 NEGOTIATION PROTOCOL

It is a reasonable assumption that there exist discrepancies between initial preferential structures of agents, which can even increase during the course of analysis. Reaching an agreement about a commonly accepted solution is therefore a hard task. It cannot be solved instantly, but rather requires iterative and progressive adapting of parameters in order to unify the requirements of all involved parties. As the agents strive to reach consensus, their behaviour is cooperative, in the sense that it provides for mutual benefits. The protocol of negotiation is defined by means of an algorithm in which DM_k denotes the k-th decision-maker, PA_k the k-th personal agent and MAA the mediation/analytical agent. The symbols ζ, z and r stand for the agreement, consensus and robustness degrees, respectively, while ξ and ψ are technical thresholds.

```
for each k = 1,...,o
    DM_k specifies initial preferences and allowed deviations
    PA_k transmits initial parameter values to MAA
repeat
    MAA evaluates alternatives for each PA_k
    MAA calculates the ζ_i^k, ζ^k, z_i, Z and r_i^k degrees
    if Z < ξ
        MAA sorts PA_k so that PA_(l) has the l-th lowest ζ^k
        while l ≤ o and conformation = false
            for each i = 1,...,m
                if ζ_i^l < 1/2 and r_i^l < ψ
                    MAA reevaluates a_i
                    reassignment ← true
            if reassignment = true
                MAA inferes new robust values of parameters
                MAA transmits infered values and initial/new
                assessments to PA_(l)
                if allowed deviations of PA_(l) are not violated
                    conformation ← true
                else   // optional
                    DM_(l) reconsiders values and deviations
                    if DM_(l) accepts required adjustments
                        conformation ← true
                        PA_(l) transmits new values to MAA
            if conformation = false
                l ← l + 1
        if l > o and ∃ l' = min l : reassignment = true
            PA_(l') is forced to conformation
until Z ≥ ξ or ∀ k = 1,...,o : reassignment = false
if Z < ξ alternatives are ranked to achieve a compromise
```

An agent is asked to conform to the others with regard to the alternative a_i if a_i is unrobustly assessed and if its evaluation contradicts judgments of more than half agents. The agent that exhibits the lowest agreement degree ζ^k is subjected to conformation. However, if all of its assessments are robust or if the adjusted parameter values violate the k-th decision-maker's constraints, it may be skipped, and the next most discordant personal agent may be chosen to negotiate. It is possible that the analytical and mediation agent must address several personal agents to find the one which is willing to accept the proposed changes. In the worst case, unsuccessful iteration over all personal agents causes the negotiation to terminate without reaching a consensus. A compromise is then made by ranking alternatives in the descending order according to their compromise levels υ_i [2]. If a tie occurs, it is resolved based on the multi-agent robustness degrees Γ_i:

$$a_i \succ a_j \Leftrightarrow \left(\upsilon_i > \upsilon_j\right) \vee \left(\left(\upsilon_i = \upsilon_j\right) \wedge \left(\Gamma_i > \Gamma_j\right)\right),$$
$$a_i \approx a_j \Leftrightarrow \left(\upsilon_i = \upsilon_j\right) \wedge \left(\Gamma_i = \Gamma_j\right).$$

Here, $\succ$ and $\approx$ are preference and indifference relations. Γ_i is obtained as the average of robustness degrees for the i-th alternative and all agents. These degrees are calculated with a nonlinear optimization algorithm [1].

6 ROBUSTNESS AND VISUALISATION

In the negotiation process, unrobustly assessed alternatives are subjected to reevaluation, since a slight modification of preferences generally results in a different decision. For this reason, the interpretation of robustness degrees becomes a prerequisite to correctly adjust parameters and to increase the level of consensus when the process is automated in an agent based setting. Moreover, the ultimate aim of decision analysis is to facilitate decision-makers in learning about the problem [6]. The decision model should therefore provide a means of reflecting back and synthesising judgements, in a manner which aids in understanding how potential decisions are supported. Because initial evaluations are seen as merely a single stage in the process that continues with an extensive robustness analysis, proper metrics are needed to determine:

- the influence of input parameters on the evaluation of alternatives, whereby effects are examined either with the what-if technique or by an automatical increase of parameter values from the lower to the upper bounds of parameter domains;
- the influence of holistic alternative assessments, either automatically inferred or manually set in the form of global judgements, on preferential parameters, by determining for what convex polyhedron of parameter values can an observed alternative be classified into a certain chosen category or ranked in a certain place, for what convex polyhedron an alternative is selected as the only one appropriate, and for which polyhedron intersections two or more alternatives become equal;
- minimal required changes of parameter values that cause reassessments of alternatives, whereby various parameters are considered in isolation or conjointly;
- how close different alternatives are to being unanimously evaluated by all decision-makers with regard to their individual preferences.

Experiences of numerous researchers and practitioners show that multi-dimensional complexity of a problem poses great challanges with regard to robustness/sensitivity analysis, as extensive analyses are difficult to communicate [6]. On the other hand, visual interactive displays are a very powerful means of communication for the majority of people. For this reason, visual tools are necessary to enhance the negotiation process. They provide insight into preferences of individual agents/decision-makers as well as into issues pertaining to the uniformity of the group, and cover all major approaches to visual interactive modelling, giving a user the means to explore sensitivity both thoroughly and in an ad-hoc way:

- All input data is graphically and tabellary displayed, together with corresponding results. Because emphasis is laid on completeness and comprehensiveness, slice, dice, roll-up and drill-down operations are enabled, to give decision-makers an opportunity to concentrate on relevant aspects of problem solving information, and to compare alternatives from different points of view and according to different levels of details.
- Dimensionality of multi-criteria preferences is reduced with the multi-variate statistical principal components analysis, so that information is presented on a plane.
- Primary focus is set on the outcomes. Graphs depict polyhedrons of parameter values for which required assessments of alternatives are obtained. Also, minimal changes of parameters, which result in reevaluations of alternatives, and positions of individual preferences with regard to potential group choices are exposed.

7 XML REPOSITORY AND DATA INTERCHANGE

Quantitative and symbolic decision models should be a part of many contemporary information systems, which support interorganizational or intraorganizational business processes. Such models have to be accessed by a variety of specialized tools, in order to collect and evaluate data from distributed sources. It is therefore a necessity to provide a common standardized framework for their representation, storage and interchange over the world wide web [8]. Hence, an XML schema is defined to specify the terminology for describing negotiation/decision models. It addresses several goals:

- Each personal agent communicates with the analytical and mediation agent via XML-based messages, which is the usual approach to invoke web services.
- Models are represented in a standard notation so that (1.) they can be exchanged with external applications, enabling agents/decision-makers that work on various technological platforms and use various information systems to participate in negotiation processes, and (2.) a means for storing these models is provided, enabling generation of new and consumption of existing organizational knowledge regarding different domains.
- Interchange of different types of decision models is enabled. Although negotiation has the highest relevance in collaborative environments, there can also exist certain workflow activities within the scope of which individual decisions have to be made. A full arsenal of analytic techniques must therefore be available, and knowledge on problem situations in connection with which these techniques are applied must be publically accessible.

Several aspects of decision models are stored in the XML repository – data on personal agents and decision-makers; thresholds; criteria; compromise, consensus, agreement and robustness degrees; alternatives; and implemented choices. Historical data about problem solving processes can be used to extract deep organizational knowledge in all subsequent negotiation situations. Each current problem setting can be compared with existing ones by utilizing fuzzy measures of similarity. If the similarity reaches a specified cut-level, the negotiation mechanism is able to derive reliable conclusions and suggest the optimal decision without going through the process of preference unification at all, or by performing a small subset of otherwise required iterations. Similarity measures and historical knowledge also allow for the assessment of robustness and accuracy of observed alternatives.

8 CONCLUSION

The first automated multiagent mechanism for cooperative negotiation that is based on the aggregation/disaggregation paradigm was introduced. Several coherent methodological solutions were proposed to address all aspects of negotiation processes. Theoretically, these solutions should give rise to many benefits. However, they will have to be experimentally and practically evaluated within the scope of further work.

References

[1] Bregar, A., 2005. Extension of the aggregation/disaggregation principle to computer guided convergent group decision-making processes. In: *Workshop on Decision Support Systems Proceedings*, pp. 95–107.

[2] Bregar, A., et al., 2003. Alternative sorting procedure for interactive group decision support based on the pseudo-criterion concept. *Journal of Systemics, Cybernetics and Informatics* 1 (4) 66–71.

[3] Choudhury, A. K., et al., 2006. Consensus-based intelligent group decision-making model for the selection of advanced technology. *Decision Support Systems* (*DSS*) 42 (3) 1776–1799.

[4] Demart, S., et al., 2006. Supporting groups in sorting decisions. *DSS* doi: 10.1016/j.dss.2006.06.002.

[5] Dias, L., et al., 2002. Aggregation/disaggregation approach to obtain robust conclusions with ELECTRE TRI. *European Journal of Operational Research* (*EJOR*) 138 (2) 332–348.

[6] Hodgkin, J., et al., 2005. Supporting the intelligent MCDA user: A case study. *EJOR* 160 (1) 172–189.

[7] Jacquet-Lagrèze, E., Siskos, Y., 2001. Preference disaggregation: 20 years of MCDA experience. *EJOR* 130 (2) 233–245.

[8] Kim, H., 2001. An XML-based modeling language for the open interchange of decision models. *DSS* 31 (4) 429–441.

[9] Lomuscio, A. R., et al., 2003. Classification scheme for negotiation in e-commerce. *Group Decision and Negotiation* (*GDN*) 12 (1) 31–56.

[10] Matsatsinis, N. F., et al., 2005. Aggregation and disaggregation of preferences for collective decision-making. *GDN* 14 (3) 217–232.

[11] Matsatsinis, N. F., Samaras, A. P., 2001. MCDA and preference disaggregation in group DSS. *EJOR* 130 (2) 414–429.

[12] Power, D. J., Sharda, R., 2007. Model-driven decision support systems: Concepts and research directions. *DSS* 43 (3) 1044–1061.

[13] Raiffa, H., et al., 2002. *Negotiation Analysis: The Science and Art of Collaborative Decision Making*. Belknap Harvard University Press.

[14] Rogers, M., Bruen, M., 1998. Choosing realistic values of indifference, preference and veto thresholds. *EJOR* 107 (3) 542–551.

[15] Shim, J. P., et al., 2002. Past, present, and future of decision support technology. *DSS* 33 (2) 111–126.

[16] Triantaphyllou, E., 2000. *Multi-Criteria Decision Ma-king Methods: A Comparative Study*. Kluwer Academic Publishers, Dordrecht.

INTEGRATED SYSTEM FOR E-MEDICINE IN A DEVELOPING INFORMATION SOCIETY

Ivan Chorbev, Dragan Mihajlov
Institute for Computer Science and Engineering
Faculty of Electrical Engineering and Information Technology
Karpos II, 1000 Skopje, R. of Macedonia
Tel: +389 2 3099156; fax: +389 2 3064262
e-mail: ivan@feit.ukim.edu.mk

ABSTRACT

This paper presents an overview of e-medicine in the world today, and its state in research and implementation in the developing information society in the Republic of Macedonia. There is a review of the recent achievements in e-medicine, telemedicine and the use of artificial intelligence and combinatorial optimization in medical diagnostics and therapy decision-making. The conclusions drawn from the situation abroad are used to propose a similar solution for the growing information society of the Republic of Macedonia. We propose a prototype of an integrated system for e-medicine suitable for the developing information society. Development strategy is presented as well as the expected benefits of the integrated system and the application of combinatorial optimization over the data collected in the information system.

1 INTRODUCTION

E-medicine is a research and application area combining medicine, information technology and telecommunications. In broader sense, e-medicine characterizes technical development in medicine, but also a tendency for global networking in order to increase the quality of service in health services locally, regionally and globally. E-medicine involves application of information and communication technologies over a wide spectrum of functionalities in the health sector, including physicians, diagnostics, therapy, managers, medical insurance and most of all patients.

The organized and structured medical information existing in e-medicine information systems can be used in research, analysis and simulations. A big portion of the research utilizing medical data is performed using algorithms for combinatorial optimization. The first step is creating the mathematical model for the disease. Then the algorithms for combinatorial optimization can be used in simulations to set the diagnosis and to achieve the optimal treatment for the patient.

Along with applying software algorithms in diagnostics, recent advances in telecommunications enable bringing health services closer to patients and bringing medical knowledge closer to the physician in the moments the decisions for diagnosis and therapy are made. In situations where the physician and the patient are not possible to be physically close, telemedicine enables the provision of medical services. Telemedicine is a concept of providing medical services at remote locations using communication and information technologies. In broader sense, telemedicine includes the use of telecommunication technologies in distributing information and expertise needed for provision of health services, cooperation among geographically separated users, including physicians and patients.

The Republic of Macedonia is a developing information society. Besides projects like e-government and e-business, e-medicine should be a major priority in terms of research and implementation. Its successful functioning will increase the quality of health care and overall performance of the health system. This paper describes a prototype of an integrated system for e-medicine suitable for the circumstances and perspective in the Republic of Macedonia.

2 BACKGROUND

There has been continuous work in using computers and artificial intelligence (AI) in solving medical problems and developing health care. One of the earliest researchers, Kulikowski in [21] has explained the gradual introduction of AI in clinical decision-making research. Evolving from pattern recognition and general AI problem-solving ideas, such methods helped researchers crystallize the notions of knowledge-based systems by the mid-1970s. Later, more advanced consultative reasoning systems and more sophisticated knowledge representations came to be. The combination of knowledge representations in terms of constraints and problem solving through heuristic algorithms has been proven as an effective tool in combinatorial optimization. Therefore there are multiple cases of its use in medical research. The authors in [6] and [7] describe various areas of usage of combinatorial optimization in medicine. Areas like set coverage and nonlinear cost functions are taken in consideration. The medical applications described include the development of diagnostic and prognostic systems in cancer research and pulmonology, risk assessment among cardiac patients, and the design of biomaterials.

The authors in [2] describe an implementation of heuristic algorithms for optimization of chemotherapy in cancer treatment. They have used Population Based Incremental Learning (PBIL), which is an Estimation of Distribution Algorithm (EDA), and Genetic Algorithms (GAs) applied to the problem of finding effective chemotherapeutic treatments. In [1] the algorithms for chemotherapy optimization are offered through web services over a distributed environment, providing an example of medical service provision through telecommunication links. In [8] genetic algorithms are used to perform simulations on a model of enzymatic reactions. In [9], a hybrid genetic algorithm and greedy search are used for surface extraction in medical images. In [10] an example is given for a spatial and temporal scheduling system, where constraints modeling and combinatorial optimization are used to schedule patients for hearth surgery.

Besides the wide use of AI and combinatorial optimization in medicine, telemedicine is developing rapidly thanks to the development of communication technologies. Telemedicine is mainly a concept for provision of medical services remotely, but also an important learning and consultation tool. The authors in [11] describe a system for digital broadcasting of surgeries and medical teleconferences in real time. Among other results, the system enables learning of new surgical techniques and different medical interventions remotely. Also, it is easy to perform consultations with subspecialists of a specific medical expertise. With the broader use of wireless telecommunication devices, medical services can be offered over small mobile devices (PDAs, 3G mobile devices). Such study for the quality of service in the wireless telemedicine is given in [12] and [13]. Naturally, security of medical data and maintaining privacy is of major concern in medical information systems. Therefore a security framework for use of handheld devices in medical systems is given in [14].

Interoperability in heterogeneous medical information systems is a key factor in system integration. The interoperability should be maintained on data as well as application level. The service oriented architectures and especially popular web services supported by the standards (UDDI, WSDL и SOAP) are a suitable solution of the interoperability problem among different software platforms. The authors in [15] and [16] describe the use of web services in communication of the components in the system. The described service architecture can be used for communication among diverse external medical systems for transfer of information, use of remote diagnostic tools etc.

There are experimental attempts for remote tracking of the detailed condition of the patients. By using network enabled sensors in the bed of the patient, the vital functions can be monitored remotely via the network. The authors in [17] describe a prototype of a system that integrates the measured values and delivers them to central data storage and processing location. Group decision-making for diagnosis and treatment is already enabled for physically remote physicians. The authors in [18] describe a multimedia system for remote presentation of X-ray images, Computer Tomography etc.

Modern telecommunication technologies are used to decentralize the health services. With direct video links the specialists physicians can offer their services on a remote location, instead of the patients to travel great distances. The authors in [19] describe the public experimental telemedicine system in Brasil, while the authors in [20] describe a similar system in Mexico.

3 THE CURRENT STATE IN THE REPUBLIC OF MACEDONIA

In Macedonia there is no integrated health information and communication system (ICT). There are only individual systems at some of the hospitals. The analysis of the current solutions show significant differences among hospitals, but the overall conclusion is a complete lack of ICT and nonexistence of integrated hospital information systems. The only exception of the general rule is the Ohrid Orthopedic hospital with relatively new computers, functional network and semi integrated hospital information system, functioning throughout the hospital and covering all major workflows. Even there, while blood test results are stored indefinitely in the database, Magnetic Resonance images are erased after handing them out to the patient. Also, it is evident that information systems operating in some facilities will be challenging to integrate and extremely difficult to enable information exchange.

Many of the clinics and institutes work without any ICT support. Advanced hospital systems like the one at the Institute for radiology and oncology are an exception rather than a rule. Generally older systems are based on terminals. Other hospitals use text processing software tools for printing reports and the computers serve as typewriters. Some hospitals have modest Internet links and they often use unlicensed software.

4 ARCHITECTURE OF A HEALTH INFORMATION SISTEM

Health Information and Communication Systems are essential in order to improve efficiency by enabling effective integration and co-operation of health professional resources over time and space. The first generation of health information systems was mainly focused on administrative and accounting functionalities, highly specialized and limited in the information exchange capacity. The second generation information systems broadened the range to support patient admission and certain diagnostical services, incorporating for the first time the integration of procedures. The third generation now in development finalizes the integrative processes. It focuses on the needs of the patient and the professional aspects, in order to develop a homogeneous and consistent set of information.

The first and main task of a health information system is the definition of a standard which will enable network integration of heterogeneous applications. The existing systems must be integrated regardless of the manufacturer and the time of creation.
The system must be modular. The architecture must define the structure of the system as a set of components clearly identifying the goals, range and interactions with the remaining of the system. When the components are thoroughly defined it is possible to change or even replace parts of the system without changing other parts of the system as a hole. The modularity also affects the existing systems in terms of migration toward newer replacements. The existing applications should undergo evolution, and the modular architecture enables incremental replacement and modernization.

4.1 International standards

Standard enable ease of integration of modular systems from different suppliers. They will lower costs and facilitate procurement. Standards are a prerequisite for preventing health hazards like drug hypersensitivity. For instance, many adverse drug reactions could have been avoided if information had been made available on-line that existed in another health institution. Research has shown that appropriate decision support systems with standard interfaces like for instance drug therapy, can decrease sub optimal drug use and reduce costs. Increasing number of Internet user - patients are starting to demand that their medical data should be available on-line, accessible to obtain from whatever source at the point of care, wherever this may be.
Such standard enforced by the European Union is CEN/TC 251. Technical Committee 251 is dedicated to Health Informatics and was established in 1990 [21].
For the system to be fully integrated, all data storage should be standardized. Therefore it is necessary to adopt a standard form of an Electronic Health Record (EHR). Detailed EHRs will enable implementation of Diagnosis Related Groups (DRG). DRGs are used for case classification purposes. In such a classification system every case created in a hospital is associated to a DRG on the basis of case attributes that include patient age, gender, principal and secondary diagnoses and procedures. Having medical data organized and classified in DRGs, it is easy to implement data mining and heuristic algorithms to draw diagnostic and therapeutic conclusions and perform various research efforts. Algorithms are being tested and research is performed on data gathered from different hospitals throughout the world. However, multiple conditions like climate, nutrition habits and diseases are specific to the region of Macedonia and in order to perform research, local standardized data is necessary.

5 IMPLEMENTATION IN MACEDONIA

There are many prerequisites for the integrated e-medicine system to be implemented. Organizational prerequisites include cooperation and communication between district actors in the complex organizational structures. Human resources need to be trained to a level of understanding and familiarity with ICT. Legal prerequisites include regulating patient related information. Major prerequisite for realizing the ICT strategy and making use of the results of the national initiatives is allocation of network resources and IT workstations.
The implementation of an integrated e-medicine system in Macedonia should be gradual, but increasingly fast in order to close the gap with the developed world. The immediate priorities should be deployment of Hospital Information Systems (HIS) in selected hospitals with a strategy for nation-wide deployment. Unified registries and coding systems should be adopted for electronic storage. In the later stages, the primary health care providers should implement ICT so that electronic reporting is fully available. Electronic health card (EHC) should be implemented. The health card can be designed as a microprocessor card that will store data and also enable access to servers. Data can only be accessed if doctors or dentists provide proof of their identity with their electronic Health Professional Card and the patient consents by entering a PIN. Recent scientific papers even suggest RFID skin implants so the patient can be identified and treated even when unconscious.
In the long term, the integrated system should implement Diagnosis Related Groups (DRG) after converting the data into standardized Electronic Health Records (EHR). DRGs as well as EHRs should be copied from the most suitable existing examples in other developed countries. Developed integrated medical information systems will result in numerous standardized records of patient data. With organized data, research can be performed with diseases that are endemic for the region. Using combinatorial optimization, modules will be developed for the integrated system that will serve as diagnosis consultants. Certain data has already been available (blood tests from 70000 patients in the Ohrid Orthopedic hospital) which already serves as simulation input in our research.
The health care system in Macedonia can benefit severely from the use of Artificial Intelligence. Using optimization tools to obtain optimal drug amounts in treatment can reduce the burden on the state health insurance fund. The limited number of existing surgery teams and equipment, kidney dialysis sets, Magnetic resonance imaging devices can be scheduled for use with combinatorial optimization, achieving maximal utilization according to specific patient needs and urgency. However, scattered results in research must be integrated in an e-medicine system for the benefits to be readily available. The modularity will enable every new diagnostic tool to be quickly integrated and delivered to physicians and patients.

6 CONCLUSION

We analyzed the current advances in e-medicine in terms of telemedicine and medical information systems. Also, we gave an overview of the use of artificial intelligence and combinatorial optimization in diagnostics and therapy. The situation of the use of ICT in the health care system in the Republic of Macedonia was also assessed.

The gathered knowledge was used to suggest directions for research and implementation of e-medicine in a developing informational society like the one in Macedonia. We explained the strategy and the expected benefits for the medical personel as well as for the patients. Integration of medical information systems and Artificial Inteligence and data mining tools will drastically improve medical care overall.

References

[1] A. Petrovski, J. McCallSmart. Problem Solving Environments for Medical Decision Support. *Proc. of the 2005 workshops on Genetic and evolutionary computation, pp: 152 - 158,*Washington, D.C.,2005.

[2] A. Petrovski, S. Shakya, J. Mccall, Optimising Cancer Chemotherapy Using an Estimation of Distribution Algorithm and Genetic Algorithms. *Proc. of Genetic and Evolutionary Computation Conference (GECCO2006)*, Seattle WA, July 2006.

[3] P. L. Hammer, T. Bonates, Logical Analysis of Data: From Combinatorial Optimization to Medical Applications, *Annals of Operations Research*, 148:203-225, 2006

[4] C. A. White, E. Nano, D. Nguyen-Ngoc, G. M. White, An Evaluation of Certain Heuristic Optimization Algorithms in Scheduling Medical Doctors and Medical Students, *Proc. of the 6th International Conference on the Practice and Theory of Automated Timetabling PATAT 2006*, pp. 320–328

[5] H. Feldman, M. Triola, ResEval: A Web-based Evaluation System for Internal Medicine House Staff, *Proc. of the 13th international World Wide Web conference* 2004, New York, USA, May 17–22, 2004

[6] O. Johnson and J. Liu, A traveling salesman approach for predicting protein functions, *Source Code for Biology and Medicine 2006, 1:3 doi:10.1186/1751-0473-1-3*

[7] P. L. Hammer, T. Bonates, Logical Analysis of Data: From Combinatorial Optimization to Medical Applications, *Rutcor Research Report*, Rutgers Center for Operations Research, Rutgers University, RRR 10 - 2005, February 2005

[8] S. Özöğür, B. Karasözen, G. W. Weber, Parameter Estimation of Enzymatic Reactions with Genetic Algorithm, August 2005

[9] J. Tohka, Global optimization-based deformable meshes for surface extraction from medical images, *Thesis*, Tampere University of Technology, September 2003

[10] J. Sauer and R. Bruns, Knowledge-Based Scheduling Systems in Industry and Medicine, IEEE Expert: *Intelligent Systems and Their Applications archive*, Volume 12 , Issue 1, Pages: 24 - 31, 1997

[11] N. Nakashima, K.Okamura et.al., Telemedicine with Digital Video Transport System in Asia –PacificArea, *Proc. of the 19th International Conference on Advanced Information Networking and Applications* (AINA’05)

[12] C. Chigan, V. Oberoi, Providing QoS in Ubiquitous Telemedicine Networks, *Proc. of the Fourth Annual IEEE International Conference on Pervasive Computing and Communications Workshops* (PERCOMW’06)

[13] M. D’Souza, M. Ros, A. Postula, Wireless Medical Information System Network for Patient ECG Monitoring, *Proc. of the 9th EUROMICRO Conference on Digital System Design* (DSD'06)

[14] F. Hansen, V. Oleshchuk, Location-based Security Framework for use of Handheld Devices in Medical Information Systems, *Proc. of the Fourth Annual IEEE International Conference on Pervasive Computing and Communications Workshops* (PERCOMW’06)

[15] M. Barhamgi, D. Benslimane, P.A. Champin, A framework for Data and Web Services semantic mediation in Peer-to-Peer based Medical Information Systems, *Proc. of the 19th IEEE Symposium on Computer-Based Medical Systems* (CBMS'06)

[16] V. de Castro, M. L. Sanz, E. Marcos, Business Process Development based on Web Services: a Web Information System for Medical Image Management and Processing, *IEEE International Conference on Web Services* (ICWS'06)

[17] C. O. Rolim, F. L. Koch, et al., Towards a Grid of Sensors for Telemedicine, *Proc. of the 19th IEEE Symposium on Computer-Based Medical Systems* (CBMS'06)

[18] F. Okuyama, T. Hirano, Telemedicine Imaging Collaboration System with Virtual Common Information Space, *Proc. of The Sixth IEEE International Conference on Computer and Information Technology* (CIT'06)

[19] R. S. Maia, A. von Wangenheim, L. F. Nobre, A Statewide Telemedicine Network for Public Health in Brazil, Proc. of the 19th IEEE Symposium on Computer-Based Medical Systems (CBMS'06)

[20] J. M. Lach, R. M. Vázquez, Simulation Model of the Telemedicine Program, *Proc. of the 2004 Winter Simulation Conference*.

[21] C. Kulikowski, Artificial Intelligence in Medicine: A Personal Retrospective on its Emergence and Early Evolution, *Proc. of ACM conf. on History of medical informatics,* Maryland, United States, Page: 199, 1987

[22] http://www.itu.int/itudoc/itu-t/workshop/e-health/addinfo/info005.pdf

WEB-BASED MEDICAL IMAGE RETRIEVAL SYSTEM

Ivica Dimitrovski, Dejan Gorgevik, Suzana Loskovska
Faculty of Electrical Engineering and Information Technology
Ss. Kiril and Methodius
Karpos bb, 1000 Skopje, Mecedonia
Tel: +389 023099159
e-mail: ivicad@feit.ukim.edu.mk

ABSTRACT

Among the applications of computer science in the field of medicine, the processing of medical image data is playing an increasingly important role. With medical imaging techniques such as X-Ray, computer tomography, magnetic resonance imaging, and ultrasound, the amount of digital images that are produced in hospitals is increasing incredibly fast. Thus the need for systems that can provide efficient retrieval of images of particular interest is becoming very high. The two different approaches used for the representation of images are: the metadata-based and the content-based approaches. For very large database personally describing and annotating every image with text indices is time-consuming and impractical. In this paper we propose a content-based image retrieval system with parallel retrieval engines to achieve higher retrieval performance and efficiency.

1 INTRODUCTION

Content-based image retrieval (CBIR) is the digital image searching problem in large databases that makes use of the contents of the images rather than relying on human-input textual information such as captions and key-words [1]. For very large databases or automatically generated (surveillance systems, medicine etc.) images, personally describing and annotating every image is time-consuming and impractical. Rather than relaying on manual indexing and text description for every image, low-level visual features automatically extracted are used for representation of the image content. Content-based image retrieval makes use of the visual contents of an image to represent and index the image. Color, shape, texture, and spatial layout are the typically used contents [2], [3], [4].

The main goal in CBIR system is searching and finding similar multimedia items (in our case images) based on their content. To accomplish this, the content should first be described in an efficient way, e.g. the so-called indexing or feature extraction. Then fast and accurate retrievals among the multimedia collections can be done according to the content description. Figure 1 illustrates a general overview of a CBIR system where "offline" indexing phase is displayed in the bottom part. Usually the visual contents of the images in the database are extracted and described by multidimensional feature vectors. A feature database is formed using the feature vectors of the images in the database. The "online" content-based retrieval is displayed in the upper part. Users provide the retrieval system with query example images, which are used to retrieve images. The system then extracts the feature vectors from the example images. The similarities/distances between the feature vectors of the query example and those of the images in the database are calculated. The online and offline phase interact with a collection of multimedia items (images, videos, etc.) from a multimedia database. The query provided by the user can be an example image, region, sketch, humming, or text [5].

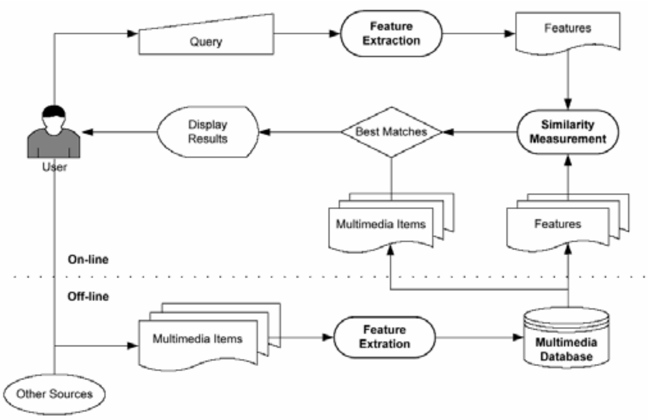


Figure 1: *Overview of general CBMR structure.*

2 APPLICATION OF CONTENT-BASED IMAGE RETRIEVAL IN MEDICINE

Content-based image retrieval is applicable in various areas. One of the potential application area is medical CBIR [6]. The growing number of digital image acquisition and storage systems in clinical routine such as: X-ray, X-ray computed tomography (CT), magnetic resonance (MR), magnetic resonance spectroscopy (MRS), single photon emission computer tomography (SPECT), positron emission tomography (PET), ultrasound, electrical source (ESI), electrical impedance tomography (EIT), rises demands for new access methods. Content-based image retrieval has been proposed by the medical community for inclusion into picture archiving and communication systems (PACS) [6]. The idea of PACS is to integrate imaging modalities and interfaces with hospital and departmental information systems to manage the storage and distribution of images to radiologists, physicians, specialists, clinics, and imaging centers. A crucial point in PACS is to provide an efficient search function to access desired images. The common file format for medical images is DICOM [7], which contains some additional information regarding image modality, acquisition device, and patient identification in its header along with raw image data. Image search in medicine is currently carried out according to the alphanumerical order of textual attributes of images. However, the information which users are interested in is the visual content of medical images rather than that residing in alphanumerical format. The content of images is a powerful and direct query which can be used to search for other images containing similar content. Hence, content-based access approaches are expected to have a great impact on PACS and health database management. In addition to PACS, medical imaging databases that are unconnected to the PACS can also obtain benefits from CBIR technology. CBIR technology can benefit any work that requires the finding of images or collections of images with similar contents. In medical research, researchers can use CBIR to find images with similar pathological areas and investigate their association. In medical education, lecturers can easily find images with particular pathological attributes, as those attributes can imply particular diseases. In addition, CBIR can be used to collect images for medical books, reports, papers, and CD-ROMs based on the educational atlas of medical cells, where typical specimens are collected according to the similarity of their features, and the most typical ones are selected from each group to compose a set of practical calibrators.

3 EXISTING MEDICAL CBIR SYSTEMS

Although content-based image retrieval has frequently been proposed for use in medical image management, only a few content-based retrieval systems have been developed specifically for medical images. These research-oriented systems are usually constructed in research institutes and continue to be improved, developed, and evaluated over time. This section will introduce several major medical content-based retrieval systems.

ASSERT - Automatic Search and Selection Engine with Retrieval Tools [8] is developed by Purdue University, Indiana University, and University of Wisconsin Hospital, USA. The system uses image database form by High-Resolution Computed Tomography (HRCT) of lung. The ASSERT system uses a physician-in-the-loop approach to retrieving images of HRCT of the lung. This approach requires users to delineate the pathology-bearing regions and identify certain anatomical landmarks for each image. This system extracts 255 features of texture, shape, edges, and gray-scale properties in pathology-bearing regions. A multi-dimensional hash table is constructed to index the HRCT images.

CasImage is another medical CBIR system [9]. The system is developed in University Hospital of Geneva, Switzerland. The image Database contains variety of images from CT, MRI, and radiographs, to color photos. The CasImage system, which has been integrated into a PACS environment, contains a teaching and reference database, and the medGIFT retrieval system, which is adapted from the open-source GIFT (GNU Image Finding Tool) [10]. The medGIFT retrieval system extracts global and regional color and texture features, including 166 colors in the HSV color space, and Gabor filter responses in four directions each at three different scales. Combinations of textual labels and visual features are used for medical image retrieval.

IRMA (Image Retrieval in Medical Applications) system [11] developed by Aachen University of Technology, Germany uses various imaging modalities. The IRMA system is implemented as a platform for content-based image retrieval in medical applications. This system splits the image retrieval process into seven consecutive steps, including categorization, registration, feature extraction, feature selection, indexing, identification, and retrieval.

NHANES II (The Second National Health And Nutrition Examination Survey) [12] is a system developed by National Library of Medicine, USA. 17,000 cervical and lumbar spine X-ray images form the database. This system contains the Active Contour Segmentation (ACS) tool, which allows the users to create a template by marking points around the vertebra. If the segmentation of a template is accepted, the ACS tool will estimate the location of the next vertebra, place the template on the image, and then segment it. In data representation, a polygon approximation process is applied for eliminating insignificant shape features and reducing the number of data points. The data obtained in the polygon approximation process represent the shape of vertebra. Then, the approximated curve of vertebra is converted to tangent space for similarity measurement.

3 SYSTEM OVERVIEW

The proposed system has two main parts: a control access module and a content-based indexing and retrieval module. Figure 2 illustrates the overall system architecture. The system is build by ASP .NET, powerful web application framework that can be used for building dynamic web sites, web applications and XML web services. The client module performs validations and basic computing operations such as: query image selection, insertion of images into the archive and displaying the results obtained from the query process. The server module consists of image processing and feature extraction sub module which is basically C++ libraries used for generation of the feature vectors. The Image and Diagnosis DB sub module contains medical images divided in separate classes. The Content-based Retrieval sub module performs the similarity matching between the example image and the images form the database, dataset selection and training. In the following section we will briefly describe the types of features used in our experiments: low resolution pixel map and blob representation which is a middle-level image feature representing shapes of objects.

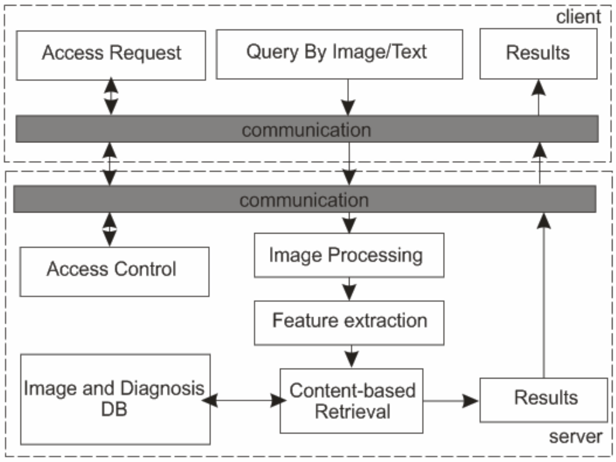


Figure 2: *System architecture.*

3.1 Features

Content-based access to images relies on numerical features that are computed from the pixel values. In our system we use several features for representing texture and shape.

The edge histogram descriptor represents the spatial distribution of five types of edges (four directional edges and one non-directional). It consists of local histograms of these edge directions, which may optionally be aggregated into global or semi-global histograms. The image is divided in 4x4 non-overlapping sub-images where the relative frequencies of five different edge types (vertical, horizontal, 45^0, 135^0, non-directional) are calculated by using 2x2-sized edge detectors for the luminance of the pixels. The descriptor is obtained with a nonlinear mapping of the relative frequencies to discrete values [13].

One of the most popular signal processing based approaches for texture extraction has been the use of Gabor filters. It has been proposed that Gabor filters can be used to model the responses of the human visual system. A range of filters at different scales and orientations allow multichannel filtering of an image into texture features. The feature is built by filtering the image with a bank of orientation and scale sensitive filters and computing the mean and standard deviation of the output in the frequency domain [14].

The use of object shape is one of the most challenging problems in creating efficient CBIR. The object's shape plays a critical role in searching for similar image objects. That shape often carries semantic information follows from the fact that many characteristic objects can be visually recognized solely from their shapes. In our experiments we used the Region-Based Shape Descriptor which is part of the MPEG-7 standard [15]. The region-based shape descriptor uses region moments which are invariant to transformations as the shape feature. It can describe complex objects with multiple disconnected regions as well as simple objects with or without holes. It gives a compact description of multiple disjoint regions simultaneously, allows for splitting of an object during segmentation into disconnected sub-regions, and is robust to segmentation noise (e.g. salt-and-pepper noise).

Figure 3 shows the diagram of the proposed parallel retrieval engines. Every retrieval engine use independent image features and descriptors. The first stage in the retrieval process is evaluation of the results produced by the retrieval engines. The images that are present in the results of half of the retrieval engines are selected as positive results. The next step includes feature fusion and training. The selected image features from the previous stage are mixed to form one feature vector. These positive images and their feature vectors are used to form an initial training sets and the query is expanded using these images. The training phase is done by using SVM [16].

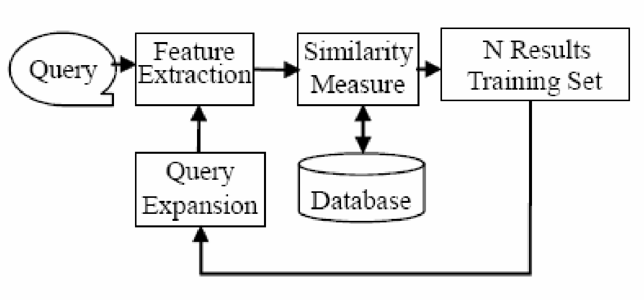


Figure 3: *Query expansion and training dataset formation*

4 RESULTS

Aiming to validate the proposed model through the demonstration of performance and quality gain in the image content retrieval process, a sequence of experiments has been performed. The database that was used in the experiments contains 12.000 images divided in 116 classes. For the expirements we have chosen 20 different query samples. We evaluate the retrieval process by counting the number of positive examples. The obtain results show that the retrival performance is better because by the merging process we eliminate the negative examples that are produced using only single retrieval feature.

5 CONCLUSION

We have created a web-based application for storage, retrieval, manipulation, and annotation of medical images and medical records for the development and evaluation of CBIR methods. The application has ability to input and store multiple feature sets and result sets for each image. The advanced querying capabilities provide rapid analysis and comparisons radiologist techniques, medical image features and CBIR techniques.

References

[1] R. Datta, D. Joshi, J. Li, J.Z. Wang, Image Retrieval: Ideas, Influences, and Trends of the New Age, ACM Transactions on Computing Surveys, Vol. , No. , 20.

[2] D. Zhang and G. Lu, Content-Based Shape Retrieval Using Different Shape Descriptors: A Comparative

Study, Gippsland School of Computing and Information Technology Monash University
[3] Kuen-Long Lee, Ling-Hwei Chen, An efficient computation method for the texture browsing descriptor of MPEG-7, Department of Computer and Information Science, National Chiao Tung University, Taiwan 2004
[4] Shengjiu Wang, A Robust CBIR Approach Using Local Color Histograms, Technical Report TR 01-13, October 2001, DEPARTMENT OF COMPUTING SCIENCE University of Alberta Edmonton, Alberta, Canada
[5] Colin C. Venters, Richard J. Hartley, William T. Hewitt, Mind the Gap: Content-Based Image Retrieval and the User Interface, 2004 Idea Group Inc.
[6] Tobias Weyand, Thomas Deselaers, Combining Content-based Image Retrieval with Textual Information Retrieval, RWTH Aachen October 2005
[7] http://medical.nema.org/
[8] Chi-Ren Shyu, ASSERT: A Physician-in-the-loop Content-Based Retrieval System for HRCT Image Databases, Computer Vision and Image Understanding: CVIUASSERT, 1999
[9] http://pubimage.hcuge.ch/
[10] http://www.gnu.org/software/gift/
[11] http://www.irma-project.org/projekte_en.php?SELECTED=00085
[12] Sameer Antania, Xiaoqian Xub, L. Rodney Longa, George R. Thomaa, Partial Shape Matching for CBIR of Spine X-ray Images, Communications Engineering Branch Lister Hill National Center for Biomedical Communications National Library of Medicine, National Institutes of Health, Bethesda
[13] Abdel-Mottaleb, M.; Krishnamachari, S., Multimedia descriptions based on MPEG-7: extraction and applications Multimedia, IEEE Transactions on Volume 6, Issue 3, June 2004 Page(s): 459 – 468
[14] http://en.wikipedia.org/wiki/Gabor_filterbor
[15] Carla Zibreira, Fernando Pereira, Image Description and Retrieval Using MPEG-7 Shape Descriptors, 4th European Conference, ECDL 2000, Lisbon, Portugal, September 2000.
[16] Amit David, Boaz Lerner, Support vector machine-based image classification for genetic syndrome diagnosis, 2004

ANALIZA KAKOVOSTI FILMOV S PROGRAMSKIM PAKETOM WEKA

Helena Halas
EF, Kardeljeva ploščad 13, 1113 Ljubljana

POVZETEK

Programski paket Weka je bil uporabljen za analizo filmov. Podatki o filmih so bili pridobljeni na spletni strani IMDB, ki je referenčna baza filmskih podatkov. Zaradi velike količine podatkov je bila določena delovna podmnožica s 1894 filmi. Analiza je bila namenjena odkrivanju povezav med različnimi značilnostmi filma, s poudarkom na kvaliteti ter zaslužku. Rezultati so potrdili postavljene hipoteze. Ugotovljene pa so bile še nekatere druge značilnosti.

1 UVOD

Značilnost sodobne informacijske družbe je tudi soočanje s poplavo podatkov. Pridobitev uporabnih informacij iz te neskončne količine podatkov je zato ključnega pomena. Podjetjem lahko prav to zagotovi obstoj na trgu ali pa jim celo prinese konkurenčno prednost. Zasičenost z informacijami je realnost tako poslovnega kot tudi neposlovnega sveta. Zato se pojavlja vse več programskih orodij za obdelavo podatkov ter analizo pridobljenih informacij. Eno izmed teh programskih orodij je tudi programski paket Weka.

Programski paket Weka je bil uporabljen za obdelavo podatkov na temo filmske industrije. Predvidene so bile sledeče povezave:

1. Zaslužek filma je primarno odvisen od razpoložljivega proračuna in popularnosti filmskih igralcev. Film z visokim proračunom je običajno dobro promoviran. V njem nastopajo znani filmski igralci, ki pritegnejo v kinodvorane množice obiskovalcev, ne glede na to ali je film dejansko kvaliteten. Če pogledamo lestvico filmov, ki so dosegli največji zaslužek, lahko opazimo, da v mnogih filmih s tega seznama nastopajo znani filmski igralci, filmi niso omejeni s proračunskimi sredstvi, za njimi stojijo znane produkcijske hiše...

2. Kvaliteta filma je bolj odvisna od zgodbe filma, režiserja, scenarista in ne toliko od igralske zasedbe. Med najbolje ocenjenimi filmi na filmski internetni bazi IMDB se najde tudi veliko filmov, ki imajo popolnoma neznano filmsko zasedbo ter bistveno skromnejši proračun.

Za odkrivanje možnih povezav je bil izbran algoritem za avtomatsko učenje iz družine klasifikatorjev, in sicer konkretno s popularnim drevesnim algoritmom J48.

Uporabljene so bile bolj ali manj privzete vrednosti parametrov algoritma J48, a s previdnim spreminjanjem parametrov confidenceFactor (faktor zaupanja pri rezanju drevesa; manjše vrednosti povzročijo več rezanja) in minNumObj (najmanjše število učnih primerov na list drevesa) je bil doseženo bolj pregledno in smiselno odločitveno drevo ter, seveda, večja klasifikacijska natančnost. Izkazalo se je tudi, da so bolj primerna binarna drevesa (parameter binarySplits).

Za razred je bil enkrat izbran zaslužek filma v ZDA (atribut grossUSA), drugič pa kvaliteta filma, izražena z oceno gledalcev (atribut rating). Rezultati so bili medsebojno primerjani. Pri prvi izbiri razreda (zaslužek filma v ZDA) je bila dosežena največja klasifikacijska natančnost 52.2175%, pri drugi izbiri (ocena gledalcev) pa le 43.717%. Vendar je to predvsem posledica tega, da pri precejšnjem delu učnih primerov (795/1894, kar je približno 42%) manjka podatek o zaslužku v ZDA. Bolj zanimivo kot sama dosežena klasifikacijska natančnost je to, katere atribute je Weka izbrala za najbolj informativne: popularnost filma in državo produkcije pri prvem izbranem razredu (zaslužek filma v ZDA) ter režiserja pri drugem izbranem razredu (ocena gledalcev).

2 IZBIRA DOMENE

Podatki o filmih so bili pridobljeni na spletni strani IMDB (The Internet Movie Database, http://www.imdb.com/), ki je referenčna baza filmskih podatkov. Uporabljen je bil v Javi napisan program, ki je avtomatsko posrkal vse potrebne podatke iz IMDB, jih sfiltriral in predelal v obliko, prepoznavno Weki (.arff format).

Zaradi velike količine podatkov je bilo treba določiti reprezentativno delovno podmnožico, ki ne sme povzročiti popačenja rezultatov. Uporabljena je bila neka primerno raznovrstna že obstoječa baza 1894 filmov.

3 OPIS ATRIBUTOV

Za obravnavo so bili izbrani naslednji atributi:

- ***popularity*** - popularnost filma

tip: numeric
Splošna popularnost filma naj bi odražala, koliko je film poznan javnosti, kako je bil sprejet med ljudmi, koliko in kako se o njem govori in piše itd. To je eden izmed težje določljivih atributov, saj ni eksaktnega pravila za določanje njegovih vrednosti. Za določanje popularnosti je treba

upoštevati splošno javno mnenje in le-to je najlaže najti na internetu.

Najprej je bil uporabljen preprostejši pristop: prešteto je bilo število zadetkov za dani film v spletnih iskalnikih. Prva izbira je bila seveda Google, vendar se je izkazalo, da ima dobro zaščito pred takimi spletnimi pajki (spletni pajek je program, ki samodejno poišče povezave na druge spletne strani in jim sledi, zaradi česar lahko preišče veliko število spletnih strani), kot je bil uporabljen. Drugi poskus je bil Yahoo in tu je šlo. Vendar število zadetkov naslova filma ni zadosti merodajno merilo za popularnost filma, ker se je večina zadetkov pravzaprav nanašala na povsem nepovezane zadeve, ki so bile podobno poimenovane kot obravnavani film.

Za rešitev tega problema je bilo potrebno uporabiti plačljivo inačico IMDB Pro (http://pro.imdb.com/), kamor se je možno poskusno prijavilti za 14 dni. Podatki o filmih in režiserjih so bili s precejšnjimi težavami - imajo namreč kar solidno zaščito s piškotki (piškotek je podatek, ki ga na pobudo spletnega programa shrani spletni brskalnik za kasnejšo uporabo) - preneseni na lokalni računalnik za nadaljnjo obdelavo. S teh shranjenih spletnih strani so bili programsko potegnjeni ven podatki o popularnosti filma (imenovan MOVIEmeter^{TM}), ki so bili spremenjeni tako, da večja vrednost pomeni večjo popularnost (originalno le-ta preprosto pomeni le zaporedno mesto na lestvici popularnosti filmov), z namenom ohraniti konsistentnost med vsemi atributi, pri katerih nastopajo številčne vrednosti.

Uporabljena formula za popularnost:
popularity=1.000.000/MOVIEmeter^{TM}.

- ***year*** - leto proizvodnje

tip: nominal, zaloga vrednosti: {30, 40, 50, 60, 70, 80, 90, 00}
Preprost, eksaktno določljiv atribut, ki pove letnico produkcije filma. Izbrani intervali vrednosti: pred letom 1939, 1940-1949, 1950-1959, 1960-1969, 1970-1979, 1980-1989, 1990-1999, leta 2000 in več.

- ***country*** – država

tip: nominal, zaloga vrednosti: {USA, other}
Tu sta bili izbrani samo dve vrednosti: ZDA in ostalo. Ker je velika večina filmov plod Hollywoodske filmske industrije, bi bilo večje drobljenje nesmiselno.

- ***language*** – jezik

tip: nominal, zaloga vrednosti: {English, French, Spanish, German, Italian, other}
Za razrede je bilo izbranih nekaj bolj razširjenih svetovnih jezikov oz. jeziki, ki se pogosteje pojavljajo v filmih (angleščina, španščina, nemščina, francoščina, italijanščina), vsi ostali jeziki pa so zajeti v kategoriji ostalo.

- ***director*** – režiser

tip: numeric
Po predvidevanjih, bi morala biti kakovost filma vsekakor dokaj odvisna tudi od režiserja. Po podobni poti kot pri naslovu filma, so bili pridobljeni podatki z IMDB Pro tudi za režiserja, in sicer z druge lestvice, imenovane STARmeter^{TM}, na kateri se nahajajo tako igralci kot režiserji. Na lestvico so uvrščeni glede na popularnost, se pravi, glede na zanimanje milijonske množice uporabnikov IMDB-ja za določeno osebo. Tega seveda ne moremo kar enačiti s kakovostjo, je pa najboljši približek, ki se ga je dalo dobiti.

Uporabljena formula za kvaliteto režiserja: director=1.000.000/STARmeter^{TM}.

- ***cast*** - igralski kader

tip: numeric
Igralci naj bi bili pomemben dejavnik za kakovost filma. Tako kot režiserje, tudi igralce najdemo na lestvici STARmeter^{TM}. Ker pa v filmu nastopa večje število igralcev, se tu pojavi vprašanje, koliko igralcev obravnavati ter na kakšen način preračunati skupno popularnost igralskega kadra glede na popularnost posameznih igralcev. Uporabljeni so bili vsi tisti igralci, ki so našteti na prvi strani obravnavanega filma IMDB Pro, to je prvih 15 igralcev, podanih v enakem vrstnem redu, kot na filmski špici. Kasneje se je pokazalo, da je lahko ta vrstni red vir težav, saj se lahko zgodi, da je prvih 15 naštetih igralcev povsem neznanih in torej nebistvenih, kadar so v odjavni špici našteti, recimo, po abecedi ali po vrstnem redu pojavljanja v filmu. A na srečo je velika večina filmskih špic podanih tako, da si igralci sledijo po popularnosti, kar je točno tisto, kar se tukaj potrebuje.

Vsak podatek o posameznem igralcu z lestvice STARmeter^{TM} je bil najprej preoblikovan na podoben način kot podatki o popularnosti filma in kakovosti režiserja, nato pa so bili sešteti skupaj.

Uporabljena formula za kvaliteto posameznega igralca: actor=100.000/STARmeter^{TM}.

Končna vrednost atributa cast pa je enostavno vsota 15 zgornjih vrednosti.

- ***budget*** – proračun

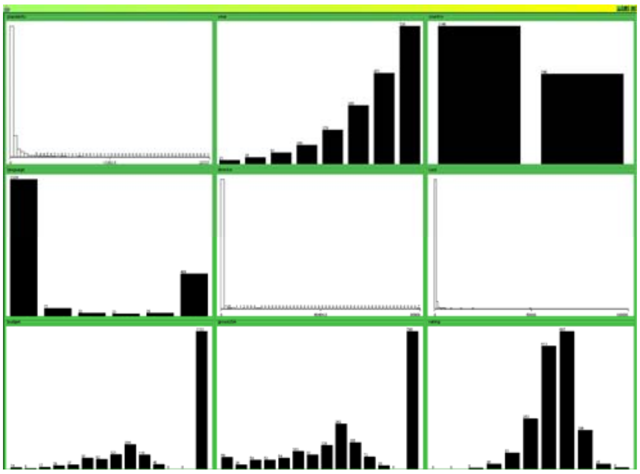
tip: nominal, zaloga vrednosti: {0, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, unknown}
Izbrani intervali vrednosti: pod 100.000 USD, od 100.000 USD do pod 200.000 USD, od 200.000 USD do pod 500.000 USD, od 500.000 USD do pod 1 mio USD, od 1 mio USD do pod 2 mio USD, od 2 mio USD do pod 5 mio USD, od 5 mio USD do pod 10 mio USD, od 10 mio USD do pod 20 mio USD, od 20 mio USD do pod 50 mio USD, od 50 mio USD do pod 100 mio USD, od 100 mio USD do pod 200 mio USD, od 200 mio USD do pod 500 mio USD, od 500 mio USD naprej ter neznano. Oznaka vrednosti intervala je torej dejanska vrednost, izražena v 100.000 USD.

▸ ***grossUSA*** - zaslužek ZDA
tip: nominal, zaloga vrednosti: {0, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, unknown}
Izbrani intervali vrednosti so enaki kot pri proračunu.

▸ ***rating*** - ocena uporabnikov
tip: nominal, zaloga vrednosti: {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, unknown}
Ocene uporabnikov so bile pridobljene na spletni strani IMDB. Ocena je tam izračunana po posebnem algoritmu na podlagi glasov prijavljenih uporabnikov, za katere se lahko po večini predpostavlja, da so dobri poznavalci filmov. Izbrani intervali vrednosti: pod 1, od 1 do pod 2, od 2 do pod 3, od 3 do pod 4, od 4 do pod 5, od 5 do pod 6, od 6 do pod 7, od 7 do pod 8, od 8 do pod 9, 9 -10, neznano.

Opis atributov v Weka .arff formatu je naslednji:

```
@attribute popularity numeric
@attribute year {30, 40, 50, 60, 70, 80, 90, 00}
@attribute country {USA, other}
@attribute language {English, French, Spanish, German, Italian, other}
@attribute director numeric
@attribute cast numeric
@attribute budget {0, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, unknown}
@attribute grossUSA {0, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, unknown}
@attribute rating {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, unknown}
```



Slika 1: *Porazdelitev vrednosti atributovv množici 1894 uporabljenih učnih primerov.*

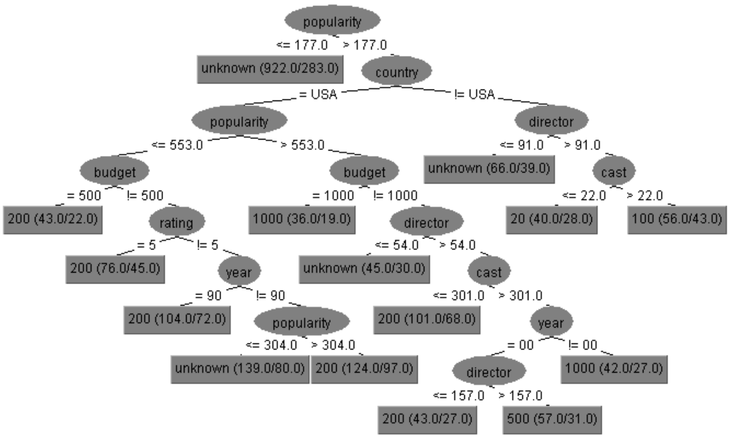
4 REZULTATI

4.1 RAZRED JE ZASLUŽEK V ZDA (grossUSA)

Pri naslednjih nastavitvah parametrov algoritma J48:
- binarySplits: True
- confidenceFactor: 0.25
- minNumObj: 35

je bila dosežena klasifikacijska natančnost 49.1552%.

Očitno je, da pri manj znanih (popularnih) filmih, podatka o zaslužku v ZDA sploh ni (vrednost atributa je »unknown«). Pri bolj znanih filmih nadalje o zaslužku odloča država produkcije. Med ameriškimi filmi spet pride do izraza popularnost. Srednje popularni filmi (med 177.0 in 553.0) niso preveč zanimivi – očitno se njihov zaslužek povečini vrti okrog 20 mio USD. Najbolj popularni filmi (nad 553.0) pa imajo zanimivo vejo pri proračunu, različnem od 100 mio USD (kar dejansko pomeni manjšem od 100 mio, saj v naši množici filmov ni nobenega, ki bi imel proračun nad 100 mio USD). Pri manj znanih režiserjih (<= 54.0) je zaslužek neznan, sicer pa je odvisen od igralske zasedbe, leta produkcije (starejši filmi, pred letom 2000, so znali z nižjim proračunom prinesti več denarja!) in režiserja.



Slika 2: *Odločitveno drevo J48 za razred zaslužek v ZDA ob parametrih –C 0.25 –B –M 35.*

Pri naslednjih nastavitvah parametrov algoritma J48:
- binarySplits: False
- confidenceFactor: 0.02
- minNumObj: 30

je bila dosežena klasifikacijska natančnost 49.0496%.

Zanimivo si je ogledati dobljeno odločitveno drevo, ki tokrat ni binarno. Najbolj informativni atribut, popularnost filma, spet razdeli drevo na dve polovici: manj znane filme, ki sploh nimajo podatka o zaslužku v ZDA, in bolj znane, pri katerih je očitno zaslužek zelo direktno odvisen od proračuna, kar je že po kmečki logiki precej pričakovan rezultat. Na kratko povedano bi lahko ugotovili, da filmi z nižjim proračunom prinesejo relativno več zaslužka, kot pa filmi z višjim proračunom. Vendar je to zelo zavajajoča ugotovitev, saj se naslanja samo na povezavo med atributoma proračun in zaslužek, kar pa očitno ni zadosti. To je bil namen prikaza tega odločitvenega drevesa na sliki 3. (Podano v tekstovni obliki zaradi nepreglednosti grafične oblike.).

popularity <= 177: unknown (922.0/283.0)

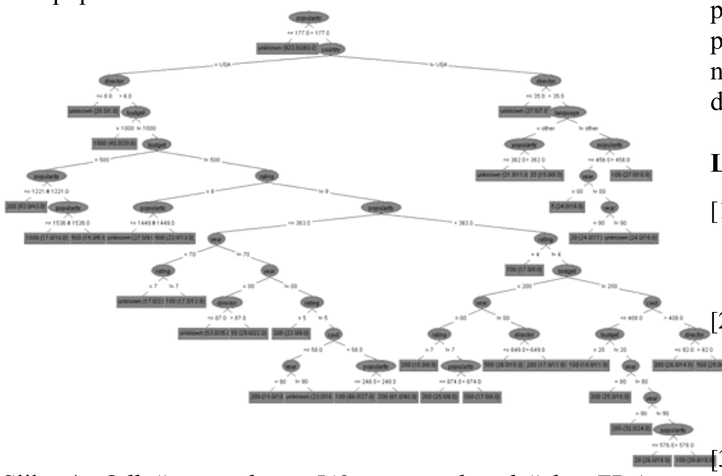
popularity > 177
| budget = 0: 10 (8.0/6.0)
| budget = 1: 20 (2.0/1.0)
| budget = 2: unknown (11.0/4.0)
| budget = 5: 50 (16.0/12.0)
| budget = 10: unknown (22.0/16.0)
| budget = 20: 200 (58.0/43.0)
| budget = 50: 200 (65.0/48.0)
| budget = 100: 200 (102.0/75.0)
| budget = 200: 200 (188.0/122.0)
| budget = 500: 200 (115.0/72.0)
| budget = 1000: 1000 (40.0/20.0)
| budget = 2000: 200 (0.0)
| budget = 5000: 200 (0.0)
| budget = unknown: unknown (345.0/246.0)

Slika 3: *Odločitveno drevo J48 za razred zaslužek v ZDA ob parametrih –C 0.02 –M 30.*

Pri naslednjih nastavitvah parametrov algoritma J48:
- binarySplits: True
- confidenceFactor: 0.2
- minNumObj: 15

je bila dosežena največja klasifikacijska natančnost 52.2175%.

Odločitveno drevo je precej nepregledno. Pravzaprav gre za bolj razdelano verzijo prvega odločitvenega drevesa s slike 2. Tu se med drugim tudi precej lepo vidi, da neameriški filmi preprosto ne prinašajo kaj dosti denarja, z izjemo res zelo popularnih filmov.



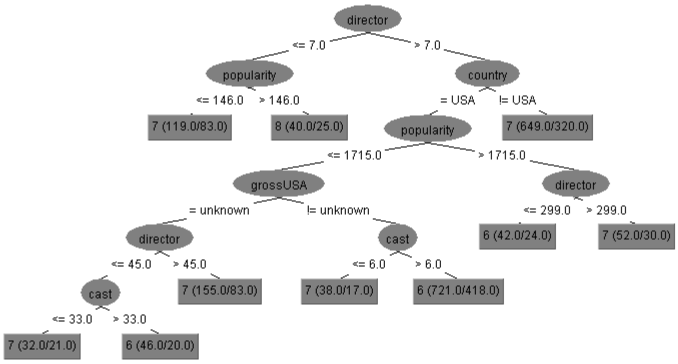
Slika 4*: Odločitveno drevo J48 za razred zaslužek v ZDA ob parametrih –C 0.2 -B –M 15.*

4.2 RAZRED JE OCENA GLEDALCEV, DOBLJENA Z GLASOVANJEM NA SPLETNI STRANI IMDB (rating).

Pri naslednjih nastavitvah parametrov algoritma J48:
- binarySplits: True
- confidenceFactor: 0.06
- minNumObj: 30

je bila dosežena največja klasifikacijska natančnost 43.717%.

Tu je najbolj informativni atribut režiser, kar je povsem v skladu s splošno veljavnim vzorcem, da je režiser tisti, ki vdihne filmu umetniško vrednost in torej naredi film kvaliteten ali pa ne. Odločilni so tudi atributi popularnost filma, država produkcije, zaslužek v ZDA in igralska zasedba.



Slika 4: *Odločitveno drevo J48 za razred ocena gledalcev ob parametrih –C 0.06 –B –M 30.*

5 ZAKLJUČEK

Rezultati so potrdili postavljene hipoteze, da je zaslužek filma primarno odvisen od razpoložljivega proračuna in popularnosti filmskih igralcev, medtem ko je kvaliteta filma bolj odvisna od zgodbe filma, režiserja, scenarista in ne toliko od igralske zasedbe. Na podlagi analize so bile ugotovljene še nekatere druge značilnosti, ki bi jih bilo sicer težko ali celo nemogoče predvideti. S tem smo dobili tudi potrditev o uporabnosti inteligentnih programskih sistemov pri sprejemanju odločitev, ko imamo na razpolago nepregledno množico podatkov in informacij, kar je dandanes tako rekoč vsakodneven pojav.

Literatura in viri

[1]Burian, S., Černelč, M., Gams, M.; Analiza zastav vrednostnih papirjev s programom Weka; KDD d.d., Autocommerce d.d., Inštitut Jožef Štefan, [URL: http://ai.ijs.si/Mezi/pedagosko/seminar-EF6.doc], 06.08.2006
[2]Eibe, F.; WEKA Explorer User Guide for Version 3-4-3; Department of Computer Science, Universitiy of Waikato, New Zeland; [URL: http://weka.sourceforge.net/manuals/ExplorerGuide.pdf], 03.01.2007.
[3]Eibe, F.; Machine Learning with WEKA; Department of Computer Science, Universitiy of Waikato, New Zeland; [URL: http://prdownloads.sourceforge.net/weka/weka.ppt], 03.01.2007.
[4]Gams, M.; Skrivnosti inteligence in zavesti; Inštitut Jožef Štefan, [URL: http://ai.ijs.si/Mezi/pedagosko/IntSisKogni.ppt], 03.01.2007
[5]IMDB Pro, [URL: http://pro.imdb.com]
[6]The Internet Movie Database, [URL: http://www.imdb.com]
[7]WEKA; Universitiy of Waikato, [URL: http://www.cs.waikato.ac.nz/~ml/weka/], 03.01.2007

INTELLIGENT CONTROL OF NUCLEAR REACTORS USING EMOTIONAL LEARNING

Sima Seidi Khorramabadi, Mehrdad Boroushaki
Department of Mechanical Engineering
Sharif University of Technology
Azadi Ave, Tehran, Iran
Tel: +98 916 6609967; fax: +98 21 66165672
e-mail: s_seidi_kh@mehr.sharif.ir

ABSTRACT

A novel approach to reactor power control based on emotional learning is investigated**.** The controller is a neuro-fuzzy system with power and its derivative as inputs. The controller updates its parameters using an emotional learning procedure. A fuzzy critic evaluates the present situation in terms of satisfactory achievement of control goals, and provides the emotional signal (stress). The controller modifies its characteristics so that the critic's stress is decreased. The simulation results show that this intelligent method can control nuclear reactor in a wide variety of transients with no power overshoot and better convergence compared to other methods.

Keywords— Emotional learning, Neuro-fuzzy controller, Nuclear reactor control, Fuzzy critic.

1 INTRODUCTION

Nuclear reactor is a nonlinear and complex system which its parameters change with the power level, fuel burnup …
In recent years great attention has been paid to the topic of intelligent control of different complex nuclear systems (e.g. steam generator, reactor core …) [1], [2], [3], [4]. Fuzzy controllers work well as supervisory controllers in conditions such as severe nonlinearities, time varying parameters or plant uncertainties [5]. Modern intelligent techniques, using neural networks and fuzzy systems, allow to satisfactory handle such a problem with combining the generalization capabilities of the neural networks and decision making capabilities of fuzzy systems [6].

It is widely believed that decision making, even in the case of human agents, is based on full rationality and the emotional cues are suppressed in order not to influence the logic of arriving at proper decisions. The assumption of full rationality, however, has sometimes been abandoned in favor of satisfying or bounded rationality models [7]. In recent years, the positive and important role of emotions has been emphasized not only in psychology, but also in Artificial Intelligence and robotics [6], [8]. In short, emotional cues can provide an approximate method for selecting good actions when uncertainties and limitations of computational resources render fully rational decision-making.

In this research, the idea of using emotional learning is applied to the reactor power control. The control system consists of a neuro-fuzzy controller and a critic, which evaluates the output behavior of the reactor (power) and provides the appropriate signal for the tuning of the controller. Simulation results are provided to show the effectiveness of the proposed methodology.

2 EMOTIONAL LEARNING BASED CONTROL

Emotional learning controller is based on the development of conventional reinforcement learning [9]. This control system includes a critic whose task is to evaluate present operation of controller and to compare it with the desired goals and to produce a continuous stress (emotional) signal (In classical reinforcement learning, reinforcement signal is a binary signal), and a Takagi-Sugeno-Kang (TSK) neuro-fuzzy controller whose weights are regulating during the control process by using the stress signal [10], [11]. The main goal of the control system is to minimize the critic's stress by regulating the TSK controller's weights.

2.1 TSK Neuro-fuzzy Controller

In this research, we have used a TSK neuro-fuzzy system [6] with power error and its derivative as inputs and one output. This fuzzy system has three linguistic labels for each input and therefore has $3^2 = 9$ rules in its rule base. We chose the membership functions to be Gaussian and Sigmoidal. The crisp output in fourth layer is calculated by:

$$y = \frac{\sum_{i=1}^{9} u_i^{\,4}\,(a_i e + b_i e' + c_i)}{\sum_{i=1}^{9} u_i^{\,4}} \quad ,i = 1,2,...,9 \qquad (1)$$

where a_i, b_i and c_i are parameters to be determined via learning and $u_i^{\,4}$ is the fourth layer's input.

2.2 Emotional Critic

In general for a multivariable system, for each output, a critic is assigned. Inputs of the critic are error of the output and its derivative, and its output is the corresponding emotional signal. The emotional signals provided by the critics contribute collaboratively for updating output layer's learning parameters of each controller. The aim of the control system is the minimization of the sum of squared of emotional signals. Accordingly, first we describe the error function E as follows,

$$E = \sum_{j=1}^{m} K_j (r_j^{\,2}/2) \tag{2}$$

where r_j is the output signal of j's critic, Kj is the corresponding output weights and m is the total number of outputs (for the special case of SISO systems, $K_j = 1$ and m=1).

2.3 Weight Updating

The purpose of learning in control is to minimize error signal E, where for adjustment of controller's output layer's weights the steepest decent method is used:

$$\Delta w_i = -\eta_i \frac{\partial E}{\partial w_i} \qquad i = 1, 2, \ldots, n \tag{3}$$

where η_i is the learning rate of the corresponding controller, w_i s are the neural network weights of each controller and n is the total number of controllers. By applying the chain rule we have:

$$\frac{\partial E}{\partial \omega_i} = \sum_{j=1}^{m} \frac{\partial E}{\partial r_j} \cdot \frac{\partial r_j}{\partial y_j} \cdot \frac{\partial y_j}{\partial u_i} \cdot \frac{\partial u_i}{\partial \omega_i} \tag{4}$$

From (2) we have:

$$\frac{\partial E}{\partial r_j} = k_j . r_j \qquad , j = 1, 2 \text{ and } \frac{\partial y_j}{\partial u_i} = J_{ji} \tag{5}$$

where J_{ji} is the element in the ith column and jth row of the Jacobin matrix of the system, and since the system's output increases with increasing the input we can approximate J with its sign. Also we have:

$$e_j = y_{ref} - y_j , \qquad j=1, 2, \ldots, m \tag{6}$$

where e_j is the error produced in the tracking of jth output and y_{ref} is the reference input (desired reactor power).

Since with the incrimination of error, r will also be incremented and on the other hand, on-line calculation of $\partial r_j / \partial e_j$ is accompanied with measurement errors, thus producing unreliable results, only the sign of it (+1) is used in our calculations.

Finally Δw_i will be calculated as follows:

$$\Delta \omega_i = \eta_i \sum_{j=1}^{m} K_j . r_j . J_{ji} \cdot \frac{\partial u_i}{\partial \omega_i} \tag{7}$$

Equation (8) is used for updating learning parameters $a_i s, b_i s$ and $c_i s$ in (1), as follows:

$$a_{i\ new} = a_{i\ old} + \alpha_i r x \frac{u_i^4}{\sum_{j=1}^{n} u_j^4} \tag{8.a}$$

$$b_{i\ new} = b_{i\ old} + \beta_i r y \frac{u_i^4}{\sum_{j=1}^{n} u_j^4} \tag{8.b}$$

$$c_{i\ new} = c_{i\ old} + \gamma_i r \frac{u_i^4}{\sum_{j=1}^{n} u_j^4} \tag{8.c}$$

where $u_i^{\,4}$ is the fourth layer's input in ith rule and α_i, β_i and γ_i are learning rates for each rule.

3 NUCLEAR RECTOR MODEL

In this work a seventh order nonlinear model similar to that used in Ref. [12] is used for simulation of the reactor core. Reactor parameters are similar to a typical PWR type Three Mile Island reactor. Some of the thermal hydraulic parameters, fuel and coolant feedbacks are functions of initial power level at $t = 0$ [12]. To achieve to a more realistic simulation than Ref. [13] the effect of Xenon concentration is also included. Parameters of Xenon concentration equations are similar to Ref. [14].

4 ARCHITECTURE OF THE PROPOSED CONTROLLER FOR NUCLEAR RECTOR

Figure 1 shows the proposed controller structure designed for reactor power control. The inputs of the controller are power error signal and its derivative and its output is multiplied by a gain G_c and thus sets control rod speed z_r. We have set G_c to 0.5.

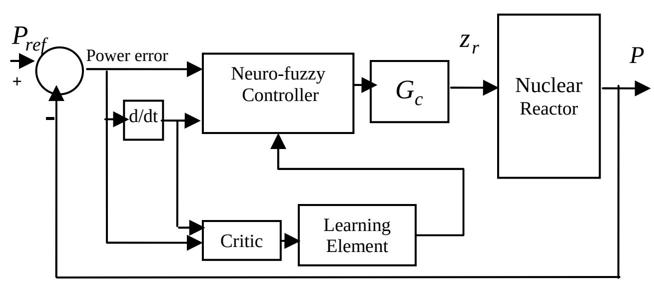


Figure 1: Reactor controller configuration

Designing of the fuzzy critic is an important part of controller synthesis. Inputs of the critic are power error and its derivative, which are used to evaluate the reactor performance. If the power error is positive but its derivative is negative then the performance is proper. Also, if the power error is negative but its derivative negative, critic value will not satisfied the controller behavior.

On the basis of these linguistic descriptions, we designed a fuzzy critic which is a fuzzy system with singleton fuzzifier, product fuzzy inference engine and center average defuzzifier. Table 1 shows nine membership functions used in fuzzy IF-THEN rules of the critic

Table 1: Critic fuzzy rule base

		Power error		
		N	**Z**	**P**
Derivative of power error	**N**	SN	SN	Z
	Z	SN	Z	SP
	P	Z	SP	SP

5 RESULTS AND DISCUSSION

The simulation is performed on the reactor model described in section 3 using MATLAB software. Four different transients used to evaluate the performance of the controller. These cases are similar to the transients considered in Ref. [13]. The reactor and controller parameters were kept fixed in different cases except the control rod worth witch is doubled in the cases C and D.

In all of these cases, our assumptions are:

- The objective is to follow the reference power in reactor
- Initial Takagi-Sugeno rule parameters are chosen randomly.
- Learning rate is a sigmoidal function of time and is chosen to be

$$\eta = 0.03 + 0.009/(1+\exp(-4(t-4)))$$

Case A: *Local Control*

1. $100\% \rightarrow 110\%$ *Step change in power level.*

Figure 2 shows the Emotional Controller response for a $100\% \rightarrow 110\%$ power level demand transient. The desired power is reached quickly and with no overshoot.

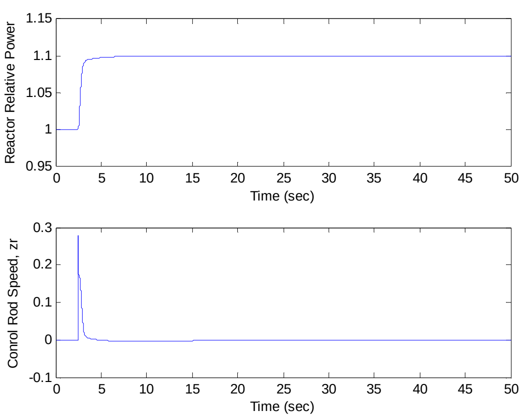


Figure 2: Case A: Local operation $100\% \rightarrow 110\%$ *Step change in power level*

Case B: *Global Operation*

$40\% \rightarrow 50\% \rightarrow 40\%$ Step *change* in power *level*.

Figure 3 illustrates the robustness characteristics to parameters uncertainty resulting from global operation. From the results of these experiments, it is evident that the emotional Controller performs best in the high power region (Figure 2) as compared to the low power region (Figure 3). Although not shown here, regions with lower power level (such as $20\% \rightarrow 10\% \rightarrow 20\%$ change in power level) showed comparable responses.

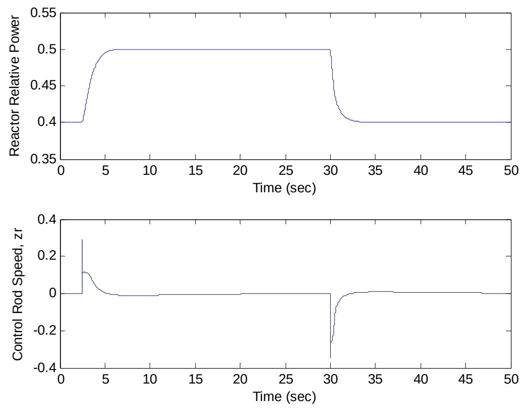


Figure 3: Case B: Global operation $40\% \rightarrow 50\% \rightarrow 40\%$ *Step change in power level*

Case C: *Emergency Operation*

1. $100\% \rightarrow 25\%$ *Huge step change in power level.*

This case represents the most stressed operation. The input signal to the system has a large step change from 100% to 25% of full power. The reactor power shows no overshoot, and this shows that Emotional controller is applicable for a wide range of operating conditions.

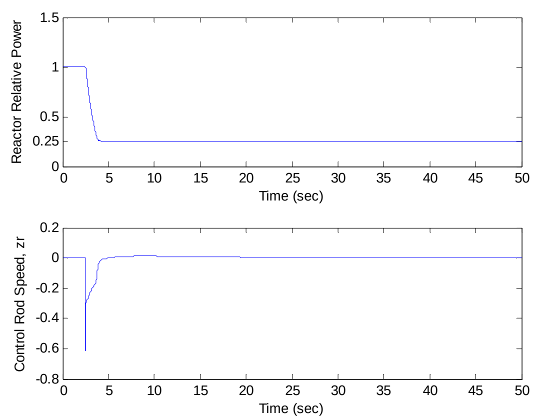


Figure 4: Case C: Emergency operation $100\% \rightarrow 25\%$ *Step change in power level*

Case D: *Shut-down/Start-up*

1. 100% $\rightarrow$ 10% *Ramp change in power level with 15% per minute rate.*

This case mimics the beginning of shut-down/the end of start-up operation with a relatively fast ramp, 15% per minute. In this case the Emotional Controller tracks the input demand signal much better than other cases both in the response shape and in control rod speed range.

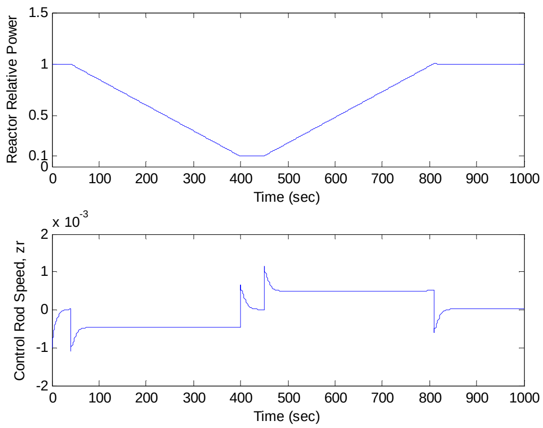


Figure 5: Case D: Shut-down-start-up 100% $\rightarrow$ 10% *Ramp change in power level*

Table 2 shows a comparison in Case A between Emotional Controller and SFAC in Ref. [12]. The difference in maximum control rod speed comes from the reference power signal shape. In most of the researches done in this area only step changes in demand power have been performed, whereas, in real cases ramp changes are used. The sharp step change in the demand power results in an instant peak in control rod speed which is practically difficult to perform with respect to safety considerations. As seen in case D where a ramp change in power demand is applied, maximum control rod speed is about 10^{-3} whereas in the similar transient performed by Ramaswamy et al. [13] the best control rod speed which has been reached is about 5×10^{-3}.

Table 2: Comparison between Emotional Controller and SFAC

	Emotional Controller	SFAC	SFAC with modified P_{ref}
Reactor model	7th order	5th order	5th order
Power overshoot	0	0	~0.13
Convergence time	~5 sec	~40 sec	~50 sec
$zr_{\max}$	~0.3	~0.04	~0.023

6 CONCLUSION

Considering the simplicity of Emotional Controller calculations and its independency from system model, these great results are noticeable. In addition to the cases considered in this work it is apparent that Emotional Controller can control the reactor in any states when the reactor core parameters change. To reduce the peak value of control rod speed, a solution which we can propose is the application of another critic to minimize control action in according to multi agent control.

REFERENCES

[1] K. S. Narendra, K. Parthasarathy, Identification and control of dynamical systems using neural networks, *IEEE Trans. Neural Networks*, 1 (1), 4-27, 1990.

[2] H. L. Akin, V. Altin, Rule-based fuzzy logic controller for a PWR-type nuclear power plant, *IEEE Trans. Nucl. Sci*., 38 (2), 883-890, 1991.

[3] B. H. Cho, H. C. No, Design of stability and performance robust fuzzy logic gain scheduler for nuclear steam generators, *IEEE Trans. Nucl. Sci.*, 44(3), 1431-1441, 1997.

[4] M. G. Na, B. R. Upadhyaya, A neuro-fuzzy controller for axial power distribution in nuclear reactors. *IEEE Trans. Nucl. Sci.*, 45 (1), 59-67, 1998.

[5] C. Von Altrock and J. Gebhardt, Recent successful fuzzy logic applications in industrial automation, *Proceedings of the fifth IEEE international conference*, 3, pp. 1845-1851, 1996.

[6] C. T. Lin and C. S. G. Lee, Neural-Network based fuzzy logic control and decision system. *IEEE transactions on computers*, 40(12), pp.1320-1327, 1991.

[7] H. A. Simon and J. Moren, Decision making and problem solving. Interfaces, 17, 1987.

[8] R. W. Kentridge and J. P. Aggleton, “Emotion: Sensory representations, reinforcement and the temporal lobe”, *Cognition and Emotion, 4*, pp. 191-208, 1990.

[9] H. R. Berenji, P. Khedkar , Learning and tuning fuzzy logic controller through reinforcements, *IEEE transactions on neural networks*, Vol.3, pp. 724-740, 1992.

[10] A. Torabi, M. Boroushaki, G. R. Vosoughi, A New Approach to Engine Idle Speed Control using Emotional Learning, submitted to *Intelligent Systems with Application Journal*, 2006.

[11] M. Fatourechi, C. Lucas, A. Khakisedigh, Control effort reduction using emotional learning, *9th Iranian conference on Electrical Engineering*, 41-1 to 41-4, 2001.

[12] R. M. Edwards, K. Y. Lee, M. A. Schultz, State feedback assisted classical control: an incremental approach to control modernization of existing and future nuclear reactors and power plants, *Nucl. Technol.*, 167-185, 1990.

[13] P. Ramaswamy, R. M. Edwards, K. y. Lee, An automatic tuning method of fuzzy logic controller for nuclear reactors, *IEEE Trans. Nucl. Sci.*, 40, 1993.

[14] H. Arab-Alibeik, S. Setayeshi, Adaptive control of a PWR core power using neural networks, *Annals of Nuclear Energy*, 32, 588-605, 2005.

ANALIZA OBNAŠANJA OGLAŠEVALCEV V TISKANIH MEDIJIH S POMOČJO ODLOČITVENIH DREVES (DECISION TREES) V PROGRAMU WEKA

Danijel Kovačić
Ekonomska fakulteta
Kardeljeva ploščad 17, 1000 Ljubljana
Tel: +386 1 5892 804
GSM: +386 31 383 193
E-mail: danijel.kovacic@ef.uni-lj.si

POVZETEK

Analizirano je bilo obnašanje potencialnih oglaševalcev v podjetju, ki se ukvarja z izdajo poslovnih edicij (revij). Določeni vzorci, ki so se pokazali, so splošni in ugotovitve lahko smiselno impliciramo tudi na ostala založniška podjetja, ki se ukvarjajo z izdajo različnih tiskanih medijev. Za potrebe raziskave je bil uporabljen program za strojno učenje WEKA, raziskava pa je temeljila na podlagi približno 1.000 podatkov (opazovana podjetja – potencialni oglaševalci), ki so bili pridobljeni preko internih informacijskih virov podjetja. Raziskava je potrdila nekaj predhodnih predvidevanj in obenem pokazala nekaj novih vzorcev obnašanja, ki bi jih bilo smiselno pretehtati.

1 UVOD

Človek si že od prazgodovine prizadeva napovedovati prihodnje dogodke, kar mu je omogočalo preživetje in bilo gonilo evolucijskega razvoja. Eno najpomembnejših prelomnic v zgodovini človeštva je nedvomno pomenila industrijska revolucija, ki je med drugim povzročila tudi eksponentno rast znanj in informacij, obvladovanje česar je v današnji t.i. informacijski dobi postala izredno zahtevna naloga. Logična posledica obilice znanj in informacij je bil razvoj informatike, katera je v začetni fazi služila zgolj obvladovanju podatkov. Kasneje so se razvila različna analitična orodja, ki so danes izredno izpopolnjena in omogočajo raznorazne obdelave in odlično vizualizacijo rezultatov. Naslednji izziv z velikim potencialom pa je razvoj inteligence, saj s strojnega stališča danes že zdaleč ne dosega nivoja človeške.
Gonilo razvoja inteligentnih sistemov je pravzaprav današnja izredno tekmovalna družba, saj hitrejše in točnejše predvidevanje pomeni konkurenčno prednost, pa naj bo to v gospodarstvu, razvoju znanosti ali kateremkoli drugem področju. Kdor razpolaga z boljšimi informacijami in zna bolje predvideti prihodnje dogajanje, ima neizmerno prednost pred ostalimi, saj se bo pričakovani situaciji pravočasno in bolje prilagodil.

Za tovrstno obdelavo in analizo podatkov je danes na voljo veliko različnih programskih rešitev, ki s pomočjo različnih algoritmov odkrivajo določene vzorce in pravila, ki na prvi pogled niso očitna. Takšen postopek pogosto imenujemo rudarjenje po podatkih oziroma data mining.

Obdelava podatkov na primeru napovedovanja obnašanja oglaševalcev je bila tako opravljena s pomočjo programa WEKA, pri čemer je bil uporabljen algoritem J48, ki je prilagojena različica bolj poznanega algoritma C4.5 in spada med hevristične, deluje pa na principu odločitvenih drevesih.

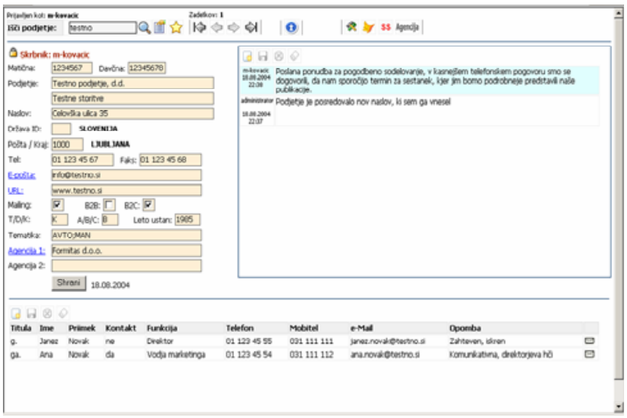
2 IZZIVI OGLAŠEVANJA

Oglaševanje večine novodobnih podjetij predstavlja pomembno orodje za ohranjanje in povečevanje tržnega deleža in dvig prepoznavnosti. Pomemben oglaševalski medij so med drugim revije, katerim oglaševanje pomeni prihodek. Za razliko od prihodkov iz naslova naročnin na revije pa velja splošno prepričanje, da je napovedovanje prihodkov iz oglaševanja izredno težavno, saj naj bi bilo obnašanje potencialnih oglaševalcev precej nepredvidljivo.

Na primeru slovenskega založnika poslovnih revij bo v nadaljevanju predstavljen model, s katerim bomo poizkusili poiskati morebitne vzorce obnašanja potencialnih oglaševalcev (zanima nas, ali podjetje poveča, zmanjša ali ohrani vrednost oglaševanja). Predpostavljamo, da imajo na obnašanje vpliv naslednji parametri, kar pa tudi želimo preveriti:

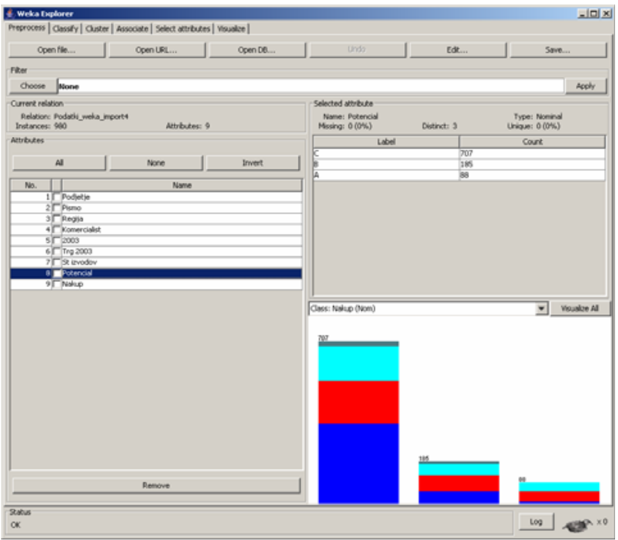
- regija, v kateri se nahaja podjetje;
- ali prodajalec prejema prodajna pisma ali ne;
- skrbnik – oseba z izključno pravico komunikacije s podjetjem;
- vrednost oglaševanja v predhodnem letu v edicijah proučevanega podjetja;
- vrednost oglaševanja na celotnem trgu tiskanih medijev;
- število naročenih izvodov revij;

- subjektivno ocenjeni potencial podjetja (A/B/C – visok/srednji/nizek).



Slika1: Prikaz izgleda sodobne aplikacije za upravljanje odnosov s strankami, ki vsebuje vse potrebne podatke za poslovno odločanje in upravljanje s strankami.

Pri pripravi modelov, ki naj bi služili analiziranju in napovedovanju, se je potrebno zavedati omejitev, s kateirmi se srečujemo. Vsekakor se je potrebno zavedati, da postavljen model uspešno deluje le v okolju, v kakršnem je bil pripravljen, v nasprotnem primeru obstaja možnost izkrivljenja informacij, saj se spremenijo osnovne predpostavke modela. V primeru obnašanja oglaševalcev je bilo tako predpostavljeno gospodarsko okolje z enakomerno rastjo, saj je sicer empirično dokazano, da je korelacija med vrednostjo oglaševanja in stopnjo gospodarske rasti izredno visoka. V proučevani vzorec je bilo izbranih približno 1.000 slovenskih podjetij z vsemi zgoraj opisanimi podatki, pri čemer so v vzorcu tako majhna kot velika podjetja, redni in priložnostni oglaševalci, ipd.

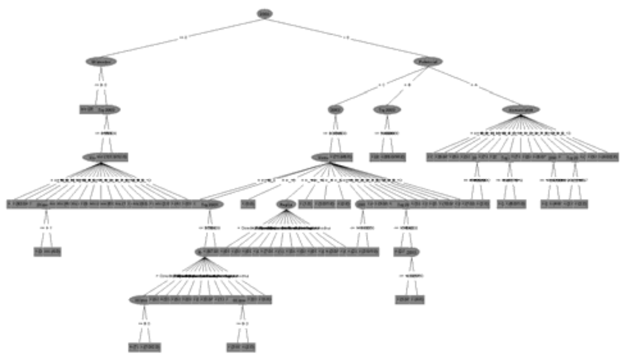


Slika 2: Prikaz osnovne strani Explorerja programskega paketa WEKA z vhodnimi atributi in vizualnim prikazom enega od njih.

Podatki so bili pridobljeni na relativno enostaven način iz internega informacijskega sistema podjetja za upravljanje odnosov s strankami, kot kriterij za izbor v vzorec pa je bil vzet podatek o tem, ali je bilo podjetje vsaj enkrat kontaktirano v zadnjih dveh letih. Podatki so bili urejeni v preglednicah Excel in nato pretvorjeni v datoteko tipa .arrf, ki je ustrezen format aplikacije WEKA.

3 SIMULACIJA Z UGOTOVITVAMI

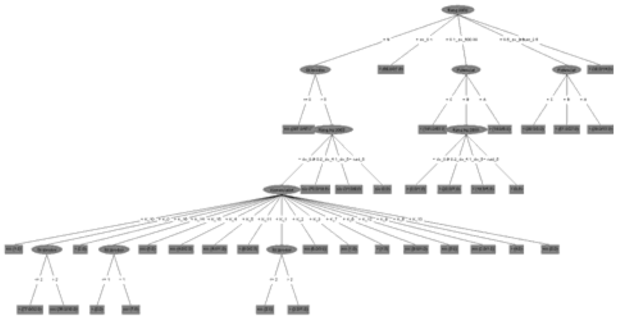
Z uporabo odločitvenih dreves in algoritma J48 smo uspeli doseči 74,5% klasifikacijsko točnost, kar pomeni, da smo na učni množici uspeli doseči, da model pravilno klasificira skoraj ¾ izmed vseh primerov. Dosežen rezultat ni impresiven, je pa v skladu s pričakovanji, saj smo že na samem začetku omenili težavno napovedljivost obnašanja oglaševalcev, ki je odvisno od mnogo več zunanjih dejavnikov kot jih v realnosti lahko spremljamo in ustrezno analiziramo. Kot je razvidno tudi iz slike 3, je model relativno kompleksen glede na število vhodnih atributov, zato bo v nadaljevanju predstavljena tudi možnost poenostavitve.



Slika 3: Vizualizacija odločitvenega drevesa, dobljenega na podlagi upoštevanja vseh vhodnih atributov.

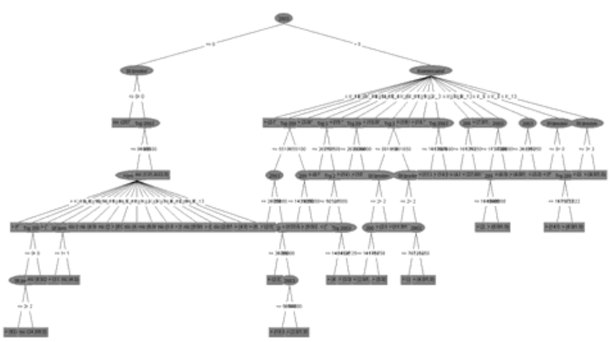
Kljub vsemu lahko trdimo, da je model uspel identificirati določene vzorce in pravila, ki jih podjetje lahko upošteva pri sprejemanju svojih odločitev. Hitro je namreč opazno, da (ne)poslano prodajno pismo na rezultat simulacije nima nikakršnega vpliva. Do tega zaključka pridemo pri vseh opravljenih simulacijah, ne glede na klasifikator in izbor atributov. Ta informacija je bila nepričakovana, je pa zelo zgovorna in koristna za obnašanje v prihodnosti. Pošiljanje prodajnih pisem je stroškovno zelo obremenjujoče za podjetje, očitno pa nima neposrednega vpliva na obnašanje potencialnih oglaševalcev. To dejstvo bi bilo smiselno dodatno analizirati ter razmisliti o morebitni ukinitvi oziroma vsaj selekciji pošiljanja prodajnih pisem. Kot najpomembnejše dejavnike v modelu lahko identificiramo vrednost predhodnega oglaševanja, srbnika in vrednost oglaševanja na celotnem trgu. Število prodanih izvodov je pomembno, vendar je vpliv manjši, za ocenjeni potencial in regijo pa lahko trdimo, da imata manjši vpliv, saj se pojavljata zelo redko in običajno na koncu drevesa.

Pri pregledu drevesa je mogoče opaziti, da WEKA razčlenjuje vrednost prometa na večih mestih (ta atribut se pojavlja v večih vozlih, tudi hierarhično). Iz numeričnih atributov za vrednost prometa in vrednost prometa na celotnem trgu sta bila zato iz numeričnih raje oblikovana nominalna atributa - namesto dejanskih vrednosti so bili za ta dva atributa raje uporabljeni štirje vrednostni rangi. Število in izbor rangov lahko vpliva na kvaliteto modela (klasifikacijsko točnost). S tem posegom smo sicer nekoliko znižali klasifikacijsko točnost, ki sedaj znaša 70,1%, rezultat pa je bil veliko enostavnejši in preglednejši model. Avtomatično je sedaj izpadel tudi atribut regija, ki je bil že prej ocenjen kot manj vpliven.



Slika 4: Vizualizacija odločitvenega drevesa, dobljenega na podlagi upoštevanja vseh vhodnih atributov in nominalizaciji glavnih dveh.

Z razvrščanjem v razrede smo sicer na nek način umetno posegli v kvaliteto podatkov atributa in posledično vplivali na sam model. To dejstvo pa niti ni problematično, saj v praksi tako kompleksna razčlenitev po vrednostih, kot jo je pripravila WEKA na osnovi celotnih podatkov, nima uporabne vrednosti. Po drugi strani razvrstitev v razrede nekako sovpada interno razdelitvijo velikosti oglaševalcev, s čimer smo dosegli praktičnost in večjo uporabno vrednost pri dejanski analizi podatkov in posledično sprejemanju odločitev.



Slika 5: Vizualizacija odločitvenega drevesa, dobljenega s pomočjo rezanja.

Postavljeni model sicer lahko poenostavimo tudi z rezanjem prvotnega modela. Ugotovili smo, da atributa regija in ocenjeni potencial nimata večjega vpliva na model, zato ju izločimo. Rezultat je delna poenostavitev modela, pri čemer pa se klasifikacijska točnost presenetljivo ni znižala ampak celo malenkost povečala (v tem primeru znaša 75%). To dejstvo si lahko pojasnimo s kompleksnostjo modela, v katerem omenjena atributa očitno delujeta moteče.

4 INTERPRETACIJA IN UPORABNA VREDNOST

Hipoteza, da se bodo pokazali določeni vzorci, se je izkazala kot resnična, a kot je bilo pričakovano, klasifikacijska točnost ni bila izredno visoka, saj se je glede na izbiro atributov gibala med 70 in 75 odstotki. To je posledica trditve, da je obnašanje oglaševalcev izredno nepredvidljivo, saj je odvisno od mnogoterih dejavnikov, ki jih pri napovedovanju težko upoštevamo.

Slabost modela je ta, da je prilagojen laboratorijskim razmeram in zanemarja določene dejavnike. Vsekakor je potrebno upoštevati, da ta model temelji na predpostavki zmerne gospodarske rasti gospodarstva. Če bi se pričakovana gospodarska rast za leto napovedi občutno razlikovala od te, na kateri temelji postavljeni model, projekcije ne bi bile pravilne. Zunanji vplivi so torej upoštevani v modelu, vendar so predpostavljeni kot konstantni, torej nespremenljivi. V primeru večjih sprememb bi bilo potrebno model prilagoditi, če bi želeli ohraniti točnost napovedovanja.

Iz modela se da razbrati, da pri oglaševalcih z večjimi vrednostmi nakupov v tekočem letu (nad 500.000 SIT) na podlagi atributov ne moremo postaviti trdnih pravil za projekcije. Izkazalo se je, da prihodnje obnašanje večjih oglaševalcev v teh primerih še najbolje definira ravno atribut subjektivna ocena potenciala. Podjetja, ki jih komercialisti označijo kot potencialna (A), so dejansko veliko bolj nagnjena k povečanju nakupa kot tista z označenim manjšim potencialom (B in C). Kljub temu, da se je zaradi subjektivnosti pojavljal dvom o kvaliteti tega atributa, se vsaj pri večjih oglaševalcih lepo vidi korelacija.

Za podjetje zelo zanimiva je ugotovitev, da pošiljanje prodajnih pisem nima opaznega učinka. Analiza stroškov prodajnih pisem je bila v podjetju izvedena že v preteklosti, nikoli pa se še ni objektivno merilo njegovega učinka. Morda bi bilo nevarno samo na podlagi tukaj predstavljenih projekcij brez pomislekov ukiniti pošiljanje prodajnih pisem, saj bi to lahko povzročilo poslovno škodo. Vsekakor pa je analiza dovolj dober pokazatelj, da je problem potrebno dodatno proučiti, saj lahko pomeni večje prihranke pri izdatkih podjetja (analiza izdatkov prodajnih pisem je sicer pokazala, da se letni celotni izdatki prodajnih pisem gibljejo okoli 2% vseh oglasnih prihodkov).

Pri večjih oglaševalcih je vpliv skrbnika zanemarljiv, po drugi strani pa je veliko bolj izrazit pri manjših oglaševalcih. To je zelo verjetno posledica dejstva, da imajo večji oglaševalci interno razdelane oglaševalske plane, na katere komercialisti v splošnem nimajo večjega vpliva. Manjša podjetja, ki teh planov nimajo, pa so bolj dovzetna za sugestije in svetovanje, kar je razvidno tudi iz odločitvenih dreves.

Vsi predstavljeni rezultati bodo s strani podjetja še dodatno analizirani in uporabljeni v prihodnjih odločitvah. Projekcije so bile koristne, saj so pokazale nove možnosti pri sprejemanju strateških odločitev podjetja, ki so v preteklosti bazirale večinoma na individualnih, mehkih informacijah in lastni miselni interpretaciji le-teh.

Smiselno je poudariti dejstvo, da vse projekcije temeljijo na določenih podatkih. Od kvalitete podatkov je odvisna kvaliteta modelov. Današnje baze podatkov in orodja za manipulacijo s podatki so izredno pripomogli k dvigu kvalitete. To je bilo opazno tudi v proučevanem primeru, saj se je postavljeni informacijski sistem za upravljanje odnosov s strankami izkazal kot enostaven in dober vir podatkov.

Izdelava projekcij pa pokaže tudi morebitne pomankljivosti v podatkih in povratno vpliva na informacijski sistem. V našem proučevanem primeru bi tako morda bila zelo koristna tudi informacija o primarni panogi oglaševalcev (ti podatki v trenutku priprave žal niso bili razpoložljivi). Prav tako bi kot zanimiv atribut pri proučevanju lahko uporabili število dejanskih enoličnih kontaktov s potencialnim oglaševalcem, saj menim, da bi ta podatek vplival na postavitev modela. Žal trenutni informacijski sistem ne omogoča zanesljive pridobitve te informacije, ki pa ni na voljo tudi v nobeni drugi obliki. Informacijski sistem bi bilo tako smiselno prilagoditi tako, da bi bilo mogoče spremljanje tudi tega atributa.

5 ZAKLJUČEK

Za zaključek lahko povzamemo, da se kljub zahtevnemu okolju tudi v oglaševanju dajo predvideti določeni vzorci in pravila. Opazimo lahko, da je vpliv komercialista izredno velik pri manjših podjetjih, klasična prodajna pisma pa nimajo opaznega vpliva na dvig vrednosti oglaševanja. Pomembno je upoštevati predpostavke pri postavitvi modelov, saj je njihov vpliv lahko velik. Predstavljeni model tako temelji na konstantni stopnji gospodarske rasti.

Dober informacijski sistem je lahko odličen vir podatkov, če je pravilno zasnovan – kvaliteta oziroma zanesljivost podatkov sta relativno visoka, dostopnost pa je lahka. Posledično je izredno olajšano opravljanje različnih analiz in projekcij.

LITERATURA

1. Hillier Frederick, Lieberman Gerald: Introduction to operations research. New York: McGraw Hill, 2001. 1214 str.
2. Kotler Philip: Marketing management: Trženjsko upravljanje. Ljubljana : Slovenska knjiga, 1996. 832 str.
3. Kumar Vipin, Steinbach Michael, Pang-Ning Tan: Introduction to data mining. Addison-Wesley, 2006. 769 str.
4. Winston L. Wayne: Operations Research: Applications and algorithms. Belmont : Brooks/Cole – Thomson Learning, 2004. 1312 str.
5. C4.5 algoritem [http://en.wikipedia.org/wiki/C4.5_algorithm], 22.12.2006
6. ID3 algoritem [http://en.wikipedia.org/wiki/ID3_algorithm], 22.12.2006
7. Programski paket WEKA. [http://www.cs.waikato.ac.nz/ml/weka], 20.12.2006
8. Seznam regij v Sloveniji. [http://www.lokalne-volitve.si/Volitve/Regije.aspx], 31.12.2006

Internet powered, server synchronized intelligent navigation & monitoring system: An Indian perspective

Prof. S. Maji[1], Sparsh Gupta[2], Siddharth Arora[3], Abhishek Agarwal[4]

Department of Mechanical Engineering, Delhi College of Engineering
Bawana Road, New Delhi – 110042, India

[1]smaji@dce.edu, [2]sparsh@dce.edu, [3]siddharth@me.dce.edu, [4]abhishek@me.dce.edu

Abstract — **Observing the escalating number of vehicles on Indian roads and the deteriorating conditions of traffic and infrastructure, several problems have come into sight. The students at Delhi College of Engineering (DCE) present a novel technique to resolve these pressing issues. Beginning with an intensive study of driving and traffic patterns across India, the prime concerns were identified. A broad concept is proposed, that aims at overcoming these glitches and equipping the user with features to make his road trip a stress-free, relaxed journey. An iVehicle (Intelligent Vehicle) has been conceptualized which aims at reducing driving related stresses in countries having similar demographics as of India. This concept of making India's first iVehicle has also been modelled and programmed to confirm its credibility.**

The system synthesized at DCE, primarily provides real time traffic updates of the routes which are of interest to the driver/ user. Initially, data is automatically collected by the central server through the various iVehicles at different places in a region. The entire system (central server and various iVehicles) operates in real time synchronization and signals are sent from the central server to other iVehicles approaching that route, presenting them the traffic, road, or even the weather conditions beforehand.

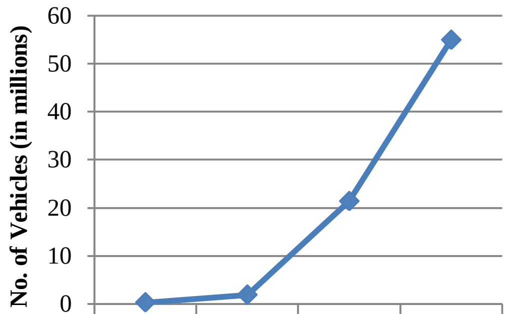
The software application part of the system presents the received data from the server in a user friendly interface so that the driver can make best possible use of the same. The proposed system has been designed to intelligently communicate with the user and also to connect to his home and office. The final iVehicle technology would be entirely adaptive to the emotions of the user. Security of the vehicle will be linked directly to the user, and the user can control the access of others into the vehicle, no matter where he or his vehicle may be.

The paper discusses the Indian scenario and then elucidates the methods used to implement and test the iVehicle concept, its operation techniques, detailed features, and its effect on the Indian transportation system. It also highlights how it can reduce the travel time and facilitate a smooth flow of traffic through busy streets, and how it can effectively be used for preventing thefts and road accidents.

Keywords: Intelligent system, Intelligent Vehicle, Intelligent navigation.

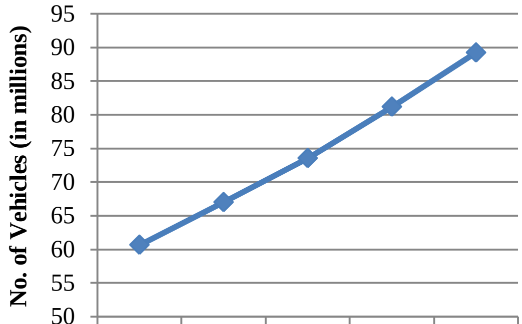
I. Current Indian Traffic Scenario

Automobile Industry in India has observed a tremendous growth over the last few years. As a result, the number of vehicles per capita has also increased inordinately. The stretch of Indian roads is more or less constant at 3.34 million kilometers but the vehicles running on them are increasing at a rate of 10.16% per year. *Fig 1* and *Fig 2* show the trend of traffic on Indian roads in past 50 years and in last 5 years respectively. Because of these factors, the density of vehicles on Indian roads is shooting up. Moreover, the road conditions and subsequently the traffic conditions are deteriorating which have made driving in India a menace and driving for even an hour turns out to be more arduous than working at office during the entire day.



Year	1951	1971	1991	2001
No of Vehicles (in millions)	0.3	1.9	21.4	55

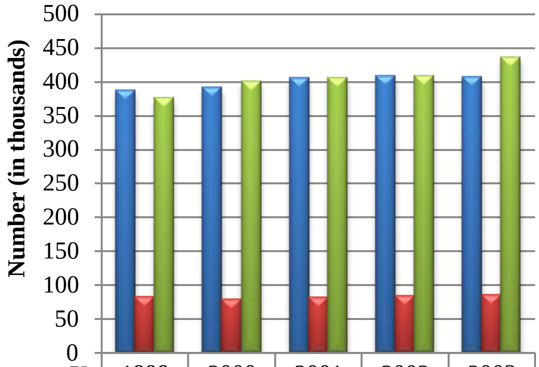
Fig 1: No of vehicles on Indian roads in last 50 years.



Year	2002	2003	2004	2005	2006
No of Vehicles (in millions)	60.65	67	73.55	81.2	89.26

Fig 2: No. of vehicles on Indian roads in last 5 years.

With driving becoming all the more bothersome, people tend to become agitated, which has adverse affects on their everyday life. In the last 5 years, the number of road accidents had increased by around 5.25%, the number of deaths on roads by around 4.9% and injuries by 16.1%. *Fig 3* shows the trends in road casualties.



Year	1999	2000	2001	2002	2003
Accidents	386456	391449	405637	407497	406726
Killed	81966	78911	80888	84674	85998
Injured	375051	399265	405216	408711	435122

Fig 3: Number of Road causalities in India

The prime factors responsible for the on road causalities were evaluated, and it was found that majority of accidents are because of driver's faults, and the rest were caused by other factors such as bad weather, fallen trees, road blockages, absence of rear reflectors, non-functioning of road signals, etc. A graphical representation of these factors has been shown in *Fig 4*.

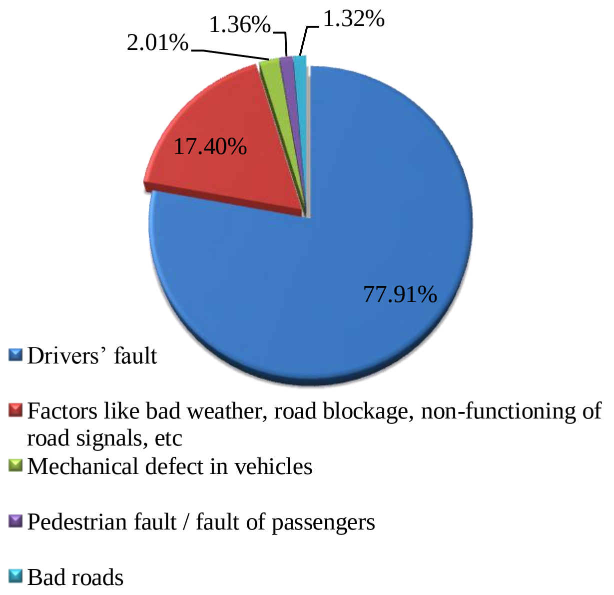


Fig 4: Factors of Road accidents in India

According to a recent survey by NHAI (National Highway Authority of India), driver's faults are primarily because of either lack of concentration or lack of his self composure both mainly caused because of irritating traffic conditions and jams. Thus the research was centered to provide an updated navigation system, to help avoid traffic jams and accidents due to negligence, and also to ensure vehicle security.

At Delhi College of Engineering, an effort has been made to conceptualize and synthesize an iVehicle that aims at reducing all these problems and providing hassle-free safe mode of driving.

II. Internet Powered Navigation System

An internet powered navigation system (IPNS) for the proposed iVehicle was conceived that would take into consideration the various fallacies, mismanagements and discrepancies in the Indian traffic conditions and would try to put forward a solution to most of them. Affectively, it will not just save time, by providing best route alternatives, but would also reduce the number of traffic jams and accidents.

The car dashboard is fixed with a minicomputer with both a Wi-Fi card as well as a modem to connect to the internet. The Wi-Fi card can be configured to connect to various internet hotspots in a city or the available Wi-max networks, while the modem can dial via a mobile GPRS to an internet ISP. The minicomputer embedded in the car's dashboard has the capability of connecting to data servers after the internet connection is successfully established.

The proposed internet connected and central server controlled navigation and management system will provide a two-way connectivity. Apart from sending information to the user's end, the server also automatically collects the vital information from his various sites to guide other users. *For example*, to go to a college the internet powered navigation system provides the user with a few route options to choose from. The user, after selecting one of them, starts traversing the chosen path and then later diverts his route as he finds it currently jammed or blocked, this information which is presently not in the server records (since the jam occurred moments ago – a common case in India), will now automatically by uploaded onto the server. For other users on that way, alternate routes will be advised so that the users may re-consider their decision of selecting the most convenient route. This way a real-time traffic management and information sharing can be realized and users have a better idea of the whole traffic situation. Thus, the navigation system automatically updates its maps wirelessly and provides a transparent view of the traffic conditions.

The Internet Powered Navigation System works in conjunction with the ever so reliable GPS (Global Positioning System). In fact, GPS forms the backbone for our IPNS. The information flow takes place as follows:

- The user enters the destination address in the IPNS module which is fitted in his car. The data packet containing the vehicles current location (obtained by the IPNS GPS interface) and the destination details are sent to the server.
- The server now searched for various routes possible to reach the destination along with the respective route lengths (using its GPS interface) and then determines the traffic, road and weather conditions (using its databases) on these routes.

- The server then calculate the approximate time of travel on each of the possible routes (taking into account all the above mentioned factors) and forwards them along with the route unique ID to the iVehicle IPNS interface.
- The IPNS device at the users end thus displays the options for the user along with the route maps taken from the IPNS GPS interface using the route unique ID. The user is then given options to choose the route manually or to choose automatically depending on:
  - ✓Shortest time
  - ✓Smoothest drive (best road conditions)
  - ✓Enjoyable drive (least traffic)
  - ✓Auto Choose (Server chooses the best route taking into account all the factors).
- Once the route is chosen by the user, the detailed information with various landmarks and the time of arrival at those points is transferred to his IPNS device for his reference. The user can also view traffic, roads and weather he should expect on that route.
- As the vehicle travels, the GPS keeps a track of the route the vehicle is following and the IPNS device checks if that route coincides with the suggested route. Frequently the IPNS also connect to the central server to check if the route earlier suggested is still the best option or if a better way is now available due to constant change in traffic and other factors.

If however, the vehicle enters some area where internet is not at all available, the IPNS can be converted into conventional GPS. The GPS device and the software have been embedded in such a way that they can be used as stand alone device in case of emergency.

Apart from Real-time navigation, wherein the user is provided with options to select a route, the navigation system would also incorporate features which enable the user to find products and locations, and provide fastest route to reach there. *For example,* the system would also have a feature wherein, if the user wants to use the services of any place, say, he wants to have lunch at a restaurant, he can type in the name of the cuisine or restaurant and he would get detailed information about the nearby places. Apart from the location of a restaurant, the data, uploaded by the restaurant on the internet, would be made available to the user and he would be notified about the present vacancies in the restaurant, its specialties, and any other relevant information the user may be interested to know. The user can then decide if he wants to dine in the restaurant or would like to place an order from his car; he can reserve a table or can also order a take-away, from the restaurant.

Thus, it's all about making systems more efficient, accessible and updated so that it saves time on the road, as well as off the road.

The third major task that the project aimed is to link the address book of his office to his car. Herein, the user can only key in the name of the person / company he want to visit and the system would itself search for the address in the users address book remotely over the internet, and then once again, decide the possible routes to reach the desired destination.

A. Test Approach

In the research, a tablet PC was employed as a minicomputer and connected via the campus Wi-Fi connection to the local server which in the present case was nothing but a Linux based machine. This acted like a web hosting server with packages: apache, MySql and Tomcat. In the experimental runs, the car was made to run up to speeds of around 65 Km/hr on the campus roads and was connected to the local server over Internet (Wi-Fi). An application in PHP was built to demonstrate and test the working. The portal was in the form of a web services running on internet explorer equipped with the facility of collecting the information from the user and synchronizing the same from the server using AJAX techniques to make it real time. In the test runs testing data was entered for a few routes and corresponding road conditions and traffic conditions and maps were fed into the server databases.

B. Test Procedure

The system was then made to work successfully in the same format proposed above by designating the college library as the destination while the campus main gate as the start point. The system successfully predicted the estimated time of arrival in each of the 3 routes possible with various options to choose the final path. *Fig 5* shows the caption from the application window with starting and ending points along with the 3 possible routes in RED, BLUE and GREEN

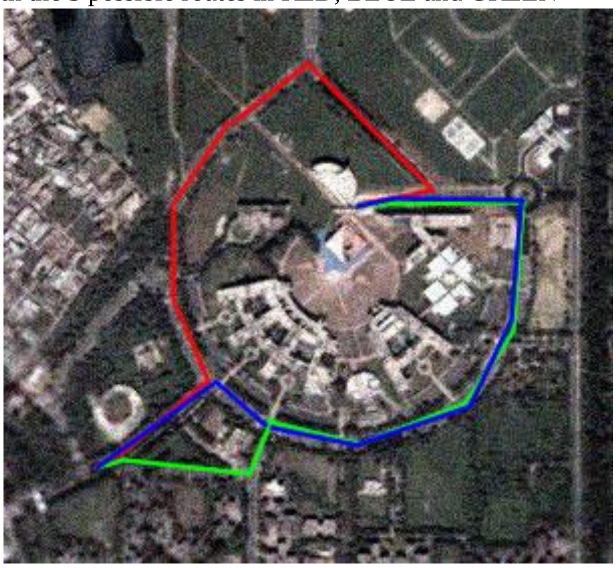


Fig. 5: Caption from the application window showing the possible routes to reach from campus main gate to the college main library.

The application calculated the displayed approximate route lengths, average speeds and approximate travel time as:

Route Red: 653 meters; 40 km/hr; 0.98 min
Route Blue: 586 meters; 40 km/hr; 0.88 min
Route Green: 599 meters; 32 km/hr; 1.12 min

The application also proposed route blue as the best alternative but asked for confirmation. Once the route was confirmed, the server tried to fetch as much information as possible about the route and displayed it on the user screen. In the test approach, few information was available on the number of traffic signals, speed breakers etc. but in actual implementation, many such parameters will be proposed.

Currently the normal driving speeds were assumed but in the actual implementation of the system, it is expected to automatically include the current vehicle speed and its (car) / driver's driving trends so as to predict the time more accurately rather then relying only on the average speed of others on the road. This can be done by using the interface between speedometer and the minicomputer.

In the final design of the system, the internet explorer (as mentioned earlier) will not be used, instead a stand alone application is being developed which undoubtedly will be similar but will have the capability to update databases automatically, while the vehicle is moving on different tracks within a city. For this, work is being performed on two different techniques, one of which involves *vehicle–to–server* interaction and the second is based on *vehicle–to–vehicle* interaction within a small domain.

III. Personal Desktop: Add On Feature

After the implementation of the Internet Powered Navigation System, we utilized the extended capabilities of the internet and programmed the minicomputer in it to act like a normal PC in its idle time. Thus the owner could work on his important files by synchronizing them with his PC at home or office while he is in his iVehicle. The services of remote desktop providers like gotomypc.com were employed to enable this feature. Each user will have a personal 'login' account, where he will be automatically logged on each time an internet connection is established. A document left undone at office will be available in his iVehicle and also at his home. Apart from the work being performed on the computer, information such as the room temperature, lightning conditions, can be uploaded into the account database. This data will now be available whenever the user again logins and similar conditions of work or environment can be maintained there too. The same music and temperature, as that of the workspace can also be maintained in the car too, as all of them are linked through the account over the internet.

IV. Vehicle Security

In the second phase of our research, we worked on the security aspects of the vehicle and tried to implement the concept of anytime anywhere vehicle monitoring. A persistent shortcoming in the Indian Automobile Scenario has been the lack of management and hence the ever increasing vehicle security concerns. The proposed system will be equipped with the Log Manager feature. With the help of this feature, every few minutes while the car is on move a checkpoint will be created in the user account. In this checkpoint, the present location of the vehicle will be stored which can be viewed later for reference. In case of a vehicle theft, whereabouts of the vehicle can be traced through the log and the local police may use this information to seize the stolen vehicle. The system will also be connected to the car's ECM (Electronic Control Module), and thus in the case of a theft the police authorities can even send commands to disconnect the vehicle ignition controls, and therefore paralyze it. It might, thus be fitted with engine immobilizers and alarming devices.

V. Adding Emotional Intelligence to the Vehicle

In the third phase of the project, cameras were employed within the vehicle to monitor the facial expressions of the driver and the owner. Initially, it was aimed to send the collected videos to a remote server using an internet connection in the dashboard computer but later the experiments called for some change in the plans. Over the low internet bandwidth in India, it was very slow for a single computer to transfer files to the server. Thereafter it was planned to use a better computer in the car with the ability to process most of the information itself and which would connect to the main server only in rare cases.

Focus is to capture and analyze the driver's emotional state and his expressions so as to monitor whether or not, he is paying enough attention while driving. Different routes demand different levels of concentration and the application in the minicomputer will compare the attention required and the attention paid. An algorithm to calculate attention required works on taking the factors of road conditions and the traffic conditions. The car driving panel would also be provided with an alarm which could be triggered by the application if the driver is found diverting from his task of driving safely.

The camera focusing on the user/ owners face would give its output to the application controlling the music, air conditioning and the lighting conditions of the vehicle. The application will conclude the emotional state of the person prior to making any intelligent decisions of changing the settings of the controlled devices. For example, take the case wherein the owner is very tired, the application thus will automatically change the music to something that suits his tired state, will reduce the volume, will dim the lights and make the temperature appropriate to give him a relaxing and cozy environment.

The analysis of the emotional state is being carried out by the Emotional Intelligent Interfaces algorithm been developed at computer laboratory, *University of Cambridge.*

Once the user leaves his vehicle, the settings of the above said devices can be sent to the system controlling his parameters at his home / office.

VI. Conclusions

Throughout the entire paper we have concentrated our research on making things more manageable and more organized in view of the Indian conditions. We have conceptualized and tested, although on a small scale, the concept in our campus at Delhi College of Engineering, in India. The results, as we could visualize, if implemented on large scale, would definitely have favorable consequences for any Indian citizen. With no such concept of iVehicle and internet based navigation in India, the research seems perfectly suited to the needs of the people.

Some of the advantages that we could conclude of the Internet powered navigation system over the conventional GPS has been shown in given figure *Fig 6* and *Fig 7:*

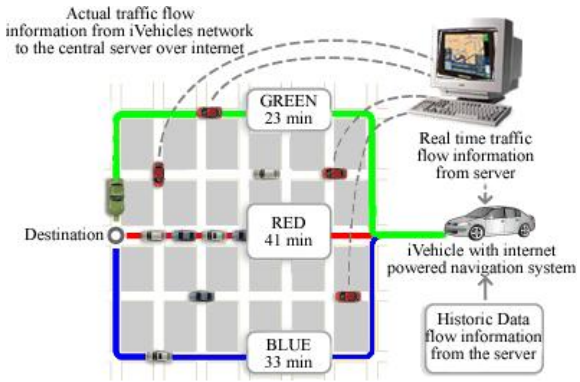


Fig 6: Internet powered navigation system

Fig 7: Conventional Global Positioning System (GPS)

The system we devised for Indian roads also projected a few shortcomings:

- Since it is completely dependent on the central server and hence any technical problem in the same would affect the whole IPNS.
- This system wont work for new routes or for people choosing an all together new route.
- System is also dependent on the internet connectivity and currently in India, wireless internet is not very reliable.

However, the research is not limited to its application in India. The concept broadly may apply to most of the countries where similar traffic conditions exist. The reason for focusing the perspective on India is because we, as the authors, could best relate to our nation and the prevailing conditions, observing the sorry state in our every-day lives.

ACKNOWLEDGMENT

The authors would like to acknowledge Prof. P.B. Sharma, Rajiv Gandhi Technical University, Bhopal and Prof. Asok De, Ambedkar Institute of Technology, Delhi for there motivation, guidance and support for carrying out this research and producing this paper.

REFERENCES

[1] Catling, I.; Warriner, D. "Using GPS as part of an on-bus video system for bus lane enforcement"

[2] Boonsrimuang, P. Kobayashi, H. Paungma, T. "Mobile Internet navigation system" Digital Object Identifier: 10.1109/ HSNMC. 2002.1032600

[3] Hariri, S. Mahesh Indran "Vehicle Internet Appliance (VIA)" Digital Object Identifier: 10.1109/AICCSA.2003.1227463

[4] Rana El Kaliouby & Peter Robinson "Real-time inference of complex mental states from facial expressions and head gestures, In Real-time vision for HCI" Springer 2005, pp 181-200.

[5] Rana El Kaliouby & Peter Robinson "Generalization of a Vision-Based Computational Model of Mind-Reading" International Conference on Affective Computing and Intelligent Interaction, Beijing, October 2005.

[6] Dunstan, W. "Computer and GPS navigation system for an autonomous ocean vessel" Digital Object Identifier: 10.1109/ANZIIS.1995.705758

[7] Thomas J. Nagle, James A. Arnold, Christopher K. Wilson, Paul M. Novak "Automotive Concepts for Use of the Modernized Global Positioning System (Gps)" SAE Technical Papers, Document Number: 2003-01-0538

[8] William G. Agnew, Gerald R. Lane, Ka C. Cheok "Intelligent Vehicles Designed By Intelligent Students " SAE Technical Papers Document Number: 2002-01-0404

[9] John Skibinski, Jim Trainor, Chad Reed "Internet-Based Vehicle Communication Network " SAE Technical Papers, Document Number: 2000-01-3503

PREDICTION OF OZONE LEVELS IN AMBIENT AIR IN SKOPJE

Biljana Mileva-Boshkoska, Mile Stankovski
Department of Automatics
Faculty for Electrotechnics and Information Technologies
Karposh 2, bb, 1000 Skopje, Republic of Macedonia
Tel: +389 75 467607;
e-mail: biljanamb|milestk@feit.ukim.edu.mk

ABCSTRACT

Instructions: In this paper we present the results from prediction of levels of ozone (O_3) in the ambient air in Skopje, Macedonia. The prediction is for two SHORT periods of time: for 24 hours and for one week in June and in December in 2005. The system is based on choosing the best values of the free parameters of support vector machines (SVM) kernels. This is the first attempt in Macedonia for prediction of levels of any air parameters in the ambient air.

1 INTRODUCTION

The aim of the current research is to fill in the existing gaps of the measured hourly data for the levels of O_3 in the ambient air for short periods of time in Karposh III, in Skopje, Republic of Macedonia.
One approach for prediction of hourly values is using neural networks for evaluating air parameters concentrations [6], [5], [1]. SVM is another method that started in the late seventies [8] and today is used for ambient air parameters prediction [2], [4] and for time series forecasting [3] in the environmental applications.
For prediction of the O_3 levels, we use the techniques of SVM and Radial Basis Function (RBF) NN.

2 OVERVIEW OF THE WHOLE PROCES

Prediction of levels of O_3 in ambient air is a complex process that consists of the following phases (Figure 1):

- Measurement of the levels of parameters of the ambient air by automatic monitoring station.
- Transmission of the measured data via radio connection from the monitoring station to the textual data base situated in the Ministry for Environment and Physical Planning (MoEPP).
- Data processing and preparation of ARFF files that are recognized by the WEKA software.
- Electing tools (software) for modeling the data.
- Modeling using the software package WEKA.
- Comparison of the received models and choosing the one that gives the best prediction results.

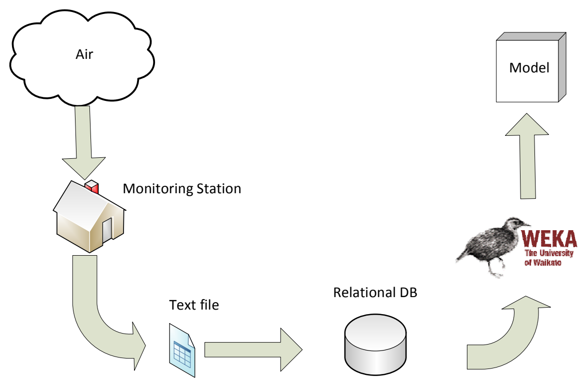


Figure 1: *Overview of the whole process of prediction*

3 USED TECHNICS

3.1 Support Vector Regression

The concept of a maximum margin hyperplane only applies to classification. However, support vector machine algorithms have been developed for numeric prediction that share many of the properties encountered in the classification case: they produce a model that can usually be expressed in terms of a few support vectors and can be applied to nonlinear problems using kernel functions.
Similar with linear regression, the basic idea here is to find a function that approximates the training points well by minimizing the prediction error. The crucial difference is that all deviations up to a user-specified parameter x_i are simply discarded. Also, when minimizing the error, the risk of overfitting is reduced by simultaneously trying to maximize the flatness of the function. Another difference is that what is minimized is normally the predictions' absolute error instead of the squared error used in linear regression. A user-specified parameter x_i defines a tube around the regression function in which errors are ignored.
SVM approximate the learning data set with a function given in a form of:

$$f(x) = \sum_{i=1}^{l} w_i \phi_i(x) + b \quad (1)$$

meaning that the original data $x \to \phi(x)$ are mapped into high dimensional space and then construct an optimal hyperplane in this space. $\phi(x)$ represents feature of the inputs, while w_i and b are coefficients. These are estimated by minimizing the risk function [10]:

$$R(f) = \int c(x, y, f(x)) dp(x, y) \quad (2)$$

Where c(x,y,f(x)) is cost function that determines how to penalize estimation errors based on the empirical data X [7]. Given that we do not know the probability measure dp(x,y) we can only use X for estimating a function f that minimizes R[f]. A possible approximation consists in replacing the integration by the empirical estimate to get so called empirical risk function

$$R_{emp}[f] = \frac{1}{l} \sum_{i=1}^{l} c(x_i; y_i; f(x_i)) \quad (3)$$

A first attempt would be to find the function $f_0 = \mathrm{argmin}_{f \in H} R_{emp}[H])$ for some hypothesis class H. However if H is very rich, i.e. its capacity is very high as for instance when dealing with few data in very high dimensional spaces, this may be not such a good idea as it will lead to overfitting and thus bad generalization properties. Hence one should add a capacity control term, which in the SV case results to be$||w||^2$, which leads to regularized risk function

$$R_{reg} = R_{emp}[f] + \frac{\lambda}{2} \|w\|^2 \quad (4)$$

3.2 Kernels

A kernel is essentially a similarity function with certain mathematical properties, and it is possible to define kernel functions over all sorts of structures-for example, sets, strings, trees, and probability distributions.

The choice of kernel $K(x_i, x_j)$ influences drastically on the performance of the SVMs depending on the problem considered. Several kernels are available for learning and they have to satisfy the so-called Mercer's condition [9].

The most commonly used kernels are the Gaussian kernel

$$K(x_i, x_j) = \exp^{-\left(\frac{\|x_i - x_j\|^2)}{2\sigma^2}\right)} \quad (5)$$

and the polynomial kernel

$$K(x_i, x_j) = (x_i x_j + 1)^p \quad (6)$$

Which are also used for the purposes of this research.

4 DATA PROCESSING

The data sets that are used are gathered by the national automatic monitoring network (AMN) by the MoEPP in Republic of Macedonia. As soon as the data are transferred to the central DB in MoEPP they are first validated, that is the missing and the unreal data are marked with -9999. We have picked a small period of time where we do not have mising data, that is the period 1-17 August and 1-17 December 2005. We used two different seasons because we wanted to show the difference of the predicted results from different models depending on the standard deviation of the input data.

The first phase is parsing of data and their storage in a relational data base. We convert the validated data into ARFF format that is recognized by the WEKA software that is used for the process of prediction of the levels.

In order to build models for prediction of O_3 levels, as input parameters we use the hourly data for the levels of NO_2, O_3, temperature and humidity for 10 days in a raw. The output function is following:

$$\boldsymbol{O_3(t)} = \boldsymbol{f}(\boldsymbol{NO_2(t-z)} + \boldsymbol{O_3(t-z)} + \boldsymbol{NO_2(t)} + temp(\boldsymbol{t-z}) + hum(\boldsymbol{t-z})) \quad (7)$$

We built eight different models for prediction of O_3 levels for $t - z$ hours, where $z = 1,2, \ldots, 8$.

For prediction of O_3 levels, first we build three types of models from which two are based on SVM, while the third one is based on RBF NN. In order to build the first two models, we use the existing functions in WEKA: SVMreg with polynomial kernel, where p=1 and SVMreg with RBF kernel, known as SVM with Gaussian kernel. For building the third model we use the function RBF with neural network which is also implemented in Weka. The three functions are used both for prediction of levels of O_3 for 24 hours and for one week. That way we get two groups of models. In the first group belong models for prediction of levels for 24 hours and in the second group belong models for prediction of levels for one week.

In order to decrease the total processing time for training the SVM we used the tool Explorer from WEKA that enabled us to distribute the whole process of learning of the model on three computers controlled by one "master" computer.

The results from the obtained models are compared. As a measure for deviation of the predicted results from the measured one we use the mean absolute error given by:

$$\boldsymbol{MAE} = \frac{\boldsymbol{1}}{\boldsymbol{n}} \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} |\boldsymbol{\alpha_i} - \boldsymbol{p_i}| \quad (8)$$

5 RESULTS FROM MODELLING

When modeling with SVM, first we choose the best values of the free parameters of the kernels: σ (Figure **3**), C (Figure **2**), and ε (Figure **4**). Once the best values for the free parameters C (factor of penalty), σ and ε (insensitive loss function) are determined, the final step is to produce the models for prediction of the missing data for O_3.

In August, the data of the levels of O_3 are very close to each other i.e. the standard deviation is very small. Therefore the three models give similar results for prediction of levels of

O3 (Figure **5** and Figure **6**). The input data in December have big standard deviation.

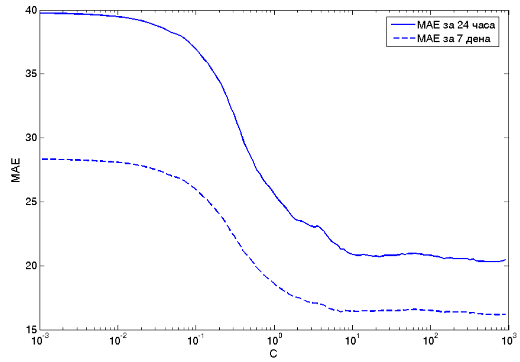


Figure 2: *Variations of MAE from the parameter C for prediction of O_3 levels for 24h and for 7 days for August, 2005*

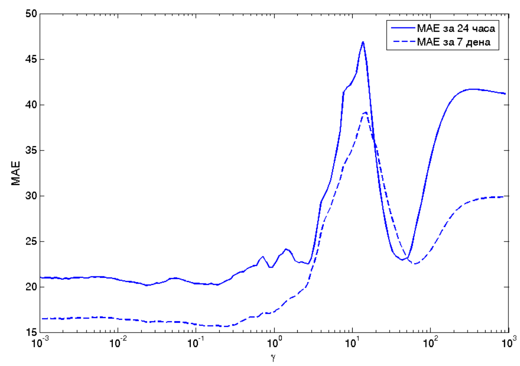


Figure 3: *Variations of MAE from the parameter σ for prediction of O_3 levels for 24h and for 7 days for August, 2005*

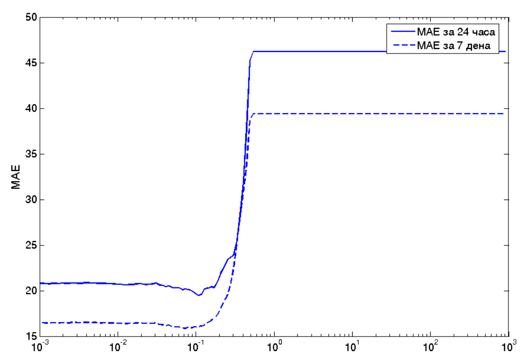


Figure 4: *Variations of MAE from the parameter **ε** for prediction of O_3 levels for 24h and for 7 days for August, 2005*

In this case due to the good generalization of the SVM, the best prediction results are achieved by SVM with polynomial kernel for z=1,2,3, and by SVM with Gaussian kernel for z=4,..,8.

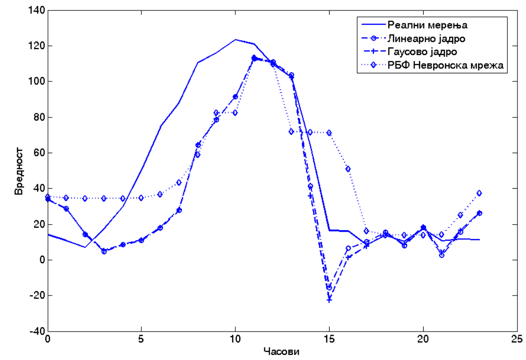


Figure 5: *Prediction of levels of O_3 for 24 hours, for August 2005, for z=3*

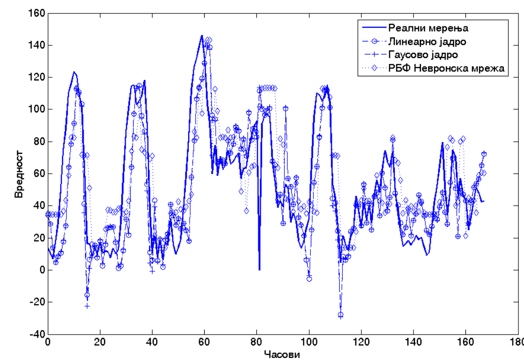


Figure 6: *Prediction of levels of O_3 for one week, for August 2005, for z=3*

Figure **5**and Figure **6** show the distribution of original O_3 data for the eleventh day and for one week in August, 2005. The same figures show the distribution of the predicted data that are obtained by the three models.

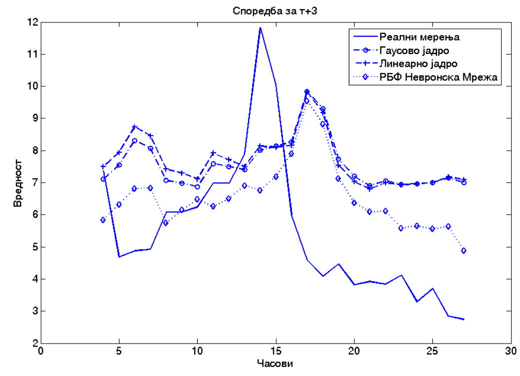


Figure 7: *Prediction of levels of O_3 for 24 hours, for December 2005, for z=3*

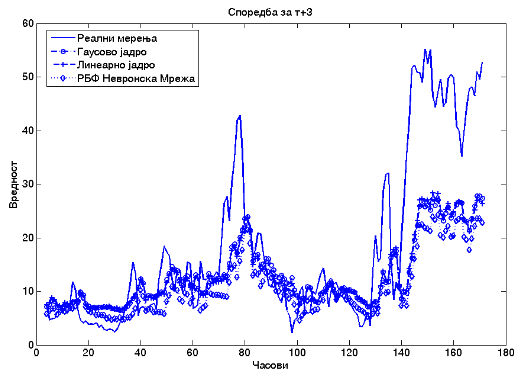


Figure 8: Prediction *of levels of O_3 for one week, for December 2005, for z=3*

In August, when predicting the O_3 levels both for one week and for 24 hours, the best results are achieved when using the model built with SVM with polynomial kernel for z=1.
In December, when predicting the O_3 levels for one week, the best results are achieved when using the model built with SVM with RBF kernel for z=1, while for 24 hours, the best results are achieved when using the model built with SVM with polynomial kernel for z=1.

6 CONCLUSION

The paper describes an attempt to predict the hourly levels of O_3 in the ambient air at one municipality in Skopje, Macedonia.
We developed a complete system for filling the gaps of missing hourly data by predicting the levels of O_3.
The experiments showed that the SVM is an appropriate tool for prediction of O_3 levels both for summer and winter seasons. The method gives good results and may be used by MoEPP for filling the data gaps for hourly O_3 values for short periods of time.

References

[1] E. Agirre-Basurko, G. Ibarra-Berastegi, and I. Madariaga: *Regression and multilayer perceptron-based models to forecast hourly o_3 and no_2 levels in the Bilbao area.* Environmental Modelling and Software, 21(4):430–446, 2006.

[2] Stephane Canu and Alain Rakotomamonjy: *Ozone peak and pollution forecasting using support vectors.* In IFAC Workshop on environmental modelling, 2001.

[3] L. Cao: *Support vector machines experts for time series forecasting*. Neurocomputing, 51:321–339(19), 2003.

[4] Wei-Zhen Lu and Wen-Jian Wang: *Potential assessment of the "support vector machine" method in forecasting ambient air pollutant trends*. Chemosphere, 59(5):693–701, Apr 2005.

[5] Weizhen Lu, Wenjian Wang, Leung, A.Y.T.Siu-Ming Lo Yuen, R.K.K. Zongben Xu, and Huiyuan Fan: *Air pollutant parameter forecasting using support vector machines*. I Neural Networks, 2002. IJCNN, 1:630–635, 2002.

[6] A. Pelliccioni and T. Tirabassi: *Air dispersion model and neural network: A new perspective for integrated models in the simulation of complex situations.* Environmental Modelling and Software, 21(4):539–546, 2006.

[7] A. Smola and B. Sch¨olkopf: *A tutorial on support vector regression*. Statistics and Computing, 1998. Invited paper, in press.

[8] V. Vapnik: *Estimation of Dependences Based on Empirical Data* [in Russian]. Nauka, Moscow, 1979. (English translation: Springer Verlag, New York, 1982).

[9] V. N. Vapnik. Statistical Learning Theory. Wiley & Sons, New York, 1998.

IMAGE RETRIEVAL BASED ON MPEG-7 COLOR DESCRIPTORS

Violeta Mircevska, Suzana Loskovska, Ivica Dimitrovski
Faculty of Electrical Engineering and Information Technology
Skopje, Macedonia
Tel: +389 70 906 484
e-mail: violeta.mircevska@gmail.com

ABSTRACT

This paper gives comparative description of the characteristics of the MPEG-7 dominant color descriptor, color structure descriptor and color layout descriptor. The retrieval quality of the search performed over personal photo galleries based on these descriptors has been tested. The tests are made with application which uses the eXperimentation Model developed on the Institute for integrated systems on the Technical University of Munich for extraction of the descriptors and retrieval of images with minimum descriptor value distance from given query image.

1 INTRODUCTION

As an answer to the need for managing the ever growing amount of multimedia content in the world, MPEG-7 provides four tools for comprehensive description of this kind of content:

- descriptors - description of single feature of the multimedia content,
- description schemes - description of the structure and semantics of the multimedia content,
- description definition language - standardizes the representation of the description and allows modification and extension of the description tools of the standard,
- system tools - tools for binarization, synchronization, transport and storage of descriptions, as well as management and protection of intellectual property.

As the most remarkable feature of visual content to the human visual system, the color has earned its place among the MPEG-7 visual descriptors. The color is important characteristic of the objects. It doesn't contain information about shapes present on an image, but provides good representation of the ambient in which certain action takes place. This makes it relevant in the image retrieval based on the background of the images.

2 MPEG-7 COLOR DESCRIPTORS

MPEG-7 specifies seven color descriptors [1] divided in two groups. The first group consists of two descriptors that give information about the color space in which the color of the image is represented (color space descriptor and color layout descriptor). The second group contains five descriptors for description of the image color (dominant color descriptor, scalable color descriptor, group of frames or group of pictures descriptor, color structure descriptor and color layout descriptor). In this paper, we will describe only the dominant color descriptor, color structure descriptor and color layout descriptor, as the search tests have been made based only on these three descriptors.

The dominant color descriptor (DCD) [2] contains the most representative colors of the image. These colors are the centroids of the clusters extracted by clustering the image with the Generalized Lloyd algorithm based on the color of the pixels [3]. For more precise representation of the color, the MPEG-7 standard defines two optional parameters for this descriptor: color variance (calculated for every dominant color separately, contains the variance of the pixels color in the cluster of one dominant color) and spatial coherence (contains information for whether the clusters are concentrated in regions or spread across the whole image).

The color structure descriptor (CSD) [4] represents the color of the image with the color structure histogram. Each element of the histogram is associated in bijective manner with one cell of the nonuniformly quantized HMMD color space. For its extraction, MPEG-7 defines a structuring element (8x8 element frame) with which the whole image is scanned. The values of the elements of the color structure histogram are equal to the number of positions where the structuring element contains at least one element colored with the associated color to the respective element.

The color layout descriptor (CLD) [5] represents the color of the image with the DCT coefficients of the Y, Cb and Cr components of the YCbCr color space for the tiny image icon. The tiny image icon is generated by splitting the original image in 8x8 blocks and representing each block with its most representative (average) color.

2.1 Comparison

The advantages and disadvantages of using each of these three color descriptors will be obtained by comparison according to three characteristics: the value of the average normalized modified retrieval rate (ANMRR) of the search done on the common color dataset (CCD) for the common color queries (CCQ) [6], the length of the binary

representation of the descriptors and the complexity of the similarity matching.
Figure 1 shows the ANMRR parameter - descriptor length relationship.

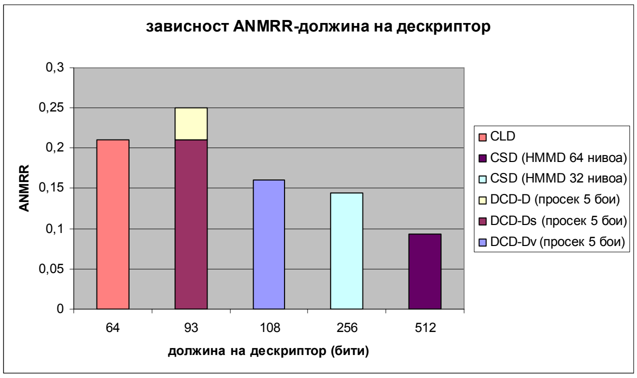


Figure 1: ANMRR-descriptor length relationship

The values in the graph correspond to the image search based on the color layout descriptor (CLD) in the form recommended by MPEG-7, the color structure descriptor (CSD) with 64 and 32 cell HMMD color space and the dominant color descriptor (DCD) without calculation of the optional parameters (D), with the space coherency parameter (D_s) and with both optional parameters (D_v). The average number of dominant colors for the images included in the search is five.
According to the value of the ANMRR measure, the best retrieval accuracy is achieved by the color structure descriptor. The longer the color structure histogram is the better retrieval accuracy the search has. Second best retrieval accuracy has the dominant color descriptor when both of the optional parameters are calculated. The retrieval accuracy of the searches based on the dominant color descriptor with spatial coherency is approximately the same as the search based on the color layout descriptor. Worst ANMRR has the dominant color descriptor without optional parameters when the average number of dominant colors per image is five.
The descriptor length is calculated according to the binary representation of each descriptor. The color layout descriptor has the shortest length. Moving to the right of the descriptor length axis comes the dominant color descriptor without optional parameters which has the same length as the dominant color descriptor with spatial coherency. The length of the dominant color descriptor with both optional parameters is a bit longer. Again, these are the average lengths of the descriptor in the case when the average number of dominant colors per image included in the search is five. The bigger the number of dominant colors per image is, the longer the descriptor length will be. The longest of all descriptors is the color structure descriptor.
The basic trend in Figure 1, if we exclude the dominant color descriptor without optional parameters, is that the longer the descriptor length is, the better color representation of the image it has, leading to higher retrieval accuracy.
Concerning the similarity matching complexity [6], the values of the color layout and color structure descriptor are far easier to compare than the values of the dominant color descriptor. The complexity of the similarity matching for the dominant color descriptor is greater as more optional parameters are calculated.
Which of these color descriptors is the best? As with everything else, there is no general best choice. Every descriptor has its own advantages and disadvantages. Which descriptor will be used, depends on the concrete application that needs to be implemented. For example, if the application is to be run on bandwidth and storage limited environment, then the color layout descriptor will be best due to its short representation length. Of course, the retrieval accuracy will not be the best possible. On the other hand, if good retrieval accuracy is important for the application, the color structure descriptor will be the best choice. Using this descriptor will require higher storage and bandwidth.

3 SEARCHING PERSONAL GALLERIES WITH THE USE OF THE MPEG-7 COLOR DESCRIPTORS

The personal galleries contain photos taken on variety of places with different people and objects on them. As the color provides good representation of the ambient of an image, the accuracy of retrieving photos taken on the same place has been tested.
Personal photo galleries can contain thousands of photos. Despite this fact, the size of the description of the photo is not crucial for the choice of the descriptor that should be used for their indexing. As the memory price has been falling, the storage media has been rising. Today's personal computers have enormous storage possibilities. Further more, the fact that this kind of search is not time critical (although it should be done in considerable time period), makes the extraction and similarity matching complexity, also, not crucial in the selection of the color descriptor. Characteristic of the color descriptors that should be considered in this kind of applications is how they represent the color in an image.
The photos in personal galleries taken on the same place differ from each other, considering that they may contain different people and objects and that they may be taken from different angle. Understandable question that arises from here is what representation of the color should be used and how precise should that representation be? Furthermore, is the retrieval accuracy good enough if the search is based only on the color descriptors?
Before presenting the results of the test, we will shortly present the application used for the experimentation.

3.1 Test application

The test application is portal for online management of photos and videos developed with ASP .NET, Figure 3. The photos are organized in photo galleries. The portal allows users to search their galleries based on their description with the MPEG-7 dominant color descriptor, color structure descriptor and color layout descriptor.
For extraction of the descriptors and their similarity matching, the server and client applications of the eXperimentation Model (XM model) developed on the Institute for integrated systems on the Technical University of Munich are used [7].
The descriptions of the photos with all descriptors (and all of their possible parameter combinations) are extracted as the user uploads the photos on the server. The extraction is done by separate background processes which start the server applications of the XM model.

In the process of similarity matching the ten best matches of photos of all galleries of the current user are found. The search starts by extracting the 10 best matches to the query image in all of the galleries that the user has. This is done by separate background processes that start the client applications of the XM model. A simple comparison algorithm combines the results that the client applications give to find the ten best matches of all images, which afterwards are shown to the user.

3.2 Test results

The tests are done on personal gallery that contains five galleries with average number of 100 photos per gallery. Three of these galleries contain photos that people have taken on a trip (they are taken on the Korab mountain, Mavrovo skiing center in winter and in a sky diving club) and two contain landscapes (sunsets in Finland and mountain peeks in Switzerland).

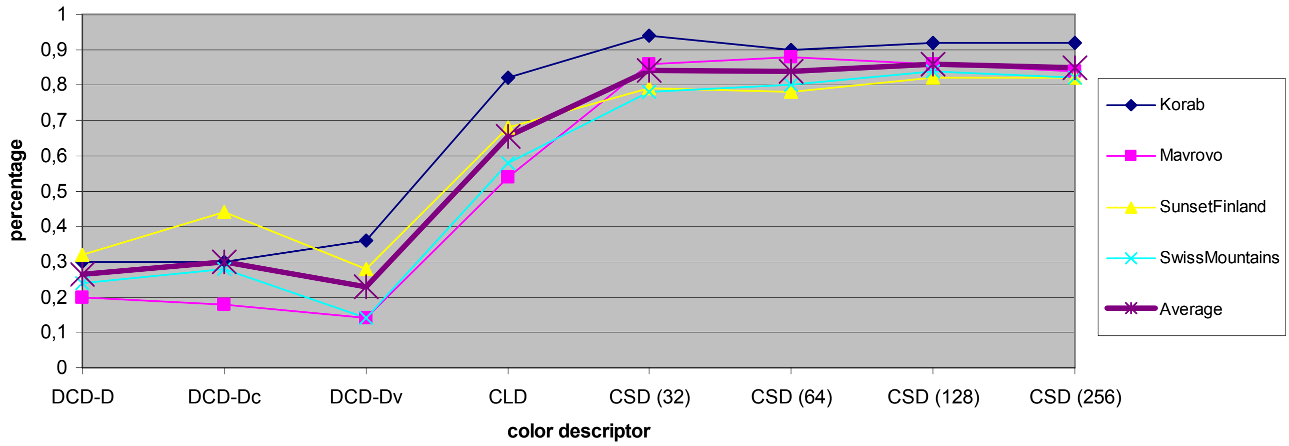


Figure 2: Search results

The photos have been selected so that some of them contain similar colors but the colors are differently spread among the photo (one example are the photos on Korab mountain and the Swiss mountains).
The searches have been made according to five query images for each of the four galleries Korab, Mavrovo, SunsetFinland and SwissMountains, based on the dominant color descriptor without the optional parameters (DCD-D), with the spatial coherency parameter (DCD-D_c) and both optional parameters (DCD-D_v); the color layout descriptor in the MPEG-7 recommended form (CLD); and color structure descriptor when the HMMD color space is quantized in 32 (CSD-32), 64 (CSD-64), 128 (CSD-128) and 256 (CSD-256) cells. The quality of each search is presented with the average percentage of images of the same gallery that have been found among the first ten best results in each search. Additionally, the average percentage of all search results per descriptor type has been calculated. The search results are shown in Figure 2.

From the graph in Figure 2, it can be seen that the percentage of 'good' search results is best when the search is done with the color structure descriptor. The length of the CSD descriptor does not visibly change the retrieval accuracy. Then comes the color layout descriptor. The results of the search based on the dominant color descriptor show lowest retrieval quality.
This means that the color structure descriptor provides best representation of the images. Beside the information about the colors, this descriptor has good information about the local layout of colors in the image thanks to the structuring element used in its extraction. This is important information that allows the descriptor to recognize certain structures in the image. Change in the position of these structures (objects on the image in certain sense) is not 'visible' to the descriptor. The color layout descriptor provides information about the colors in the image, as well as their overall layout. This is not as good color representation as with the color structure descriptor, but gives good results. Adding the fact that the length of the color layout descriptor is far

shorter than the length of the color structure descriptor makes this descriptor the number one choice in memory and bandwidth limited applications.

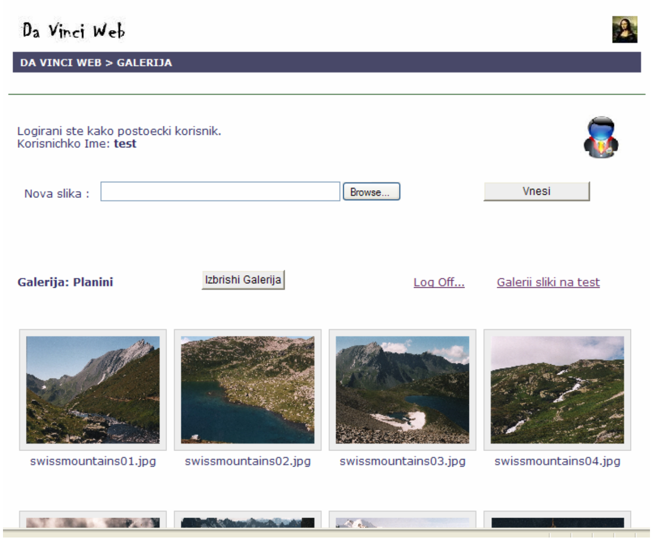


Figure 3: Image gallery

The search results in Figure 2 show that the information in the dominant color descriptor is not enough for accurate search retrieval in personal photo galleries.

4 CONCLUSION

The dominant color descriptor, color structure descriptor and color layout descriptor provide different ways for representing the color in an image. Search results show that better retrieval quality have the descriptors which contain information about the layout of the color on the image. The low ANMRR of the color structure descriptor and the high percentage (over 70%) of 'good' photos retrieved in the tests based on it, make the searching of visual content based only on this descriptor relevant in this kind of applications.
For more precise representation of the visual content the color descriptors can be combined with MPEG-7 visual descriptors which provide information about textures and shapes present in the images. This will make the search sensitive, beside to the overall color, also to certain objects and textures present in the image, leading to better retrieval accuracy.

References

[1] http://www.chiariglione.org/mpeg/standards/mpeg-7/mpeg-7.htm

[2] Ka-Man Wong and Lai-Man Po, MPEG-7 dominant color descriptor based relevance feedback using merged palette histogram, Acoustics, Speech, and Signal Processing, 2004. Proceedings, International Conference on Volume 3, Issue , 17-21 May 2004

[3] http://scalab.uc3m.es/~ffernand/publicaciones/robocup99/node5.html

[4] Messing, D.S van Beek, P. Errico, J.H., The MPEG-7 colour structure descriptor: image description usingcolour and local spatial information, Image Processing, 2001.

[5] Kasutani, E.; Yamada, A., The MPEG-7 color layout descriptor: a compact image feature description for high-speed image/video segment retrieval, Image Processing, 2001.

[6] Gunhan Park, Yunju Baek, Heung-Kyu Lee, A Ranking Algorithm Using Dynamic Clustering for Content-Based Image Retrieval, Image and Video Retrieval: International Conference, CIVR 2002, London, UK.

[7] http://www.lis.ei.tum.de/research/bv/topics/mmdb/e_mpeg7.html

ISKANJE ZNAČILNOSTI V PRODAJNIH PODATKIH TISKARSKE INDUSTRIJE S POMOČJO METODE UMETNE INTELIGENCE

Primož Panjan
Mislejeva 3, 1000 Ljubljana, Slovenia
e-mail: student@panjan.com

POVZETEK

Tiskarska industrija se že leta ukvarja s proizvodnjo po naročilu in veliko truda se posveča dogovarjanju med kupcem in prodajalcem o prodajni ceni naročila. V podjetju, ki ga obravnavam, se je oblikovalo mnenje, da se pri določanju prodajne cene pojavljajo vzorci, na podlagi katerih bi lahko napovedali odstotek dobička za vsak projekt že v času dogovarjanja za izvedbo projekta. V prispevku sem z metodo umetne inteligence poskušal odkriti vzorce in napovedati odstotek dobička.

1 UVOD

Proizvodnja kvalitetnih knjig je zahteven proces z relativno nizko dodano vrednostjo. Uporabniki vse bolj želijo kvalitetne in poceni artikle. Podjetja, ki se ukvarjajo s tiskanjem knjig, se torej soočajo z večanjem kvalitete izdelkov, manjšanjem stroškov ter iskanjem čim večje dodane vrednosti na projektih. V obravnavanem podjetju Knjiga želijo poleg zmanjševanja stroškov optimirati dodano vrednost do čim višje mere in biti obenem še konkurenčni. Tu se pojavi priložnost inteligentnih sistemov, da bi na podlagi preteklih podatkov ustvarili znanje v pomoč pri iskanju pravega razmerja med višino dodane vrednosti in gotovostjo pridobivanja projektov.

2 PROBLEM

Kupca knjige, tj. založbo, največkrat zanimajo le tri stvari: *kvaliteta izdelave*, *dogovorjeni rok dobave* in *cena artikla*. Dogovarjanje komercialista s kupcem o potencialni izdelavi artikla je občutljiv postopek. Poznati je treba tako zmožnosti tiskarne kot trga, na katerem tiskarna nastopa. V preteklosti so se oblikovala neka nepisana pravila, ki jih komercialisti upoštevajo pri oblikovanju dogovorjene prodajne cene. Problem je, ker so ta pravila netransparentna, nazapisana in temeljijo na trenutnih občutkih komercialista. V prispevku bom zato poskušal na podlagi preteklih podatkov oblikovati pravila, ki bi komercialistom pomagala določiti dogovorjeno prodajno ceno za vsako pripravljeno ponudbo.

Moja ***hipoteza*** *je, da obstajajo pravila, na podlagi katerih bi lahko oblikovali prodajno ceno artiklov v prihajajočih projektih.*

Cilj *prispevka je oblikovanje pravil, ki potrdijo tezo in pomagajo komercialistom pri oblikovanju dogovorjene prodajne cene artikla.*

3 ISKANJE ZAKONITOSTI V PODATKIH

3.1 Priprava podatkov

Izkušnje kažejo, da je največji del vloženega napora v sklopu procesa zbiranja in priprave potrebnih podatkov. Tudi sam sem največ časa porabil za ta korak, v okviru katerega sem:

- združeval podatke iz različnih virov,
- opredelil in pripravil izračunane atribute,
- uredil manjkajoče vrednosti,
- pretvoril nenumerične vrednosti v numerične in nasprotno,
- uredil nekonsistentne podatke in osamelce ter
- odstranil šume in podobno.

V okviru priprave podatkov sem poskušal zbrati tiste podatke, ki so na voljo pri odprtju novega povpraševanja s strani kupca. Na njihovi podlagi lahko ocenimo prihajajoči projekt in se s pomočjo odločitvenih pravil odločimo o višini dobička nad lastno proizvodno ceno, kar je tudi moj namen. V poslovanju se pojavita dve skupini prodajnih podatkov:

- *Kalkulacijski*: Naročniki pridobijo od tiskarne mnogo odgovorov na svoja povpraševanja v obliki ponudb in kalkulacij za različne oblike artikla. Na njihovi podlagi se odločajo za obliko svojega izdelka in tiskarno, v kateri bodo proizvedli svoj artikel. Teh podatkov ne moremo vključiti med podatke za podatkovno rudarjenje, ker so nepreverjeni (na njihovi podlagi ni bil izveden noben projekt) in premalo zanesljivi.
- *Razpisani in obračunani*: Ko tiskarna in naročnik skleneta posel pridobimo mnogo realnih podatkov o obstoječih projektih. Razpisani podatki so predvideni stroški za izdelavo artikla, obračunani pa dejanski stroški izdelave artikla. Ti podatki so preverjeni in bolj zanesljivi za podatkovno rudarjenje.

Pri odprtju novega povpraševanja imamo na voljo mnogo različnih podatkov preteklih projektov in novega potencialnega projekta. Za uporabo v prispevku sem zbral osnovne proizvodne in komercialne podatke dosedanjih projektov, za katere se mi zdi, da najbolj vplivajo na višino dobička, iz katerih lahko pridobimo neke zakonitosti ali pa jih uporabimo za izračunavanje novih atributov. Le ti so podani v naslednji tabeli.

Podatek	*Opis*
Mesec	Mesec datuma zaprtja delovnega naloga.
ProdPodrocje	Prodajno področje, iz katerega izhaja naročnik.
TipIzdelka	Tip artikla
Naklada	Razpisana oz. predvidena naklada artiklov.
Obseg	Število strani
FormatCM2	Površina strani artikla
BarveKB	Število uporabljenih barv v osnovnem delu artikla tj. knjižnem bloku.
RSkupaj	Razpisani oz. predvideni stroški projekta.
FZnesek	Znesek fakture, izdane naročniku, za posamezni projekt.
FR OdstDobicka_ TXT	Odstotek razlike med predvidenimi stroški, na katerih temelji dogovorjena cena in prodajnim zneskom (FZnesek / RSkupaj)

Tabela 1: *Podatki, ki so na voljo za rudarjenje*

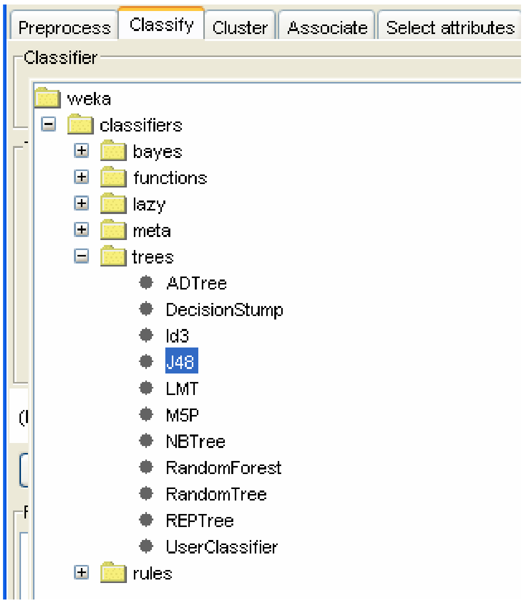
Podatke iz več virov sem prenesel v MS Excel, kjer sem jih primerno obdelal. Ob koncu zbiranja podatkov sem zbral 574 primernih zapisov zaključenih projektov v preteklem letu tj. letu 2005. Podatke sem najprej shranil v obliko CSV, ustvarjeno datoteko odprl v Weki in shranil v njenem osnovnem formatu ARFF.

3.2 Obdelava podatkov

Obdelave podatkov v Weki sem se lotil postopno. Najprej sem poskušal odkriti povezavo komercialnih ali proizvodnih atributov na doseženi dobiček nad lastno ceno z vključevanjem in izključevanjem različnih atributov. Nato sem združil vse atribute in poskušal ugotoviti, ali so predhodna pravila pravilna ali ne. Podatke sem obdeloval s klasifikacijskim algoritmom C4.5 (v WEKI poimenovan J48) za izdelavo odločitvenih dreves z naslednjimi nastavitvami:

- Prečno preverjanje[1]: 10.
- Najmanjše število objektov v listu drevesa[2]: 5, 10 in 20.

[1] Ang: Cross-validation, folds
[2] Ang: The minimum number of instances per leaf (minNumObjects)



Slika 1: *Weka - Izbira algoritma rudarjenja (Trees, J48)*

V nadaljevanju sem pripravil tri variante oz. skupine atributov, iz katerih sem s pomočjo rudarjenja po podatkih poskušal pridobiti skrite zakonitosti:

- poslovni atributi,
- tehnološki atributi,
- združeni atributi.

Za vsako varianto sem pripravil verzijo, ki se ločijo med seboj le po omejitvi števila instanc v listu drevesa, in sicer 5, 10 ali 20.

Varianta 1 – poslovni atributi
Ko prodajalec podjetja Knjiga oblikuje ceno za kupca, mora upoštevati različne lastnosti projekta. Po dosedanjih nepisanih ugotovitvah na ceno vpliva:

- ***Obdobje v letu***: V proizvodnji se v podjetju Knjiga oblikujejo obdobje visokega povpraševanja in obdobje nizkega povpraševanja. Odvisno od ponudbe in povpraševanja v nekem obdobju se oblikujejo prodajne cene in s tem določa višina dobička nad lastno ceno.
- ***Prodajno področje***: Na višino prodajne cene vpliva področje, iz katerega izhaja naročnik. Nekako se je uveljavilo dejstvo, da se dosegajo najnižji dobički v vzhodnem delu Evrope, največji pa v zahodnem delu.
- ***Tip artikla***: Tip artikla ima po dosedanjih izkušnjah še najmanjši vpliv na dobiček. Nekako pa se uveljavlja mnenje, da se ustvari največji dobiček pri zahtevnih artiklih, tj. *TV 4/B*, manjši pa pri nezahtevnih projektih, kot so *Periodika* in *MV 2/B*.

Izbrani atributi za varianto so:

Mesec
ProdPodrocje
TipIzdelka
FR OdstDobicka_TXT

Varianta 2 – tehnološki atributi
Izmed vseh atributov, ki nekako najbolj vplivajo na višino notranjih stroškov pri proizvodnji artikla, sem izbral naslednje:

- ***Predvidena naklada***: To je število končnih artiklov, ki jih je naročil naročnik. Pri manjših nakladah se pojavi večji odstotek fiksnih stroškov, ki pa z večanjem naklade pada. Pri velikih nakladah, tj. 100.000 kosov, je delež fiksnih stroškov zelo majhen, velik pa je odstotek variabilnih stroškov.
- ***Obseg***: Obseg pomeni skupno število strani artikla.
- ***Barve KB***: Tu upoštevam število barv, ki se pojavijo v tisku notranjega dela artikla. Če je artikel označen kot 1/1 pomeni, da so vse tiskarske pole natisnjene le s črno barvo. Iz tega sledi v povprečju 1 barva na artikel. Artikel 4/4 se tiska po obeh straneh tiskarskih pol s štirimi barvami. Iz tega sledi, da se povprečno v artiklu pojavijo 4 različne barve.

Do sedaj v podjetju nismo imeli občutka, da bi katerikoli omenjeni atribut vplival na doseganje dobička nad lastno ceno. Zato bo zanimivo videti, ali odvisnost obstaja ali ne.

<u>Izbrani atributi za varianto so:</u>
Naklada
Obseg
BarveKB
FR OdstDobicka_TXT

Varianta 3 – vsi atributi skupaj
<u>Izbrani atributi za varianto so:</u>
Naklada
Obseg
BarveKB
Mesec
ProdPodrocje
TipIzdelka
FR OdstDobicka_TXT

Rezultat za vse tri variante
Povzetek za vse tri variante:

- Za vse variante velja, da imajo nizko klasifikacijsko točnost, ki se giblje okoli 25 - 30%.
- Z večanjem števila instanc v listu drevesa pada klasifikacijska točnost, vendar le za dobra 2 - 5 odstotkov.
- V »Confusion matrix« sem zasledil, da so nepravilno razvrščeni projekti večinoma razvrščeni v bližnji razred. Instance z ekstremnimi vrednostmi dobička je sistem večinoma razvrstil v najbolj zastopane razrede.

V spodnji tabeli so združeni nekateri rezultati rudarjenja.

Var.	*Element rezultata*	*Verzija* 1	2	3
1	Število elementov v listu drevesa	5	10	20
	Velikost drevesa / število listov	64 / 40	48 / 31	32 / 23
	Klasifikacijska točnost [%]	30,66	30,31	28,57
2	Število elementov v listu drevesa	5	10	20
	Velikost drevesa / število listov	57 / 29	35 7 18	19 / 10
	Klasifikacijska točnost [%]	23,87	26,83	28,40
3	Število elementov v listu drevesa	5	10	20
	Velikost drevesa / število listov	98 / 57	56 / 35	34 / 24
	Klasifikacijska točnost [%]	31,71	31,02	28,57

Tabela 2: *Rezultati variant iz Weke*

Z dodatnim podrobnim preverjanjem rezultatov sem prišel do ugotovitve, da je na podlagi podanih atributov dejansko nemogoče doseči večjo klasifikacijsko točnost, ker delež dobička nad lastno ceno preveč niha od instance do instance znotraj istih vrednosti atributov. Tudi če bi zmanjšal korak razreda dobička iz 10% na 50% ali več, z mejo na dobičku/izgubi, bi bila klasifikacijska točnost še vedno slaba, saj dobiček instanc enega lista drevesa preveč niha oz. se giblje v velikem razponu čez mejo dobiček/izguba.

4 UGOTOVITEV

Zaključna ugotovitev je naslednja:

Hipoteze, da obstajajo pravila za lažje določanje prodajne cene artikla, ne morem potrditi in cilj s tem ni dosežen.

Odločilni dejavnik neuspeha je verjetno premalo zastopanih atributov. Obstoječi atributi niso dovolj za dobro klasifikacijo prihajajočega projekta. Mogoče bi moral bolj upošteval lastnosti projektne stranke, njeno stalnost in število projektov v nekem obdobju, plačilno disciplino in podobno. Mogoče bi moral upoštevati lastnosti udeleženega prodajalca in njegove pogajalske sposobnosti ali pa več lastnosti projekta, kot so nujnost, kompleksnost, kvaliteta in podobno. Dejstvo je, da je določanje dobička bolj kompleksno, kot sem si predstavljal in na podlagi trenutnih atributov ne morem definirati pravil, po katerih bi lahko določevali delež dobička nad lastno ceno pri posameznem projektu.

5 LITERATURA IN VIRI

Literatura

[1] Berry Michael J. A., Linof Gordon: Mastering Data Mining: the Art and Science of Customer Relationship Management. New York: John Wiley & Sons, Inc., 2002. 494 str.

[2] Goonatilake Suran, Treleaven Philip: Intelligent Systems for Finance and Business. Chichester: John Wiley & Sons, 1996. 335 str.

[3] Kirkby Richard, Eibe Frank: WEKA Explorer User Guide for Version 3-4. New Zeland: The University of Waikato, 2005. 12 str.

[4] Witten Ian H., Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations. San Francisco (California): Morgan Kaufmann, 2000. 371 str.

[5] Witten Ian H., Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques. Amsterdam (etc.): Morgan Kaufman, 2005. 525 str.

Viri

[1] WEKA. Universitiy of Waikato. [URL: http://www.cs.waikato.ac.nz/ml/weka/], 01.06.2005.

[2] What are NACE codes? Euro Info Centre. [URL: http://www.eic.ie/faq_nace.htm], 02.08.2006

A SURVEY OF CLUSTERING ALGORITHMS OF MICROARRAY GENE EXPRESSION DATA ANALYSIS

Blagoj Ristevski [1], *Suzana Loskovska* [2]

[1] Department of Management Information Systems, Faculty of Administration and Management Information Systems, Bitola, blagoj.ristevski@uklo.edu.mk

[2] Department of Computer Science and Informatics, Faculty of Electrical Engineering and Information Technologies, Skopje, suze@feit.ukim.edu.mk

ABSTRACT

In this article, it is given a survey of clustering algorithms that are used in gene expression data analysis. Here, the most frequently used clustering algorithms are described and a comparison between their advantages and disadvantages are given. At the end, in the Section 3 we suggest the further directions to improve clustering results.

1 INTRODUCTION TO MICROARRAY TECHNOLOGY

Monitoring of gene expression levels of thousands genes is provided by microarray technology. One microarray is a glass microscopical slide on which some amount of RNA on particular spots is brought labeled with fluorescent dyes from control cells and test tissue cells. Both RNA extracts are incubated on the microarrray simultaneously, so hybridization of gene sequences is provided. After the process of hybridization and washing of the microarray, laser excitation and scanning of the both dye intensities is performed, separately. The gene expression level is measured by measuring the fluorescent dye intensities of the particular spots, in different condition (samples/time moments). Thus, the gene expression matrix A is obtained. The data of *i*-th gene in the *j*-th condition is given by the following equation:

$$a_{ij} = \log_2 \frac{Int(Cy5)}{Int(Cy3)} .$$

Before starting any further analysis of the microarray data, it is necessary to make data preprocessing. The preprocessing is a base for efficient cluster analysis and removes the systematic noise as good as possible. The preprocessing includes the following stages: normalization, nonlinear (logarithmic) transformation, filtration of those genes with a small change in different experimental conditions and standardization of gene expression profiles. Also, handling with the missing values and outliers is very important, because they may influence the results obtained by the microarray data analysis.

2 CLUSTERING

The aim of clustering is to group the genes (or the experimental conditions, such as cancer samples), based on their similarity, and to obtain clusters with statistical and biological significance. Depending on the way of cluster defining, the cluster algorithms may be divided into model-based and distance-based cluster algorithms [15]. The model-based algorithms assume that the data in high dimensional space are a mixture of probabilistic methods with different parameters. Each of the models is defined as a cluster. On the other hand, with the distance-based cluster algorithms, the data is assigned to some clusters, according to their mutual distances.

2.1 Hierarchical clustering

This algorithm [1] became standard in the gene expression data analysis because of its intuitive presentation of clustering results. The clustering process is presented as a tree so-called dendogram. The data is presented in a heap map, so the relations among genes (or conditions) are shown in a very intuitive way. At hierarchical agglomerative clustering at the beginning, each gene expression profile is assigned to one cluster; and the distances between all cluster pairs are calculated. Those clusters with minimal intercluster distance are merged, until one cluster is obtained. Since the whole dendogram is obtained, determination of the final clusters is obtained by cutting the dendogram on a particular level or height. It corresponds to putting a threshold of the distance between the cluster pairs. The lengths of the dendogram branches are proportional to distances between appropriate cluster pairs. The dendogram leaves may be ordered in such respect that the similarity between adjacent genes is maximal and the clusters in the heat map are obvious. But the time complexity of such optimal dendogram reorganization is very big ($O(2^{N-1})$).

2.2 *k*-means clustering

The algorithm with gene expression data is proposed by Tavazoie *et al.*, 1999 [2]. There are two necessary input parameters: the number of clusters *k* and *k* initial seeds of the *k* clusters. The algorithm is performed iteratively: 1. the genes are assigned to clusters with the closest mean, 2. the algorithm recalculates the vectors of all the cluster means. The main disadvantages are the input parameters and the algorithm convergence to local minimum. For different input seeds different cluster results are obtained. So, the algorithm is performed many times to obtain the best results.

2.3 Self-organizing maps (SOM)

The SOM algorithm [3] is a method to visualize a high dimensional input data into an output neuron map. The map is a two-dimensional grid of neurons usually hexagonal or rectangular. In high dimensional space, the data structure is shown by the prototype-vectors. The vectors have a similar function as the vectors of the mean (seeds) at *k*-means algorithm. Each prototype-vector is linked to a neuron from the output space. Similarly to *k*-means algorithm, and SOM algorithm is performed iteratively, until convergence or the previously given number of training iterations is obtained. The prototype-vectors might be determined by using the Principal Component Analysis (PCA). The final clustering results may be significantly influenced by the outliers.

Genes may be involved (directly or indirectly) in some biological processes. For this purpose, better algorithms are those that allow one gene to belong to many clusters. Also, better cluster results are obtained by combining many algorithms.

2.4 Self-organizing trees (SOTA)

SOTA [4] combines SOM and hierarchical clustering. With both SOM and SOTA the original gene profiles are mapped in output space of nodes. Differently from the nodes of SOM, the nodes of SOTA are binary trees and the number of nodes is not given in advance. The tree as a structure of nodes grows up during the clustering process. The algorithm starts from a binary tree with two leaves. Every gene expression profile is joined to the best matching cell (the leaves of the tree are called cells). After the convergence, the cell that contains the most variable population of gene profiles is divided in two daughter-cells. Thus, the tree grows up and process restarts. The algorithm stops when the threshold of variability of each cell is obtained.

2.5 Hybrid hierarchical-*k*-means clustering algorithm (H-*k*-means)

This algorithm surpasses the disadvantages of hiearachical and k-means clustering [5]. It is carried out in two stages. The hierarchical clustering is carried out in the first stage, where k clusters are obtained. By calculating the mean of the k clusters, the initial centroids of *k* clusters are obtained. Then the second stage of *k* means is performed. To handle outliers, the threshold for *k*-means clustering is put.

2.6 Cluster Identification via Connectivity Kernels (CLICK)

CLICK presents the input data as weighted graph [6]. The results obtained from this clustering are homogenic and the process of clustering carries out very fast.

2.7 Quality-based clustering algorithm

With these algorithms, the quality of each cluster is guaranteed.

QT_Clust (Quality cluster algorithm)

QT_Clust is a greedy procedure and it monitors the quality profiles in data, one at a time [8]. For each expressed profile, the algorithm determines other profiles that are in the frameworks of a particular distance in its neighborhood. This distance provides quality. A candidate cluster is formed for each expressed profile. The candidate cluster with the greatest number of expressed profiles is chosen as an output of the algorithm. Furthermore, the expressed profiles from the chosen cluster are removed and the whole procedure starts again, so that the following cluster will be found. The algorithm stops when the number of the other expressed profiles in the biggest cluster is under the threshold given in advance. This algorithm may find clusters with tightly assigned expressed profiles. The genes which are not really coexpressed with the other members of the data set, are not included in any cluster.

Adaptive quality-based clustering

This clustering uses a heuristic approach in two steps to identify clusters [7]. In the first step, the quality based approach is carried out to identify the centers of the clusters. By using preliminary evaluation of the cluster radius (quality), the cluster center is located in the area where the density (number of gene expression profiles) is local maximum. Then, the cluster quality is recalculated, so that the genes that belong to that cluster are significantly coexpressed. With this type of clustering, the user must determine the level of significance as a threshold for quality control. The threshold has a strictly statistical meaning and can be chosen independently from a particular data set or cluster. By allowing clusters with different radii, the adaptive clustering produces clusters accommodated to the local data structure.

2.8 Model-based clustering

The model-based clustering supposes that the generated data is a finite mixture of the basic probability distributions, where each distribution represents one cluster [9]. Each gene (condition) should be assigned with the best matching distribution in the mixture and at the same time, the parameters of each distribution should be determined.

Mixed model-based clustering based on normal distributions

When the multivariate normal distributions are used, each cluster is presented by hypersphere or hyperellipse in the data space. The mean of the normal distribution presents the hypersphere center, and the distribution covariance determines its orientation, shape and volume. The covariance matrix of every cluster could be presented by Singular Value Decomposition (SVD), with eigenvectors which determine the cluster orientation, and eigenvalues which determine the shape and volume of the cluster. Apart from the normal distribution, the Gamma distribution or a mixture of Gamma and normal distributions is used, too. Regardless of the choice of the basic distributions, the mixture model learns with EM (Expectation-Maximization) algorithm. For given microarray data, the probability that one gene will be assigned to every cluster, is calculated with the E step. Then the M step finds the parameters which maximize the probability of complete data. The EM procedure is repeated for different number of clusters and different covariance structure. At the end, the best model with the most adequate number of clusters and covariance structure is chosen in this group of models.

Mixture clustering model based on factor analysis

The clustering of the experiments (samples of tumors, cancer), encounters a problem which is connected with the adjustment of the normal mixture of the data, because the number of genes is much bigger than the number of experiments. In the factor analysis, the vectors of the experiments which are located in the original *n*-dimensional hyperellipse (*n* is the number of genes) are projected in their corresponding factor vectors, which are located in m dimensional single sphere ($m<<n$). The clustering is performed in a reduced characteristic space instead of the original high dimensional space. And here the EM algorithm is used, too. The problem is the choice of the number of the factors. If this number is very small, the whole gene structure cannot be surrounded and if the number of the factors is very big, computational difficulties appear in the EM algorithms. To overcome this problem, a new phase (t distributions) is added to reduce the gene space dimension before the application of the mixture factor analysis.

2.9 Biclustering algorithms

The process of biclustering means clustering both genes and experiments, simultaneously. There are many types of biclustering algorithms. The first types of such algorithms used to reorganize the genes and experiments to improve their presentation in clusters, simultaneously. The goal of the other type of biclustering algorithms is to uncover the genes, which are responsible for sample classification. One such algorithm is the method of gene shaving [13], that searches the genes which are the most different through samples by means of the Principal Component Analysis (PCA). The biclustering algorithm [12] searches for genes which have similar expression only over a subset of experimental conditions. The aim of Couple two way clustering (CTWC) [14] finds the genes with correlation expression profiles (the members of these clusters may take part in the same biological processes), as well as dividing tissues into groups with similar gene expression profiles. With this clustering the ratio signal to noise is increasing. The clustering of the samples is based on their expression levels over small correlated sets of genes, and vice versa.

SOM biclustering (coupled self-organizing maps) [17] differs from the other biclustering algorithm by the symmetry basic of the method which permits visualization of clusters of samples (conditions) and clusters of genes simultaneously. That may be useful in proposed hypotheses about gene patways.

2.10 Fuzzy c-means clustering

According to this clustering algorithm each expression data point might belong to many clusters, and that is determined by their membership function [10]. The aim of this clustering is to find the most distinctive object in every cluster and to determine its memberships to the clusters. The problem of this clustering is the data with noise which can have similar membership to every cluster. To overcome this problem, fuzzy probabilistic c-means clustering was introduced by Pet *et al*.

2.11 Consensual clustering

This clustering method combines the results from heterogenic data sets based on consensual clustering formalism [11]. With this clustering the consensual division of data sets to clusters is identified, as close as possible to the results from all the clusterings. Also with the evaluation of clustering results, the more information is obtained by the heterogenic sets, than the results obtained from individual gene expression data sets.

2.12 Wavelet-based clustering algorithm for temporal gene expression data

This algorithm [16] uses the wavelet analysis to transform the temporal gene expression data with continuous wavelet analysis and then the hierarchical clustering is performed. Clustering after wavelet transformation overcomes the problem of temporal shifts in expression patterns observed under different experimental conditions.

3 CONCLUSION AND FURTHER WORK

Clustering is only a starting point for further analysis and therefore algorithms that will improve the final biological predictions are necessary to be developed. The biclustering, fuzzy, model-based and time-series algorithms offer greater possibilities in that respect, and therefore those algorithms should be improved. The aim of clustering is to gain biologically relevant clusters, but it is difficult to evaluate the cluster quality, to detect whether a cluster is enriched for a particular functional attribute. There is a lot of challenge in this analysis such as handling systematic noise, detecting significantly different gene expression, efficient clustering, validation of clustering results, as well as sample analysis. The greatest challenge is development of gene expression data analysis algorithms, that efficiently integrate (combine) several methods. These algorithms should provide clustering results that are both statistically and biologically relevant. These novel algorithms require an appropriate visualization for more intuitive presentation where conclusions referring to clusters are significantly transparent.

References

[1] Eisen M., Spellman P., Brown P., Botstein D., *Clustering analysis and display of genome-wide expression patterns*, 1998

[2] Tavazoie S., Hughes J., Campbell M. et al., *Systematic determination of genetic network architecture*, 1999

[3] Tamayao P., Slonim D., Mesirov J. et al., *Interpreting patterns of gene expression with self-organizing maps: Methods and application to hematopoietic differentiation*, 1999

[4] Herrero J., Valencia A., Dopazo J., *A hierarchical unsupervised growing neural network for clustering gene expression patterns*, 2000

[5] Chen, B., Tai, P.C., Harrison, R., Yi Pan, *Novel hybrid hierarchical-K-means clustering method (H-K-means) for microarray analysis***,** 2005
[6] Shamir R., Sharan R., *CLICK: A clustering algorithm for gene expression analysis*, 2000
[7] De Smet F., Mathys J., Marchal K., Thijs G. et al., *Adaptive quality-based clustering of gene expression profiles*, 2002
[8] Heyer L, Kruglyak S., Yooseph S., *Exploring expression data: Identification and analysis of coexpressed genes*, 1999
[9] Yeung K.Y, Fraley C., Murua A. et al., *Model-based clustering and data transformations for gene expression data*, 2001
[10] Dembele D., Kastner P., *Fuzzy c-means for clustering microarray data,* 2003
[11] Filkov V., Skiena S., *Integrating microarray data by consensus clustering,* 2003
[12] Cheng Y., Church G., *Biclustering of expression data*, 2000
[13] Hastie T., Tibshirani R., Eisen M., et al., *'Gene shaving' as a method for identifying distinct sets of genes with similar expression patterns*, 2000
[14] Getz G., Levin E., Domany E., *Coupled two way clustering analysis of gene microarray data,* 2000
[15] Sheng Q., Moreau Y., De Smet F. et al., *Advances in cluster analysis of microarray data*, chapter from book Data analysis and visualization in genomics and proteomics, 2005
[16] Song J.Z., Duan K.M., Ware T.,Surette M., *The wavelet-based cluster analysis for temporal gene expression data*, 2007
[17] Hoang T.M., Olteanu M., *SOM biclustering - coupled self organizing maps for the biclustering of microarray data*, 2003

METODOLOGIJE RAZVOJA VEČAGENTNIH SISTEMOV

Ana Šaša, Marjan Krisper
Univerza v Ljubljani,
Fakulteta za računalništvo in informatiko,
Tržaška 25, 1000 Ljubljana
Tel: +386 1 4773419; fax: +386 1 4251038
e-pošta: ana.sasa@fri.uni-lj.si

POVZETEK

Množica metodologij za razvoj večagentnih sistemov je zelo obširna, zato je odločitev za izbor ene izmed njih pri razvoju večagentnega sistema lahko težka naloga. V prispevku je podan pregled štirih metodologij večagentnih sistemov: Gaia, INGENIAS, PASSI in Tropos. Predstavljeno je trenutno stanje tega področja, kjer veliko število med seboj bolj ali manj si podobnih metodologij povzroča potrebo po poenotenju pristopa k razvoju, in sicer bodisi v opredelitvi standardne metodologije bodisi v obliki kakšne druge rešitve, na primer s področja konstruiranja metodologij.

1 UVOD

Večagentni sistemi predstavljajo relativno mlado področje računalništva. Preučevati so jih začeli okoli leta 1980, bolj pa so se razširili šele od sredine devetdesetih let. Od takrat se je zanimanje zanje zelo povečalo in dandanes so postali ena izmed bolj privlačnih in obetavnih poglavij računalništva.

Z naraščajočo popularnostjo večagentnih sistemov, se je pojavila potreba po ustrezni metodologiji razvoja tudi za to področje. Različne raziskovalne skupine so se lotile izdelave take metodologije in danes je množica metodologij za razvoj večagentnih sistemov zelo obširna.

V nadaljevanju so predstavljene in primerjane nekatere metodologije večagentnih sistemov. V tretjem poglavju je opisano trenutno stanje področja metodologij za razvoj večagentnih sistemov in prizadevanja k izboljšanju le-tega. Na koncu je v četrtem poglavju podan še zaključek ter v petem viri in literatura.

2 PREGLED METODOLOGIJ RAZVOJA VEČAGENTNIH SISTEMOV

Problematika primerjave metodologij razvoja večagentnih sistemov (*Multi-Agent System*, v nadaljevanju MAS) je bila v literaturi že večkrat izpostavljena. Gre za to, da se metodologije lahko med seboj zelo razlikujejo, saj se ukvarjajo z zelo različnimi vidiki MAS. Za primerjavo so različni avtorji predlagali več kriterijev. Nekateri izmed njih zahtevajo zelo podrobno poznavanje danih metodologij in večje število ocenjevalcev. Glede na namen te naloge in glede na število metodologij, ki jih bom predstavila, sem se za analizo in primerjavo oprla na deli Shehoryja in Sturma [1] oziroma Dama in Winikoffa [2], ki predlagajo ocenjevanje metodologij glede na štiri osi: obravnavani koncepti in njihove lastnosti, notacija in jezik modeliranja, proces razvoja ter praktični vidik.

V nadaljevanju poglavja so krajše predstavljene štiri metodologije, ki so bile podrobneje obravnavane. Pri preučevanju smo se oprli na različne vire, ki jih opisujejo, ter na dela nekaterih drugih avtorjev, ki so se ukvarjali z njihovim preučevanjem in ocenjevanjem [1, 2, 4]. Na koncu poglavja so v tabeli zbrane ocene po posameznih kriterijih, podane ugotovitve in primerjava.

Primere metodologij, ki jih v prispevku nismo obravnavali, lahko najdemo na primer v [13], [14], [15], [16], [17] ali [18]. Glede na obseg prispevka bi bil pregled in primerjava vseh preobsežen, menimo pa, da tudi tako pridemo do zelo podobnih splošnih sklepov glede področja večagentnih metodologij.

2.1 Gaia

Beseda "Gaia" prihaja iz grške mitologije in pomeni "mati Zemlja". V skladu z imenom tudi metodologija Gaia [9] predlaga, da večagentne sisteme predstavimo s prispodobo človeške organizacije – množica entitet z različnimi vlogami, ki delujejo skupaj za doseganje določenih ciljev.

Osrednja entiteta metodologije Gaie je agent, ki svoje obnašanje izraža z igranjem vlog. Vloga je definirana je s pravicami, odgovornostmi, aktivnostmi in sodelovanjem z drugimi vlogami. Sodelovanje med vlogami opisujejo protokoli. Agent lahko drugim agentom omogoča del svojega izvajanja, s tem da jim nudi določene storitve. Pomembna entiteta metodologije je tudi organizacija, ki določa topologijo vzorcev sodelovanja in kontrolni režim aktivnosti. Organizacija upošteva določena organizacijska pravila, ki so definirana horizontalno ter tako postavljajo omejitve vsem vlogam in protokolom organizacije oziroma definira odnose med vlogami, med protokoli ter med vlogami in protokoli. Eden izmed ključnih elementov Gaie je še okolje, ki predstavlja entitete in vire, s katerimi bi naj bodoči sistem sodeloval.

V postopku razvoja metodologije Gaia opredeljuje dve fazi, in sicer fazo analize in fazo načrtovanja. Gaia privzema, da izdelki, ki nastanejo med razvojem predstavljajo zadostno specifikacijo, ki jo lahko uporabimo za implementacijo v kateri izmed tradicionalnih metod ali z uporabo primernega agentnega programskega okolja.

2.2 INGENIAS

Metodologija INGENIAS [10] izhaja iz želje po poenotenju večih pristopov k razvoju MAS, ki izvirajo iz različnih idej o tem, kakšen bi MAS naj bil. Eden izmed takšnih predhodnih poskusov je bila metodologija MESSAGE, iz katere INGENIAS tudi izhaja.

INGENIAS opredeljuje pet poglavitnih pogledov na večagentni sistem in z njimi povezanih metamodelov, in sicer: organizacijski pogled, agentni pogled, pogled interakcij, pogled ciljev/opravil in pogled okolja. V organizacijskem pogledu je predstavljena organizacija, njeni cilji in notranja zgradba. Organizacija se deli v skupine, te na podskupine, na najnižjem nivoju pa so sestavljene iz vlog, agentov, virov in aplikacij. Agentni model opisuje posamezne agente, njihove odgovornosti in sposobnosti. Obnašanje agenta je zajeto s komponentami mentalno stanje, upravljavec mentalnega stanja in izvajalec mentalnega stanja. Pogled interakcij opisuje potek izvajanj interakcij med agenti, cilje, zaradi katerih pride do interakcije, sporočila in protokole interakcije. Pogled ciljev/opravil prikazuje zgradbo ciljev in opravil, razmerja med njimi in vpliv, ki ga ima izvajanje določenega opravila na mentalna stanja agentov. Pogled okolja opisuje zunanje entitete, s katerimi bo MAS sodeloval. Te so lahko sistemski viri, aplikacije ali agenti drugih organizacij.

Pri procesu razvoja, ki ga predlaga razvojna skupina metodologije INGENIAS, gre za integracijo v proces RUP. Proces razvoja je podprt z množico orodij pod imenom INGENIAS Development Kit (IDK), ki poleg samega modeliranja zagotavlja tudi konsistentost modelov in omogoča kreiranje prototipov.

2.3 PASSI

PASSI (*Process for Agent Societies Specification and Implementation*) ali "koraki", kar beseda pomeni v itaijanskem jeziku, je metodologija, ki korak za korakom vodi razvoj MAS skozi različne ravni podrobnosti. V njej so integrirani načrtovalski modeli in koncepti objektno orientiranega inženiringa skupaj s pristopi umetne inteligence.

Koncepte, ki jih obravnava metodologija PASSI [11], lahko razdelimo na tri logična področja, in sicer na problemsko domeno, domeno agentov ter domeno rešitve. Na ravni problemske domene se nahajajo komponente, ki izvirajo iz sveta uporabnika bodoče programske opreme. S tem je ta raven neposredno povezana z opredelitvijo zahtev uporabnika, ki jih določi s pojmi scenarija, zahtev, ontologije in virov. V domeni agenta je rešitev opisana s koncepti agenta. V PASSI je vsak agent odgovoren za uresničevanje določenih funkcionalnosti sistema, ki izvirajo iz zahtev definiranih v problemski domeni. Agent lahko igra več vlog, ki so vključene v scenarije in so sposobne opravljati storitve. Vsaka vloga izvaja vsaj eno opravilo, ki predstavlja atomarni del obnašanja agenta. Poleg tega so vloge posredniki prenašanja informacij s sporočili. Tok izmenjave sporočil in semantika je določena s protokolom interakcije agentov. V domeni rešitve je podana struktura rešitve na ravni kode, ki je v skladu z izbrano implementacijsko platformo FIPA [5].

Razvojni proces po PASSI je inkrementalno-iterativen proces, ki poteka vse od opredelitve zahtev do kodiranja in testiranja. Podprt je z orodjem *PASSI ToolKit*.

2.4 Tropos

Pri razvoju po metodologiji Tropos [12] je pomembno predvsem dvoje:

- Pojem agenta, cilja, načrta in drugih mentalnih konceptov se uporablja v vseh fazah razvoja, od zgodnje analize zahtev do dejanske izvedbe načrta. Ključni mentalni pojmi temeljijo na arhitekturi BDI [6].
- Ključen poudarek je na zgodnji analizi zahtev.

Za razliko od drugih metodologij Tropos uvaja koncept akterja, ki je posplošitev pojma agenta. Z akterjem modeliramo entiteto, ki ima znotraj sistema strateške cilje in namene. Akter lahko dosega svoje cilje tako, da izvaja načrt, pri tem pa lahko potrebuje določene vire. Pri doseganju ciljev ali pri dostopanju do virov so akterji lahko med seboj odvisni eden od drugega. Vloga je abstraktna predstavitev obnašanja družbenega akterja, množica vlog pa sestavlja pozicijo. Akterji se v postopku razvoja preslikajo v programske agente s svojimi sposobnostmi, cilji, verovanji in interakcijami. Pozicijo navadno sestavljajo vloge, ki jih izvaja eden agent.

Metodologija obravnava celoten življenjski cikel razvoja, vendar pa bolj podrobno obravnava predvsem zgodnje faze. Loči pet glavnih razvojnih faz: zgodnja analiza zahtev, pozna analiza zahtev, arhitekturno načrtovanje, podrobno načrtovanje in izvedba.

2.5 Ugotovitve in primerjava metodologij

Tabela 1 združeno prikazuje ocene metodologij glede na izbrane kriterije. Opazimo lahko, da je nekaj konceptov, ki so v veliki meri obravnavani v vseh metodologijah. To so agent, avtonomnost, reaktivnost, proaktivnost, organizacija, interakcija, vloga in okolje. Poleg tega omogočajo njihove notacije in jeziki modeliranja visoko modularnost, bolj ali manj pa so primerne za večino razvojnih kontekstov.

		Gaia	*INGENIAS*	*PASSI*	*Tropos*
Koncepti in lastnosti metodologije	Avtonomnost	□	□	+	+
	Reaktivnost	+	□	+	+
	Proaktivnost	+	□	+	□
	Socialnost	+	□	□	○
	Agent	□	□	□	□
	Verovanje	-	□	○	□
	Želja	-	+	○	□
	Namen	-	□	○	□
	Sporočilo, interakcija	+	□	□	+
	Norma	□	□	+	○
	Organizacija	□	□	+	*
	Protokol	□	+	□	○
	Vloga	□	□	□	□
	Storitev	□	○	□	○
	Družba	□	□	□	+
	Opravilo	+	□	□	+
	Cilj	-	□	+	□
	Okolje	+	□	□	+
Notacija in jezik modeliranja	Dostopnost	○	□	+	+
	Analiziranje, konsistentnost	○	+	+	–
	Upravljanje kompleksnosti	–	+	+	□
	Izvedljivost in testiranje	–	+	□	□
	Ekspresivnost	○	+	○	+
	Modularnost	□	□	□	□
	Natančnost, nedvoumnost	□	○	○	□
Proces razvoja	Razvojni kontekst	+	□	□	□
	Življenjski cikel	○	□	□	□
	Faze, podfaze, aktivnosti	○	+	□	+
	Izdelki	□	□	□	○
	Verifikacija, validacija	–	+	+	□
	Zagotavljanje kakovosti	–	○	–	–
	Napotki vodenju projekta	–	□	–	–
Praktični vidik	Viri, orodja	○	+	□	□
	Potrebno predznanje	+	–	+	+
	Predpisanost jezika,	□	□	+	–
	Primernost domeni	+	□	+	+
	Skalabilnost	○	+	□	–

Tabela 1: Metodologije razvoja MAS glede na štiri skupine kriterijev;
Legenda: □ metodologija v celoti in eksplicitno vključuje/podpira dani pojem; + metodologija posredno vključuje/podpira dani pojem; ○ metodologija le deloma vključuje/podpira dani pojem; – pojem v metodologiji ni obravnavan.

Z izjemo nekaterih skupnih točk je vsaka izmed obravnavanih metodologij primer zase, tako glede arhitekture, modelov kot notacije. Bistvene razlike je opaziti ne le v posameznih množicah konceptov, ki jih obravnavajo, temveč tudi njihovem razumevanju. Določene metodologije so osredotočene predvsem na to, da izčrpno zajamejo množico konceptov področja večagentnih sistemov, kot na primer INGENIAS. Gaia na primer vidi sistem kot družbeno organizacijo, zato je velik poudarek na vlogi in organizacijskih konceptih, medtem ko konceptov znanja in BDI ne obravnava. V nasprotju s tem Tropos izhaja prav iz arhitekture BDI in vse se vrti okoli agentov, njihovih ciljev, želja, verovanj in namenov.

Kar se tiče samega procesa razvoja lahko agentno usmerjene metodologije razvrstimo v dve širši kategoriji. V prvi je razvoj MAS integriran v že obstoječe procese razvoja programske opreme, kot na primer INGENIAS, ki temelji na RUP. Dobra stran tega je, da so vsi vidiki, ki bi jih naj metodologija kot taka obravnavala, zajeti. V drugi kategoriji metodologije določijo svoj proces razvoja. Velikokrat izvirajo neposredno iz teorije agentov in dajejo večji poudarek analizi in načrtovanju, kot Gaia in Tropos. Pri tem včasih še vedno zajemajo določene pristope že obstoječih metodologij, in sicer z uporabo notacije UML, na primer PASSI.

V procesu razvoja metodologije ne obravnavajo vedno vseh faz, poleg tega se razlikujejo tudi v tem, katerim fazam dajejo poudarek. Tropos pokriva celoten razvojni postopek, poudarek pa daje na zgodnjo analizo zahtev. V nasprotju s tem na primer Gaia opredelitve zahtev sploh ne obravnava, prav tako ne izvedbe ter faz, ki ji sledijo.

3 SMERI NADALJNJEGA RAZVOJA METODOLOGIJ MAS

Današnje stanje metodologij večagentnih sistemov lahko primerjamo s področjem objektno usmerjenih metodologij pred dobrim desetletjem, kjer je narasla potreba po enotnosti in različni pristopi k razvoju so bili integrirani s skupno notacijo (UML) in razvojnim procesom (Unified process, UP). V nasprotju z objektno usmerjenim področjem, katerega glavno gonilo razvoja je bila predvsem industrija, večino agentno usmerjenih metodologij podpirajo manjše skupine akademskih raziskovalcev [7]. Tako danes obstaja več priznanih pristopov razvoja večagentnih sistemov, ki temeljijo na različnih mnenjih o tem, kaj bi naj večagentni sistem bil, ob tem pa se je seveda pojavila potreba po določitvi enotne in vsesplošne metodologije.

Različne skupine raziskovalcev so že predlagale več poskusov poenotenja metodologij (med njimi tudi INGENIAS), vendar pa žal nobena izmed njih še ni splošno priznana. Pomembno mesto pri tem so igrala srečanja Techical Fora organizacije AgentLink III, ki združuje različne evropske raziskovalce tega področja. Eden izmed namenov teh srečanj je bil namreč ravno ta, da bi se različne skupine raziskovalcev dogovorile o skupnem pristopu. Žal zaradi pomanjkanja finančne podpore AgentLink III trenutno svoje aktivnosti več ne nadaljuje, delne rezultate v obliki osnutka skupnega metamodela pa lahko najdemo v [3].

Po drugi strani pa se pojavlja vprašanje, ali ob naraščajoči kompleksnosti sistemov z eno samo metodologijo res lahko zajamemo vse mogoče vidike takih sistemov. Nekatere raziskovalne skupine so mnenja, da je takšna vseobsegajoča metodologija neracionalen cilj, in da lahko imamo bodisi večjo množico metodologij, vsako za določeno ciljno področje, bodisi metodologijo, ki dopušča določene prilagoditve ob izvajanju, bodisi opredelimo metodološko ogrodje oziroma metamodel, v katerem so zajeti različni delci metodologij, ki jih sestavljamo v ustrezne metodologije - konstruiranje metodologij (*method engineering*).

Primer pristopa situacijskega konstruiranja metodologij k razvoju večagentnih sistemov je Agent OPEN (Object-Oriented Process, ENvironment and Notation) [7, 8], ki ga sestavljata repozitorij in metamodel. V osnovi gre za razširitev objektno usmerjenega metodološkega repozitorija za potrebe grajenja metodologij razvoja večagentnih sistemov. Procesne komponente so dodali s preučevanjem različnih metodologij razvoja večagentnih sistemov, med njimi tudi Tropos, Prometheus, MaSE, Gaia itd.

4 ZAKLJUČEK

Zaradi vse večje popularnosti večagentnih sistemov obstaja danes precej predlogov različnih metodologij razvoja, ki pa so trenutno še vse večinoma v začetnih fazah, razvite in testirane v okviru manjšega števila ne preveč kompleksnih aplikacij in so velikokrat še potrebne izpopolnitve.

Zaradi različnosti pristopov k razvoju se hkrati pojavlja tudi vedno večja potreba po neki enotni in splošno priznani metodologiji, ki bi pripomogla, da pride področje večagentnih sistemov v širšo uporabo tudi v sami gospodarski ponogi razvoja programske opreme. Po drugi strani pa se pojavlja vprašanje, ali ob naraščajoči kompleksnosti sistemov z eno samo metodologijo res lahko zajamemo vse mogoče vidike takih sistemov. Vsekakor bodo raziskovalci tega področja skušali določiti množico standardnih konceptov in tehnik, morda pa bo rešitev v pristopu konstruiranja metodologij ali v definiciji metodologije z ožjo množico skupnih konceptov in njenih razširitev, namenjenim za potrebe različnih vidikov MAS.

5 VIRI IN LITERATURA

[1] A. Sturn, O. Shehory: A Framework for Evaluating Agent-Oriented Methodologies. V zborniku Fifth International Bi-Conference Workshop on Agent-Oriented Information Systems (AOIS-2003), AAMAS 2003, Melbourne, Australia.

[2] K. H. Dam, M. Winikoff: Comparing Agent-Oriented Methodologies. V zborniku Fifth International Bi-Conference Workshop on Agent-Oriented Information Systems (AOIS-2003), AAMAS 2003, Melbourne, Australia.

[3] M. Cossentino, C. Bernon, J. Pavon: Modelling and Metamodelling Issues in Agent Oriented Software Engineering. Poročilo srečanja AgentLink III, AOSE TFG2, Ljubljana 2005.

[4] Agentlink III: Methodologies evaluation. AOSE TFG Budapest, 2005.

[5] Foundation for Intelligent Physical Agents: http://www.fipa.org/.

[6] A. S. Rao, M. Georgeff: BDI Agents: from theory to practice. V zborniku ICMAS 1995, San Francisco, California.

[7] P. Giorgini, B. Henderson-Sellers: Agent-Oriented Methodologies. Idea Group Inc., 2005.

[8] B. Henderson-Sellers: Agent-oriented methodologies – the value of method engineering. Agents-vic, Melbourne, Australia, 2004.

[9] F. Zambonelli, N. R. Jennings, M. Wooldridge: Developing Multiagent Systems: The Gaia Methodology. ACM Transactions on Software Engineering and Methodology, 12(3): 317-370, 2003.

[10] J. Pavon, J. J. GomezSanz: Agent Oriented Software Engineering with INGENIAS. V zborniku CEEMAS 2003, Praga, Češka.

[11] M. Cossentino: Different perspectives in designing multiagent systems. V zborniku AGES 2002 workshop, NODe 2002, Erfurt, Germany.

[12] P. Bresciani, F. Giunchiglia, P. Giorgini, A. Perini, J. Mylopoulos: Tropos: An AgentOriented Software Development Methodology. JAAMAS, 8(3): 203-236. Kluwer Academic Publishers, 2004.

[13] G. Picard, M. P. Gleizes: The ADELFE Methodology – Designing Adaptive Cooperative Multi-Agent Systems. V Methodologies and Software Engineering for Agent Systems. Kluwer Publishing, 2004.

[14] J. M. Serrano, S. Ossowski: On the Impact of Agent Communication Languages on the Implementation of Agent Systems. Cooperative Information Agents VIII, Lecture Notes in Computer Science, 3191: 92-106, Springer Berlin / Heidelberg, 2004.

[15] C. Iglesias, M. Garijo, J. Centeno-Gonzalez, J. R. Velasco: Analysis and Design of Multiagent Systems Using MAS-CommonKADS. Agent Theories, Architectures, and Languages. Lecture Notes in Artifical Intellegence, 1365: 313-326, Springer-Verlag, 1998.

[16] J. Ferber, O. Gutknecht: AALAADIN: A meta-model for the analysis and design of organizations in multi-agent systems. V zborniku ICMAS 1998, Paris, France.

[17] L. Padgham and M. Winikoff. Prometheus: A Methodology for Developing Intelligent Agents. V zborniku Agent-Oriented Software Engineering III: Third International Workshop, AAMAS 2002, Bologna, Italija.

[18] MaSE: http://macr.cis.ksu.edu/projects/mase.htm.

A QUALITATIVE DECISION-SUPPORT MODEL FOR EVALUATING RESEARCHERS

Daniela Stojanova[1] , *Katerina Taškova*[2] , *Marko Bohanec*[3] , *Sašo Džeroski*[3]
[1] Slovenian Forestry Institute,
[2] Department of Computer Systems, [3] Department of Knowledge Technologies,
Jožef Stefan Institute, Slovenia
e-mail: daniela.stojanova@gozdis.si, katerina.taskova@ijs.si

ABSTRACT

The evaluation of research work has been an essential element of the scientific enterprise. In general, the evaluation of researchers and their work is a dynamic system that is highly dependent on the social and economic condition of the country in which the researchers work. The most frequently used evaluation form worldwide is based on peer review. In Slovenia, a quantitative model for evaluating researchers has been built by the Slovenian Research Agency, and has been heavily criticized by the public. In order to alleviate some problems with this model and motivate further discussion on this issue, we propose an alternative qualitative model, based on a literature survey on existing models in foreign countries.

1 INTRODUCTION

Evaluation is an essential characteristic of human activity and is perhaps the single most important and sophisticated cognitive process in the repertoire of human reasoning and logic. It is also one which has defied adequate explanation for nearly two millennia [1]. Without such processes there is simply no means for distinguishing the bad from the good, the worthwhile from the worthless, or the significant from the insignificant.

In science, evaluation has been an essential element of the scientific enterprise, even before the appearance of the first scientific journals, usually in the form of peer review. In the past few decades, the evaluation of scientific research, and in particular researcher performance, has changed substantially in terms of scale and scope [2], as well as methodology. In part, these changes have occurred as a result of attempts to guide, regulate and control research agendas and priorities, not only in regard to distributing research funds, but also to influence the system of scientific research itself [3]. Therefore, criteria other than strictly scientific ones (e.g., social and political criteria) have been introduced, which further increase the complexity of evaluation. The new pillars of research evaluation include: governments; politicians; the media; social movements and non-governmental organizations.

Typically, the evaluation takes place on a national level and each country has its own national model for evaluating research and allocating research funds. In Slovenia, such a model has been built by the Slovenian Research Agency (ARRS) [5]. This model uses data from the (Slovenian Current Research Information System - SICRIS) [4] and the COBISS database that maintains detailed information for every registered researcher in Slovenia; it also relies on the Web of Science database [6]. Different variants of the model are used for different disciplines and for evaluating applications to different ARRS's calls (for young researchers, for project leaders etc). Several of the variants of the model have been published together with the specific calls; these use several scientific performance indicators and combine them in a linear fashion. In the past decade, the model has been a very popular topic of discussion and criticism from the public. audience.

Inspired from this situation, we built a system for evaluating researchers, using the paradigm of hierarchical models for multi-attribute decision making. Our qualitative model was built after a literature survey was performed and takes into account existing foreign models for evaluation of researchers and their work. The model proposes a new methodological approach, based on qualitative multi-attribute modeling, and uses some new indicators. We propose it as an initial alternative to the existing model used by ARRS and hope to motivate further discussion on this important topic in Slovenia.

2 INDICATORS OF RESEARCH PERFORMANCE

Applying research performance indicators in practice is not a straightforward task. It is important to clarify what role the indicators will play in the assessment of research, which indicators should be selected, and what possible unintended consequences could arise from their application. The problem with all quantitative indicators is that research practices vary across different fields, and it is necessary to determine what level of aggregation is to be used and the form in which the results will be presented. The vast majority of the literature discusses these issues for bibliometric indicators only. However, they affect all quantitative indicators.

A literature review was undertaken to examine quantitative performance indicators used in the evaluation of research. Quantitative evaluations of research have generally been

conducted by scientometricians, bibliometricians, information and library scientists, and have used indicators of quantity, quality, impact, or influence of research [7].
The indicators can be easily divided into bibliometric and non-bibliometric. Bibliometric indicators are based on published literature in all of its forms – journal articles, monographs, book chapters, conference papers, patents, and citations. Non-bibliometric measures encompass all other readily quantifiable indicators, such as the ability to attract external funding and measures of esteem (honors and awards, editorship of journals, membership of major national and international professional societies, keynote addresses, PhD students data etc) [8], but we should be careful when using them because they can be a poor reflection of research activities in areas of applied research.
The number of citations is a measure of the strength of influence of a body of research, when applied to sufficiently large aggregates. Citation analyses are more difficult to undertake than publication analyses. The citations used in standard bibliometric analyses are the references contained in selected journals to other journals in the Web of Science (WoS) framework [9].
.

3 DEFINITION OF THE MODEL

Clarifying the role of the performance indicators was the first step towards the definition of the new model. Having in mind the multi-attribute nature of our evaluation problem, the next step was building a multi-attribute model organized hierarchically into a tree of attributes. We used DEXi, a computer program for the development of qualitative multi-attribute decision models and evaluation of options [7]. DEXi is particularly suitable for a hierarchical decomposition of evaluation problems that require judgment and are characterized by qualitative reasoning.
At the top of our proposed hierarchy is the root attribute *Evaluation of Researcher*. It is decomposed into two descendants: *Quality* and *Relevance*. *Quality* aggregates *Productivity* and *Impact* (citations)*. Productivity* reflects the bibliometric indicators, while *Relevance* basically incorporates the non-bibliometric indicators. At the bottom level we have 10 (or 11 in models M2, M2a) independent input attributes. The tree structure is presented in Fig.1.
In the process, we actually developed five similar models, with slight variations of the tree structure, utility functions and attribute scales. The first model, M1, includes the *Impact* attribute with 70% influence on the utility function of the aggregate attribute *Quality* and the *Productivity* attribute with 30 % influence. The second model, M2, further decomposes the attribute *Impact* into the normalized number of citations and number of cited papers. These two models have been modified by changing the influence of the *Impact* factor to 60% for the first model (M1a) and to *50%* for the second model (M2a). In M1k, we have equal influence of the descendants of attribute *Other* (as opposed to 70% vs. 30% for *SU*/Forms of research acknowledgement. vs. *Indicators of esteem*).

We used several qualitative attributes with increasing scales for the representation of input values. The scales are shown in Fig. 1. The lowest value is considered "bad" and it is labeled as "Low" or "No" in the model. The values of the scales increase and the most preferred values are labeled as "Very high" or "Yes". The lowest value, out of five possible, for the target (root) attribute *Evaluation of Researcher* is labeled as "Unsatisfactory" and the most preferred as "Excellent".
The input values of the basic attributes of the evaluated researchers (one dataset is presented in Fig.3) were obtained indirectly by applying discretization over the continuous space across which all basic attributes were initially defined. The original quantitative values of the attributes were extracted from the COBISS database that maintains detailed data about the work of researchers in Slovenia. The extracted data covered the performance of researchers in the time interval 2002-2006, because we chose the evaluation period of five years (ARRS uses a five year period in several current calls).

Attribute	Scale
Evaluation of Researcher	Unsatisfactory; Satisfactory; Good; Very good; *Excellent*
├**Quality**	Very Low; Low; Medium; High; *Very High*
│├**Productivity**	Low; Medium; High; *VeryHigh*
││├**Journal publication**	Low; Medium; High; *VeryHigh*
│││├Indexed journals	Low; Medium; *High*
│││└Other journals	Low; Medium; *High*
││└**Non-journal publications**	Low; Medium; *High*
││ ├Conference publications	Low; Medium; *High*
││ └Monographs and other completed work	Low; Medium; *High*
│└Impact	Low; Medium; *High*
└**Relevance**	Low; Medium; High; *Very High*
├**Projects**	Low; Medium; *High*
│├National projects	No; *Yes*
│└EU projects	No; *Yes*
└**Other**	Low; Medium; *High*
├SU	Low; Medium; *High*
└**Indicators of esteem**	No; *Yes*
├Prizes and awards	No; *Yes*
└Membership	No; *Yes*

Fig.1. The structure and scales of the evaluation model

Two techniques were used to discretize the available data, which came in two batches: the first included 14 researchers, and the second 171 researchers, all from the field of Computer science in Slovenia. The first discretization approach used equi-distant intervals to cover the range of the specific attribute up to a threshold. As a threshold we used the performance of the top 1% of the researchers in the first case and the top 10 % of the researchers in the second case, ranked by attributes separately. This means that the interval below the threshold was divided into equal subintervals and mapped to the corresponded qualitative values. The second approach was based on calculating percentiles: values belonging to the interval between 25^{th} and 75^{th} percentile were classified as "medium", below the 25^{th} percentile as "low" and above the 75^{th} percentile as "high".
For each aggregate attribute, a utility function was defined that maps all the combinations of the low-level attribute values into values of their aggregate attribute. An example mapping is represented in Fig.2. Each row of the table gives the value of the aggregate attribute for one combination of the low-level attribute values. Each row can also be interpreted as an if-then rule.

	Quality	Relevance	Evaluation of Researcher
	71%	29%	
1	Very Low	<=Medium	Unsatisfactory
2	Very Low	Very High	Unsatisfactory
3	<=Low	High	Satisfactory
4	Low	<=High	Satisfactory
5	Low	Very High	Good
6	Medium	<=High	Good
7	Medium:High	Low	Good
8	Medium	Very High	Very good
9	High	Medium:High	Very good
10	>=High	Medium	Very good
11	Very High	<=Medium	Very good
12	>=High	Very High	Excellent
13	Very High	>=High	Excellent

Fig.2. The topmost utility function

Each attribute has a different level of influence on the global model. The *Quality* is included with 75% (*Productivity* with 27% and *Impact* with 48%) and the *Relevance* with 25% (*Projects* with 17% and *Other* with 7%) in all models.

3. USING AND EVALUATING THE MODELS

Outputs from the five generated evaluation models are presented in Fig.5. In the case of 171 researchers being evaluated, we did not consider the M2 model, due to the missing data about the number of citations per paper that this model takes as input in the calculations of the impact value. All given models were applied on data obtained by statistically (percentile) based discretization. Additionally, we performed evaluation on researchers with the linear scale data discretization presented in Fig.5 (a.4, 7, 8 and b.1, 4).

Evaluation of the inputs for 14 researchers shows that linear discretization with 1% threshold results in stricter evaluation. Changing the utility function of the node *Other* from 50% (Fig.5.a5) influence of SU to 70% (Fig.5.a1), gives better results for 40% of the evaluated researchers on the smallest dataset. Changing the utility function of the node *Quality* from 70% (Fig.5.a.1) and the influence of *Impact* node to 60% (Fig.5.a.2), gives better results for 28% of the evaluated researchers. If node *Impact* is aggregated from the nodes *Num.Cited papers* and *Norm.Num Citations*, both with equal influence in the utility function (Fig.5.a.3), the obtained results give better evaluation for 28% of the researchers than the results presented in Fig.5.a.1. The distribution of evaluation outcomes from DEXi models, i.e., percent of researchers for each class is presented in Fig 4.

4 CONCLUSION

We have developed a hierarchical multi-attribute model for evaluating the performance of researchers and applied it to two sets of computer science researchers in Slovenia. In contrast to the current approach taken by the Slovenian Research Agency, which is quantitative and calculates a weighted sum of performance indicators, our model is qualitative and combines indicators in a more sound manner. Namely, in the case of summation we can get very high overall scores, even with very low scores along some dimensions, which is not desirable.

The model we have constructed encompasses knowledge from a wide range of studies carried out in the literature. These include researcher evaluation methods from several countries, such as the United Kingdom, the Netherlands and Australia. It is based on performance indicators that are also used in these countries.

In addition, the decision support framework in which we have implemented the model has many other desirable properties. It produces evaluations for each of the intermediate levels of evaluation (such as *Quality* or *Relevance*) and provides explanations at several levels of detail. It also produces several graphical representations of the evaluations.

The proposed models are a possible alternative to the model used by ARRS and we hope it will motivate further discussion on this important topic in Slovenia.

References

[1] Scriven, M. (2001). An overview of evaluation theories. Evaluation Journal of Australasia, 1(2), 27-29.

[2] Frederiksen, L. F., Hannson, F., & Wennberg, S. B. (2003). The Agora and the role of research evaluation. Evaluation: The International Journal of Theory, Research and Practice, 9(2), 149-172.

[3] Hansson, F. (2006). Organizational use of evaluation: Governance and control in research evaluation. Evaluation: The International Journal of Theory, Research and Practice, 12(2), 159-178.

[4] SICRIS (2007). Slovenian Current Research Information System. http://sicris.izum.si/

[5] ARRS (2007). Slovenian Research Agency. http://www.arrs.si

[6] COBBIS (2007). Co-operative Online Bibliographic System & Services. http://www.cobiss.si/

[7] Coryn, C. L. S., & Hattie, J. A. (2006). The transdisciplinary model of evaluation. Journal of MultiDisciplinary Evaluation, 4, 107-114.

[8] Quantitative indicators for research assessment – a literature review

[9] WoS (2007).Web of Science, *http://scientific.thomson.com/products/wos/*

[10] Bohanec, M. (2007). DEXi: A Program for Multi-Attribute Decision Making http://www-ai.ijs.si/MarkoBohanec/dexi.html

Option	X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Z1	Z2	V1	V2
Indexed journals	Low	Low	Medium	Medium	Medium	Medium	High	High	Medium	Medium	Medium	High	Medium	Low
Other journals	High	Low	Low	High	Low	Medium	Medium	Medium	Medium	High	Low	Medium	High	Medium
Conference publications	Medium	Low	Medium	Medium	Low	Medium	Medium	High	High	High	Medium	Medium	Low	Low
Monographs and other completed work	High	Low	High	Medium	Low	Medium	Low	Medium	Medium	Low	Medium	Medium	Low	High
Impact	Medium	Low	Low	Low	Medium	Medium	High	High	Medium	Low	High	High	Medium	Low
National projects	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High	Medium	High	Medium	Medium	Medium	Medium
EU projects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	*	*
SU	Medium	Low	High	Low	Medium	Medium	Low	High	Medium	High	Medium	Medium	Medium	Low
Prizes and awards	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Membership	yes	yes	yes	yes	*	*	yes	yes	*	*	yes	yes	*	*

Fig.3 Input values of 14 evaluated researchers obtained by percentile discretization

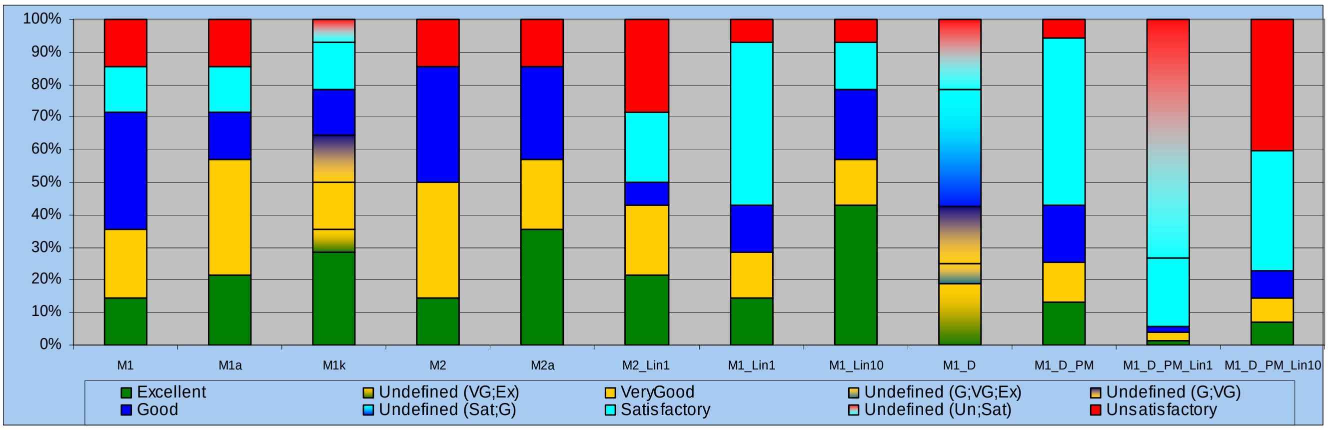


Fig.4 Distribution of evaluation results from DEXi models, percent of classified researchers per model per class of research (Unsatisfactory – Excellent) on scale to 100%

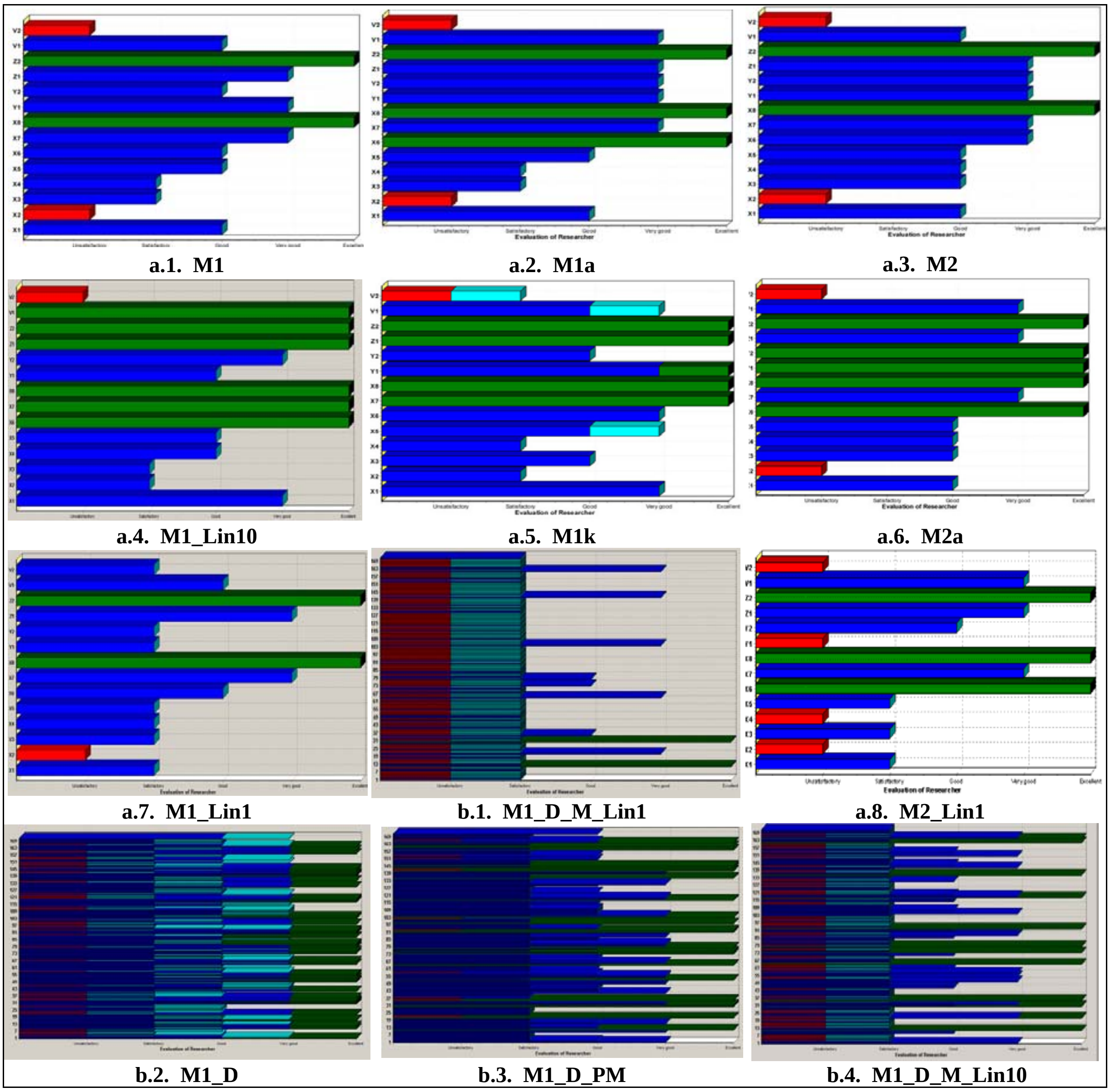


Fig.5 DEXi output charts from performed evaluations with all generated models on a.) input data from 14 researchers b.) data from 171 researchers from the filed of Computer Science in Slovenia

ADVERSARIAL REASONING IN A GAME WITH MULTIPLE OPPONENTS

Aki Vainio
Department of Computer Sciences
Faculty of Technology
University of Vaasa
Box 700
65101 Vaasa
Tel: +358-6-324 8438; fax: +358-6-324 8467
Email: akivain@uwasa.fi

ABSTRACT

This paper explores the difficulties presented by having multiple opponents in a game, including planning through negotiations and with the possibility of betrayal. The game used as an example is *Diplomacy*, a strategy game which uses simultaneous moves.

1. INTRODUCTION

Competitive games with two players differ from games with multiple players in one major way: In a game with multiple players negotiation becomes a major tool in improving ones situation. The ability to negotiate becomes the key to survival.

The key to successful negotiations is the ability to come to a conclusion which satisfies both or all parties involved in the negotiation. However, there will always be several negotiations going on at once and the parties a player is negotiating with can already have an agreement with a third party. Therefore the player can never fully trust those he is negotiating with, which means that any offers made must anticipate backstabs in some manner.

All these elements are present in *Diplomacy*. In *Diplomacy*, a player must out-negotiate and outsmart their opponents. Using simple brute force will usually mean quick destruction at the hands of the other players.

In order to negotiate successfully, a player must have an understanding of his or her opponents' goals. In order to be able to do this, a player must employ adversarial reasoning.

2. *DIPLOMACY*

Diplomacy was first published in 1959. Although it has never reached widespread popularity, it has remained a cult-favorite throughout its existence. During its early years, it was advertised as the favorite game of John F. Kennedy and Dr. Henry Kissinger.

Diplomacy is a grand strategy game set in early 20^{th} century Europe. The game is designed for seven players, each representing a European great power of the period (England, France, Germany, Russia, Austria-Hungary, Italy and anachronistically Turkey). Each player has roughly the same material strength (in other words, armies and fleets) at the beginning of the game, but geography forces many limitations on the players from early on, leaving some players in a poor position. Ideally, they can use their position as an advantage in negotiations.

The goal in the game is to control eighteen of the 34 supply centers in Europe. By achieving this, a player wins the game. The game can also end in a draw, if the players agree on one.

In the game, all units (armies and fleets) are equal in power and each unit has a movement rate of one per round. A battle is won by being able to employ a superior number of units. There is no random element. Also, all moves are simultaneous, which means that correctly analyzing the moves of the opposing player is very important. Strategically the game can be played by the same principles as chess: material, space and time are very important, as well as understanding commonly used opening moves.

2.1 Computer *Diplomacy*

Due to the games nature (complexity, the length of a game and the number of people required to play it), *Diplomacy* has been very actively played using computers and the Internet.

Two different commercial computer games have been made based on the game. Both have been criticized for poor AI performance and the limitations of the negotiation system. In the earlier 1999 version, forming plans with other players was impossible, and in the newer 2005 version does not allow the players to correspond with reasoning as to why they rejected a proposal.

A more successful approach (in terms of popularity) has been the use of a computer (usually online) as a judge. The judge generally handles communication between the players and resolves moves.

Several AIs have been designed to play *Diplomacy*, but they are generally not capable of negotiations and are designed to play in no-press (no-communication) games and are therefore incapable of negotiation or coordination of actions. Automatic *Diplomacy* players are usually known as diplomats.

Even leaving out the negotiations, diplomats have a huge task. In chess, there are exactly 20 different opening moves. This figure rises up to roughly 40 in the midgame. In *Go*, a player has 361 opening moves and roughly 250 possible moves on the average to choose from. In *Diplomacy* there are 4,430,690,040,914,420 legal openings, not including meaningless support moves. This figure also rises quickly as new units are introduced. Obviously using classic minimax search is impossible and several more refined methods have been devised [9], but none have been able to compete on the same level with human players.

3. ADVERSARIAL REASONING

Adversarial reasoning is the use of understanding one's opponents' goals and his actions. Adversarial reasoning has been successfully implemented to playing games such as Go [7] and poker [8], but there are numerous practical problems where adversarial reasoning can help find a solution. Most current practical problems seem to revolve around military issues, but since similar thinking is already important in human interaction in business, computational adversarial reasoning could help businesses and negotiators with their strategies.

3.1 Plan Recognition

Understanding the opposition requires information. Generally complete information is impossible to achieve, which means that a lot has to be pieced together from the limited sources that are available.
BDI (belief-desire-intention) –architecture is an attempt to bring agent thinking closer to human thinking. . It is based on the philosophical traditions concerning human thinking in practical real-life situations [1, 2, 15]. Its roots lie in the works of Bratman [2] regarding the role of intentions in human reasoning. Bratman was also a part of the team producing the first BDI-based architecture [3]. BDI-architecture has become very popular among agent designers [e.g. 4, 10, 11]. See figure 1 for details on the workings of BDI.
When using BDI for adversarial reasoning, the beliefs are constructed from what we know about the opposition. This information is then appended by what we believe the opposition knows about us. We can also make educated guesses on further beliefs by connecting the dots, so to speak. Also, since the opposition will likely be using similar methods, it is reasonable to assume that the enemy will make similar assumptions.
Based on the beliefs of our own agent and those of the opposition, we must then infer the desires or goals of the opposing agent. In real life pragmatic cases this would involve understanding the motivations and philosophy of the opposition.
After this, we can infer intentions based on the known capabilities of the opposition. Understanding the capabilities has been key information in military history [8] and failure to do so can lead to disaster.

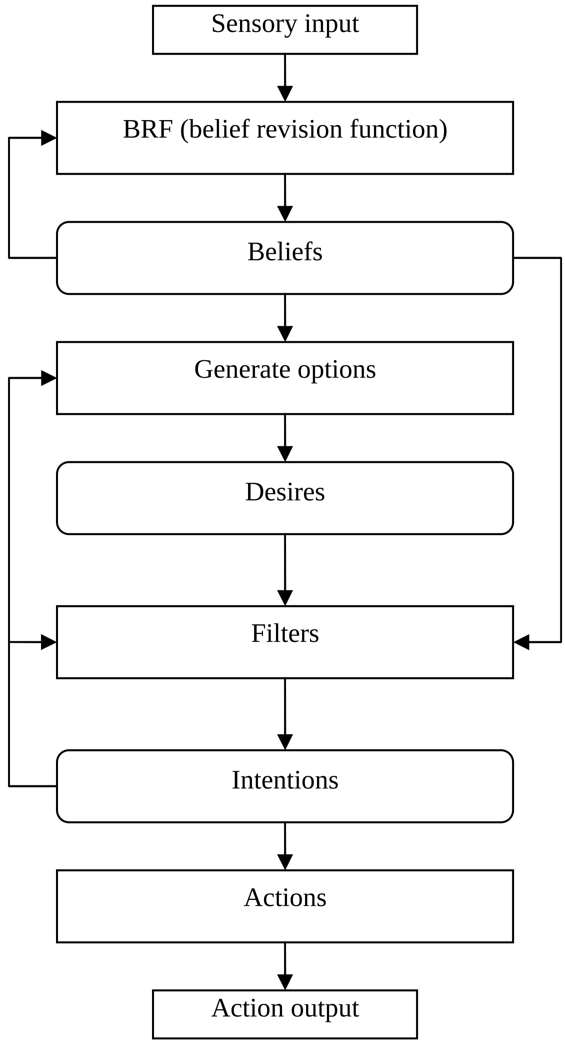


Figure 1: Generic BDI-architecture [15]

3.2 Deception and Counter-Deception

In environments where adversarial reasoning is used, deception often becomes an important tool. Using deception can throw off the opposition as it is as dependent on knowledge about us as we are on knowledge about them. Obviously, the opposition will also try to deceive us, which potentially leads to a very complicated situation.
Deception can be used to obscure all parts of the BDI-architecture. Decoys can make forces seem stronger or deployed differently than they really are. Using reconnaissance to gather intelligence on certain areas will alert the opposition that you are interested in the area. However, this can be used to deceive as well.
Deception is hard to counter. It is often hard to infer whether we are being deceived or whether our own earlier inference on the beliefs or desires was not as good as it was previously thought to be. These situations can be seen as games with partial information [8]. In this way at least no objective which is important to us, is left out of the decision-making.

3.3 Strategy

After we have all the information previously presented, we must still form a plan of our own. In the BDI-architecture, this would be choosing the intentions and the actions. Supposing the opposition is using an adversarial reasoning approach, our planning must take into account that the opposition is also trying to find the best actions against us.

4. ADVERSARIAL REASONING IN *DIPLOMACY*

In a sense, *Diplomacy* is a game of complete information. Each player has a clear view of all units in the game at all times. On the other hand, we don't have perfect information as to why the units are where they are and on the alliances between other players. The goal of each player is clear: They wish to win or participate in a draw. In tournament settings, draws are worth more points if there are fewer players. Therefore eliminating a player is also a desire.
Since beliefs and desires are mostly known, we are left with reasoning about intentions and actions. In order to be able to reason about them, we must have first reason about the relationships between the players.

4.1 Reasoning about Alliances and DMZs

Diplomacy is a game of alliances. No player can win without help. Therefore being able to find and maintain a good alliance is important. Each player will seek to align itself in the best possible way strategically.
The most obvious allies are those who have common borders with great powers who have common borders with us. Often this means that our allies are geographically next to us, which also means that they are also a potential ally against us for the player we are seeking an alliance against. Figure 2 gives a rough idea on who are potential enemies and allies in the early game. This does not include enemy alliances and many of the alliances and enemies are fairly uncommon.

	F	R	I	G	A	T	E
F	X	A	E	A/E	A	A	A/E
R	A	X	A	A/E	A/E	A/E	A/E
I	E	A	X	A	A/E	A/E	A
G	A/E	A/E	A	X	A/E	A	A/E
A	A	A/E	A/E	A/E	X	A/E	A
T	A	A/E	A/E	A	A/E	X	X
E	A/E	A/E	A	A/E	A	X	X

Figure 2: Potential allies and enemies in early game based on geography (A = potential ally, E = potential enemy)

Also, it should be noted that practically everyone is a potential ally from the beginning. Becoming an ally is a way to diffuse a potential enemy at least for the time being. Those who are left alone against an alliance in the beginning of the game, will perish quickly. Usually, the biggest threats to a great power are it's closest neighbors. Diffusing them either through becoming an ally or forming an alliance against them is a big priority. Therefore, by looking at figure 2, we can find out who each player will try to diffuse as early as possible.
First clues on who allied with whom and who was betrayed in the early stages come from opening movements. There is a number of well-known openings and they involve alliances against the other players. By identifying openings and their variants, alliances can be easily inferred. Also, if a player made moves which are part of a common opening, but the supposed ally or allies didn't, than that player has probably been betrayed.
Alliances can shift anytime. As players fall, new alliances are made and old alliances are broken. Generally alliances are only broken when a player has the opportunity to backstab an ally and steal his or her supply centers. This means that only neighbors will betray each other. The point at which this will happen is hard to predict.

4.2 Reasoning about Intentions and Actions

As time is an important factor in the game, it is reasonable to presume that players will generally apply their forces where they stand instead of moving them to another location. Therefore we can safely assume that the opponent will attack whoever is closest to their main force. Even if this assumption is false, we have enough time to make another assumption by the time the opponent has moved its forces.
The opponent will most probably apply its forces in order to capture or control supply centers or other strategically important locations. Usually these locations are important due to access to a large number of other locations (see figure 3).

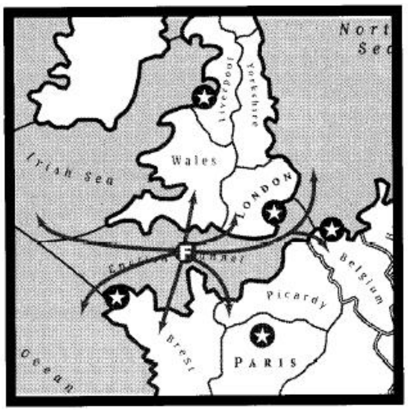


Figure 3: English Channel is of great strategic importance due to number of locations accessible from it [6].
Since conflicts are
Having identified the probable theatre of action, which removes most of the possibilities and in this limited environment, minmax-trees are again a viable option. The larger picture can be lost using this method, but if a conflict in a certain area seems to stall, then we can assume that the

great power will attempt to resolve the situation by bringing more material to the conflict or forming an alliance which would help them.

5. CONCLUSIONS

Like *Go*, *Diplomacy* is not complicated due to complex rules, but rather due to the possibilities presented by the complex strategies available. Both games are much too complicated for methods used in playing games such as chess, as the number of possibilities is simply too large.

The complex environment requires a method of simplifying the situation. This can be achieved through the use of adversarial reasoning. BDI-architecture is a good basis for understanding the opposition.

Diplomacy doesn't only involve war, but a more important aspect of the game is the diplomacy, as the name implies. Identifying alliances and potential alliances can be very helpful in predicting how the opponent will act. There are a number of earlier tools related to diplomats, which could be integrated into the adversarial reasoning approach.

References

[1] S. Agar: Artificial Intelligence and Diplomacy. (1994). Available: http://www.diplomacy-archive.com/resources/postal/artificial.htm

[2] M.E. Bratman: Intentions, Plans, and Practical Reasoning. (1987)

[3] M.E. Bratman, D.J. Israel & M.E. Pollack: Plans and Resource-Bounded Practical Reasoning. (1988) Available: http://citeseer.ist.psu.edu/bratman88plans.html

[4] L. Cholvy & C. Garion: Desires, Norms and Constraints. (2004) Available: http://citeseer.ist.psu.edu/cholvy04desires.html

[5] D. Christian & R.M. Young: Strategic Deception in Agents (2004). Available: http://www.aamas2004.org/proceedings/029_christiand_deception.pdf

[6] Diplomacy Rules (Avalon Hill): http://www.wizards.com/avalonhill/rules/diplomacy.pdf

[7] T. Klinger: A Logical Approach for Computer Go (2001).

[8] A. Kott & W.M. McEneaney (eds.): Adversarial Reasoning – Computational Approaches to Reading the Opponent's Mind (2007).

[9] D. Loeb: Challenges in Multi-Player Gaming by Computers: A Treatise on the Diplomacy Programming Project. (1995). Available: http://devel.diplom.org/DipPouch/Zine/S1995M/Loeb/Project.html

[10] E. Norling: Folk Psychology for Human Modelling: Extending the BDI Paradigm. (2004). Available: http://www.aamas2004.org/proceedings/027_norlinge_folk_psychology.pdf

[11] A. Rao & M.P. Georgeff: Modeling Rational Agents within a BDI-Architecture – Technical Note 14. (1991). Available: http://citeseer.ist.psu.edu/rao91modeling.html

[12] S. Russell & P. Norvig: Artificial Intelligence – A Modern Approach, 1st and 2nd edition. (1995 and 2003)

[13] A. Shapiro, G. Fuchs & R. Levinson: Learning a Game Strategy Using Pattern-Weights and Self-Play. (2002). Available: http://www.cs.ucla.edu/~ashapiro/ShapiroA_CG2002.pdf

[14] M.P. Singh & M.H. Huhns: Service-Oriented Computing – Semantics, Processes, Agents. (2005)

[15] G. Weiss (ed.): Multiagent Systems – A Modern Approach to Distributed Artificial Intelligence (1999).

LASERSKO OPTIČNA KARTICA

Robert Blatnik
Odsek za inteligentne sisteme
Institut Jožef Stefan
Jamova 39, 1000 Ljubljana, Slovenija
Tel: +386 1 4773269; fax: +386 1 4773131
e-mail: robert.blatnik@ijs.si

POVZETEK
Članek predstavlja tehnologijo lasersko optične kartice in uporabo biometrije v osebnih identifikacijskih dokumentih.

UVOD
Vztrajno povečevanje geopolitične in tehnološke kompleksnosti sveta povečuje potrebo po učinkovitejšem preverjanju identitete in osebnih dokumentov. Povečana migracija in mobilnost ljudi obremenjujeta mejne kontrolne točke bolj kot kadarkoli v zgodovini. Evropske integracije še povečujejo to mobilnost. Medtem ko se nadzor notranjih meja držav članic Evropske skupnosti rahlja, pa se povečuje potreba po učinkovitejšemu nadzoru zunanjih meja in vsaj delnemu poenotenju osebnih dokumentov. Razmišlja se tudi o uvedbi evropske migracijske kartice (Blue Card) po vzoru ameriške Green Card [1].

Rezultat informacijske družbe je tudi vseobsegajoča digitalizacija in dostopnost informacij praktično od koder koli in kadar koli. Dostop do visoke tehnologije že zdavnaj ni več omejen na vladne, znanstvene in gospodarske organizacije, temveč postaja javna dobrina, dosegljiva praktično iz domačega naslanjača. To hkrati prinaša dodatna tveganja za prenarejanje in ponarejanje osebnih dokumentov, zlorabo osebnih podatkov, virtualne kraje znanja in denarja. Kraja identitete postaja eden najbolj perečih problemov Evrope in ZDA, ki samo evropske davkoplačevalce in gospodarstvo stane preko 30 miljard evrov letno [2].

Zahteve po učinkovitemu lokalnemu (off-line) in daljinskemu (on-line) preverjanju identitete se povečujejo z razvojem tehnologije. Medtem ko je nalepljena papirnata fotografija v potnem listu še pred 10 leti predstavljala zadostno obliko identifikacijskega elementa, pa danes potekajo obsežne standardizacijske aktivnosti na področju vgrajevanja biometrije v osebne dokumente in poenotenje standardov za strojno branje osebnih dokumentov [3]. Z digitalizacijo osebnih dokumentov pa se ne pojavljajo le vprašanja o primernosti posameznih tehnologij za varno preverjanje identitete ter varno izdajanje in preverjanje avtentičnosti dokumentov, temveč tudi način zajemanja, prenosa med sistemi in hranjenja biometričnih in drugih osebnih podatkov v podatkovnih bazah, načinu dostopa in varovanja teh podatkov.

Odnos javnosti do uvajanja bančnih, varnostnih, kartic ugodnosti in identifikacijskih kartic je neločljivo povezan z ugodnostmi, ki jih tovrstne kartice prinašajo za uporabnike. Večnamenskost identifikacijskih kartic, ki so prvenstveno sicer namenjene za potrebe državne varnosti, hkrati pa jih je možno uporabljati za dostop do množice storitev, postaja nujnost za javno sprejemanje tovrstnih identifikacijskih dokumentov. Hkrati ni tehničnih razlogov, da se ne bi osebna identifikacijska kartica hkrati uporabljala tudi kot zdravstvena izkaznica, vozniško dovoljenje in vrsta drugih dokazil.

V javnosti pa obstajata dva pogleda na prihodnost sistemov za osebno identifikacijo. Prvi pogled dopušča možnosti vsenavzočega oddaljenega preverjanja identitete od koder koli in kadar koli, ki bo prilagodljivo glede na stopnjo varnostnih zahtev. Konzervativnejši zagovorniki pa dajejo za varnostno najbolj kritične aplikacije prednost trdoživemu vizualnemu lokalnemu preverjanju varnih osebnih dokumentov z bolj ali manj avtonomnimi varnimi čitalniki.

Razvoj identifikacijskih sistemov je v zadnjih letih zelo zaznamovan z razvojem arhitektur povezanih "federated" podatkovnih baz in odprtih standardov, ki naj bi omogočili državljanom, gospodarstvu in državnim upravam učinkovitejše izvajanje transakcij s souporabo porazdeljenih podatkov v javnem in privatnem sektorju z zagotovitvijo zasebnosti in varovanja osebnih identifikacijskih podatkov. Množica inciativ in standardizacijskih aktivnosti (SAML, Liberty Alliance, Shiboleth, WS-Federation) in evropskih projektov [12, 13, 14, 15, 16] na tem področju dokazuje aktalnost problematike, ki pa spričo množice političnih, socioloških, kulturnih in nenazadnje tehnoloških vidikov postavlja vlade in gospodarstvo v nezavidljiv položaj pri postavljanju infrastrukture za varno zagotavljanje storitev e-države.

Vsekakor je za uspešno uvajanje kartičnih tehnologij pomembno zagotavljanje varnih, udobnih in za uporabnike privlačnih ter uporabnih storitev.

Primer italijanske osebne izkaznice, ki na osnovi integracije tehnologije lasersko optične kartice in čipne tehnologije pametnih kartic združuje oba svetova v hibridni pametni optični kartici, kaže na potrebo po pokrivanju javnih storitev e-države, ki jih zagotavlja tehnologija pametnih kartic in brezkompromisne varnosti osebnega identifikacijskega dokumenta [17].

V nadaljevanju članka je predstavljena tehnologija lasersko optične kartice, njena primerjava z ostalimi kartičnimi tehnologijami ter problematika zanesljivosti in varnosti izdajanja osebnih dokumentov.

PREGLED KARTIČNIH TEHNOLOGIJ

V nadaljevanju so opisane predvsem kartice v standardni fizični velikosti kreditne kartice (ISO/IEC 7810), ki se uporabljajo v osebnih dokumentih. V ospredju kartičnih tehnologij s strojno zapisljivimi in berljivimi podatki so predvsem kartice z vgrajenimi polprevodniškimi čipi, med katere spadajo pomnilniške kartice, ki se uporabljajo zgolj za shranjevanje podatkov, kartice z vgrajenim mikroprocesorjem (pametne "smart" kartice) in kartice s pasivnim optičnim podatkovnim spominom (optične kartice).
Čipne kartice obstajajo v različicah s kontaktnim podatkovnim vmesnikom (ISO/IEC 7816) ali brezkontaktnim vmesnikom (ISO/IEC 14443), obstajajo pa tudi kobinirane pametne kartice z dvojnim (kontaktnim in brezkontaktnim) vmesnikom. Obstajajo še druge cenejše tehnologije zapisa (magnetni trak, črtna koda), ki pa so prvenstveno v uporabi v varnostno manj zahtevnih aplikacijah in niso primerne za uporabo v identifikacijskih dokumentih.

Čipne kartice se v osnovi razlikujejo od optične kartice po načinu zapisa in hranjenja podatkov, ki jih je v polprevodniški tehnologiji mogoče aktivno obdelovati, medtem ko so zapisani podatki na optičnem spominu trajni in nespremenljivi, lahko se le inkrementalno dodajajo. Ta lastnost WORM optičnega zapisa (Write Once Read Many) predstavlja tudi osnovni pogoj za nedvomno sledljivost zgodovine zapisa skozi vso življenjsko dobo kartice, kar je še posebno pomembno pri uporabi v zdravstvu ali osebnih dokumentih.

Kartične tehnologije se poleg načina obdelave podatkov razlikujejo predvsem po načinu hranjenja podatkov (magnetni, polprevodniški, optični), kapacitetah spomina (od reda nekaj KB pri čipnih karticah do 4MB pri optičnih karticah), načina zaščite podatkov (uporaba infrastrukture javnih ključev pri pametnih karticah ter navadna enkripcija zapisa pri optičnih karticah), hitrosti branja in zapisovanja (nekaj 10KB/s do nekaj MB/s za pametne kartice in 5 do 10KB/s za optične kartice) in nenazadnje ceni, ki je do 10$ za optične kartice, od 10$ za osnovne čipne kartice, pa tudi nekaj 100$ za pametne kartice z najnovejšimi tehnologijami.

LASERSKO OPTIČNA KARTICA

Leta 1982 je podjetje Drexler Technology Corporation, predhodnik današnjega podjetja LaserCard Corporation, patentiral optično spominsko kartico in pričel z licenciranjem laserske kartice »LaserCard«, ki je bila leta 1991 prvič komercialno uveljavljena v okviru logističnih operacij ameriške vojske. Danes je laserska kartica uveljavljena v ZDA kot zelena kartica stalnega prebivališča »Green Card« in v programu »Laser Visa« za izdajanje vstopnih dovoljenj mehiškim državljanom. Kanada, Italija in nekatere države Bližnjega vzhoda so sprejele lasersko kartico za izdajanje osebnih dokumentov. Indija uporablja lasersko kartico za prometno dovoljenje, širi pa se na področja v zdravstvu in vojski. Do danes je bilo izdanih preko 30 milijonov dokumentov na osnovi tehnologije laserke kartice [4]. V letu 2004 je podjetje Prevent Global kupilo proizvodno licenco lasersko optičnih kartic in načrtuje skorajšnjo izgradnjo tovarne laserskih kartic v Sloveniji, kar bo predstavljalo drugi vir teh kartic na svetu.

Laserska kartica uporablja linearno metodo zapisa podatkov, ki je določen v standardu ISO/IEC 11694 [5], splošne karakteristike kartice, npr. standardni ID-1 format kartice pa so pokrite s standardom ISO/IEC 11693 [6]. Kartica ustreza normativom ICAO [3], ki pomembno usmerjajo standardizacijske aktivnosti za interoperabilnost strojno berljivih potovalnih dokumentov. Testiranje odpornosti kartice na zunanje obremenitve je definirano s standardom ISO/IEC 10373 [7].

Linearen laserski zapis omogoča enkratno zapisovanje v optični pomnilniški trak in je zaradi fizičnega načina zapisa neizbrisljiv in nespremenljiv. Zanesljivost zapisanih podatkov je zagotovljena z visoko stopnjo redundantnosti. Metoda EDAC (Error Detection and Correction) tipa B.E.S.T. (Bust Error Correction for Satellite Transmitions) za zaznavanje in odpravljanje napak zagotavlja nemoteno zapisovanje in branje podatkov kljub površinskim praskam in umazaniji na kartici [9].

Optični trak je s posebnim postopkom laminiran med več plasti odpornega polikarbonata, kar daje kartici izredno robustnost in odpornost pred zunanjimi vplivi, mehanskimi poškodbami in prepogibanjem. Poskus razdvojitve polikarnbonatnih plasti z namenom manipulacije z optičnim trakom pa je praktično nemogoč in uniči kartico.

Laserska kartica je prestala serijo obsežnih testiranj ameriškega ministrstva za obrambo, ki je na laserski kartici izvedlo preizkuse robustnosti in odpornosti na vplive elektromagnetnih polj, elektrostatike, ekstremnih okoljskih pogojev, vibracij, kemikalij itd. [8].

Laserske kartice so na voljo v izvedbi s širokim, 35 milimetrskim optičnim trakom in kapaciteto spomina do

2,8MB, in ozkim, 16 milimetrskim trakom s kapaciteto do 1,1MB. Podatki so organizirani po sledeh in mehko formatiranih sektorjih, kar omogoča hitrejši dostop do posameznih podatkov. Podatki na kartici so zaščiteni z enkripcijo, večnivojska zaščita podatkovnega dostopa na nivoju particij, posameznih datotek ali podatkovnih polj pa omogoča hkratno uporabo kartice za različne namene in pooblaščen dostop do tistega dela podatkov, ki je namenjen le posamezni aplikaciji.

Življenjska doba zapisa podatkov na optičnem traku je praktično neomejena, za razliko od 10-letne deklarirane življenjske dobe EEPROM ali FLASH zapisa. Poleg zapisa digitalnih podatkov je možno med proizvodnjo s fotolitografskim postopkom zapisati na optični trak tudi grafične oznake z natančnostjo 12.000 dpi, v postopku izdajanja kartice med personifikacijo pa na optični trak lasersko zapisano hologramsko fotografijo in ostale osebne podatke.

Vsaka posamezna aplikacija laserske kartice je uporabniško definirana z edinstveno fotomasko, ki se uporablja kot kliše za izdelavo optičnega traku in definira format kartice. Formati kartice se razlikujejo v odvisnosti od varnostnih zahtev same aplikacije in vsebujejo različne razporeditve podatkovnih stez, vidne varnostne elemente, sinhronizacijske podatke, podatkovne naslove ter ostale elemente, ki definirajo zapis podatkov na kartico.

Edinstveni postopek izdelave optičnega traku in večslojna polikarbonatna zaščita z ostalimi zaščitnimi elementi je zagotovilo za praktično neponaredljivost laserske kartice. O neponaredljivosti laserske kartice nenazadnje priča uporaba sama, saj od uvajanja prvih osebnih dokumentov v devetdesetih letih ni znan niti eden pomembnejši uspešen primer ponareditve ali prenareditve [4].

BIOMETRIJA V OSEBNIH DOKUMENTIH

S komercialno uporabo biometrije v informacijskih sistemih, proizvodih široke potrošnje in osebnih dokumentih se pojavljajo vprašanja o varovanju biometričnih podatkov. Del javnosti občuti nelagodje ob možnosti, da bi se njihovi biometrični podatki nahajali na oddaljenem diskovju podatkovnih centrov. Vprašanja potreb in upravičenosti hranjenja biometričnih podatkov v centralnih podatkovnih bazah presegajo namen tega članka. Vsekakor pa možnosti hranjenja biometričnih podatkov v samih karticah ali potnih listih in posledično osebno odgovornost in možnost vsaj delnega nadzora nad podatki povečuje možnosti za rahljanje trdih stališč dela javnosti do uporabe biometrije.

Posebno področje biometrije je biometrična enkripcija, ki se v zadnjem času pospešeno razvija in bi lahko omogočila generiranje varnih privatnih ključev na osnovi biometričnih podatkov [11].

Zaradi nestandardiziranih metod zajemanja in obdelave biometričnih podatkov je ICAO v svojih priporočilih predvidela hranjenje biometričnih podatkov v osebnih dokumentih v izvorni obliki in ne le računsko zreducirani obliki, kar posledično poveča potrebe po predvidenih kapacitetah pomnilnika najmanj na 256KB.

Pri uvajanju biometrije na osebnih dokumentih pa je smiselno upoštevati nekatera priporočila [10].

Na osebnih dokumentih je potrebno zagotoviti večje število biometričnih tehnologij, ki se lahko uporabljajo v odvisnosti od zahtev in okoliščin. Prav tako lahko naključna uporaba različnih tipov biometrije na kontrolnih točkah povečuje zahtevnost predstavljanja z lažno identiteto in posledično večjo varnost.

Pri razvoju osebnih dokumentov je potrebno omogočiti dodajanje novih biometričnih metod, ki se s časom in razvojem tehnologije spreminjajo in izpopolnjujejo. Poleg tega niso vse biometrične metode primerne za vsako okolje in kulturo – nekateri ljudje nimajo prstov, drugi zakrivajo obraz iz verskih razlogov, za prepoznavanje geometrije rok je potrebno predvideti različne velikosti čitalcev. Vse oblike fizičnega stika z biometrično napravo so tudi higiensko zahtevne. Skeniranje očesne roženice zahteva prilagajanje na različne višine oseb in pri nekaterih ljudeh vzbuja nelagodje.

Način avtentikacije z bioemetrijo, ki je zapisana na osebnem dokumentu, odpravlja potrebo po stalnem neprekinjenem dostopu do podatkovnih baz, saj se avtentikacija lahko izvaja v oddaljenem (off-line) načinu. Kartica je v trenutku verificirana s primerjavo zajetega biometričnega podatka osebe in biometričnega podatka na kartici.

V postopku izdajanja osebnega dokumenta je potrebno zagotoviti integriteto zapisa biometričnega podatka od zajema do zapisa na kartico, brez možnosti zunanjega posega in nepooblaščene vstavitve tujega biometričnega zapisa v osebni dokument. Naknadno spreminjanje podatka je fizično nemogoče le v neizbrisljivem optičnem spominu.

IZDAJANJE OSEBNIH DOKUMENTOV

Varnost sistema osebne identifikacije je zelo odvisna od varnosti procesa izdajanja osebnih dokumentov, ki je praviloma porazdeljena med množico vključenih organizacij. V procesu proizvodnje in izdajanja osebnega dokumenta je potrebno izločiti vse možnosti za nepooblaščen dostop do podatkov ali tehnologije za izdajanje dokumentov. Eden od pomembnih elementov v procesu izdajanja osebnih dokumenov je sledljivost vseh korakov v procesu od proizvodnje kartičnega blanketa do izročitve dokumenta uporabniku. Vsak podatkovni vnos na kartico mora biti evidentiran in neizbrisljivo zabeležen na kartici, kar dopušča izsledljivost v primeru zlorab. Vsaka izdana kartica mora imeti podpis operaterja ali uradnika, ki je kartico izdal ali dopolnil z novim podatkom. Drug pomemben dejavnik je avtenticiranje opreme za zapisovanje podatkov s strani pooblaščenih operaterjev in onemogočanje uporabe opreme s strani nepooblaščenih oseb. V procesu izdajanja italijanske osebne izkaznice je vsaka kartica že v fazi proizvodnje, po inicializaciji optičnega traku, zakodirana s kodo ustreznega organa, kamor je namenjena, kar preprečuje možnost izdajanja kartice na drugih lokacijah.

ZAKLJUČKI

Vsekakor tehnologija laserskih kartic predstavlja pomembno alternativo za pokrivanje kartičnih aplikacij v zdravstvu, logistiki, vstopni kontroli in avtomobilski industriji. Pomembna prednost laserske kartice je tudi v neodvisnosti od obstoja integriranih informacijskih sistemov in podatkovnih baz. Za varnostno najbolj občutljive aplikacije, kjer je nedvomno potrebno zagotavljati sledenje zgodovine zapisa, robustnost pomnjenja podatkov, spominski prostor za multi-biometrične aplikacije, arhiviranje občutljivih osebnih podatkov, neponaredljivost kartice in optičnega zapisa, pa je laserska optična kartica nepogrešljiva za izdelavo varnih osebnih identifikacijskih dokumentov.

REFERENCE

[1] J. Weizsäcker. A European Blue Card Proposal. Horizons Strategiques. 2006.
[2] G. R. Gordon, N. A. Willox. Identity Fraud: A Critical National and Global Threat. Economic Crime Institute of Utica College. 2003.
[3] International civil aviation organization, Doc 9303, Machine readable travel documents, part 3. 2002.
[4] LaserCard corporation. Annual Report. 2007.
[5] International standard ISO/IEC 11694-1, Identification cards – Optical memory cards – Linear recording method, part 1: Physical characteristics. 2005.
[6] International standard ISO/IEC 11693. Identification cards – Optical memory cards – General characteristics. 2005.
[7] International standard ISO/IEC 10373. Identification cards - Test methods.
[8] LaserCard Corporation. US Army Test and Evaluation Command Aberdeen Proving Ground, Detailed Test Report for the Personal Information Carrier. MD 21005-5055. 1998.
[9] LaserCard System Corporation. Comparative Analysis of DELA and SIOC Optical Recording Formats for Optical Memory Cards.
[10] R. Haddock. Biometric Identifiers and the Modern Face of Terror: New Technologies in the Global War on Terrorism. United States Senate Judiciary Committee, Subcommittee on Technology, Terrorism, and Government Information. 2001.
[11] A. Cavoukian, A. Stoianov. Biometric Encryption: A Positive-Sum Technology that Achieves Strong Authentication, Security AND Privacy. Information and Privacy Commissioner. Ontario. 2007.
[12] R. Leenes, J. Schallabock, M. Hansen. Prime white paper v2. 2007.
[13] D. O. Jaquet-Chiffelle (ed.), E. Benoist (ed.), B. Anrig (ed.). FIDIS project. Future of Identity in the Information Society. D2.6: Identity in a Networked World – Use Cases and Scenarios.
[14] Kindt, E. Biometric applications and the data protection legislation, Datenschutz und Datensicherheit 3/2007, pp. 166-170. 2007.
[15] GUIDE project. Identity Interoperability Services Report: Core Services Descriptions. 2005.
[16] C. Hildebrand, H. Demski, P. Pharow, R. Engelbrecht. BioHealth - Encouraging the Use of eHealth Security and Identity Management Standards. Medinfo. Australia. 2007.
[17] F. Arcieri, M. Ciclosi, A. Dimitri, F. Fioravanti, E. Nardelli, M. Talamo. The italian electronic identity card: overall architecture and IT infrastructure. CSES. 2004.

EVOLUTIONARY MULTIOBJECTIVE OPTIMIZATION AS A BUILDING-BLOCK OF ENGINEERING DESIGN

Bogdan Filipič
Department of Intelligent Systems, Jožef Stefan Institute
Jamova cesta 39, SI-1000 Ljubljana, Slovenia
Tel.: +386 1 477 3352, fax: +386 1 477 3131
E-mail: bogdan.filipic@ijs.si

ABSTRACT

Engineering design has gained new opportunities by involving evolutionary computation support. A methodology particularly suitable to enhance search in complex decision and objective spaces is evolutionary multiobjective optimization. Computer algorithms of this kind are capable of providing multiple trade-off solutions from which a designer can choose the most appropriate one according to higher-level information. This paper provides illustrative examples of what benefit this methodology can be in the design of devices and processes.

1 INTRODUCTION

Computers have long been used as a design tool and recent new paradigms in computing have rapidly found their way to the design field as well. Evolutionary computation [3], a study of problem solving techniques mimicking the principles of natural selection and genetics, has led to evolutionary design [1] that exploits the power of evolutionary algorithms in search for and optimization of engineering designs and even artistic creations. The appropriateness of evolutionary algorithms for this task arises from their robustness and inherently parallel population-based search. They can also be linked with specific techniques needed in the design process, such as evolution-guided physical experimentation and subjective evaluation of solutions.

The most recent methodology in the evolutionary designers' toolbag is evolutionary multiobjective optimization [2]. Multiobjective optimization problems differ from singleobjective ones in that they require not a single objective but a vector of objectives to be optimized. In solving such problems we deal with two spaces: the decision (variable) space and the objective space. Solutions are compared with respect to dominance relation, and when the objectives are conflicting, there exists a set of optimal objective vectors called *Pareto optimal front*. Vectors from the Pareto optimal front represents a different trade-offs between the objectives.

As a population-based method, evolutionary algorithms are well suited for solving multiobjective optimization problems. We have implemented DEMO [8], an algorithm for numerical multiobjective optimization, based on differential evolution [7]. In this paper, examples of its application on three multiobjective engineering design problems are used to show its potentials in the design process.

2 A TEXTBOOK EXAMPLE

Let us first consider a modified version of the beam design problem presented in [2] where two decision variables are regarded, the beam diameter d and its length l. The beam is to carry an end load P that will result in developed maximum stress $\sigma_{\max}$ and beam end deflection δ. The design task is to minimize two conflicting objectives, beam weight

$$W(d,l) = \rho\frac{\pi d^2}{4}l \qquad (1)$$

and beam end deflection

$$\delta(d,l) = \frac{64Pl^3}{3E\pi d^4}, \qquad (2)$$

subject to $\sigma_{\max} \leq 300\,\mathrm{MPa}$ and $\delta \leq 5\,\mathrm{mm}$. The constants are as follows: beam density $\rho = 7800\,\mathrm{kg/m}^3$, elasticity module $E = 207\,\mathrm{GPa}$ and the load $P = 2\,\mathrm{kN}$. The decision space in constrained by $0.01\,\mathrm{m} \leq d \leq 0.05\,\mathrm{m}$ and $0.2\,\mathrm{m} \leq l \leq 1.0\,\mathrm{m}$.

Formally, this is a constrained two-variable two-objective optimization problem. A designer would traditionally handle it by first transforming it into a singleobjective problem and then solving it with a suitable optimization method. The transformation is usually done either by the weighted-sum approach or by the ϵ-constraint method. The former requires a new objective function to be composed of the original ones: $f(d,l) = w_1W(d,l) + w_2\delta(d,l)$, where w_1 and w_2 are objective weights. In the latter approach, one of the objectives is regarded as a constraint and the other optimized. An example is minimizing the beam deflection, provided that its weight is less than or equal to 2 kg. Both techniques belong to the preference-based way of dealing with multiobjective problems, where the user provides higher-level information in the form of either objective weights or constraints, and solves the transformed problem in a traditional singleobjective manner. While this is a straightforward approach, it provides only one solution at a time and is not applicable when higher-level information is not available (see [2] for further discussion of its strengths and weaknesses).

Evolutionary multiobjective algorithms support the so called ideal scenario in multiobjective optimization. Here, a problem is first solved in its original form, and once having Pareto-optimal solutions, the user can choose the most suitable one according to higher-level information. This might become clear as late as during the inspection of the provided Pareto-optimal solutions.

Consider the beam design example again. To understand the result of the ideal multiobjective optimization, it is informative to see the feasible objective space as shown in Figure 1. For this problem, the DEMO algorithm run for 50 generations with population size 30 provides the solutions shown in Figure 2. This result enables a much better insight into optimized beam properties and makes it possible to choose the eventual single solution considering additional preferences or constraints.

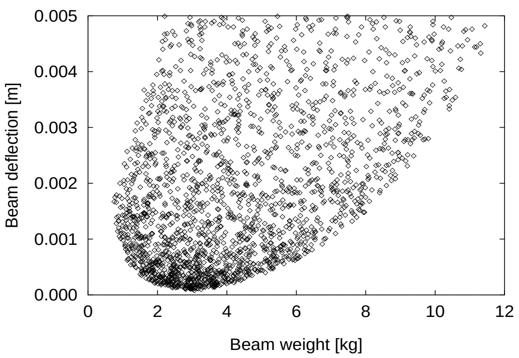


Figure 1: Feasible objective space for the beam design problem.

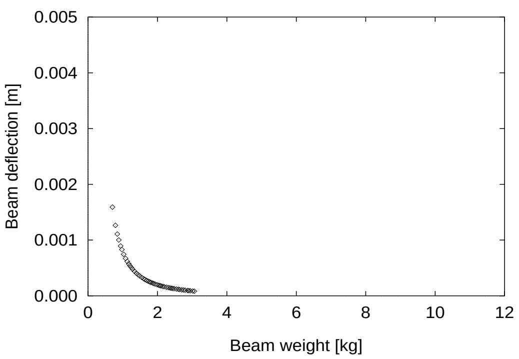


Figure 2: Non-dominated solutions to the beam design problem found by DEMO in a single run.

3 A LABORATORY CONTROLLER DESIGN EXPERIMENT

The next example of multiobjective design is taken from control engineering. Of key interest to this field is design of controllers for dynamic systems. In general, this is a two stage procedure consisting of determining the controller structure and tuning of its parameters, but once the structure is selected, the controller parameter values are crucial for the performance of the controlled process. We illustrate how evolutionary multiobjective optimization can enhance parameter tuning of a PID controller applied to a laboratory experimental device.

The PID (proportional-integral-derivative) controller operates in a feedback loop with the system to be controlled and affects the process through the control input $u(t)$, determined by the difference $e(t)$ between the actual system output and the reference value. The value of the control input is obtained as

$$u(t) = k_{\mathrm{P}}\, e(t) + k_{\mathrm{I}} \int_0^t e(\tau) d\tau + k_{\mathrm{D}}\, \dot{e}(t). \qquad (3)$$

Mathematical optimization of the parameters k_{P}, k_{I} and k_{D} involves an error measure to be minimized. It is however known that mathematically optimal controllers may result in process performance not acceptable in practice. On the other hand, human operators often tune parameters intuitively, using their own preferences for the optimality of the controlled process.

We performed controller parameter optimization with respect to multiple, human-preferred objectives on a PID-controlled laboratory device built for the purpose of control synthesis studies [4]. The device consists of a container filled with water and a rocket-shaped object floating in the water on an air bubble. The vertical position of the object depends on the size of the bubble, which depends on the water pressure, and the water pressure is influenced by the pump voltage that is the control input variable. Typical experiments on this device consist of stabilizing the floating object at a given reference position, changing the reference value and then bringing the object to the new reference position in the shortest possible time and with as little oscillation as possible. Because of process nonlinearity and instability, this is not trivial to accomplish.

The two human-oriented objectives considered in controller parameter tuning were settling time t_{set} and overshoot Δy. Settling time is the time needed by the process to stabilize (oscillation to sufficiently decrease) after the control action. Overshoot is the maximum excess over the new reference value resulting from the control action. Numerical experiments using a computer-simulated controlled device were performed by increasing the reference vertical position of the floating object for 0.2 m and considering it settled when its oscillation amplitude fell under than 0.005 m. Constraints were imposed on both settling time (maximum allowed value was 16 s) and overshoot (0.4 m). For this constrained three-variable two-objective optimization problem, the result of optimization with DEMO obtained with population size 20 in 100 generations is presented in Figure 3, while Figure 4 shows three specific solutions in terms of their settling time t_{set} and overshoot Δy. Again, the notable advantage of this approach is its ability to efficiently explore the decision space and present a set of alternative trade-off controller settings.

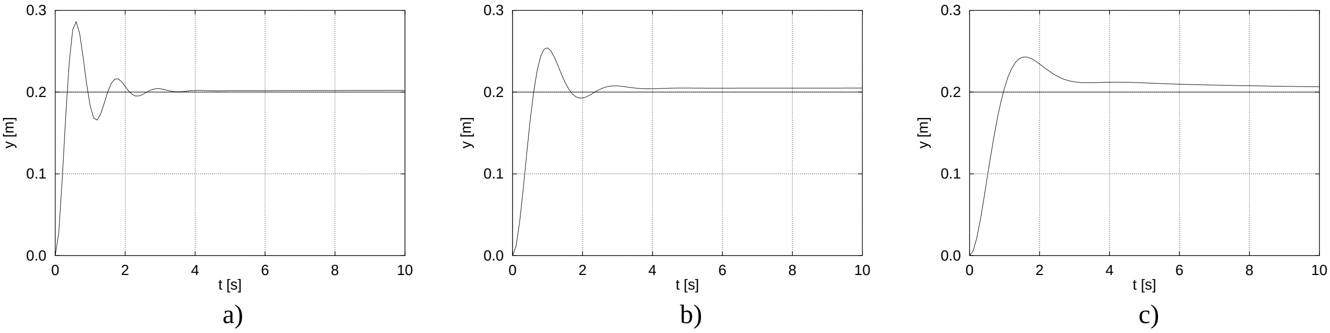


Figure 4: Performance of the experimental device under three optimized controller parameter settings: a) $t_{\text{set}} = 2.0$ s, $\Delta y = 0.086$ m, b) $t_{\text{set}} = 3.5$ s, $\Delta y = 0.054$ m, c) $t_{\text{set}} = 7.7$ s, $\Delta y = 0.054$ m.

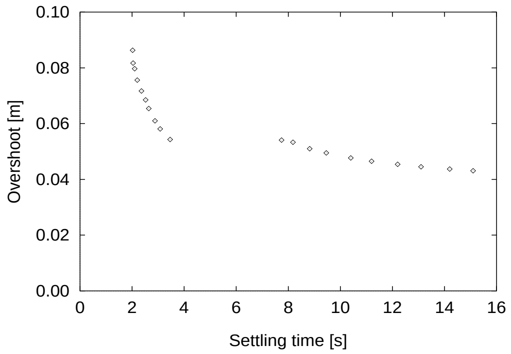


Figure 3: Non-dominated solutions to the PID controller tuning problem found by DEMO in a single run.

4 AN INDUSTRIAL PROCESS CASE STUDY

The final case shows the potential of multiobjective optimization in tuning a real-world production process. It refers to continuous casting of steel where numerous process parameters need to be properly set to ensure the process safety, high productivity and required quality of the cast steel. We focus on tuning coolant flows in the secondary cooling zone of the casting machine where the steel slab passing through the machine gradually solidifies and hence proper cooling is crucial for the product quality.

The parameter tuning studies for a particular casting machine rely on a numerical simulator of the casting process [5]. There are 18 coolant flows to be set and the empirical metallurgical criteria for appropriate process performance consist of approaching the target steel surface temperatures in 18 zones and the target core length (the point of complete steel solidification) as closely as possible. Formally, the task is to minimize the sum of differences between the actual and the target temperatures over N zones

$$c_1 = \sum_{i=1}^{N} |T_i - T_i^*| \tag{4}$$

and the difference between the actual and the target core length in the slab

$$c_2 = |l_{\text{core}} - l_{\text{core}}^*|. \tag{5}$$

There are intervals of feasible coolant flow values and constraints specifying the minimum and maximum allowed core length (see [6] for a detailed specification). Dealing with this constrained 18-variable two-objective optimization problem, we found approximations of Pareto-optimal fronts (DEMO with population size 50 and 200 generations) for various casting speeds as shown in Figure 5. This result allows for a trade-off analysis of the solutions that optimize the criteria to acceptable degrees. However, it turned out that the domain experts would prefer the temperature differences resulting from these solutions to be more uniform along the zones. Hence, the optimization problem was restated by adding an additional objective, c_3, which was the standard deviation of the temperature differences. The obtained set of non-dominated solutions for this three-objective optimization task can be seen in Figure 6 and the temperature differences for the three extreme solutions are visualized in Figure 7.

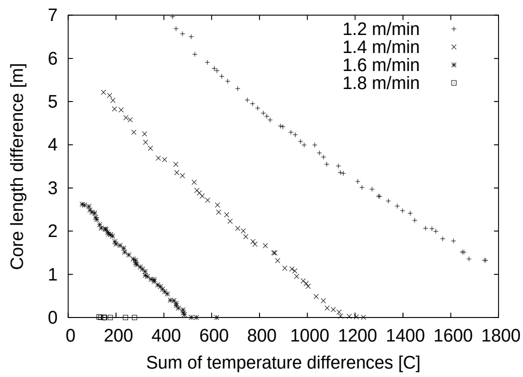
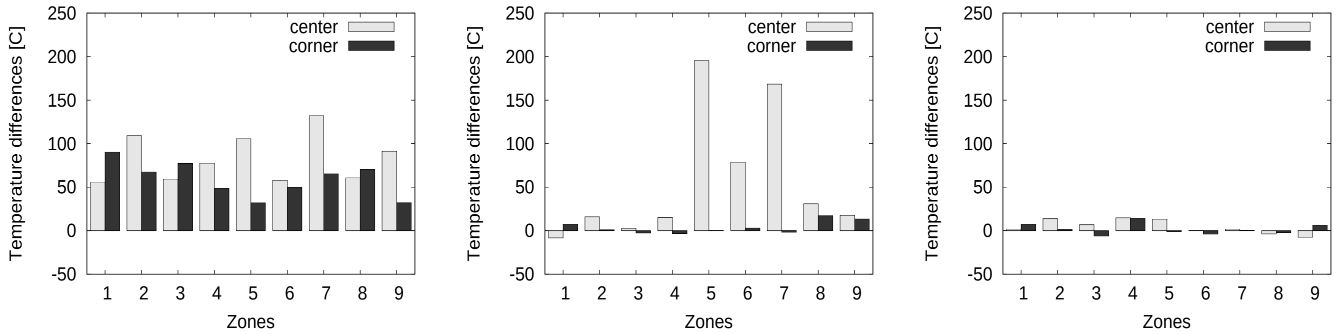


Figure 5: Non-dominated solutions to the two-objective steel casting optimization problem found with DEMO for different casting speeds.

These results offer a more general view of the process properties and clearly indicate at what cost comes the minimum deviation of temperature differences. It is now up to the process engineer which setting to apply under specific circumstances. The findings of this study are also useful for the design of new casting devices.



a) b) c)

Figure 7: Temperature differences for the three extreme solutions from Figure 6: a) solution 1, b) solution 2, c) solution 3.

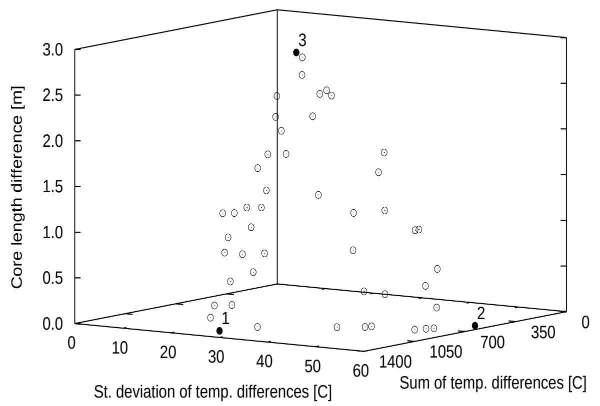


Figure 6: Non-dominated solutions to the three-objective steel casting optimization problem found with DEMO for the casting speed of 1.6 m/min.

5 CONCLUSION

We presented results of evolutionary multiobjective optimization in three engineering design problems: a textbook beam design task, tuning parameters of a PID controller for an experimental laboratory device, and a real-world problem of finding optimal process parameter values in continuous casting of steel. A distinguished feature of providing a set of non-dominated solutions as an approximation for the Pareto optimal front in a single run makes evolutionary multiobjective algorithms, such as DEMO, a powerful tool to assist the designers in pursuing the ideal approach to multiobjective optimization. Future development of this methodology calls for involvement of decision making strategies to further constrain the usually huge search space and for incorporating interactive evolution in the design process.

ACKNOWLEDGMENT

This work was supported by the Slovenian Research Agency under the Research Programme P2-0209-0106 *Artificial Intelligence and Intelligent Systems*. Many thanks to Đani Juričić, Juš Kocijan, Erkki Laitinen and Tea Tušar for their participation in the presented studies, and to the students of the University of Oulu for their inspiring questions during the September 2007 course *Multiobjective Optimization with Evolutionary Algorithms*.

REFERENCES

[1] P. J. Bentley (Ed.). *Evolutionary Design by Computers*. Morgan Kaufmann, San Francisco, 1999.

[2] K. Deb. *Multi-Objective Optimization Using Evolutionary Algorithms*. John Wiley & Sons, Chichester, 2001.

[3] A. E. Eiben, J. E. Smith. *Introduction to Evolutionary Computing*. Springer-Verlag, Berlin, 2003.

[4] B. Filipič. Evolutionary multiobjective optimization as a new approach to parameter tuning in dynamic systems control. To appear in *Proceedings of the 16th International Electrotechnical and Computer Science Conference ERK 2007*, Portorož, Slovenia, 2007 (in Slovene).

[5] B. Filipič, E. Laitinen. Model-based tuning of process parameters for steady-state steel casting. *Informatica*, 29 (4): 491–496, 2005.

[6] B. Filipič, T. Tušar, E. Laitinen. Preliminary numerical experiments in multiobjective optimization of a metallurgical production process. *Informatica*, 31 (2): 233–240, 2007.

[7] K. V. Price, R. Storn. Differential evolution – a simple evolution strategy for fast optimization. *Dr. Dobb's Journal*, 22 (4): 18–24, 1997.

[8] T. Robič, B. Filipič. DEMO: Differential evolution for multiobjective optimization. In C. A. Coello Coello, A. Hernandez Aguirre, E. Zitzler (Eds.): *Proceedings of the Third International Conference on Evolutionary Multi-Criterion Optimization EMO 2005*, pp. 520–533, Guanajuato, Mexico, 2005. Lecture Notes in Computer Science, Vol. 3410, Springer, Berlin.

INTELIGENTNA BIOMETRIJA ZA NADZOR VSTOPA

Matjaž Gams, Tea Tušar
Odsek za inteligentne sisteme, Institut Jožef Stefan
Jamova 39, 1000 Ljubljana, Slovenija
Tel: +386 1 4773900; fax: +386 61 1251038
e-mail: matjaz.gams@ijs.si, http://ai.ijs.si/mezi/matjaz.html

Povzetek

V tem prispevku bomo opisali CIVaBiS - Celovit inteligentni varnostni biometrični sistem, tj. projekt ARRS in MORS z namenom nadzora vstopa in predvsem v zvezi z varnostnimi grožnjami. Sistem je zasnovan za preprečevanje groženj v zvezi s teroristi, vendar so varnostne komponente načeloma uporabne kjerkoli. Projekt se nahaja v ključni fazi testiranja in integriranja, vsebuje pa vrsto že izdelanih modulov za nadzor vstopa: biometrijo, integracijo, mikroučenje, makroučenje, ekspertni sistem in umetni vid. Ideja projekta je v tem, da se z integracijo več modulov in posebej z inteligentnim prilagajanjem na vsakega vstopajočega bistveno zmanjša možnost penetracije sistema. Sedanje izkušnje kažejo, da je integracija več modulov z inteligentnim sklepanjem pomembna izboljšava.

1 UVOD

Teroristični napadi in vse pogostejši vdori v varovane objekte (banke, poslovni prostori) so v splošni javnosti povišali zavest o pomembnosti **zagotavljanja varnosti oseb in varovanih prostorov**. Zato je pomembno, da se zagotovi učinkovit nadzor nad vstopom v varovane prostore. Zahteve po podobnih sistemih nadzora postajajo vse pogostejše in se uveljavljajo tudi na drugih področjih, kot so varovanje mejnih prehodov in pomembnih turističnih in poslovnih objektov.

Na področju avtentikacije ljudi postajajo čedalje bolj pomembne in razširjene biometrične identifikacijske metode, ki omogočajo višji nivo varnosti pri nadzoru vstopa. Taki prijemi lahko zagotovijo večjo stopnjo osebne varnosti, učinkovitejše izvajanje osebnih pravic in varnejšo državno in evropsko mejo. Po besedah M. Kirkpatricka, enega direktorjev FBI: "Teroristu je mogoče slediti edino s pomočjo biometrije." (angl. "The only way to trace a terrorist is through biometrics.")

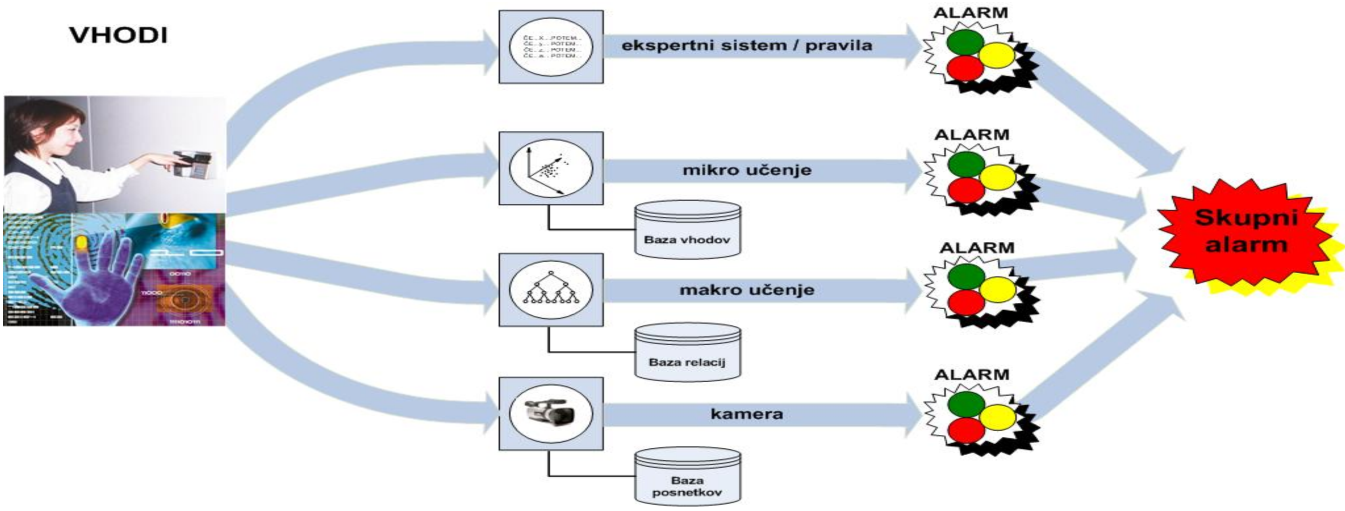
Pri tem moramo upoštevati, da vse varnostne situacije niso enake, tudi znotraj istega sistema ne. En odgovor na potrebo po prilagajanju posameznim varnostnim situacijam je **kombiniranje različnih identifikacijskih metod**. Izbira, usklajevanje in uravnoteženje varnostnih prijemov, vključno z metodo identifikacije, je ključnega pomena, saj omogoča ustrezno prilagajanje varnostnim potrebam. Kombinirane metode identifikacije je bistveno težje pretentati kot eno samo ne glede na to, da so nekateri sistemi izredno zanesljivi že sami zase.

Posebej po terorističnih napadih v ZDA in drugod po svetu je izredno poskočilo vlaganje v raziskave in razvoj na področju inteligentnih sistemov za biometrični nadzor oseb. Danes v razvitem svetu velja, da je najučinkovitejše sredstvo v boju proti terorizmu inteligenca. ZDA so zato sprejele vrsto zakonov, ki omogočajo obširnejše zbiranje (osebnih) podatkov in elektronski nadzor. Z več podatki tako postaja eden ključnih mehanizmov v boju proti terorizmu **uporaba inteligentnih metod za nadzor oseb** (Gams 2001, Luštrek idr. 2006, Reddy 2006). Z novimi metodami lahko inteligentni sistemi opazijo **sumljivo ali deviantno obnašanje posameznika**, ki je lažne identitete ali pa celo prave identitete (ali neznane), vendar iz kakršnihkoli razlogov odstopa od običajnega za znanega posameznika (npr. pod vplivom opojnih substanc ali s porušenim duševnim ravnotežjem) ali izstopa od običajnega za posameznika svojega tipa (npr. glede na starost, videz itd.). Metode biometrične identifikacije omogočajo zbiranje podatkov o osebah, ki jih nato obdelamo z inteligentnimi sistemi, kar nam omogoča višji in bolj poglobljeni nivo ugotavljanja morebitnih varnostnih vdorov (Kolbe idr. 2005).

Primer vstopne kontrole na dejanskem vhodu je predstavljen na Sliki 1. Zaposleni približa kartico čitalniku kartic in položi prst v čitalnik prstnih odtisov. Sistem v primeru pozitivne identifikacije odpre vrata.

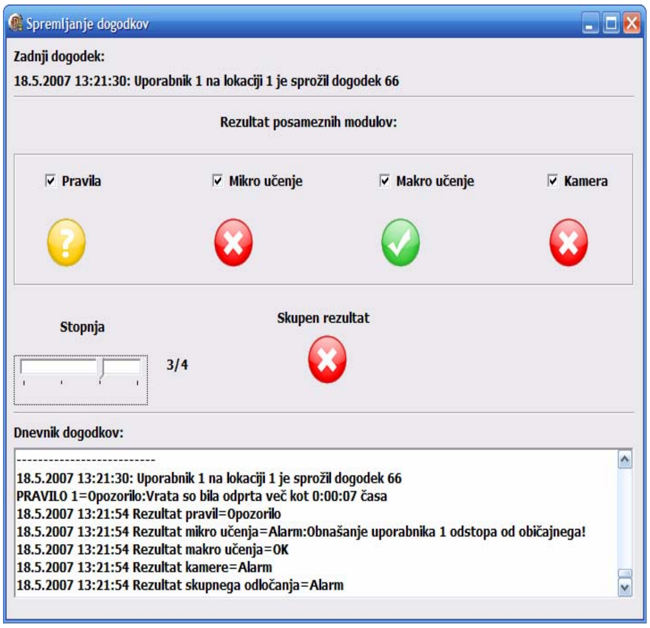
Slika 1: Primer vstopne kontrole. Na desni sta čitalnik prstnik odtisov in čitalnik kartice.

2 CiVaBiS – zgradba



Slika 2: Struktura sistema CiVaBiS.

Shema sistema je prikazana na sliki 2. Po registraciji z eno ali več napravami inteligentni sistem preveri vstop še s štirimi koduli: ekspertni sistem, mikroučenje, makroučenje in umetni vid. Vsak od modulov oceni verjetnost pravilne identitete ter zaključek grafično sporoči z ustrezno barvo. Odgovori modulov se integrirajo.



Slika 3: Sporočilo sistema ob vstopu.

Na Sliki 3 vidimo sporočilo sistema ob vstopu. Prvi modul, ekspertni sistem, ni prepričan ne o alarmu, ne o pravilni identiteti, zato sporoči svojo neodločnost z rumeno bravo. Modula mikroučenje in kamera sporočita resen sum z rdečo barvo, medtem ko v primeru makroučenja ni bilo nobenih dvomov v pravilno identiteto vstopajočega.
Vhodne signale sistem pobira z naprav komercialnih dobaviteljev podjetja Špica, integriranje pa poteka preko izvirno razvitega HW (Slika 4).

Slika 4: Integracija vhodnih naprav poteka s sistemom DOGS, razvitim v podjetju Špica.

SW celotnega sistema razvijajo vsi trije partnerji, poleg Špice še Fakulteta za elektrotehniko (kamera, vid) in Inštitut Jožef Stefan (inteligenca, integracija).

3 CiVaBiS – opis modulov

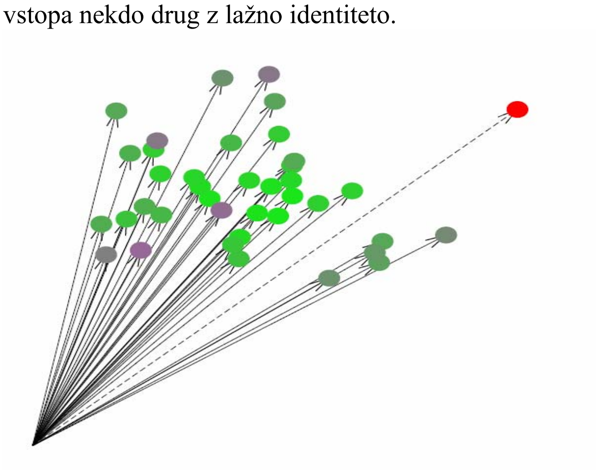
3.1. Ekspertni sistem

Sistem pravil, imenovan tudi ekspertni sistem, je nakazan na Sliki 2. Ob vhodu sistem testira pravila in glede na vzorec sproži alarm ali ne. Pravila so naslednje oblike:

a. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če uporabnik PARAM2 sproži dogodek med časom PARAM3 in časom PARAM4 na dan PARAM5 (PON, TOR, SRE, CET, PET, SOB, NED ali VSAK_DAN).
b. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če uporabnik PARAM2 sproži več kot PARAM3 dogodkov v času PARAM4.
c. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če uporabnik PARAM2 po vstopu ne izstopi v času PARAM3.
d. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če med časoma PARAM2 in PARAM3 zapustijo prostor uporabniki PARAM4 (napišite uporabnike, ločene z vejico), ki so prišli noter.
e. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če se vrata po odprtju ne zaprejo v času PARAM2.
f. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če se pred dogodkom PARAM2 ni zgodil dogodek PARAM3 (KARTICA, PRSTNI_ODTIS, ODPIRANJE_VRAT ali ZAPIRANJE_VRAT) v času PARAM4.
g. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če se pred dogodkom PARAM2 ni zgodil dogodek PARAM3 (KARTICA, PRSTNI_ODTIS, ODPIRANJE_VRAT ali ZAPIRANJE_VRAT) v času PARAM4.
h. Pravilo sproži PARAM1 (OPOZORILO ali ALARM), če uporabnik PARAM2 ni odšel iz prostora do časa PARAM3.

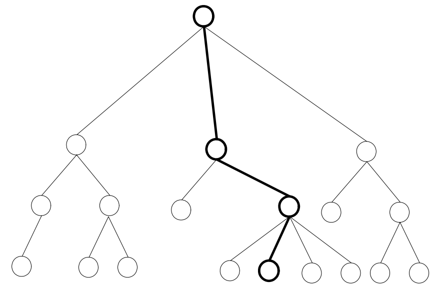
3.2. **Mikroučenje**

Modul mikroučenja za vhodne podatke uporabi čase med čitalnikom kartice in čitalnikom odtisov, med čitalnikom in odprtjem vrat ter med odprtjem in zaprtjem vrat. Skupno imamo 3 čase, torej 3D prostor, na katerem se učimo glede na učne primere – prejšnje vhode določene osebe. Ko vstopi nova oseba, npr. terorist, primerjamo njene časovne podatke s podatki tiste osebe, za katero se terorist izdaja. V naših testih se je pokazalo, da se ljudje registrirajo dokaj stabilno, zato se običajno hitro in jasno pokaže, kadar vstopa nekdo drug z lažno identiteto.



Slika 5: Mikroučenje išče "outlierje" glede na 3 čase (2 čitalnika in vrata) ter glede na prejšnje vstope.

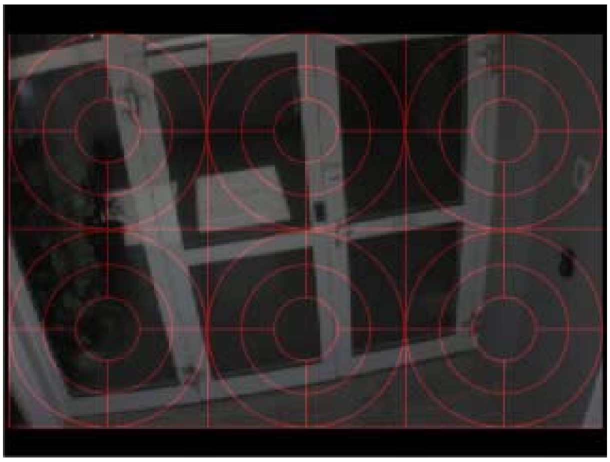
3.3. **Makroučenje**



Slika 6: Makroučenje išče globalne zakonitosti glede na istočasne vhode, običajno uro itd.

Makroučenje za razliko od mikroučenja išče bolj globalne zakonitosti, npr. kdo vstopa običajno kdaj in s kom … Tu gre za klasično rudarjenje podatkov.

3.4. **Kamera / umetni vid**



Slika 7: Vektorji gibanja so osnova za analizo identitete vstopajočega.

Zadnji modul se podobno kot prejšnji dve učenji skuša naučiti vzorcev vstopajočega, konkretno dinamiki oseb, opazovani preko kamere. Nastali vektorski premiki služijo prepoznavanju vstopajočega (Perš idr. 2002).

4 ZAKLJUČKI

Varnost postaja v svetu vedno pomembnejše področje, zato mora tudi Slovenija slediti temu trendu. Med ključnimi elementi varnosti je zagotavljanje nadzora vstopa v prostore z omejenim dostopom ter nadzor varovanih odprtih prostorov, kot je na primer prestop državne meje. Tak nadzor se najučinkoviteje izvaja z biometričnimi metodami, integriranimi z metodami inteligentnih sistemov.

V okviru projekta CIVaBiS smo razvili **celovit inteligentni varnostni biometrični sistem za avtentikacijo oseb za**

potrebe obrambnega sistema in boja proti terorizmu. V sistem je moč vključiti poljubno kombinacijo biometričnih senzorjev. Poglavitna novost je v inteligentni komponenti sistema, ki je na osnovi znanja in sprotnega učenja iz zbranih podatkov sposobna opozoriti na nenavadno obnašanje pri kontroli vstopa.

Zahvala: Zahvaljujemo se MORS in ARRS za financiranje projekta CiVaBiS. Zahvaljujemo se tudi g. M. Štruklju za pripombe in nadzorovanje izvajanja sistema.
Zahvaljujemo se tudi sodelavcem: Mitji Kolbetu, M. Luštreku, E. Dovganu, B. Kaluži in Robertu Blatniku.

Literatura

[1] Gams, M. Weak intelligence: Through the principle and paradox of multiple knowledge, Advances in computation: Theory and practice, Vol. 6, Nova sc. Pub., inc., NY, 2001.

[2] Kolbe, M., Gams, M., Kovačič, S., Perš, J. Sistem za avtomatsko razpoznavanje obnašanja z metodami računalniška vida. V: Zbornik 8. mednarodne multikonference Informacijska družba IS 2005, 11. do 17. oktober 2005, (Informacijska družba). Ljubljana: Institut "Jožef Stefan", 2005, str. 357-361.

[3] Luštrek, M., Gams, M., Bratko, I. Is real-valued minimax pathological?. Artif. intell.., 2006, vol. 170, str. 620-642.

[4] Reddy, R. Robotics and Intelligent Systems in Support of Society, Intelligent Systems, pp. 24-31, May/June 2006.

[5] Perš, J., Bon, M., Kovačič, S., Šibila, M., Dežman, B. Observation and analysis of large-scale human motion. Hum. mov. sci., July 2002, vol. 21, str. 295-311.

AVTOMATSKI ŠAHOVSKI TUTOR

Matej Guid[1], Jana Krivec[1,2], Martin Možina[1], Aleksander Sadikov[1], Ivan Bratko[1,2]

Laboratorij za umetno inteligenco[1],
Fakulteta za računalništvo in informatiko
Tržaška 25, 1000 Ljubljana, Slovenia

in

Odsek za inteligentne sisteme[2]
Institut Jožeta Stefana
Jamova cesta 39, 1000 Ljubljana, Slovenia

e-mail: matej.guid@fri.uni-lj.si

ABSTRACT

Z razvojem inteligentnega računalniškega sistema, ki bo na človeku razumljiv, prijazen in zanimiv način komentiral šahovske poteze, bi radi šahovsko moč, ki jo demonstrirajo današnji programi za igranje šaha, izkoristili za poučevanje šaha ter za komentiranje šahovskih partij. Glavna prednost našega pristopa ni le ta, da omogoča komentiranje šahovskih partij v vseh fazah igre, pač pa avtomatsko generirani komentarji poleg zmožnosti komentiranja taktičnih pozicij izražajo tudi razumevanje strateških nians v pozicijah. V članku izpostavljamo nekatere razlike med programom, specializiranim za igranje šaha, in programom, katerega cilj je podajati kvalitetne komentarje, ter predstavljamo naš pristop pri razvoju ekspertnega sistema, ki kombinira tehnike strojnega učenja z ekspertnim znanjem.

1 UVOD

Dandanašnji šahovski programi se enakovredno kosajo s človeškimi velemojstri, v številnih pogledih pa jih tudi že prekašajo. Kljub temu so njihove sposobnosti razložiti v ljudem razumljivem jeziku, zakaj so določene poteze dobre in zakaj ne, zelo omejene. Avtomatskemu inteligentnemu komentiranju šahovskih partij je bilo posvečeno le malo pozornosti, napredek na tem področju pa je zanemarljiv v primerjavi z gromozanskim skokom v šahovski moči programov, ki smo mu bili priče v zadnjih desetletjih. Tipični "komentarji" v obliki najboljših nadaljevanj in njihovih numeričnih ocen so le stežka v pomoč šahistu, ki bi se rad naučil pomembnih konceptov, ki se skrivajo za izbranimi potezami.

Ideja o avtomatskem komentiranju šahovskih partij ni nova. Verjetno prvi, ki je predlagal raziskave v tej smeri, je bil leta 1980 Donald Michie. Revija ICGA je kmalu nato začela podeljevati letne t.i. Herschbergove nagrade za najboljši šahovski komentatorski program [1]. Komentarji zmagovalcev kljub temu še do danes ostajajo zelo skopi ter so pretežno taktične narave, medtem ko kompleksnejši strateški koncepti in plani ostajajo bolj ali manj neomenjeni. Znanstvene raziskave s tega področja so večinoma omejene le na končnice šahovskih partij, predstavljeni koncepti pa imajo skupno slabost – nezmožnost praktične razširitve komentiranja na celotno šahovsko partijo [2, 3, 4].

Z razvojem računalniškega sistema, ki bo na človeku razumljiv, prijazen in zanimiv način komentiral poteze ter variante, bi radi šahovsko moč programov izkoristili za poučevanje šaha ter za komentiranje šahovskih partij. Uporabili smo odprtokodni program CRAFTY in predstavili nov koncept, ki omogoča ne samo komentiranje šahovskih partij v vseh fazah igre, pač pa komentarji poleg zmožnosti komentiranja taktičnih pozicij izražajo tudi razumevanje strateških nians v pozicijah.

Naš program, avtomatski šahovski "Tutor", je bil prvič predstavljen na mednarodni konferenci *Computers and Games* v Torinu leta 2006 [5]. Namen tega članka je izpostaviti nekatere razlike med programom, specializiranim za igranje šaha, ter programom, katerega cilj je podajati kvalitetne komentarje. Predstavljamo tehnike strojnega učenja, ki smo jih uporabili za razumevanje kompleksnejših konceptov, ki sicer računalniškim programom niso potrebni za uspešno igranje šaha, vendar njihova uporaba omogoča komentarje, koristne za razlago strateških konceptov, ki se skrivajo v šahovskih pozicijah.

2 AVTOMATSKI ŠAHOVSKI TUTOR

Osnovna ideja tutoringa je zasnovana na bazi znanja, saj je to hkrati tudi osnova človeškega razmišljanja [6]. V našem primeru smo za osnovno bazo učenja vzeli kar CRAFTY-jevo ocenjevalno funkcijo. Šahovsko znanje je v njej opisano z okrog 100 atributi, ki so pomembni za uspešno igranje šaha, saj z njimi ocenjujemo pozicije in opredeljujemo njihove lastnosti. Naš sistem temelji na več različnih komponentah: (1) šahovskemu motorju, ki podaja rezultate hevrističnega preiskovanja, baziranem na omenjeni funkciji, (2) modulu za komentiranje, ki pretvarja »surove« izpise vrednosti posameznih atributov v ocenjevanih pozicijah v preproste

komentarje, ter (3) ekspertnem sistemu, ki združuje osnovne komentarje v človeku (še bolj) razumljiv jezik.
Šahovski motor Crafty ima moč šahovskega velemojstra. Globina preiskovanja je lahko omejena s časom ali pa z globino; večje globine omogočajo kvalitetnejše predlagane poteze in variante. Pravzaprav bi lahko uporabili katerikoli šahovski motor; prednost pri izbiri motorja bi veljalo dati programom, ki favorizirajo znanje, vsebovano v ocenjevalni funkciji, pred hitrostjo iskalnih algoritmov.
Šahovski motor nam omogoča pridobitev ocen potez ter nadaljevanj (principalnih variant), ki vodijo do podanih ocen. Prav tako nam podaja vrednosti posameznih atributov ocenjevalne funkcije, ki predstavljajo uporabne podatke o karakteristikah ocenjevanih potez in nadaljevanj. Večina šahovskih motorjev (Crafty pri tem ni izjema) uporablja ocenjevalno funkcijo, ki jo oblikuje obtežena vsota posameznih karakteristik v poziciji. Uteži teh karakteristik – atributov – v ocenjevalni funkciji so prav tako pomembne, saj podajajo relativno pomembnost posameznih karakteristik.
Potem ko pridobimo analize šahovskega motorja, pride na vrsto komentatorski modul. Komentiranje je v veliki meri osredotočeno na spremembe v poziciji, ki bi jih prinesla izbira najboljšega nadaljevanja. Spremembe lahko izražajo bodisi napredek pri doseganju določenih ciljev, bodisi odpravitev določenih slabosti. To je tudi najbolj naraven in pogost način komentiranja partij v šahovski literaturi: komentatorji navadno utemeljijo predlagana nadaljevanja s serijo potez, pospremljeno s komentarji o spremembah, ki bi jih izbrano nadaljevanje prineslo, in/ali opisom končne pozicije, ki bi nastala po odigranih optimalnih potezah za obe strani.
Slika 1 prikazuje tipičen komentar programa. Prikazan je komentar poteze 19. Sb4, ki prav tako kot odigrana poteza (obema program prisoja približno enako vrednost) pride v poštev v dani poziciji. Tutor navaja, da bi vodila do malo boljše pozicije za črne, ter svojo oceno podkrepi z nadaljevanjem, ki ga program opredeljuje kot optimalnega za obe strani. Ocena je izražena tako kvalitativno kot numerično (-0,58), podana pa je tudi globina (10), pri kateri je bila pridobljena. Komentarji so podani v angleškem jeziku, vendar način implementacije omogoča enostavno uvedbo možnosti izbire jezika. V prevodu bi se prikazani komentar lahko glasil: *»Beli je zamenjal lovca in konja za trdnjavo in dva kmeta, vendar razmerje materiala ni njemu v prid. Črni vrši pritisk na nasprotnega kralja. Ima izolirane kmete b5, h7 in izolirane dvojne kmete f6, f7. Črni je izboljšal aktivnost svojega lovca. Sedaj ima dodatne izolirane kmete.«* Diagram na levi strani slike prikazuje ocenjevano pozicijo, medtem ko desni diagram predstavlja končno pozicijo, ki bi nastala po navedenem nadaljevanju. Komentarje sestavljajo naslednje komponente:

- predlagano nadaljevanje (principalna varianta),
- kvalitativno in numerično izražena ocena,
- globina iskanja,
- ocena materialnega stanja,
- opis pomembnih karakteristik končne pozicije,
- opis pomembnih sprememb.

Bistveni del komentiranja predstavljata zadnji dve komponenti. Komentarji so ciljno orientirani; cilj predstavlja pozicija na koncu principalne variante. Za končno pozicijo lahko privzamemo tisto, ki jo igralec ima v mislih, ko odigra določeno potezo. Ko pridobimo to pozicijo, lahko pregledamo, katere karakteristike ocenjevalne funkcije so se spremenile v primerjavi z izhodiščno pozicijo in za koliko.

Kasparov - Kramnik, Novgorod 1997,
pozicija po 18... e4 in pred 19.Le2

Pozicija na koncu nadaljevanja,
ki ga program predlaga

19. Nb4 leads to a slightly better position for Black after **Qc5 20. Bxe4 Bxe4 21. Nxa6 Qc4 22. Nxb8 Rxb8 23. Qd4 Qc6** (10|-0.58) White has exchanged a bishop and a knight for a rook and 2 pawns, but material evaluation does not favour him. Black has a pressure against the opponent's king. He has isolated pawns b5, h7, and isolated doubled pawns f6, f7. Black has improved the activity of his bishop. He now has additional isolated pawns.

Poglejmo na primer, kako je program prišel do komentarja »*Črni je izboljšal aktivnost svojega lovca.*« H generiranju tega komentarja sta prispevali predvsem vrednosti naslednjih dveh atributov:

(a) BLACK_BISHOPS_MOBILITY in
(b) BLACK_BISHOPS_POSITION.

Njuni vrednosti sta bili na začetku -15(a) in -2(b), na koncu pa -30(a) in -6(b); negativne vrednosti izražajo doprinos teh karakteristik k izboljšanju pozicije s perspektive črnega.
Potem, ko identificira relativno velik vpliv spremembe vrednosti atributa BLACK_BISHOPS_MOBILITY glede na ostale spremembe, se komentatorski modul poveže z ekspertnim modulom, kjer je podano pravilo oblike:

```
if (BLACK_BISHOPS = 1) then
  if (change(BLACK_BISHOPS_MOBILITY) <= X) then
    if (change(BLACK_BISHOPS_POSITION) <= Y) then
      comment ("Black has improved the activity of his bishop.")
```

Pravilo kombinira dve elementarni karakteristiki, da ugotovi izboljšano aktivnost črnega lovca. Vrednosti X in Y je pri tem relativno preprostem pravilu bilo mogoče dovolj natančno opredeliti z ekspertnim znanjem[1], po seznanitvi z vrednostmi, ki jih CRAFTY uporablja pri operiranju s tema dvema atributoma. Tudi pri opredelitvi ocene materialnega stanja si je program pomagal z vgrajenim CRAFTY-jevim atributom EVALUATE_MATERIAL, ki v danem primeru izraža prednost dveh lahkih figur črnega pred belo trdnjavo.
Vendar pa, kot bomo videli v nadaljevanju, pri določanju bolj kompleksnih pravil tudi ekspertno znanje ne zadošča več. Nastopi potreba po strojnem učenju, s katerim lahko ugotavljamo odvisnosti med elementarnimi atributi, ki omogočajo prepoznavanje višjenivojskih konceptov, kot so pritisk na nasprotnega kralja, stisnjena pozicija itd.

3 UPORABA TEHNIK STROJNEGA UČENJA

Elementarni atributi, ki jih ima CRAFTY vgrajene v svojo ocenjevalno funkcijo, niso vselej primerni za komentiranje. Tako na primer nobeden od naslednjih atributov, ki so povezani z višjim konceptom, kot je pritisk na nasprotnega kralja, ne bi sam po sebi zadoščal za ugotavljanje, ali ima katera od strani realne možnosti za matni napad.

(c) WHITE_TROPISM
(d) BLACK_SAFETY
(e) EVALUATE_KING_SAFETY
(f) WHITE_PIECE_ACTIVITY
(g) WHITE_QUEEN_IS_STRONG

Atribut WHITE_TROPISM npr. izraža bližino belih figur nasprotnemu kralju. Vendar komentarji v stilu »*Beli je uspel (še bolj) približati svoje figure nasprotnemu kralju.*« niso tipični za komentiranje šahovskih partij. Še bolj absurdno bi deloval komentar »*Črni je izboljšal varnost svojega kralja relativno glede na varnost kralja nasprotnika.«* Atribut EVALUATE_KING_SAFETY namreč izraža prav to.

1 Ekspertno znanje s področja šaha sta ponudila ženska mednarodna mojstrica Jana Krivec in mojster FIDE Matej Guid.

Na prvi pogled deluje domena šaha s svojimi kompleksnimi zakonitostmi in številnimi izjemami neprimerna za uspešno implementacijo strojnega učenja, vsaj za naš namen. Težko je namreč z danimi atributi povsem natančno določiti, kdaj ima katera od strani izglede za napad in kdaj ne. Vendar pa nam pri tem gre močno na roke ena okoliščina: predvsem si želimo, da bi bili izraženi komentarji točni in ne komentirati za vsako ceno, tudi ko ne moremo biti dovolj prepričani o resničnosti potencialno zanimivih opisov. Npr. v primeru iz prejšnjega poglavja, kjer izrazimo izboljšanje mobilnosti črnega lovca, nam atribut BLACK_BISHOP_POSITION služi kot varovalka, ki preprečuje nenavadne oz. nesmiselne komentarje v primerih, ko bi hvalili sicer bolj mobilnega, vendar slabo postavljenega lovca. Hkrati je olajševalna okoliščina tudi to, da imamo na voljo možnost dodajanja novih atributov, ki sicer ne vplivajo na ocenjevalno funkcijo programa, vendar nam lahko podajo dodatne informacije o poziciji.
Pri strojnem učenju nam kot učni primeri služijo pozicije, za katere ekspert predhodno opredeli vrednost razreda (npr. »beli ima napad«). Primeri so podani z opisom v obliki vektorjev atributnih vrednosti in razreda, pri čemer kot atributne vrednosti služijo kar izpisi vrednosti atributov CRAFTY-jeve ocenjevalne funkcije ter dodanih atributov. Ne glede na izbiro metode strojnega učenja [7] (kot so gradnja klasifikacijskih dreves, indukcija odločitvenih (IF-THEN) pravil z algoritmom CN2 itd.), ki so na voljo v paketih Orange [8] in Weka [9], ki ju uporabljamo, je cilj vedno isti: najti smiselne skupine vrednosti atributov, kjer je v čim večjem številu primerov zabeležena prisotnost iskanega razreda, brez enega samega protiprimera oz. kvečjemu z le nekaj osamljenimi protiprimeri, za katere skušamo odkriti vzroke (kot so npr. napake v učnih podatkih, mejni primeri itd.) ter jih, ko je to mogoče, odpraviti (npr. z vpeljavo dodatnih atributov).
Na učni množici okrog 400 naključno izbranih pozicij (izmed katerih je bilo približno polovica pozitivnih in polovica negativnih primerov), kjer je bil iskani razred prisotnost napada oz. pritiska na nasprotnega kralja, je eno od pridobljenih pravil (19 pozitivnih primerov, brez protiprimera) bilo naslednje:

```
if ((BLACK_SAFETY < -5)
   and (WHITE_PIECE_ACTIVITY >= 43)
   and (KING_TROPISM >= 30)
   and (WHITE_QUEEN_POSITION >= 3)
   and (BLACK_QUEEN_POSITION >= -3))
then
   comment ("White has a pressure against the opponent's king.")
```

Pravilo bi lahko razumeli nekako takole: če pozicija črnega kralja ni varna in ima beli dovolj aktivne figure, več figur v bližini nasprotnega kralja ter je hkrati njegova kraljica bolje postavljena od nasprotne kraljice, potem beli vrši pritisk na nasprotnega kralja. Pravilo vsekakor deluje logično, hkrati pa tudi ilustrira, kako kompleksna so lahko tovrstna pravila in zakaj tudi ekspertno znanje brez pomoči strojnega učenja ne zadošča pri njihovem sestavljanju. Po pridobitvi pravil s pomočjo strojnega učenja lahko pogoje še zaostrimo (npr. zahtevamo še večjo aktivnost belih figur), saj, kot je bilo rečeno, želimo predvsem točne komentarje, tudi na račun tega, da kdaj v pozicijah, ki bi jih morda lahko opredelili kot tiste, kjer ima ena od strani napad (ali pa tudi ne), tega raje ne omenjamo (v izogib potencialnim netočnostim).

Omenjena učna množica se nanaša na pozicije, kjer je razred prisotnost ali odsotnost napada belih figur na črnega kralja, medtem ko imamo v tem primeru na voljo tudi dodatnih 200 pozicij, kjer ugotavljamo napad črnih figur na belega kralja. Pravila, ki jih pridobimo na učnih pozicijah, lahko tako (s pomočjo vpeljave nasprotnih mejnih vrednosti) preizkusimo tudi na drugi množici pozicij, za obe strani morajo namreč veljati iste zakonitosti.

Slabost strojnega učenja v dani domeni je, da uporabljeni algoritmi zaradi razmeroma majhnega vzorca podatkov včasih najdejo popolnoma nesmiselna pravila, pa čeprav so le-ta točna za izbrani set pozicij. Prav tako očitna slabost je tudi ta, da nam razmeroma velik odstotek pozicij s pravili ni uspelo klasificirati.

Rešitev omenjenih problemov predstavlja ekspertni pregled naučenih pravil in avtomatsko prepoznanih problematičnih pozicij. Slednje je še posebej zanimivo, saj nam omogoči odkritje pomanjkljivosti posameznih atributov, ki sicer računalnikom verjetno omogočajo kvalitetno igranje šaha, vendar so lahko pri komentiranju zavajajoči. Tako na primer bližina dame nasprotnemu kralju ne prispeva k izgledom za napad, če je med njima npr. veriga blokiranih kmetov, ki preprečujejo njeno vključitev v matni napad. Nasprotno, dama s povsem druge strani šahovnice, ki ima odprto pot do nasprotnega kralja, lahko povsem upraviči komentar, da figure vršijo pritisk na nasprotnega kralja. V takem primeru lahko npr. z vpeljavo novega atributa, ki izraža število napadenih polj v bližini nasprotnega kralja, približamo atributne opise potrebam komentiranja. Pozitiven učinek vpeljave smiselnih atributov je tudi ta, da bo ob komentiranju program tudi sposoben navesti informativne (in razumljive) argumente ter z njimi obogatiti svoje komentarje, npr. »črni ima pritisk na *oslabljenega* belega kralja«.

Ekspertno znanje nam je v pomoč tudi pri odpravljanju drugega tipa težav, povezanega z nemočjo algoritmov za učenje. Algoritem CN2 se tako ne more naučiti pravila tipa WHITE_QUEEN_POSITION >= -BLACK_QUEEN_POSITION, ki bi verjetno bil popolnoma smiseln atribut. Uvedba takšnega atributa bi npr. lahko omogočila dodaten tip komentarjev, sicer tipičnih za komentiranje šahovskih partij: »bela dama je postavljena bolje od črne dame«. Vendar je tako pri uvedbi tovrstnih atributov kot pri njihovi uporabi potrebno biti izredno previden. Program CRAFTY namreč v primeru omenjenih dveh atributov pri določitvi njunih vrednosti upošteva le polje na šahovnici, kjer se nahaja dama, ter pri tem uporablja statične, vnaprej določene vrednosti, brez upoštevanja ostalih lastnosti pozicije, kaj šele dinamičnih dejavnikov, praktično vselej prisotnih v šahovski igri.

4 ZAKLJUČEK

Z razvojem inteligentnega računalniškega sistema, ki bo na človeku razumljiv, prijazen in zanimiv način komentiral šahovske poteze, bi radi šahovsko moč, ki jo demonstrirajo današnji programi za igranje šaha, izkoristili za poučevanje šaha ter za komentiranje šahovskih partij. Glavna prednost našega pristopa je tako omogočenje komentiranja šahovskih partij v vseh fazah igre, kot tudi ta, da komentarji poleg zmožnosti komentiranja taktičnih pozicij izražajo tudi razumevanje strateških nians v pozicijah.

V članku smo izpostavili nekatere razlike med programom, specializiranim za igranje šaha, ter programom, katerega cilj je podajati kvalitetne komentarje. Predstavili smo naš pristop pri razvoju ekspertnega sistema, ki kombinira tehnike strojnega učenja z ekspertnim znanjem. Z njegovo pomočjo je program sposoben prepoznavati kompleksnejše koncepte, ki sicer računalniškim programom niso potrebni za uspešno igranje šaha, vendar njihova uporaba omogoča komentarje, koristne za razlago strateških elementov, ki se skrivajo v šahovskih pozicijah.

Na poti do cilja nas čakajo še prenekateri izzivi. Poleg predstavljenih težav pri uporabi strojnega učenja pri razvoju ekspertnega sistema, je potrebno rešiti še nekatere probleme kognitivne narave, npr. kdaj komentirati in kdaj ne, kako dolge variante podajati, podajati komentarje za uporabnike z različnim šahovskim predznanjem itd. Eden izmed ciljev, ki jih želimo doseči, je uporabiti naš inteligentni sistem tudi za avtomatsko generiranje povzetkov šahovskih partij.

Literatura

[1] Y. Bjoernsson in T. Marsland. Fritz 5.0 Wins the 1997 Herschberg Best-Annotation Award. *ICCA Journal,* Vol. 21, No. 1, 1998, str. 135-136.

[2] Seidel, R. Self-annotating elementary endgames. *ICCA Journal,* Vol. 17, No. 2, 1994, str. 51-62.

[3] Herbeck, H. in Barth, W. An explanation tool for chess endgames based on rules. *ICCA Journal,* Vol. 19, No. 2, 1996, str. 75-82.

[4] Gadwal, D., Greer, J.E., McCalla, G.I. Tutoring Bishop-Pawn endgames: An experiment in using knowledge-based chess as a domain for intelligent tutoring. *Applied Intelligence 3*, 1995, str. 207-224.

[5] Sadikov, A., Možina, M., Guid, M., Krivec, J., Bratko, I. Automated Chess Tutor. *Proc. of the 5th International Conference of Computers and Games (CG2006).*

[6] Freedmann, R. What is an Intelligent Tutoring System? *Intelligence*, Vol. 11, No. 3, 2000, str. 15-16.

[7] Mitchell,T.M. *Machine Learning*. McGraw Hill, 1997.

[8] Demšar, J., Zupan, B., Leban, G. Orange: From experimental machine learning to interactive data mining, http://www.ailab.si/orange (White Paper), University of Ljubljana, 2004.

[9] Witten, I. in Frank, E. *Data Mining: Practical machine learning tools and techniques*, 2nd Edition, Morgan Kaufmann, San Francisco, 2005.

PATOLOGIJA MINIMAKSA V SINTETIČNIH DREVESIH IN PEARLOVI IGRI

Boštjan Kaluža, Mitja Luštrek, Matjaž Gams
Odsek za inteligentne sisteme
Institut Jožef Stefan
Jamova 39, 1000 Ljubljana, Slovenija
Tel: 01 477 3944; fax:01 477 3131
E-pošta: bostjan.kaluza@ijs.si

POVZETEK

Pri igranju iger, ki temeljijo na načelu minimaks, običajno z globljim preiskovanjem dobimo boljše rezultate. Teoretične analize kažejo, da pri določenih pogojih iskanje z minimaksom z globljim preiskovanjem povzroči slabše rezultate, kar predstavlja patologijo. Prispevek predstavi model preiskovanja z minimaksom in dejavnike, ki vplivajo na stopnjo patologije. V nadaljevanju je model preiskovanja preizkušen na Pearlovi igri. Prikazan je izbor hevristične funkcije in skladnost rezultatov z modelom.

1 UVOD

Načelo minimaksa uporabljajo skorajda vsi programi za igranje iger. Tovrstni programi zgradijo drevo igre do neke globine, ocenijo situacijo igre in vrednosti z minimaksom prenesejo v koren drevesa. Praksa kaže, da z globljim preiskovanjem dobimo boljše rezultate, teoretične analize [1, 2, 3] pa so pokazale, da lahko z globljim preiskovanjem dobimo manj zanesljive rezultate kot pri plitvejšem preiskovanju. Pojav so poimenovali patologija.

V 2. sekciji so predstavljeni zgradba modela preiskovanja z minimaksom ter parametri modela. Drugi del sekcije predstavi patologijo v modelu in metode, s katerimi smo preučevali zakonitosti v modelu. V 3. sekciji je opisana Pearlova igra in razširitev igre na model. V nadaljevanju je razložen izbor primerne hevristične funkcije in predstavljene so meritve stopnje patologije v igri.

2 MODEL PREISKOVANJA Z MINIMAKSOM

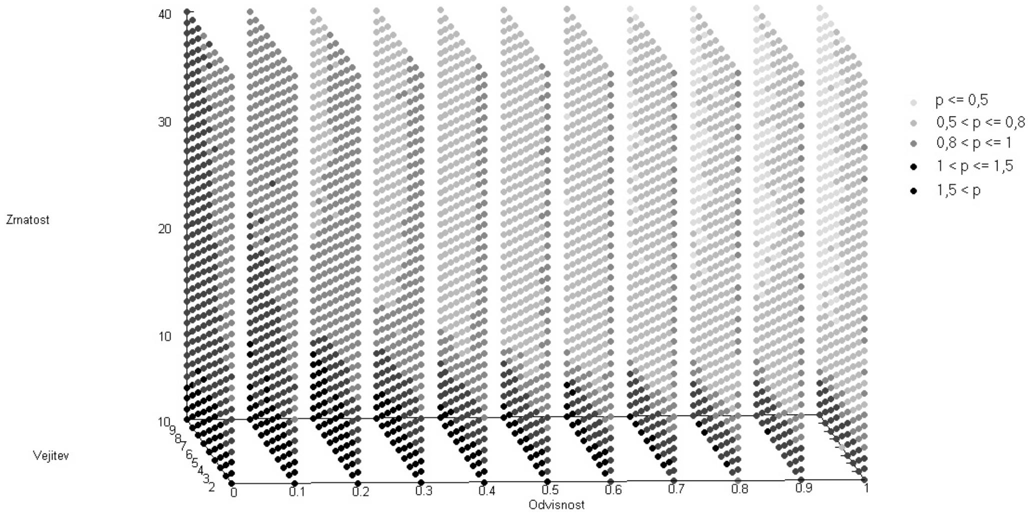
2.1 Zgradba modela

Za preučevanje patologije smo zgradili model preiskovanja z minimaksom [4], ki poskuša posnemati dogajanje v igri. Model ima tri parametre: vejitev - b (branching), zrnatost - g (granularity) in odvisnost - s (similarity). Vejitev predstavlja število možnosti, med katerimi se igralec v vsaki potezi odloča. V modelu smo predpostavili, da je vejitev med igro konstantna. Zrnatost pomeni število različnih vrednosti, ki lahko nastopajo v vozliščih drevesa. Tako pri igri, kjer sta izida zmaga ali poraz, nastopata vrednosti 0 in 1 in zrnatost $g = 2$. Drevesa z odvisnostjo $s = 0$ imenujemo neodvisna drevesa in so zgrajena povsem naključno. V delno odvisnih drevesih ima delež s bratskih listov podobne vrednosti, ki smo jih zgradili s pomočjo pomožnih vrednosti. Korenu smo pripisali vrednost $0,5$, nato pa smo pri vsakem prehodu na nižji nivo pomožne vrednosti sinov porazdelili z normalno porazdelitvijo okrog pomožne vrednosti starša. V listih so pomožne vrednosti postale prave vrednosti. S tem smo dosegli, da imajo bratska vozlišča podobne prave vrednosti, ki se razlikujejo za en nivo porazdeljevanja. Delno odvisnost drevesa glede na stopnjo s smo zgradili tako, da smo deležu s vozlišč na predzadnjem nivoju dodeli sinove s porazdeljeno pravo vrednostjo, preostalemu deležu $(1 - s)$ pa sinove z naključno pravo vrednostjo.

Prave vrednosti v listih so normalno porazdeljene in predstavljajo prave izide igre. Model z minimaksom prenese vrednosti v listih v koren drevesa in pri tem določi prave vrednosti notranjih vozlišč. Za simulacijo napake hevristične funkcije, ki na dani globini oceni situacijo igre, smo uporabili Gaussov šum. Hevristične ocene pri preiskovanju do globine d smo dobili s šumljenjem pravih vrednosti vozlišč na globini d. Prenesli smo jih pod koren in pri tem določili hevristične vrednosti notranjih vozlišč. Napaka v korenu pri izbrani globini preiskovanja d predstavlja verjetnost za napačno potezo, ki je pridobljena z oceno hevristične funkcije, in jo označimo z $error_d$.

Do pojava patologije pride, ko je napaka pri globljem preiskovanju večja od napake pri plitvejšem preiskovanju. V modelu smo opazovali količnik med napakama na petem in prvem nivoju in ga označili s $p - pathology$. Patologija je torej prisotna, ko je $p > 1$, kar pomeni, da je napaka pri preiskovanju do globine 5 večja od napake pri preiskovanju do globine 1.

Zanimajo nas predvsem neodločene igre, kjer sta igralca izenačena, saj je v igrah, kjer je izid že odločen, vseeno, katero potezo igralec izbere. Pri dvovrednostnem modelu se verjetnost zmage in poraza uravnava s parametrom c_b [5], ki v listih določa delež pravih vrednosti, ki predstavljajo zmago. Pri večvrednostnem modelu se interval $[0, 1]$ razdelili na g podintervalov enake dolžine in premakne notranje meje podintervalov za najmanjšo razliko med c_b in notranjo mejo [6]. Parameter c_b je pri dvovrednostnih neodvisnih drevesih definiran tako, da se verjetnost zmage in poraza na sodih in lihih nivojih izmenjujeta. Izkazalo se je, da za doseganje iste lastnosti pri odvisnih drevesih potrebujemo nekoliko drugačne vrednosti. Parameter smo označili s c_b' in ga izračunali s pomočjo dvovrednostnega delno odvisnega modela. Generi-



Slika 1 *Stopnja patologije v modelu preiskovanja z minimaksom*

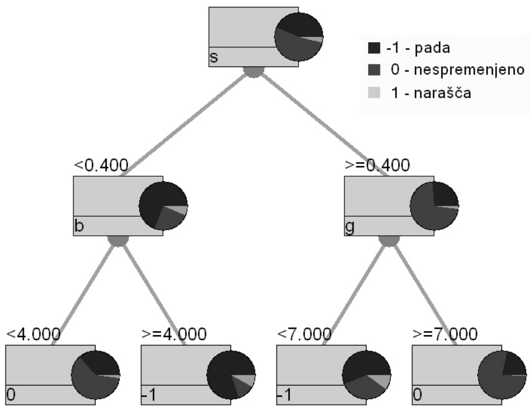
rali smo drevesa z različnimi vrednostmi parametra c'_b z intervala $[0, 1]$ in na sodih nivojih opazovali količnik med deležem vrednosti, ki predstavljajo zmago in deležem vrednosti, ki predstavljajo poraz, na lihih nivojih pa njegovo obratno vrednost. Za parameter c'_b smo izbrali vrednost, pri kateri je bil standardni odklon med količniki najmanjši. V ločenih izračunih smo parameter c'_b določili za vsako stopnjo odvisnosti in vejitve.

2.2 Patologija v modelu

Obnašanje modela smo preučevali s simulacijo. Tvorili smo veliko število dreves z različnimi parametri (običajno 10000 za vsak nabor parametrov) in na njih merili stopnjo patologije. Rezultati meritev zanimivega dela prostora, kjer je mogoče zaznati prehod med patološkim in nepatološkim delom, so povzeti na sliki 1. Prikazan je prostor parametrov vejitve, odvisnosti in zrnatosti, s sivino pa je ponazorjena stopnja patologije: črna predstavlja visoko, svetla pa nizko stopnjo patologije.

Za razlago stopnje patologije smo si pri preučevanju pomagali s strojnim učenjem. Za učenje smo uporabljali algoritem C4.5 v programskem paketu Orange. Učni primeri so vsebovali 3762 meritev, ki so prikazane na sliki 1. Atributi učnih primerov so bili vejitev, odvisnost in zrnatost, predstavljeni so bili kot vrednosti na zveznem intervalu. Ciljni razred je stopnja patologije, razdeljena v tri diskretne intervale: $\{[0, 0.8], (0.8, 1], (1, \infty)\}$. Odločitveno drevo nakazuje, da je patologija pri manjši zrnatosti vedno prisotna, neodvisno od vejitve in odvisnosti, in izgine šele pri večji zrnatosti z veliko stopnjo odvisnosti. Da to drži, je mogoče preveriti na sliki 1. S slike je razvidno, da stopnja patologije z zrnatostjo intenzivno pada pri manjši stopnji odvisnosti, medtem ko je pri večji odvisnosti padanje zmerno.

Ker je s slike težko razbrati vse zakonitosti, ki pogojujejo stopnjo patologije, smo se ponovno zatekli k strojnemu učenju. Uporabili smo že opisane učne podatke in atribute, za ciljni razred pa smo postavili spremembo stopnje patologije vzdolž opazovanega parametra a_i in označili smo jo z $\frac{dp}{da_i}$. Zaradi naključnosti simulacije rezultati rahlo nihajo, zato smo manjše nihaje zanemarili z definiranjem epsilona $\varepsilon = 0,05$. Stopnjo patologije, ki se vzdolž a_i razlikuje za več kot ε, smo označili za naraščajočo in obratno smo stopnjo patologije, ki se razlikuje za več kot $-\varepsilon$, označili za padajočo. Ciljni razred $\frac{dp}{da_i}$ je zavzemal diskretne vrednosti $\{-1, 0, 1\}$.



Slika 2 *Spreminjanje patologije vzdolž odvisnosti* $\frac{dp}{da_s}$.

Z odločitvenega drevesa na sliki 2 je mogoče razbrati, da patologija s odvisnostjo povečini pada, intenzivneje pri manjših vejitvah z nizko stopnjo odvisnosti in manjših zrnatostih z visoko stopnjo odvisnosti. Vejitev pri popolnoma neodvisnih drevesih pogojuje mejo patologije, medtem ko pri delno odvisnih drevesih na mejo nima posebnega vpliva. Povečevanje vejitve se odraža v stopnji patologije, saj območjem, ki so patološka, stopnja patologije naraste, in obratno, stopnja patologije v nepatoloških območjih pade. Odločitvena drevesa tega pojava niso jasno prikazala, mogoče pa ga je razbrati iz slike 1.

3 PREIZKUS MODELA NA PEARLOVI IGRI

Pearlova igra [7] se igra na plošči velikosti $b^{\lceil \frac{d}{2} \rceil} \times b^{\lfloor \frac{d}{2} \rfloor}$, kjer sta b in d celi pozitivni števili ter d pomeni število potez do konca igre, b pa število delitev plošče, ki jih v posamezni potezi naredi igralec. Poljem na plošči se naključno pripiše vrednosti 0 ali 1 tako, da je število enic in ničel v razmerju c_b:$(1 - c_b)$. Naloga prvega igralca je, da ploščo navpično razdeli na polovico in izbere bodisi levo bodisi desno polovico. Drugi igralec razdeli ploščo vodoravno in izbere bodisi zgornjo bodisi spodnjo polovico. Igralca izmenično vlečeta potezi, dokler na plošči ne ostane eno samo polje. Če je vrednost v polju enaka 1, zmaga igralec, ki je naredil prvo potezo, sicer zmaga njegov nasprotnik.

Igra v osnovi predstavlja dvovrednostni neodvisni model. Razširitev na večvrednostni model je dokaj enostavna, saj lahko poljem pripišemo več vrednosti. V nasprotju z dvovrednostnim modelom sedaj ne moremo več govoriti o zmagi in porazu, lahko pa vrednosti interpretiramo kot točke, kjer si prvi igralec prizadeva za čim višje in drugi igralec za čim nižje število točk. Odvisnost med posameznimi polji smo vpeljali na enak način kot pri modelu iz sekcije 2. Pri izvirni igri igralca v vsaki potezi delita ploščo na polovico, kar predstavlja vejitev $b = 2$. Če želimo doseči drugačno vejitev b, morata igralca v vsaki potezi razdeliti ploščo na b delov in izbrati enega.

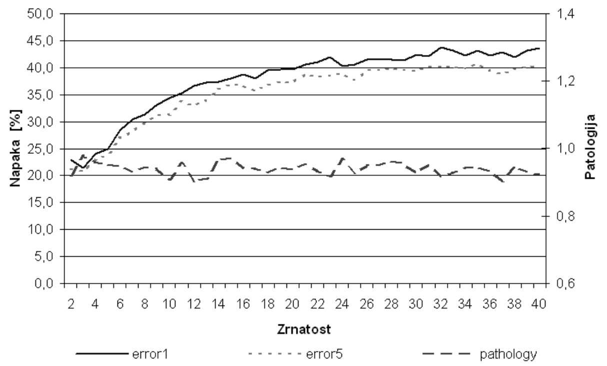
Simulacija igre je potekala na igralni plošči $b^4 \times b^3$, kar pomeni 7 potez in drevo igre višine $d = 7$. Globina drevesa je v igri večja kot v modelu, ker ne uporabljamo zašumljenih pravih vrednosti, ampak hevristične funkcije, kakršne bi lahko uporabljali programi za igranje iger. Te funkcije pa na spodnjih dveh nivojih ne delajo napak. Za izračun pravih vrednosti vozlišč smo igro odigrali do konca in vrednosti prenesli pod koren. Hevristične vrednosti smo pridobili tako, da smo igro odigrali do izbrane globine (1 ali 5) in uporabili hevristično funkcijo. Napako pri izbrani globini preiskovanja in patologijo smo izračunali na enak način kot v modelu.

3.1 Hevristične funkcije

Napaka in posledično patologija je odvisna od hevristične funkcije. Ker za Pearlovo igro ni splošno sprejete hevristične funkcije, smo se odločili, da bi veljalo preizkusiti nekaj hevrističnih funkcij, preveriti njihove napake in oceniti patologijo.

Najprej smo za hevristično funkcijo preizkusili šum, ki smo ga uporabljali v modelu. Rezultati so bili povsem skladni z modelom, kar smo tudi pričakovali.

Nau [7] je za hevristično oceno uporabljal povprečje, ki ga je izračunal iz vrednosti na preostalem delu plošče. Igralec, ki želi večjo vrednost, bo izbral del plošče z večjim povprečjem in obratno bo njegov nasprotnik, ki želi manjšo vrednost izbral del plošče z manjšim povprečjem. Na sliki 3 so prikazane napaka na prvem in petem nivoju, ki se nanašata na levo navpično os, in stopnja patologije, ki se nanaša na desno navpično os.



Slika 3 *Hevristična funkcija povprečje pri vejitvi $b = 2$ in odvisnosti $s = 0$*

Naslednja hevristična funkcija, ki smo jo preizkusili, je mediana in izhajali smo iz podobnih predpostavk kot pri povprečju. Izkaže se, da je hevristična funkcija z mediano pri ocenjevanju na globini 1 enako dobra kot ocenjevanje s povprečjem, pri ocenjevanju na globini 5 pa je pri manjši zrnatosti bistveno slabša, saj je napaka skoraj dvakrat večja. Stopnja patologije je v tem delu bistveno nižja.

Pri tretji hevristični funkciji smo izhajali iz dejstva, da je za igralca ugodno, če so sosednje vrednosti polj po delitvi čim bolj enake (čim večje za prvega in čim manjše za drugega igralca), saj s tem postane vseeno, kakšno potezo bo izbral nasprotnik. Hevristična funkcija h_d na b-delih plošče izračuna vsoto absolutnih razlik vseh polj do svojih sosedov. Izračun hevristične ocene je prikazan v formuli 1, kjer so P polja iz dela plošče, $N(p)$ pa polja, ki so sosednja polju p.

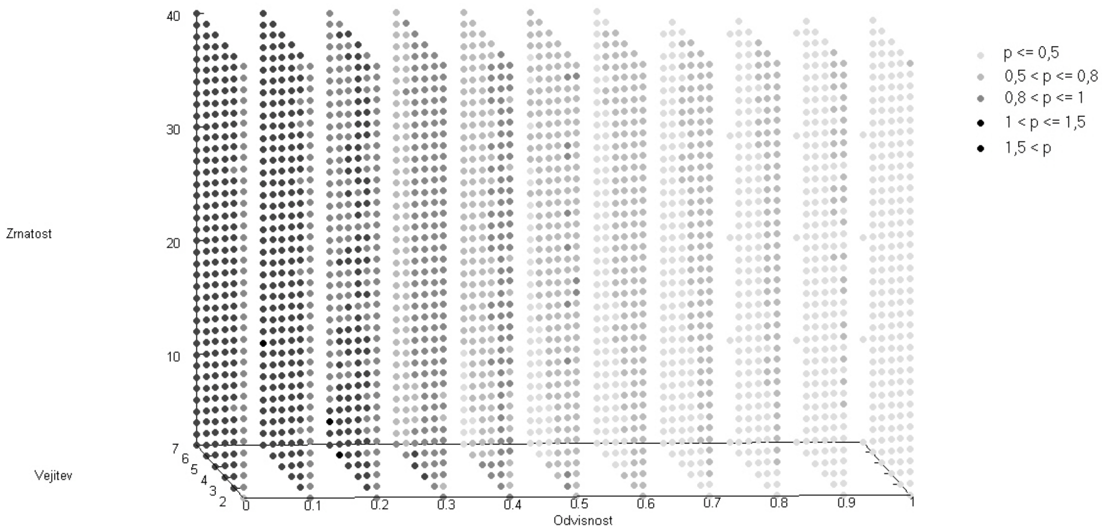
$$h_d = \sum_{p \in P} \sum_{v_i \in N(p)} (|v_i - p|) \tag{1}$$

Graf napake in stopnje patologije pri uporabi hevristične funkcije h_d je podoben grafu na sliki 3, le da sta napaki zamenjani. Opazimo lahko zanimiv pojav, da je ocena funkcije na nivoju 1 vedno nekoliko boljša (manjša napaka) od ocene na nivoju 5 (večja napaka) in posledično je patologija vedno prisotna.

Četrta hevristična funkcija, ki smo jo poimenovali *maxmin*, najprej izračuna minimalne vrednosti stolpcev na b-delih plošče in vrne maksimalno vrednost. Izračuna se po formuli 2, kjer so R vrednosti stolpcev na delu plošče.

$$h_{mm} = \max(\min_{r \in R}(r)) \tag{2}$$

Funkcija h_{mm} se obnaša precej podobno kot hevristična



Slika 4 *Stopnja patologije pri Pearlovi igri*

funkcija povprečje (slika 3), le da sta obe napaki v povprečju višji za 10 odstotnih točk.

Izbira hevristične funkcije močno vpliva na velikost napake in posledično na stopnjo patologije. Odločitev, katero hevristično funkcijo bomo uporabili za nadaljnje meritve, smo sprejeli na osnovi napake hevristične funkcije. V praksi si namreč želimo, da bi imela hevristična funkcija čim manjšo napako. Kot najprimernejša se izkaže hevristična funkcija povprečje, saj ima najmanjšo napako pri ocenjevanju. Ostale preizkušene funkcije imajo bodisi v celoti bodisi deloma večjo napako.

3.2 Meritve in rezultati

Nadaljnje meritve smo simulirali s hevristično funkcijo povprečje, kjer smo za vsak nabor parametrov b, s in g odigrali 5000 iger. Opazovano napako in patologijo smo povprečili po igrah, rezultati stopnje patologije pa so povzeti na sliki 4.

Patologija se pojavi šele pri vejitvi $b > 2$, stopnja patologije pa po napovedih modela z odvisnostjo pada. Nekoliko presenetljivo pa na stopnjo patologije zrnatost nima vpliva. Pri večji stopnji odvisnosti je mogoče zaznati celo manjši trend povečevanja stopnje patologije z naraščanjem zrnatosti, vendar je stopnja patologije še vedno v nepatološkem območju. Vpliv vejitve ustreza napovedim modela, saj stopnja patologije pri povečevanju vejitve upada v nepatoloških in narašča v patoloških področjih.

4 ZAKLJUČEK

Rezultati modela s skladni z obstoječimi raziskavami [5, 6] in predstavijo celoten prostor parametrov vejitve, zrnatosti in odvisnosti. Osvetlili smo patologijo v modelu ter s pomočjo simulacije in strojnega učenja pokazali vpliv parametrov na stopnjo patologije.

Stopnja patologije v Pearlovi igri v skladu z modelom pada z odvisnostjo in vejitev potencira stopnjo patologije. Zrnatost na stopnjo patologije nima večjega vpliva, kar gre pripisati hevristični funkciji.

V nadaljnjem delu bomo preizkusili še druge realne igre, kot je npr. šah, in preverili skladnost z modelom. Vzporedno opravljamo meritve tudi na minimin drevesih, ki kažejo, da je pojav patologije prisoten tudi pri tem tipu dreves.

Literatura

[1] Dana S. Nau: *Quality of decision versus depth of search on game trees*. Doktorska disertacija, Duke University, 1979.

[2] Mitja Luštrek, Matjaž Gams, Ivan Bratko: *Is Real-Valued Minimax Pathological?*. Artificial Intelligence, 2006.

[3] Mitja Luštrek, Ivan Bratko, Matjaž Gams: *Why Minimax Works: An Alternative Explanation*. IJCAI conference, 2005.

[4] Boštjan Kaluža, Mitja Luštrek, Matjaž Gams, Aleš Tavčar: *Patologija pri iskanju z minimaksom*. International Electrotechnical and Computer Science Conference (sprejeto), 2007.

[5] Dana S. Nau: *Pathology on Game Trees Revisited, and an Alternative to Minimaxing*. Artificial Intelligence, 1983.

[6] Mitja Luštrek: *Patologija v hevrističnih preiskovalnih algoritmih*. Doktorska disertacija, Univerza v Ljubljani, 2007.

[7] Dana S. Nau: *An Investigation of the Causes of Pathology in Games*. Artificial Intelligence, 1982.

ZAKAJ PREISKOVATI GLOBLJE?

Mitja Luštrek, Matjaž Gams
Odsek za inteligentne sisteme
Institut Jožef Stefan
Jamova cesta 39, 1000 Ljubljana, Slovenija
Telefon: +386 1 4773380; telefaks: +386 1 4773131
E-pošta: mitja.lustrek@ijs.si

Ivan Bratko
Fakulteta za računalništvo in informatiko
Univerza v Ljubljani
Tržaška cesta 25, 1000 Ljubljana, Slovenija

POVZETEK

Iz prakse je znano, da pri igranju iger z minimaksom in pri reševanju problemov z miniminom dobimo boljše rezultate, če preiskujemo globlje. Prispevek razloži mehanizem, zaradi katerega to velja: medsebojni vpliv hevrističnih vrednosti bratskih vozlišč v preiskovalnem drevesu povzroči, da je napaka njihovega minimuma ali maksimuma manjša od napake samih vozlišč.

1 UVOD

Hevristično preiskovanje je pogost način reševanja problemov. Ena njegovih najbolj znanih oblik je preiskovanje z minimaksom, ki se uporablja za igranje iger, kakršna je denimo šah. Za programe za igranje iger je znano, da igrajo bolje, kadar 'premislijo' več potez naprej, torej kadar drevo igre preiščejo globlje. Vendar so prvi poizkusi [1, 8], da bi to formalno utemeljili, pokazali, da globlje preiskovanje daje slabše rezultate. Ta pojav je bil poimenovan patologija minimaksa in je pozornost raziskovalcev odvrnil od vprašanja, zakaj je koristno preiskovati globlje. V tem prispevku obravnavamo to vprašanje pri preiskovanju z minimaksom in miniminom.

Igranje igre predstavimo z drevesom igre, v katerem so vozlišča položaji, povezave med njimi pa poteze. V korenu je trenutni položaj, za izbiro poteze pa moramo najti njegovega najboljšega naslednika. V ta namen preiščemo del drevesa pod korenom, vozlišča na robu preiskanega prostora hevristično ocenimo in ocene prenesemo v naslednike korena. Hevristične ocene vozlišč ustrezajo pričakovanim izidom igre, ki jih iz njih lahko dosežemo. Prenašamo jih po načelu minimaksa: vozliščem na nivojih maks, kjer smo na potezi mi, pripišemo maksimum vrednosti naslednikov, ker svoj izid želimo maksimizirati, vozliščem na nivojih min, kjer je na potezi nasprotnik, pa minimum, ker nasprotnik naš izid želi minimizirati. Za razliko od igranja iger se za reševanje enoagentnih problemov, kakršen je denimo iskanje najkrajše poti, uporablja preiskovanje z miniminom. Od preiskovanja z minimaksom se razlikuje le po tem, da so vsa vozlišča vrste min, ker navadno stremimo k čim krajši rešitvi.

V razdelku 2 bomo opisali, kako so se problema patologije in z njo povezane koristnosti globljega preiskovanja lotevali raziskovalci v preteklosti, ter pojasnili, v čem se naša obravnava od njihovega dela razlikuje. V razdelku 3 bomo podrobno razložili mehanizem, ki globlje preiskovanje z minimaksom naredi koristno. V razdelku 4 bomo pokazali, da je isti mehanizem na delu tudi pri preiskovanju z miniminom. Z razdelkom 5 bomo prispevek sklenili.

2 SORODNO DELO IN KAKO SE BOMO PROBLEMA LOTILI MI

V preteklosti je bila preiskovalna patologija deležna večje pozornosti kot mehanizem, ki globlje preiskovanje naredi koristno. Je pa res, da je razlaga, zakaj preiskovanje ni patološko, hkrati razlaga, zakaj je preiskovati globlje koristno. Razlika je predvsem v tem, da so razlage patologije največkrat privzele, da je preiskovanje patološko in da je v model preiskovanja treba uvesti lastnosti, ki to odpravijo, naš model preiskovanja že v osnovi ni patološki in bomo na njem le pokazali, zakaj je tako.

Večina preteklih modelov preiskovanja z minimaksom je poznala le dve pravi vrednosti položajev: poraz in zmago. Hevristični vrednosti sta bili v nekaterih modelih prav tako dve [1-3, 10], v nekaterih pa jih je bilo več [8, 9, 11]. Obeh vrst modeli so se navadno izkazali za patološke, dokler niso avtorji vanje uvedli kake posebne lastnosti, ki je bila največkrat podobnost vrednosti bližnjih vozlišč [2, 3, 9-11].

Naš model preiskovanja uporablja realne prave in hevristične vrednosti položajev. Razlog za to je, da mnogih iger z zgolj dvema vrednostma ni mogoče dobro igrati, čeprav sta možna izida le dva (to je bilo ugotovljeno tudi eksperimentalno [11]). Z dvema vrednostma se je sicer moč premikati med samimi dobljenimi položaji, dejansko zmagati pa se da le po naključju ali s pomočjo pomnjenja preteklih položajev in izogibanja njihovemu ponavljanju. Za pravočasno zmago je zato treba razlikovati med različnimi dobljenimi (ali izgubljenimi, če so na voljo le taki) položaji. Kot prave vrednosti razumemo tiste, ki to nalogo opravljajo najbolje možno (z vprašanjem, kaj točno to pomeni, se tu ne ukvarjamo, ker je odgovor nanj odvisen od konkretne igre), hevristične pa so njihov približek.

Realnovrednostni model minimaksa smo uporabljali že v preteklosti, tudi za razlago koristnosti globljega preiskovanja [5, 7]. Tovrstnih razlag za minimin pa iz literature ne poznamo. Na področju minimina je bilo narejenih le nekaj raziskav o patologiji [4, 6].

3 PREISKOVANJE Z MINIMAKSOM

3.1 Razlaga na enostavnem modelu

Za razlago koristnosti globljega preiskovanja z minimaksom bomo uporabili enostaven model, ki ima vejitev $b = 2$, pravi vrednosti bratskih vozlišč pa se povsod razlikujeta za 1. Napako hevrističnih ocen položajev bomo ponazorili z normalno porazdeljenim šumom, katerega standardni odklon $\sigma_e = 1$. Zanimala nas bo predvsem napaka poteze, ki je verjetnost, da v vozlišču izberemo napačno potezo zaradi napake hevrističnih ocen položajev v njegovih naslednikih. Nas cilj je pokazati, da napaka poteze v korenu drevesa igre z globino preiskovanja pada.

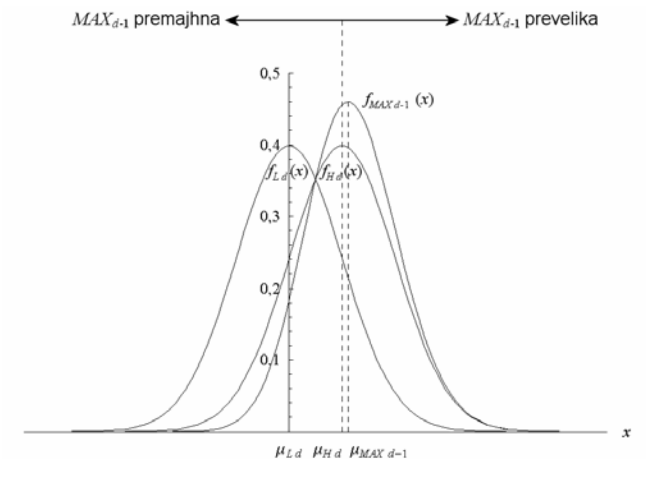
Vozlišče na nivoju $i - 1$ ima dva sinova, katerih hevristični vrednosti sta slučajni spremenljivki L_i (manjša) in H_i (večja) s srednjima vrednostma $\mu_{L\,i}$ in $\mu_{H\,i}$. Hevristične vrednosti na najnižjem nivoju preiskovanja d imenujemo statične. Porazdeljene so normalno: srednji hevristični vrednosti bratskih vozlišč sta $\mu_{L\,d}$ in $\mu_{H\,d}$ (obenem sta to tudi pravi vrednosti teh vozlišč), njun standardni odklon pa je σ_e. Gostota njunih porazdelitev je podana z enačbama (1).

$$f_{L\,d}(x) = \frac{1}{\sigma_e\sqrt{2\pi}} e^{\frac{-(x-\mu_{L\,d})^2}{2\sigma_e^2}} \qquad f_{H\,d}(x) = \frac{1}{\sigma_e\sqrt{2\pi}} e^{\frac{-(x-\mu_{H\,d})^2}{2\sigma_e^2}} \tag{1}$$

Če je nivo $i - 1$ vrste maks, je vrednost vozlišča na njem slučajna spremenljivka $MAX_{i-1} = \max(L_i, H_i)$, gostota njene porazdelitve pa se izračuna z enačbo (2).

$$\begin{aligned} f_{MAX\,i-1}(x) &= f_{H\,i}(x)P(L_i < x) + f_{L\,i}(x)P(H_i < x) = \\ &= f_{H\,i}(x)\int_{-\infty}^{x} f_{L\,i}(l)dl + f_{L\,i}(x)\int_{-\infty}^{x} f_{H\,i}(h)dh \end{aligned} \tag{2}$$

Gostote porazdelitev L_d, H_d in MAX_{d-1} kaže slika 1. Spremenljivka MAX_{d-1} v nasprotju z L_d in H_d ni porazdeljena normalno, čeprav to na prvi pogled ni očitno. Njeno porazdelitev smo dobili z numerično integracijo.



Slika 1. *Gostote porazdelitev statičnih hevrističnih vrednosti bratskih vozlišč in hevristične vrednosti njunega starša pri minimaksu.*

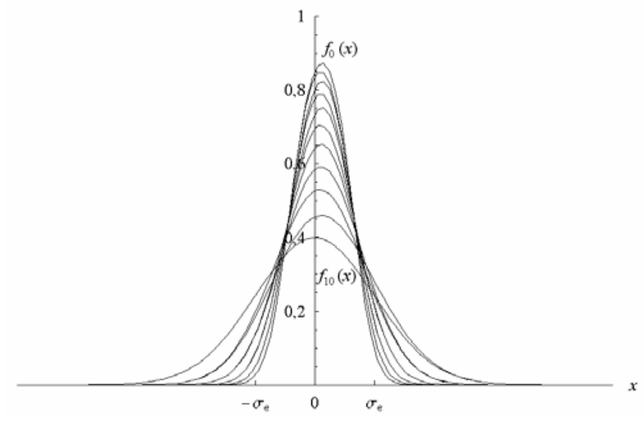
Na sliki 1 vidimo, da je vzpetina krivulje starša ($f_{MAX\,d-1}$) ožja od vzpetin krivulj njegovih sinov ($f_{L\,d}$ in $f_{H\,d}$), kar pomeni, da je varianca hevristične vrednosti starša manjša. Ker je razlika med pravimi vrednostmi bratskih vozlišč konstantna, je taka tudi razlika med njihovimi srednjimi hevrističnimi vrednostmi. Zato na napako poteze vpliva le varianca: pri manjši varianci je napaka poteze manjša.

Najprej razložimo, zakaj maksimum povzroči zmanjšanje variance. Če manjša od vrednosti bratskih vozlišč ne bi imela vpliva na vrednost svojega starša, bi bila $f_{MAX\,i-1}$ enaka $f_{H\,i}$. Ker to ne drži, si moramo ogledati dva primera, označena na vrhu slike 1. Kadar je MAX_{i-1} prevelika ($MAX_{i-1} > \mu_{H\,i}$), je najverjetnejši razlog za to, da je prevelika H_i ($H_i > \mu_{H\,i}$). Manj verjeten razlog pa je, da H_i sicer ni prevelika ($H_i \leq \mu_{H\,i}$), je pa močno prevelika L_i ($L_i > \mu_{H\,i}$). Kadar je MAX_{i-1} premajhna ($MAX_{i-1} < \mu_{H\,i}$), mora biti premajhna tudi H_i ($H_i < \mu_{H\,i}$), kar se zgodi z enako verjetnostjo, kot da je prevelika. Lahko pa napako H_i popravi L_i s tem, da je večja od H_i ($H_i < L_i \leq \mu_{H\,i}$). Ker je verjetnost za manjše L_i večja kot za večje, je koristni učinek L_i v drugem primeru večji od škodljivega v prvem. Zato L_i pravilnosti svojega starša MAX_{i-1} koristi bolj kot škoduje.

Če je nivo $i - 1$ vrste min, je vrednost vozlišča na njem slučajna spremenljivka $MIN_{i-1} = \min(L_i, H_i)$, gostota njene porazdelitve pa se izračuna z enačbo (3). Slika in razlaga učinkov minimuma je domala enaka kot pri maksimumu.

$$\begin{aligned} f_{MIN\,i-1}(x) &= f_{L\,i}(x)P(H_i > x) + f_{H\,i}(x)P(L_i > x) = \\ &= f_{L\,i}(x)\int_{x}^{\infty} f_{H\,i}(h)dh + f_{H\,i}(x)\int_{x}^{\infty} f_{L\,i}(l)dl \end{aligned} \tag{3}$$

Enačbi (1) opisujeta gostoti porazdelitve na najnižjem nivoju preiskovanja, za vsak višji nivo pa je gostoto porazdelitve moč izračunati rekurzivno z izmenično uporabo enačb (2) in (3). Gostote porazdelitev hevrističnih vrednosti za vse nivoje pri $d = 10$ so prikazane na sliki 2.

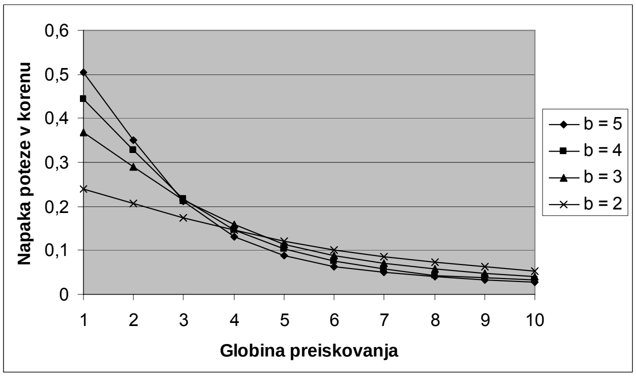


Slika 2. *Gostote porazdelitev hevrističnih vrednosti za deset nivojev pri minimaksu.*

Na sliki 2 vidimo, da se vzpetine krivulj gostot porazdelitev hevrističnih vrednosti proti vrhu drevesa igre ožijo, kar pomeni, da se varianca hevrističnih vrednosti manjša. Zaradi enostavnosti modela gostote porazdelitev na sliki ustrezajo tudi hevrističnim vrednostim v korenu pri različnih globinah preiskovanja: od f_{10} pri d = 0 do f_0 pri d = 10. Torej se varianca hevrističnih vrednosti v korenu in posledično napaka poteze z globino preiskovanja manjša.

3.2 Posplošitev modela

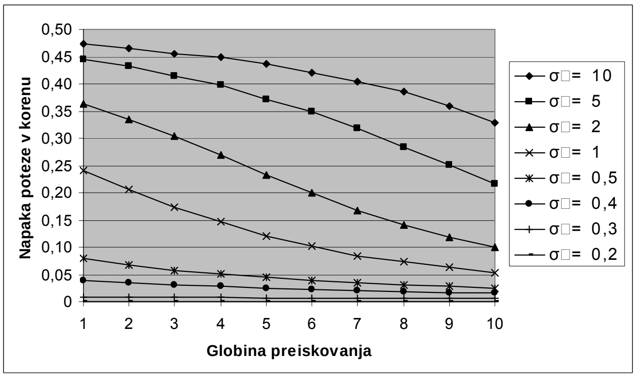
Najprej si oglejmo, kaj se zgodi pri **vejitvah drevesa igre** večjih od 2. Slika 3 kaže napako poteze v korenu v odvisnosti od globine preiskovanja pri različnih vejitvah; razlika med pravimi vrednostmi bratskih vozlišč je še vedno 1, največja globina preiskovanja $d_{\max}$ = 10 in σ_e = 1.



Slika 3. *Napaka poteze v korenu v odvisnosti od globine preiskovanja pri različnih vejitvah.*

Na sliki 3 vidimo, da je globlje preiskovanja z minimaksom pri večjih vejitvah bolj koristno. Pri plitvih preiskovanjih je napaka poteze v korenu pri večjih vejitvah večja, ker je izbrati pravo potezo med več potezami teže kot med manj. Pri globljih preiskovanjih velja obratno. Kot vemo, v vozliščih na nivojih maks manjša hevristična vrednost sina popravi večjo. Če imamo manjših hevrističnih vrednosti več, ima vsaka od njih enak koristen učinek, tako da je skupna korist večja kot od ene same manjše vrednosti. Na nivojih min je podobno.

Slika 4 kaže napako poteze v korenu v odvisnosti od globine preiskovanja pri različnih **standardnih odklonih statičnega šuma**; b = 2, razlika med pravimi vrednostmi bratskih vozlišč je 1 in $d_{\max}$ = 10.



Slika 4. *Napaka poteze v korenu v odvisnosti od globine preiskovanja pri različnih σ_e.*

Na sliki 4 vidimo, da se napaka poteze pri povečanju globine preiskovanja najbolj zmanjša pri σ_e = 1, pri večjih in manjših σ_e pa je preiskovanje manj koristno. Če je varianca hevrističnih vrednosti majhna, na nivojih maks manjše vrednosti največje navadno sploh ne dosežejo, zato je ne morejo popraviti in je pri majhnih σ_e koristi od preiskovanja malo (na nivojih min je podobno). Pri večjih σ_e se napaka poteze približa 0,5, kar je pri b = 2 največje možna napaka, ki pomeni naključne odločitve. Če je napaka blizu 0,5 že pri srednjih globinah, se pri majhnih ne more več dosti poslabšati, kar zmanjša koristnost preiskovanja do srednjih globin v primerjavi z majhnimi. Velike globine so v primerjavi s srednjimi še vedno koristne, ker ima tam napaka na voljo dovolj nivojev, da se zadosti oddalji od 0,5.

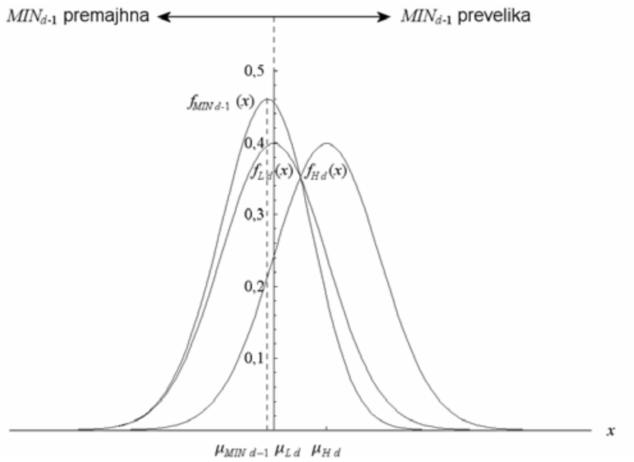
Posvetimo se še **razliki med pravimi vrednostmi bratskih vozlišč** v drevesu igre. Zanima nas, ali bi bile prave vrednosti lahko porazdeljene tako, da bi prišlo do patologije – ali bi lahko izničile opisani koristni učinek globljega preiskovanja z minimaksom. Denimo, da povsem splošno drevo igre preiskujemo do globin d in d + 1. Preiskovanje do globine d + 1 si predstavljajmo kot preiskovanje do globine d, kjer namesto običajne hevristične ocenjevalne funkcijo e uporabimo e'. Funkcija e' preiskovanje poglobi za en nivo in nato pokliče e. Vemo, da vsak nivo preiskovanja varianco hevrističnih vrednosti zmanjša, s tem pa zmanjša tudi napako poteze. Torej je funkcija e', kar se tiče napake poteze, bolj točna od e, to pa pomeni, da je napaka pri preiskovanju do globine d + 1 manjša kot pri preiskovanju do globine d in do patologije ne more priti.

4 PREISKOVANJE Z MINIMINOM

Razlago koristnosti globljega preiskovanja z miniminom bomo izpeljali na enak način, kot smo to storili za minimaks. Uporabili bomo enostaven model preiskovanja, ki je enak enostavnem modelu pri minimaksu, torej ima vejitev 2 in razliko med pravima vrednostma bratskih vozlišč povsod 1, le da so vsa njegova vozlišča vrste min. Napako hevristične ocenjevalne funkcije bomo zopet ponazorili z normalno porazdeljenim šumom s standardnim odklonom 1. Tudi patologijo bomo obravnavali na enak način kot pri minimaksu.

Hevristične vrednosti vozlišč pri miniminu so porazdeljene podobno kot pri minimaksu. Vozlišče na nivoju i – 1 enostavnega modela ima dva sinova, katerih hevristični vrednosti sta slučajni spremenljivki L_i (manjša) in H_i (večja) s srednjima vrednostma $\mu_{L\,i}$ in $\mu_{H\,i}$. Statične hevristične vrednosti so porazdeljene normalno, gostoti porazdelitev statičnih hevrističnih vrednosti bratskih vozlišč pa sta podani z enačbama (1), ki veljata tudi pri minimaksu. Hevristična vrednost vozlišča na nivoju i – 1 je slučajna spremenljivka MIN_{i-1} = min (L_i, H_i), gostota njene porazdelitve pa se izračuna z enačbo (3), ki je takisto znana iz modela minimaksa. S tema dvema enačbama lahko rekurzivno izračunamo porazdelitev hevristične vrednosti na kateremkoli nivoju.

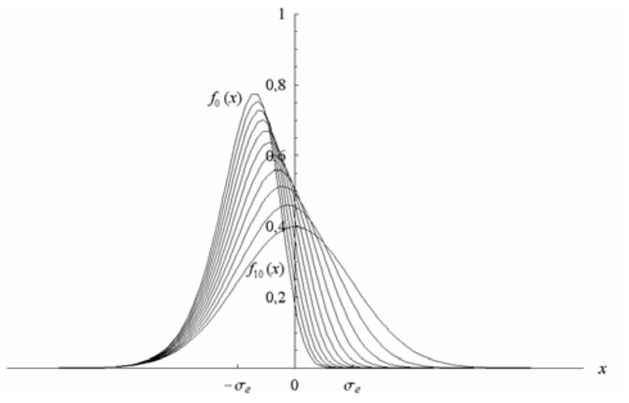
Sliki 1, ob kateri smo razložili koristnost globljega preiskovanja z minimaksom, pri preiskovanju z miniminom ustreza slika 5: na njej so prikazane gostote porazdelitev L_d, H_d in MIN_{d-1}.



Slika 5. *Gostote porazdelitev statičnih hevrističnih vrednosti bratskih vozlišč in hevristične vrednosti njunega starša pri miniminu.*

Na sliki 5 vidimo, da je pri preiskovanju z miniminom enako kot pri minimaksu vzpetina krivulje starša ($f_{MIN\,d-1}$) ožja od vzpetin krivulj njegovih sinov ($f_{L\,d}$ in $f_{H\,d}$) in da je torej varianca hevristične vrednosti starša manjša, kar zmanjša napako poteze. Razlaga za zmanjšanje variance je enaka kot pri minimaksu: MIN_{i-1} je podobna L_i, kadar je prevelika, jo H_i zmanjša, kadar je premajhna, pa jo H_i lahko naredi še manjšo. Ker H_i na prvi način vpliva verjetneje kot na drugi, pravilnosti svojega starša koristi bolj kot škodi.

Sliki 2, kjer so prikazane gostote porazdelitev hevrističnih vrednosti za več nivojev pri minimaksu, pri miniminu ustreza slika 6: na njej vidimo gostote porazdelitev hevrističnih vrednosti za vse nivoje pri $d = 10$.



Slika 6. *Gostote porazdelitev hevrističnih vrednosti za deset nivojev pri miniminu.*

Na sliki 6 vidimo, da se vzpetine krivulj gostot porazdelitev hevrističnih vrednosti proti vrhu preiskovalnega drevesa ožijo, kar pomeni manjšo varianco hevrističnih vrednosti. Zato se z globino preiskovanja manjša tudi varianca hevrističnih vrednosti v korenu in torej napaka poteze.

Enostavni model preiskovanja z miniminom bi lahko posplošili enako, kot smo to storili pri minimaksu. Podobnost razlage koristnosti globljega preiskovanja z miniminom in minimaksom nam pove, da bi v vseh točkah prišli do enakih ugotovitev: da sklepi, ki smo jih naredili na podlagi enostavnega modela, veljajo tudi za posplošenega.

5 ZAKLJUČEK

V prispevku smo pokazali, zakaj globlje preiskovanje z minimaksom in miniminom daje boljše rezultate od plitvejšega. Na koristnost globljega preiskovanja sicer vplivajo mnogi dejavniki, nekateri lahko opisani mehanizem tudi preglasijo in povzročijo patologijo, a naša razlaga vseeno velja dokaj splošno.

Literatura

[1] Beal, D. F. (1980). An analysis of minimax. V Advances in Computer Chess 2 (Clarke, M. R. B., ur.), 103-109. Edinburgh University Press, Edinburgh, VB.

[2] Beal, D. F. (1982). Benefits of minimax search. V Advances in Computer Chess 3 (Clarke, M. R. B., ur.), 17-24. Pergamon Press, Oxford, VB.

[3] Bratko, I., in Gams, M. (1982). Error analysis of the minimax principle. V Advances in Computer Chess 3 (Clarke, M. R. B., ur.), 1-15. Pergamon Press, Oxford, VB.

[4] Bulitko, V., Li, L., Greiner, R., in Levner, I. (2003). Lookahead pathologies for single agent search. V zborniku International Joint Conference on Artificial Intelligence (IJCAI), Posters Section, Acapulco, Mehika, 1531-1533.

[5] Luštrek, M., Bratko, I., in Gams, M. (2005). Why minimax works: An alternative explanation. V zborniku International Joint Conference on Artificial Intelligence (IJCAI), Edinburgh, VB, 212-217.

[6] Luštrek, M., in Bulitko, V. (2006). Lookahead pathology in real-time path-finding. V zborniku National Conference for Artificial Intelligence (AAAI), Learning for Search Workshop, Boston, ZDA, 108-114.

[7] Luštrek, M., Gams, M., in Bratko, I. (2006). Is real-valued minimax pathological? Artificial Intelligence, 170 (6-7), 620-642.

[8] Nau, D. S. (1979). Quality of decision versus depth of search on game trees. Doktorska disertacija, Duke University.

[9] Nau, D. S. (1982). An investigation of the causes of pathology in games. Artificial Intelligence, 19 (3), 257-278.

[10] Pearl, J. (1983). On the nature of pathology in game searching. Artificial Intelligence, 20 (4), 427-453.

[11] Scheucher, A., in Kaindl, H. (1998). Benefits of using multivalued functions for minimaxing. Artificial Intelligence, 99 (2), 187-208.

HOW MUCH CAN CLAUSE IDENTIFICATION HELP TO IMPROVE DEPENDENCY PARSING?

Domen Marinčič, Matjaž Gams, Tomaž Šef
Odsek za inteligentne sisteme
Institut "Jožef Stefan"
Jamova 39, 1000 Ljubljana, Slovenija
domen.marincic@ijs.si, matjaz.gams@ijs.si, tomaz.sef@ijs.si

Abstract

In this paper an analysis of parsing complex sentences is presented. Experiments to determine the impact of clause identification as a preprocessing step to parsing were conducted. The experiments were done with MST Parser and MALT parser on Slovene language using SDT (Slovene Dependency Treebank) as train and test data. With a reliable clause identification method we can estimate the accuracy of parsing to be improved by up to 5.5 percentage points.

1 Introduction

In dependency parsing, the most successful algorithms treat sentences as a whole, using the bottom-up direction or being direction-unspecific. The other, top-down direction currently seems to be less popular. An aspect of understanding the the top-down approach is the "divide et impera" principle of solving problems. In this context, long sentences can be treated as large complex problems that should first be split into smaller easier manageable ones. One of the measures to describe the complexity of sentences is the number of verbs contained in it. That accuracy drops with increasing number of verbs has already been shown for example by [13] who reports a 15% decrease of accuracy when comparing parsing 1-verb sentences and sentences containing 4 or more verbs for one of the described parsers. Another indicator of the complexity of a sentences is the number of clauses constituting a sentence.

Clauses are an appropriate intermediary level for identification sentences, since they represent a closed unit of text. Constituency parsing was the field where this notion was exploited the first. [1] is one of the early works where clause identification is used prior to detailed parsing of English text. In this work only simplex clauses [1] are treated. Recursive interclausal hierarchy is not dealt with at this stage, although a module for repairing some detectable errors is used. Similar approach using simplex clause identification is used by [3] at discourse analysis of spoken and written Swedish. Later on, clause identification in the constituency based framework seems to have been treated predominantly as a standalone problem such as in [14], [12] although some authors do claim that clauses identification could help detailed text parsing [4], [11].

In dependency parsing clause identification seems to have attracted attention only recently. [10] uses clause identification as a preprocessing step for incremental dependency parsing of Japanese spoken monologue. In the rule-based parser for Czech, described in [5], clause identification is intertwined with the bottom-up processing of sentences and helps to reduce simpler elements of sentences into higher level structures. [6], although not explicitly dealing with deep dependency parsing, proposes an interesting framework for sentence segmentation. The work was evaluated with help of PDT (Prague Dependency Treebank) [7]. The results of the work can subsequently be used for clause identification.

As shown above, some interesting approaches of combination of clause identification and deep parsing have already been tried, which show that successful clause identification does help full sentence parsing. The more complex the sentences the larger accuracy gain we can expect if we split them to clauses correctly, so complex sentences should be paid more attention to.

In our work, parsing of SDT [2], dependency treebank of Slovene text was analysed. MaltParser [9] and the MST parser described in [8], were tested. Parsing accuracy was measured depending on the number of clauses in sentences.

In Section 2 we describe the rules for identifying clauses in dependency trees. In section 3 we present the experiments and the results. Section 4 contains our conclusions and some proposals how to contintue the work.

[1]A simplex clause is defined as a sequence of tokens starting at the beginning of one simplex clause and ending with the last token before the beginning of the next simplex clause. This means that a simplex clauses cannot contain embedded clauses.

2 Identifying clauses from dependency trees of whole sentences

The first issue to be resolved is the definition of a clause in Slovene language. In [15], one of the fundamental grammar books of modern Slovene, we can find the following theoretical definition: a clause is a text unit, whose core is a complex verb form. It can contain optional additional constituents, such as subject, object, adjunct etc., which describe the verb form more exactly. On the other hand, our test data, SDT was build using PDT [7] as a model, which is based on a different type of grammar, a dependency grammar. To ease the process of data preparation, we adopted SDT as a standard for the definition of a clause, while trying to find such rules to match the theoretical definition as exactly as possible.

A clause in an SDT dependecy tree is represented as a subtree of the whole sentence tree. We distinguish two types of clauses (see Fig. 2):

- Coordinate clause: a subtree having a finite non-auxiliary [2] verb as its root. The subtree's direct ancestor has to be a coordinating conjunction.

- Subordinate clause: (i) a subtree having a subordinating conjunction as its root, one of its direct descendants being a finite non-auxiliary verb and (ii) a subtree, having a finite non-auxiliary verb as its root, where subtree's direct ancestor is not a coordinating conjunction.

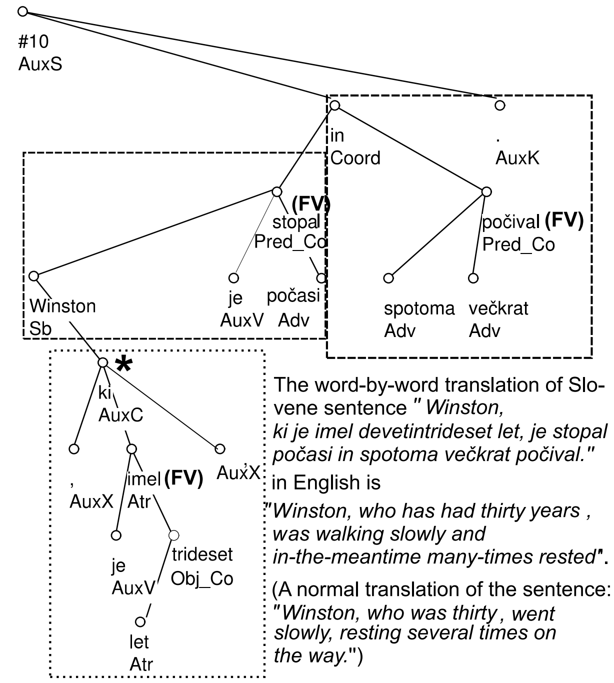


Figure 1: An example sentence tree with clauses. The coordinate clauses are inside dashed rectangles. The subordinate clause is inside a dotted rectangle. The finite verbs are marked by (FV). The subordinate conjunction is marked by *.

3 Experiments

Ten-fold cross-validation method was used to measure the parsing accuracy. The whole corpus was randomly split into ten disjoint parts, containing the same number of sentences [3]. For each of the parsers in every step of the training-evaluation cycle a different part was used as the test set, the others were used as the learn set. The test set was divided into six disjoint sets of sentences. Sentences of set 0 can be described as no-verb sentences, because they contain no verbs at all. Other sets contain clauses with at least one finite verb. Sets 1, 2, 3 and 4 include sentences with 1, 2, 3 and 4 clauses respectively. Set 5 is a group of sentences with 5 or more clauses. The last type of test set, Set X is the union of all the others, thus containing all types of sentences. For all of the described sets parsing accuracy was measured separately.

Parsing accuracy (labeled attachment score) was measured separately for each parser. The weighted average accuracy over all folds was taken as the accuracy of the experiments [4] Table 1 gives the overview of the results. In the first row, there is the accuracy of MaltParser. In the second row, there is the accuracy of MST parser. In the last row, there is the number of nodes included in each test set (summed over all folds).

As expected, sentences with more clauses were parsed worse (with exception of no-verb sentences). The best result, 78.3%, was achieved by MST parser tested on one-clause sentences.

4 Conclusion and future work

We have conducted the experiments to analyse parsing performance of complex sentences. The results confirm that the more clauses per sentence, the worse the accuracy. With a reliable clause identification method we can estimate the accuracy of MST parser to be improved by up to 5.3 percentage points, while we could

[2] 'AuxV' is the grammatical function of auxiliary verbs in SDT

[3] Actually, in some of the sets the number was higher for one sentence than in others, since the total number of sentences in SDT is not a multiple of ten

[4] The number of nodes per sentence varies. The ratio of the number of nodes in the fold to the total number of test nodes for each test was taken as the weight for each fold.

	Set 0	Set 1	Set 2	Set 3	Set 4	Set 5	Set X
Acc. [%], MaltParser	44.0	68.8	66.7	63.6	61.3	56.8	63.2
Acc. [%], MST parser	67.5	78.3	76.4	72.3	72.5	64.8	73.0
Test set size in nodes	607	7714	10245	8505	4912	5777	37760

Table 1: Results of experiments

expect the improvement of MALT parser to be as high as 5.5 percentage points.

A surprising result is low accuracy of parsing no-verb sentences. To parse this sentences it would probably make sense to use a completely different approach, for example templates of dependency trees proposed by [16].

The results presented in this paper encourage us to follow the two-stage approach to parsing. First, preprocess the text with algorithms for clause identification and subsequently use standard parsing algorithms to get the full parse of a sentence.

References

[1] Abney, S. (1990). Rapid Incremental Parsing with Repair. In *Proceedings of the 6th New OED Conference,* University of Waterloo, Waterloo, Ontario.

[2] Džeroski, S., Erjavec, T., Ledinek, N., Pajas, P., Žabokrtský, Z., Žele, A. (2006). Towards a Slovene dependency treebank. In *Proceedings of the 5th International Conference on Language Resources and Evaluation (LREC),* Genova, Italy.

[3] Ejerhed, E. (1996). Finite state segmentation of discourse into clauses. In *Proceedings of the ECAI '96 Workshop on extended finite state models of language,* ECAI '96, Budapest , Hungary.

[4] Hammerton, J., Osborne, M., Armstrong, S., Daelemans, W. (2002) Introduction to Special issue on machine learning approaches to shallow parsing. *The Journal of Machine Learning Research, Volume 2 , March 2002, ISSN:1533-7928*

[5] Holán, T., Žabokrtský, Z. (2006). Combining Czech Dependency Parsers. To appear at TSD 2006, Brno, Czech Republic.

[6] Kuboň, V. Segmentation of Complex Sentences. (2006). To appear at TSD 2006, Brno, Czech Republic.

[7] Linguistic Data Consortium. (2001). Prague Dependency Treebank 1. LDC2001T10.

[8] McDonald, R., Pereira, F., Ribarov, K., Hajič, J. (2005). Non-projective dependency parsing using spanning tree algorithms. In *Proceedings of the Joint Conference on Human Language Technology and Empirical Methods in Natural Language Processing (HLT/EMNLP).*, Vancouver, British Colombia, Canada.

[9] Nivre, J., Hall, J. (2005). MaltParser: A languageindependet system for data-driven dependency parsing. In *Proceedings of the fourth workshop on Treebanks and Linguistic theories, TLT 2005*, Barcelona, Catalonia, Spain.

[10] Ohno, T., Matsubara, S., Kashioka, H., Maruyama, T., Inagaki, Y. (2006). Incremental dependency parsing of japanese spoken monologue based on clause boundaries. In *Proceedings of Joint 21th International Conference on Computational Linguistics and 44th Annual Meeting of the Association for Computational Linguistics (COLING/ACL-2006),* Sydney, Australia.

[11] Orasăn, C. (2000). A hybrid method for clause splitting in unrestricted English texts. In *Proceedings of ACIDCA '2000*, Monastir, Tunisia, 2000.

[12] Puscasu, G. (2004). A Multilingual Method for Clause Splitting. In *Proceedings of CLUK 2004.* Birmingham, UK.

[13] Ribarov, K. (2004). Automatic building of a dependency tree - the rule-based approach and beyond. *Ph.D. thesis*, Faculty of mathematics and physics, Charles university, Prague, Czech Republic.

[14] Sang, E. F. T. K., Djean, H. (2001). Introduction to the CoNLL-2001 Shared Task: Clause Identification. In *Proceedings of CoNLL-2001.* Toulouse, France.

[15] Toporišič, J. (1984), Slovenska slovnica, Založba obzorja Maribor, Slovenia.

[16] Zeman, D. (2004). Parsing with a statistical dependency model, *Ph.D. thesis*, Faculty of mathematics and physics, Charles university, Prague, Czech Republic.

SEARCH PATHOLOGY OF 8-PUZZLE

Rok Piltaver, Mitja Luštrek, Matjaž Gams
Department of Intelligent Systems
Jozef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
e-mail: {rok.piltaver | mitja.lustrek | matjaz.gams}@ijs.si

ABSTRACT

8-puzzle is typically solved by heuristic search. Real-time heuristic search usually gives better results when searching deeper. But sometimes deeper search leads to worse results than shallower which is a phenomenon called search pathology. In this paper we present the results of our investigation of the causes for pathology in 8-puzzle and some of its variations.

1 INTRODUCTION

8-puzzle (or 8-tiles sliding game) is a simple game in which one has to rearrange 8 tiles on 3 by 3 grid by sliding one tile at a time into an empty slot. The objective of the game is to rearrange the tiles into given order in as few moves as possible. Figure 1 shows how to solve start position (a) in 4 moves to obtain goal position (e).

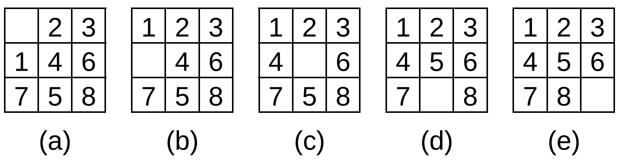


Figure 1: *An example of solving 8-puzzle.*

A program that is trying to solve a given start position in the (8-puzzle) game generates a tree representing all possible sequences of moves of a certain length. Nodes of the tree represent positions in the game. Two nodes are connected with directed edge pointing from position p_1 to position p_2 if a move that transforms p_1 into p_2 exists. The program evaluates the minimal number of moves needed to solve positions in the leaves of that tree by using a certain heuristic function [4]. The move that leads to the sub tree that has the minimal value of the heuristic function in a leaf is chosen as the best move. Usually the deeper the tree is (the longer the sequence of moves) the more likely it is to choose the optimal move. But sometimes deeper trees mislead the algorithm into choosing wrong moves, whereas shallower trees would suggest correct moves. That is called search pathology [1, 3 and 7] and we want to avoid it if we can. In this paper we investigate when and why pathology happens by varying number of factors that may influence pathology and evaluating the correlation between them and measured pathology of a certain variation of 8-puzzle solved using a certain heuristic function.

The pathology of minimax search was independently discovered by D. S. Nau in 1979 [10] and D. F. Beal in 1980 [11]. Pathology of single-agent search was discovered much later in 2003 by V. Bulitko [7]. The causes for pathology of minimax search and their influences on pathology are described in [1, 3 and 6] so we studied the influence of the same factors and some additional ones in the domain of 8-puzzle (and its variations) which is known to be pathological [9, 2]. We investigate the pathology of single-agent search with the assumption that it behaves similarly as pathology of minimax search.

The rest of the paper is structured as follows. In Section 2 we explain how we modeled heuristic function, how we evaluated percent of correct decisions and pathology and influence of granularity of heuristic function on pathology. In Section 3 we present variations of 8-puzzle and some statistic about them. We also describe influence of similarity of sibling nodes in the search tree and branching factor of the search tree on pathology. In Section 4 we present results obtained using some other heuristic functions. Section 6 gives the conclusions.

2 THE USUAL 8-PUZZLE

It is known that 8-puzzle is pathological [2] so for the first part of our paper we use similar heuristic function as Sadikov and Bratko did in their paper. To obtain it we first calculated the optimal (minimal) numbers of moves needed to solve each solvable start position $h^*(n)$ with the use of retrograde analysis, a technique known from computer chess, where it is used to generate endgame databases [8]. We started from goal position and expanded the search tree in reverse order until depth of 31 where we found all solvable positions of 8-puzzle [5]. A solvable position is a position that can be solved using the allowed moves of the empty slot. There are 9!/2 solvable positions in the usual 8-puzzle [5].

Then we simulated the heuristic values $h(n)$ by corrupting the optimal values in two steps. In the first step we took position's true value $h^*(n)$ and added to it a certain amount of Gaussian noise. The added noise caused that some of the heuristic values were grater and the others were smaller than the true values. Sadikov and Bratko used two different heuristic functions one that was pessimistic and the other optimistic which means that in the first case the positive noise was added to the true values and in the second it was subtracted. Results of using pessimistic and optimistic heuristic functions are presented in Section 4.

For standard deviation of added Gaussian noise we choose $\sigma = 2.5$ to equal the standard deviation of Manhattan distance heuristic function [2, 4], which is well known optimistic heuristic for the 8-puzzle domain. We did not corrupt the optimal evaluations for the first 7 levels of difficulty ($h^*(n) \le 7$), because few positions belong to these levels and it is therefore practically impossible to corrupt them so that they would maintain more or less constant dispersion [2].

In the second step we limited the number of possible heuristic values as follows. We limited maximal and minimal heuristic value so that $\forall n$: $h(n) \in [0, M]$ where $M = \max_n\{h^*(n)\} + \lfloor\sigma\rfloor + 1$. We choose M so that it was close to maximal heuristic value and that only few heuristic values of certain positions were greater than M. If $h(n) > M$ we set it to M and if $h(n) < 0$ we set it to 0. Then we multiplied all heuristic values by a certain factor to scale the interval of possible heuristic values to $[0, g]$ and rounded them to the closest integer value. We call g granularity of heuristic function because it denotes the number of possible values of the heuristic function.

In the next step of our experiment we calculated average percentage of wrong decisions in the case of 1 and 5 levels of lookahead among all solvable positions. The percentage of wrong decisions using d levels of lookahead for given position m was calculated using the following formula:

$$\text{wrong}_d(m) = \frac{\#(\text{mintree}_d\ h(n) \wedge \neg \min h^*(n))}{\#\,\text{mintree}_d\ h(n)} \qquad (1)$$

Denominator $\#\,\text{mintree}_d\ h(n)$ means the number of nodes n reachable from m in one move that have the smallest value of $h(p)$ where p is a leaf of the subtree rooted in n with depth $d - 1$. In other words, it is the number of sibling nodes that have the smallest backed-up value of heuristic function. In case of $d = 1$ the only node of subtree is its root so the backed-up value is equal to the value of heuristic function in the root. Numerator $\#(\text{mintree}_d\ h(n) \wedge \neg\min h^*(n))$ is the number of positions n reachable from m by one move that have smallest value of backed-up heuristic function among sibling nodes and do not have the smallest value of $h^*(n)$ among all their siblings. In other words, the numerator represents the number of moves that are the best according to the heuristic function but are not optimal. The formula 1 gives the probability that the search algorithm will choose the wrong move in a position m if we let it look d levels deep and if it randomly decides which move to make when more than one sibling node has the smallest value of backed-up heuristic function. An example of calculating $\text{wrong}_1(m)$ and $\text{wrong}_5(m)$ is shown in Figure 2 and Figure 3.

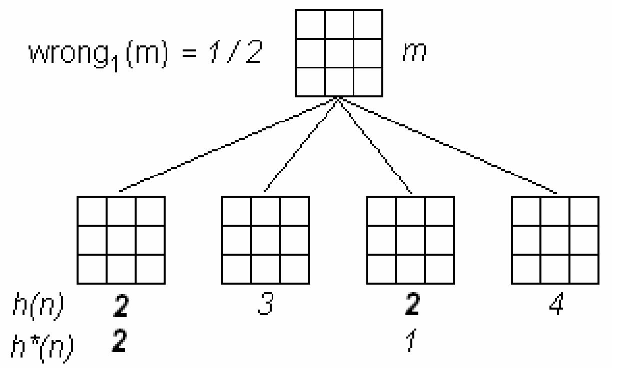


Figure 2: *Example of calculating $wrong_1(m)$*

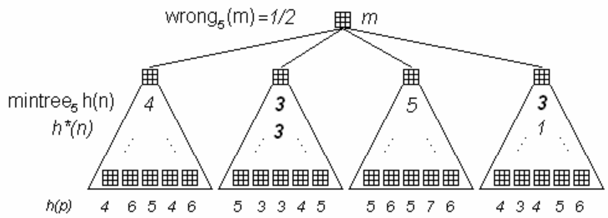


Figure 3: *Example of calculating $wrong_5(m)$.*

In last step of our expermint we calculated pathology using the follownig formula:

$$\text{pat}\ j/1 = \frac{arv(j)}{avr(1)},\ avr(k) = \frac{\sum_{i \in SolvPos} wrong_k(i)}{|SolvPos|} \qquad (2)$$

All solvable positions in 8-puzzle compose a set denoted by *SolvPos*.

Graph of *pat5/1* with respect to g (the granularity of the heuristic function) is shown in Figure 4. We see that *pat5/1* decreases with increasing g and that solving the puzzle is pathological for $g < 10$ and is not pathological for $g \ge 10$. Result is qualitatively the same as in min-max search model described in [6].

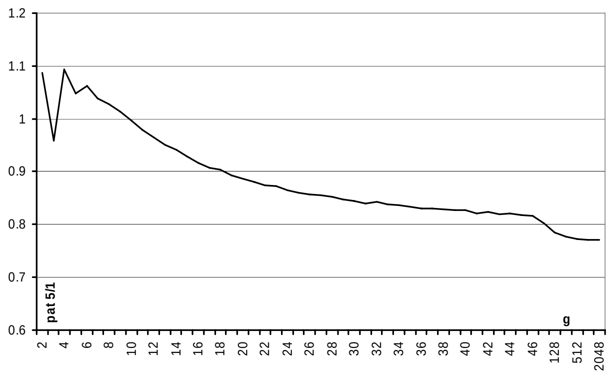


Figure 4: *Pat5/1 of usaual 8-puzzle.*

3 VARIATIOS OF 8-PUZZLE

After experiments on the usual 8-puzzle we tried to vary the branching factor and similarity of sibling nodes in the search tree. In order to do so we had to introduce additional moves. Besides the 4 usual moves we considered 4 additional ones. All possible moves are shown in Figure 5.

By selecting all possible subsets of the 8 moves we came up with

$$\sum_{i=1}^{8}\binom{8}{i} = 255 \tag{3}$$

different games. There were 129 games that had only a few solvable start positions (less than 202), 31 games with 9!/2 = 181440 solvable start positions and 95 games with 9! = 362880 solvable positions. We decided to study only the games with many (≥ 9!/2) solvable positions because the results from games with less than 202 solvable start positions are statistically much less significant and those games are not very playable either.

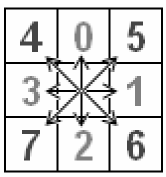


Figure 5: *Possible moves in variations of 8-puzzle.*

We found out that even some games with only 3 moves produce 9! solvable start positions. In the worst case 46 moves are needed to solve the most difficult start position (in a game with 3 moves), whereas in the game with all (8) possible moves there are only 20 moves needed to solve the most difficult start position. We measured the average branching factor of the interesting games and came up with 13 groups of games with branching factors: 1.56, 1.78, 2, 2.22, 2.44, 2.67, 2.89, 3.11, 3.33, 3.56, 3.78, 4 and 4.44.

We run the same tests as for the usual 8-puzzle on all the 126 interesting games (including the usual 8-puzzle) and draw the graph of *pat5/1* with respect to the branching factor. We expected to see the influence of branching factor on pathology [6], but that did not happen. A likely explanation is that the games differ in many aspects besides the branching factor: in the **number of possible moves**, the **number of solvable start positions** (two groups with 9! and 9!/2 solvable start positions), the **length of optimal solution for worst-case start position** denoted *maxOD* (21 groups of games with *maxOD* ranging from 20 to 46) and the **percentage of the positions in which all possible moves are optimal** (percentage is ranging from 12% to 70.7% but 61% of the games have less then 25% of positions in which all moves are optimal and only 6% of games have more than 45% of such positions). We were unable to determine the exact influence of these factors on pathology. But we know that games with 3, 7 and 8 possible moves are highly pathological and that pathology of games with the same branching factor decreases with increasing *maxOD*.

According to [6] the similarity of sibling nodes is also an important factor that causes or reduces the pathology so we calculated the similarity of sibling nodes for all the games using correlation (which indicates the strength and direction of a linear relationship between two random variables). Correlation is calculated for pairs (X, Y), in our case the pairs were the true value of a position and its descendants (node, $decs_1$), (node, $decs_2$), ... , (node, $decs_b$). Similarity of interesting games varied from 0.877 to 0.966. That means that there is not much difference in similarity, so we did not expect a strong influence of similarity on *pat5/1*. Despite this we noticed that the *pat5/1* is slowly decreasing with increasing similarity (Figure 6). Again result is qualitatively the same as in min-max search model described in [6].

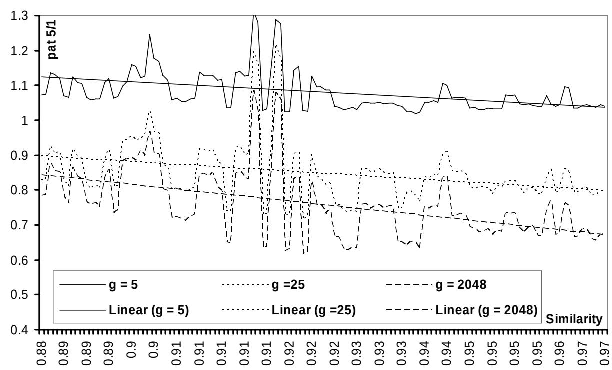


Figure 6: *The influence of similarity on pat5/1 for g∈ {5,25,2048} in variations of 8-puzzle.*

4 OTHER HEURISTIC FUNCTIONS

We also studied the influence of σ the standard deviation of the heuristic error. We run the tests described above on the usual 8-puzzle (only 4 basic moves of an empty slot allowed) for a number of different values of σ. The results of some of the test are shown in Figure 7. We see that higher values of σ (larger heuristic error) result in higher *pat5/1* for low granularity and lower *pat5/1* for high granularity.

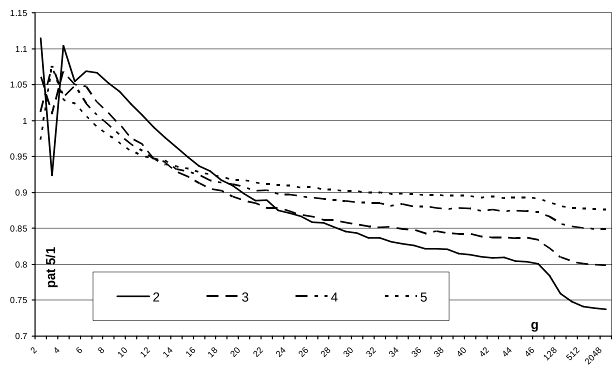


Figure 7: *pat5/1 of usual 8-puzzle for $\sigma \in$ {2, 3, 4, 5}.*

We repeated the same experiment as in Section 1 for other heuristic functions. We used optimistic and pessimistic heuristic functions obtained by corrupting the true values with either Gaussian noise (as in [2]) or by uniformly distributed noise (as in [1]). We noticed that pessimistic heuristic functions cause less pathology than optimistic ones. Sadikov and Bratko [2] showed that only for heuristic functions that were obtained by adding Gaussian noise to true values where as we found out that results are the same if we use uniformly distributed noise. The pathology in the case of heuristic function that is neither pessimistic nor optimistic (the one used in Sections 1-3) is greater than the pathology in the case of pessimistic and lower than in the case of optimistic heuristic function. These results can be seen in Figure 8. We also used some other heuristic functions but the main result was always the same: the higher the granularity the lower the pathology.

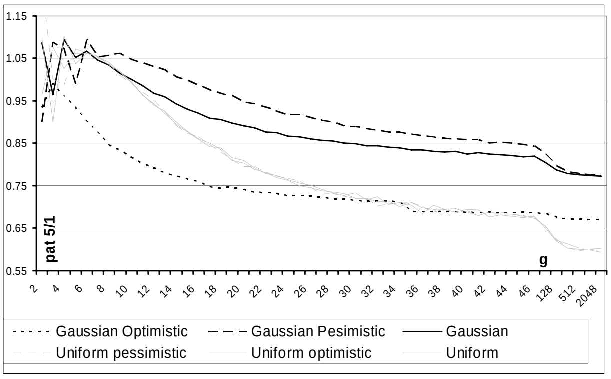


Figure 8: *pat 5/1 for different heuristic functions.*

4. CONCLUSION

We showed that higher granularity of heuristic function causes lower pathology in all interesting variations of 8-puzzle for a number of different heuristic functions (which can be seen in Figures 4, 6, 7 and 8). We also showed that higher similarity of sibling nodes slightly decreases pathology (Figure 6). We were unable to determine the effect of branching factor on pathology due to differences of games with different branching factors. Finally we showed that higher noise produces lower *pat5/1* if there are only a few possible values of heuristic function (granularity) and higher pathology if there are many possible values of heuristic function (Figure 8). The influence of noise is the same for Gaussian and uniformly distributed noise.

The results of our research regarding granularity and similarity are consistent with the results presented in [1 and 6]. According to those sources the branching factor also influences the pathology but as mentioned above we were unable to determine its effect in the domain of 8-puzzle and its variations. The advantage of pessimistic heuristic functions over optimistic ones is consistent with the results presented in [2]. The influence of amount of noise added to true values to obtain values of heuristic function is not studied in related work.

References

[1] M. Luštrek. *Patologija v hevrističnih preiskovalnih algoritmih*. Ph. D. thesis, University of Ljubljana, Faculty of Computer and Information Science, 2007.

[2] A. Sadikov, I. Bratko. *Pessimistic Heuristics Beat Optimistic Ones in Real-Time Search.* ECAI, 2006.

[3] M. Luštrek. *Pathology in Single-Agent Search*. Information Society conference, 2005.

[4] D. R. Kunkle. *Solving the 8 Puzzle in a Minimum Number of Moves: An Application of the A* Algorithm*. http://www.ccs.neu.edu/home/kunkle/docs/EightPuzzle.pdf

[5] A. Reinefeld. *Complete Solution of the Eight-Puzzle and the Benefit of Node Ordering in IDA*.* International Joint Conference on Artificial Intelligence, pp. 248-253, 1993.

[6] B. Kaluža, M. Luštrek, M. Gams, A. Tavčar. *Pathology in Minimax Searching.* International Electrotechnical and Computer Science Conference, 2007.

[7] V. Bulitko, Lihong Li, R. Greiner, I. Levner. *Lookahead pathologies for single agent search.* Proceedings of the Eighteenth International Joint Conference on Artificial Intelligence, 2003.

[8] K. Thompson. *Retrograde analysis of certain endgames*. ICCA Journal, 9(3), 131–139, 1986.

[9] V. Bulitko. *Lookahead pathologies and meta-level control in real-time heuristic search*. 15th Euromicro Conference on Real-Time Systems 13-16, 2003.

[10] D. S. Nau. *Quality of decision versus depth of search on game trees*. Ph. D. thesis, Duke University, 1979.

[11] D. F. Beal. *An analysis of minimax*. V Advances in Computer Chess 2. 103-109. Edinburgh University Press, 1980.

RAZPOZNAVANJE (IDENTIFIKACIJA/VERIFIKACIJA) GOVORCEV V FORENZIČNE NAMENE

Tomaž Šef
Odsek za inteligentne sisteme, Institut "Jožef Stefan"
Jamova cesta 39, 1000 Ljubljana, Slovenija
tomaz.sef@ijs.si

POVZETEK

Rezultati analiz razpoznavanja govorcev so lahko ključnega pomena v katerikoli fazi kazenskega postopka; bodisi že na samem začetku preiskave ali pa v fazi sojenja (glavne obravnave). Pri tem s posebnimi izrazito interdisciplinarnimi raziskavami prilagajamo najnovejše metode procesiranja govora potrebam in izzivom kriminalistične stvarnosti.

Različne metode identifikacije govorcev so lahko bolj ali manj subjektivne oz. objektivne. Najbolj subjektivna je slušno-zaznavna metoda oz. slušna analiza. Sledi ji vizualno odkrivanje govornih vzorcev z uporabo spektrogramov po metodi »glasovnega odtisa«. Nekoliko bolj objektivna je slušno-instrumentalna metoda. Med najbolj objektivne štejemo polavtomatske in avtomatske metode identifikacije govorcev, ki se še intenzivno razvijajo.

Zaradi »stvarnih pogojev« pridobivanja posnetkov je govorni signal bolj spremenljiv oz. variabilen, kar vnaša v proces identifikacije dodatno stopnjo kompleksnosti. Na Institutu Jožef Stefan trenutno gradimo novo specializirano govorno bazo za potrebe razpoznavanja govorcev v forenzične namene. Na njeni osnovi želimo podrobneje ovrednotiti razlike v snemalnih pogojih, ki nastopajo pri posnetkih iz sodne prakse, kompenzirati njihove učinke ter kvantitativno opredeliti negotovost oz nezanesljivost, ki je posledica teh dejavnikov.

1 UVOD

Raziskave in razvoj metod razpoznavanja govorcev so se začele že pred več kot štirimi desetletji in se še vedno aktivno nadaljujejo. Prvi poskusi so obsegali slušne primerjave glasov in primerjavo spektrogramov, sledilo je preprosto preverjanje vzorcev, razvoj metod dinamičnih časovnih ovojnic, vse do modernih postopkov razpoznavanja vzorcev, kot npr. nevronske mreže in prikriti Markovski modeli. Raziskave so potekale tudi v smeri iskanja in razpoznavanja novih informacij v govornem signalu. Ob tem je zanimivo, da so se pri razpoznavanju govorcev uveljavile nekatere enake metode in govorne značilke kot pri razpoznavanju govora.

Vzporedno so potekale tudi intenzivne raziskave in razvoj na področju govornih korpusov, kjer so se majhni, neuradni korpusi (5-10 govorcev) posneti v nadzorovanih laboratorij-skih razmerah (eno samo snemanje, brani govor) razvili v obsežne, javno dostopne korpuse (500+ govorcev), ki odražajo bolj realistične in zahtevne pogoje (improviziran govor preko fiksne in mobilne telefonije). Že vrsto let se izvajajo primerjalne analize ob uporabi skupnih korpusov in paradigem (npr. YOHO, projekt CAVE, NIST), ki omogočajo primerjavo različnih tehničnih postopkov.

Na Institutu »Jožef Stefan« imamo dolgoletne izkušnje s prepoznavanjem govorcev v forenzične namene in smo edini v Sloveniji, ki se ukvarjamo s tem področjem. Za potrebe slovenskih (kazenskih) sodišč smo uspešno verificirali glasove v ca. 100 sodnih postopkih; sodelovali smo v skoraj vseh medijsko najbolj odmevnih procesih zoper organizirani kriminal.

2 METODE RAZPOZNAVANJA GOVORCEV

Različne metode identifikacije govorcev so lahko bolj ali manj subjektivne oz. objektivne. Pri subjektivnih metodah identifikacije govorcev je odločitev posledica človeškega razmišljanja, pri objektivnih metodah pa je rezultat različnih algoritmičnih postopkov. Tudi pri objektivnih metodah imamo opraviti z določenim vplivom človeka; npr. računalnik je sprogramiran, rezultati pa so interpretirani s strani eksperta. Najbolj subjektivna metoda identifikacije govorcev v forenzične namene je slušno-zaznavna metoda oz. slušna analiza. Sledi ji vizualno odkrivanje govornih vzorcev z uporabo spektrogramov po metodi »glasovnega odtisa«. Nekoliko bolj objektivna je slušno-instrumentalna metoda. Med najbolj objektivne štejemo polavtomatske in avtomatske metode identifikacije govorcev.

Slušno-zaznavna metoda (angl. »aural-perceptual approach«) oz. slušna analiza (angl. »auditory analysis«) v osnovi temelji na pozornem poslušanju posnetkov s strani izkušenega fonetika, pri čemer se zaznane razlike v govoru uporabijo za ocenjevanje stopnje podobnosti med glasovi. Prvi pristopi k omenjeni metodi so vključevali pozorno poslušanje narečnih posebnosti, govornih napak in kvalitete glasov, vendar je bila primernost teh postopkov vseskozi vprašljiva. Čeprav so se te metode izkazale za neprimerne pri razpoznavanju govorcev v forenzične namene, koristijo pri iskanju značilnosti govorcev in njihovem razvrščanju v skupine. Poleg prej navedenih razlik se govorci razlikujejo še po hitrosti govora, trajanju premorov, izgovarjavi glasov in slogu govorjenja. Pri razpoznavanju govorcev so pomembne tudi višjenivojske govorne karakteristike, kot npr. narečne in jezikoslovne posebnosti ter prozodične lastnosti. Z upoštevanjem vseh navedenih značilnosti lahko podamo subjektivno oceno verjetnosti glede podobnosti dveh glasov. Slušna analiza ima svoje omejitve in se pri običajni fonetični analizi uporablja predvsem za izluščenje zanimivih lastnosti in parametrov, ki jih nato podrobneje analiziramo s slušno-instrumentalno metodo [1].

Vizualno odkrivanje govornih vzorcev z uporabo spektrogramov po metodi »glasovnega odtisa« (angl. »voiceprint approach« ali »aural-spectrographic approach«) temelji na dejstvu, da je človek sposoben dokaj natančno odkrivati govorne vzorce iz spektrogramov. Nekatere raziskave so pokazale, da lahko že netrenirani preiskovalci, ki ne znajo razložiti tehničnih značilnosti govornih spektrogramov, izdelajo zanesljive in natančne identifikacijske primerjave [2]. Vendar pa treniranje preiskovalcev bistveno izboljša natančnost. Pričakovana natančnost naj bi znašala 99%. Ob tem je potrebno poudariti, da je uporaba spektrogramov po metodi »glasovnega odtisa« podvržena številnim kritikam [3]. Prvi problem je, da ne obstaja enotna splošno sprejeta metodologija. Značilnosti vseh postopkov so, da ekspert izbere vzorce obdolženca, ki so smiselno enaki preiskovanemu vzorcu. Nato so ti vzorci medsebojno primerjani in sicer najprej slušno, nato pa še spektrografsko. Na koncu preiskovalec pride do zaključka, ali preiskovani vzorec pripada obdolžencu ali ne. Najbolj resna splošna kritika metode se nanaša na dejstvo, da ni povsem eksaktno določeno, kaj naj primerjava glasov obsega. To onemogoča kakršnokoli pravo oceno metode. Poleg tega deluje metoda kolikor toliko zanesljivo le v primerih, ko imamo na razpolago dovolj podobnega govornega materiala (npr. enakih besed) za primerjavo. Naslednji zaskrbljujoč vidik je, da protokol predvideva, da naj obdolženec ne le ponavlja preiskovano besedilo, temveč ga poizkuša tudi čim bolj posnemati. Metoda ne more jamčiti, da se nedolžni obdolženec s tem ne bi samoinkriminiral, saj preiskovalec ne more vedeti, kako različno je obdolženec govoril glede na svoj običajni govor. Nekateri ljudje znajo glasove bolje posnemati kot drugi. Prav tako ni jasno določeno, kdaj je dosežena zadostna stopnja posnemanja. Zastavlja se še pravno vprašanje, ali se od obdolženca sme zahtevati, da posreduje svoj govorni vzorec, in dodatno, ali se lahko zahteva, da posnema glas preiskovanega vzorca. Jasni niso tudi kriteriji odločanja. Vse kritike so predvsem posledica dejstva, da metoda ni dovolj teoretično obdelana in osnovana [4].

Slušno-instrumentalna metoda (angl. »auditory instrumental approach) vključuje meritve različnih parametrov, kot so npr. osnovna frekvenca (F0), hitrost govora, potek osnovnega tona, razne spektralne karakteristike govornega signala itd. Parametri se nato medsebojno primerjajo po srednjih ali povprečnih vrednostih in variancah. Pri **računalniški akustični analizi (angl. »computerised acoustic analysis)** dobimo numerične vrednosti različnih govornih parametrov s pomočjo posebne programske opreme. Pri tem je vloga eksperta še vedno zelo pomembna, saj se je potrebno odločiti, kateri govorni vzorci so dovolj dobre kvalitete za analizo. Poleg tega je potrebno izbrati oz. določiti primerljive dele govornih vzorcev, ki bodo analizirani, in ovrednotiti dobljene rezultate. Parametri pri akustično forenzični analizi večinoma izvirajo iz lingvistično-fonetičnih raziskav in so neposredno povezani s slišnimi fonetičnimi značilnostmi [5].

Polavtomatsko (angl. »forensic semiautomatic speaker recognition«) in avtomatsko (angl. »forensic automatic speaker recognition«) razpoznavanje govorcev v forenzične namene je uveljavljen termin za metode (pol)avtomatskega razpoznavanja govorcev, ki so prilagojene za uporabo v forenzične namene. Pri polavtomatskih metodah prihaja med preiskavo do interakcije eksperta in računalnika. Pri avtomatskem razpoznavanju govorcev pa se medsebojno primerjajo statistični modeli akustičnih parametrov glasov znanih govorcev (iz govorne baze) s statističnim modelom akustičnih parametrov nepoznane osebe, ki jo želimo identificirati. Na podlagi te primerjave izračunamo kvantitativno oceno podobnosti med (od govorca odvisnimi) parametri glasu nepoznane osebe na posnetku in parametri obdolženca s čimer ocenimo prepričljivost dokaza. Pri avtomatskem razpoznavanju govorcev v forenzične namene je prepričljivost dokaza odvisna od relativne verjetnosti, da opazimo neke značilnosti nepoznanega glasu v statističnem modelu akustičnih parametrov obdolženca in v statističnih modelih glasov potencialne populacije. Metode razpoznavanja govorcev, ki temeljijo na tehnikah statističnega modeliranja, kot npr. Gaussov mešani model (angl. Gaussian Mixture Modell, GMM), imajo to dobro lastnost, da neposredno vrnejo verjetnost, ali posamezna izgovorjava lahko pripada statističnemu modelu govorca [6]. Zadnje čase temeljijo sistemi za (pol)avtomatsko razpoznavanje govorcev v forenzične namene na oceni kvocienta verjetnosti (angl. »likelihood ratio«) dveh medsebojno konkurenčnih hipotez (obdolženec je vir preiskovanega (vprašljivega) posnetka ali obdolženec ni vir preiskovanega posnetka), ki podaja stopnjo zanesljivosti dokaza. Parametri uporabljeni pri (pol)avtomatskih metodah razpoznavanja govorcev niso nujno neposredno povezani s slišnimi fonetičnimi značilno-stmi ampak so dokaj abstraktni ter matematično in statisti-čno zahtevni. Imajo zelo dobre identifikacijske sposobnosti.

Rezultate slušno-zaznavne metode (rezultati temeljijo na subjektivni oceni), slušno-instrumentalne metode (rezultati temeljijo na subjektivni oceni in statističnih verjetnostih) in avtomatskih metod (rezultati temeljijo zgolj na statističnih verjetnostih) lahko v praksi preučujemo povezano s čimer dobimo **kombinirano oceno zanesljivosti** dokaznega gradiva.

3 RAZLIKE MED »STVARNIMI« IN »LABORATORIJSKIMI« POGOJI

Razpoznavanje govorca je zahtevno opravilo tako pri komercialnih kot forenzičnih aplikacijah. Medtem ko pri nekaterih aplikacijah lahko ocenimo, privzamemo ali predvidimo delovne pogoje, pri večini komercialnih aplikacij razpoznavanja govorcev in skoraj vseh metodah razpoznavanja govorcev v forenzične namene to ni možno. Pri razpoznavanju govorcev v forenzične namene imamo opravka s spornimi posnetki izgovarjav, ki predstavljajo dokazno gradivo in so posneti v »**stvarnih pogojih**« med samim izvajanjem kaznivih dejanj. V večini primerov govorni posnetki predstavljajo telefonske pogovore, pridobljene predvsem na dva načina:

(i) anonimen klic, kadar je pričakovan ali kako drugače dostopen,

(ii) prisluškovanje telefonskim pogovorom s strani policije.

Pojem »stvarni pogoji« uporabljamo kot nasprotje »**laboratorijskim pogojem**«, ko ne moremo nadzirati, pričakovati ali predvidevati pogojev v katerih se bodo pridobili posamezni govorni posnetki. Celo več; obtoženec ponavadi ne želi korektno sodelovati in skuša ovirati ali preprečiti pridobitev kakršnihkoli zanj obremenilnih informacij.

Zaradi »stvarnih pogojev« pridobivanja posnetkov je govorni signal bolj spremenljiv oz. variabilen. Vire variabilnosti govornega signala lahko razvrstimo v naslednje kategorije:

(i) *svojske variabilnosti govornih signalov istega govorca*: vrsta govora, staranje, časovni presledek med dvema posnetkoma, narečje, žargon, socialni status, čustveno stanje, vpliv omamnih sredstev itd.,

(ii) *izsiljene oz. umetne variabilnosti govornih signalov istega govorca*: »Lombardov« učinek, stres zaradi zunanjega vpliva, »cocktail-party« učinek itd.,

(iii) *zunanja variabilnost odvisna od kanala*: tip telefona ali mikrofona, fiksna/mobilna telefonija, komunikacijski kanal, pasovna širina, dinamični obseg oz. razpon, električni in akustični šum, odmev, popačenje itd.

Forenzični pogoji so doseženi, ko se dejavniki variabilnosti, ki predstavljajo t.i. »stvarne pogoje«, pojavljajo brez kakršnegakoli principa, pravila ali norme. Lahko so konstantni preko celotnega klica ali pa se hipoma pojavijo ali izginejo; na celoten proces vplivajo povsem nepredvidljivo.

Ena od najpomembnejših naloga vsakega sistema za avtomatsko razpoznavanje govorcev je **izluščenje govornih značilk** iz govora. Značilke naj bi bile čim manj občutljive na zgoraj navedene dejavnike variabilnosti in bi v idealnem primeru imele naslednje karakteristike:

- enostavno jih je izmeriti,
- čim bolj se morajo razlikovati med posameznimi govorci, pri istem govorcu pa morajo biti konsistentne,
- s časom se ne smejo spreminjati, prav tako nanje ne sme vplivati zdravje govorca,
- odporne morajo biti na šum iz ozadja, ne smejo biti odvisne od prenosnega medija,
- v različnih govornih okoliščinah se morajo čim manj razlikovati,
- ne da se jih zavestno spreminjati (navkljub prizadevanju govorca), ne smejo se spreminjati pri pačenju oz. hlinjenju, so odporne na posnemanje drugih glasov,
- v govoru se pojavljajo pogosto in spontano.

Glede na obsežne raziskave s tega področja so se **za avtomatsko razpoznavanje govorcev v forenzične namene uveljavili naslednji govorni parametri**: formantne frekvence in pasovna širina, širokopasovni spekter, koeficienti pri linearnem napovedovanju, osnovna frekvenca in njen potek, intenziteta signala in njegova časovna energijska porazdelitev itd. Nekateri izmed njih so bolj odvisni od govorca in odporni na posnemanje kot drugi.

Uporaba metod za razpoznavanje govorcev v razmerah, ko obstaja nevarnost, da je **prestopnik poizkušal prikriti oz. popačiti svoj glas**, v splošnem ni mogoča. Vendar je uporaba govornih značilnosti, ki so kombinacija večih različnih govornih značilk, bolj neodvisna od govorca in manj občutljiva na poizkuse posnemanja. V normalnih razgovorih storilci kaznivih dejanj govora ne pačijo ali kako drugače zavestno spreminjajo, če ne sumijo na prisluškovanje. Prav tako je skoraj nemogoče potvarjati govor med obsežnejšim zasliševanjem na policijski postaji.

4 TEKOČE RAZISKAVE S PODROČJA RAZPOZNAVANJA GOVORCEV V FORENZIČNE NAMENE V SLOVENIJI

Poglavitni cilj dejavnosti s področja razpoznavanja govorcev v forenzične namene, ki trenutno potekajo na Institutu Jožef Stefan, je **izgradnja nove specializirane govorne baze** (v slovenskem jeziku) za namene določanja, analize in meritve učinkov oz. posledic najpomembnejših virov variabilnosti, ki jih najdemo v (dejanskih) komercialnih in forenzičnih aplikacijah, in proučevanja njihovega vpliva na sisteme avtomatskega razpoznavanja. S tem se želi doseči nadzorovane pogoje za razpoznavanje govorcev:

- Govorna baza mora biti posneta v večih delih, vključno z direktnim snemanjem in snemanjem preko telefona, branjem besedil z različnimi hitrostmi, branim govorom nasproti spontanemu govoru, uporabi različnih mikrofonov in telefonskih aparatov, različna narečja govorcev (lahko se spreminja že pri istem govorcu glede na to ali besedilo bere ali pa spontano govori), stalne izgovarjave besedil za vse govorce preko vseh delov posnetkov napram specifičnim izgovarjavam vsakega govorca znotraj posameznega posnetka.
- Govorna baza mora biti fonološko in zlogovno uravnotežena tako, da posnema frekvenco pojavljanja fonemov in zlogov v govorjenem slovenskem jeziku.
- Starostna porazdelitev govorcev v podatkovni bazi mora upoštevati sociološke dejavnike povezane z uporabo različnih tehnologij. Enakomerna starostna porazdelitev vedno ne odraža dejanske starostne porazdelitve uporabnikov v specifični aplikaciji. Tudi pri forenzičnih aplikacijah enakomerna starostna porazdelitev obdolžencev storitve kaznivih dejanj ne ustreza dejanskemu stanju. Večjo utež je potrebno dati starostni skupini med 25 in 45 leti.

- Variabilnost parametrov med posameznimi posnetki je pomemben dejavnik, ki ga je potrebno upoštevati. Med posameznimi snemanji mora biti vsaj 14 dnevni zamik.

Način zbiranja podatkov in snemanja govornih posnetkov:

- »Neposredno« snemanje preko mikrofonov mora potekati v mirni sobi in je nadzorovano s strani izkušenega tonskega tehnika. Pri vsakem »neposrednem« snemanju se uporablja dva simultana kanala: na enem kanalu se ves čas snemanja uporablja isti mikrofon, na drugem kanalu pa je pri vsakem snemanju drugačen mikrofon. Uporabljajo se neusmerjeni mikrofon (postavljen na mizo v razdalji okrog 30 cm od govorca), dinamični mikrofon (postavljen na mizo v razdalji okrog 10 cm od govorca) in dinamični mikrofon na slušalkah.
- Pri uporabi običajne telefonske linije za zbiranje govornih posnetkov vsak govorec izvede telefonski pogovor preko istega telefona v obliki internega klica. Nato je vsak govorec naprošen, da izvede lokalni telefonski klic iz svojega doma in sicer tako, da zagotovi ustrezno mirno okolje (govorci so naprošeni, da so med izvajanjem klica sami v zaprtem prostoru). Pri naslednjem snemanju so lokalni telefonski pogovori opravljeni iz mirnega prostora, pri čemer se pogovori snemajo z različnimi naključno izbranimi telefonskimi aparati (hkrati se govor snema tudi z mikrofonom).
- Pri vseh snemanjih so vsi mikrofoni in telefonske linije priključeni direktno na ustrezen specializirani računalniški sistem, kjer se govor zapisuje v digitalni obliki s frekvenco vzorčenja 44,1 kHz.
- Sestavni del opisanega govornega korpusa so tudi posnetki preko GSM mobilne telefonije.

Na osnovi opisane govorne baze želimo ovrednotili razlike v snemalnih pogojih, ki nastopajo pri posnetkih iz sodne prakse, skušamo kompenzirati njihove učinke ter kvantitativno opredelili negotovost oz nezanesljivost, ki je posledica teh dejavnikov. Snemalni pogoji vplivajo tako na slušno kot instrumentalno in avtomatsko razpoznavanje govorcev.

Omejitev problema variabilnosti govora, skupaj z analizo kvantitativnih rezultatov sistemov za razpoznavanje govorcev, bo omogočilo **razvoj celostnega in vsestranskega avtomatskega sistema za razpoznavanje govorcev v komercialne in forenzične namene**.

5 SKLEP

Napredek na področju računalništva in digitalnega procesiranja signalov je prinesel številne izboljšave tako pri hitrosti kot samih zmožnostih različnih akustičnih analiz govornega signala in statistične obdelave podatkov. Ob vsem tem se nam pogosto zastavlja vprašanje, ali se bo vse to pokazalo tudi pri izboljšani identifikaciji govorcev v forenzične namene?

Vsekakor nam bo tehnologija omogočala, da bomo to delo opravljali vedno hitreje, s čimer bodo ti postopki čedalje bolj dosegljivi. Le redko kdo pa zaenkrat verjame, da bodo postopki identifikacije govorcev v forenzične namene postali popolnoma avtomatizirani (kot je to npr. prikazano v ameriških kriminalkah). Med strokovnjaki s tega področja prevladuje mnenje, da zaradi same narave človeškega glasu in zvočnih lastnosti posameznega jezika ter pomanjkanja nadzora nad forenzičnimi govornimi vzorci, nikdar ne bomo imeli popolnoma avtomatskega sistema identifikacije govorcev v forenzične namene in to neglede na razvoj same tehnologije. Pred akustično analizo govornega signala, ki bo navadno selektivna in ne avtomatska, bo vedno potrebno izvesti tudi skrbno slušno analizo (npr. za ugotavljanje raznih lingvističnih posebnosti).

Napredek na področju identifikacije govorcev v forenzične namene lahko prinese le ovrednotenje številnih omejitev, ki smo jih obravnavali v pričujočem članku. K izboljšanju rezultatov lahko veliko prispeva tudi razvoj govornih tehnologij, kjer se uporabljajo precej drugačni parametri kot na področju fonetike in glasoslovja. Samodejni parametri, kot so »kepstrum« ali »delta kepstrum« delujejo zelo dobro pri avtomatski identifikaciji in verifikaciji govorcev v komercialne namene. Zelo malo pa je bilo opravljenih raziskav, kako se ti samodejni parametri obnesejo pri forenzičnih »stvarnih pogojih«.

Iz vsega navedenega lahko razberemo, da si zgolj zaradi tehnološkega razvoja ne smemo preveč obetati. Pravi napredek pri identifikaciji govorcev v forenzične namene nam lahko prinesejo le dodatna znanja: boljše poznavanje ozadja podatkov ter kako jih pravilno obdelati, boljše razumevanje in poznavanje individualnosti vsebovane v govoru, kateri so najboljši parametri, kje naj jih iščemo in pod kakšnimi »stvarnimi pogoji« so primerljivi.

Literatura

[1] C. D. Tanner in E. M. Tanner, *Forensic Aspects of Speech Patterns: Voice Prints, Speaker Profiling, Lie and Intoxication Detection*, Lawyers & Judges Publishing Company Inc., 2004.

[2] O. Tosi, *Voice Identification: Theory and Legal Applications*, Baltimore, University Park Press, 1979.

[3] H. Hollien, *Forensic Voice Identification*, Academic Press, 2002.

[4] P. Rose, *Forensic speaker Identification*, Taylor & Francis, 2002.

[5] P. Rose, Technical forensic speaker recognition: evaluation, types and testing of evidence, *Computer Speech and Language*, 2005.

[6] A. Alexander, Forensic Automatic Speaker Recognition Using Bayesian Interpretation and Statistical Compensation for Mismatched Conditions, *doktorska disertacija*, Lausanne, EPFL, 2005.

ISKANJE DOBRIH NASTAVITEV MODULA V INTELIGENTNEM SISTEMU ZA NADZOR PRISTOPA

Tea Tušar, Matjaž Gams
Odsek za inteligentne sisteme
Institut "Jožef Stefan"
Jamova cesta 39, 1000 Ljubljana, Slovenija
tea.tusar@ijs.si, matjaz.gams@ijs.si

POVZETEK

Predstavljamo modul mikro učenja v inteligentnem sistemu za nadzor pristopa, ki opazuje obnašanje uporabnikov pred posameznimi točkami vstopa in s pomočjo algoritma za odkrivanje izjem opozarja na nenavadne vstope. Naša naloga je nastaviti parametre modula tako, da bo delal čim bolje tj. čim bolj pravilno prepoznaval neobičajne vstope od običajnih. V ta namen na množici poskusnih vstopov definiramo želene oznake teh vstopov in preiskujemo prostor parametrov modula, da bi dobili oznake, ki so čim bolj podobne želenim. Najboljša nastavitev parametrov modula mikro učenja doseže 92.5% točnost na poskusnih vstopih.

1 UVOD

Sisteme za nadzor pristopa običajno sestavlja nekaj (biometričnih) senzorjev, ki se uporabljajo za identifikacijo in verifikacijo uporabnikov. Če uporabnik pristopi k vsem senzorjem pravilno, ima omogočen vstop v varovani prostor. Z uporabo inteligentnih metod želimo obstoječi sistem za nadzor pristopa nadgraditi tako, da bo omogočal prepoznavanje ustaljenih vzorcev obnašanja za vsakega posameznega uporabnika in posledično odkrivanje izjem, ki lahko predstavljajo poskus vstopa neavtorizirane osebe. Na neobičajne vstope se bo odzival s posredovanjem *opozorila* ali *alarma* nadzorniku, ki bo lahko nato ustrezno ukrepal.

Obravnavani inteligentni sistem za nadzor pristopa je sestavljen iz štirih modulov:

- modula, ki za odkrivanje prepovedanih vstopov uporablja *ekspertna pravila*,
- modula *mikro učenja*, ki opazuje obnašanje pred posamezno točko vstopa,
- modula *makro učenja*, ki nadzoruje gibanje med različnimi točkami vstopa, ter
- *kamere*, ki snema vse vstope in pri tem spremlja gibe uporabnika.

Po vstopu uporabnika bo vsak modul sporočil ali je pri vstopu opazil kakšne posebnosti. Možni izidi vsakega modula so: *OK* (✓), *opozorilo* (?) in *alarm* (X). Ko sistem dobi izhode vseh modulov, iz njih sestavi skupen rezultat, ki je odvisen od izbrane občutljivosti. Računanje skupnega izida si lahko ogledamo s pomočjo primera s slike 1. Tu modul z ekspertnimi pravili ni zaznal težav, medtem ko je modul makro učenja vrnil opozorilo, modula mikro učenja in kamere pa alarm. Občutljivost je nastavljena na 3/4, kar pomeni da bo skupni rezultat enak tretjemu najboljšemu izidu – v našem primeru je to alarm.

Slika 1: Izidi posameznih modulov in skupni rezultat na primeru vstopa nekega uporabnika.

V tem prispevku se bomo omejili le na modul mikro učenja – natančneje, na iskanje nastavitev tega modula tako, da bodo rezultati modula in posledično inteligentnega sistema za nadzor pristopa čim boljši.

2 MODUL MIKRO UČENJA

Obravnavali bomo sistem za nadzor pristopa, ki ga sestavljajo čitalnik brezkontaktnih identifikacijskih kartic, biometrični čitalnik prstnih odtisov in senzorji na vratih. V našem primeru modul mikro učenja spremlja običajno obnašanje uporabnika pred posameznim vstopom, ki ga merimo s pomočjo naslednjih treh časov:

– čas med identifikacijo z brezkontaktno kartico in verifikacijo s prstnim odtisom,

– čas med verifikacijo s prstnim odtisom in odprtjem vrat,

– čas med odprtjem in zaprtjem vrat.

S spremljanjem teh treh časov se modul s pomočjo algoritma za odkrivanje izjem lahko nauči kakšno je običajno vstopanje uporabnika in opozori, ko pride do odstopanj. Pri tem je treba v modulu nastaviti nekaj parametrov, ki vplivajo na njegovo delovanje.

2.1 Algoritem LOF

Med množico algoritmov, ki se lahko uporabijo za odkrivanje izjem [3], smo za naš konkreten primer izbrali algoritem LOF[2, 1]. Zanj smo se odločili, ker nam ne vrne zgolj podatka, ali je nek vstop izjemen ali ne, ampak definira oceno izjemnosti kot realno število, imenovano *lokalni koeficient izjemnosti*, ali krajše LOF. To je zelo zaželena lastnost, saj moramo za vsak vstop posebej določiti ali je običajen ali ne – v slednjem primeru pa rabimo tudi informacijo o tem, kolikšno je odstopanje od običajnih vstopov, da se lahko odločimo ali bomo sprožili alarm ali samo opozorilo.

Dodatna prednost algoritma LOF je v tem, da izjemnost opazovanega vstopa definira glede na lokalno gostoto tega vstopa in lokalne gostote njegovih najbližjih sosedov kot:

$$LOF(p) = \frac{1}{|\{sosedi(p)\}|} \sum_{o \in \{sosedi(p)\}} \frac{lokalna\ gostota(o)}{lokalna\ gostota(p)}.$$

Zato dela dobro tudi v primerih, ko so časi vstopov neenakomerno distribuirani po prostoru. Število najbližjih sosedov, ki jih upoštevamo v tem izračunu, je parameter algoritma. Za običajne vstope je $LOF \leq 1$, medtem ko lahko vstope, pri katerih je $LOF > 1$ štejemo za izjemne – večji kot je LOF, večja je izjemnost vstopa.

2.2 Nastavitve modula mikro učenja

Za praktično uporabo modula mikro učenja na našem primeru moramo določiti vrednosti naslednjih parametrov:

– število najbližjih sosedov v algoritmu LOF (n_s),

– mejno vrednost LOF med običajnimi vstopi in tistimi, ki sprožijo opozorilo (m_o),

– mejno vrednost LOF med vstopi, ki sprožijo opozorilo, in vstopi, ki sprožijo alarm (m_a).

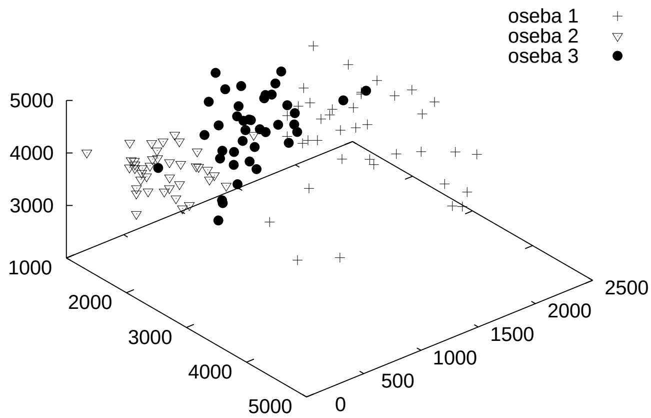
Ker je od izbire vrednosti teh parametrov močno odvisno delovanje modula za mikro učenje, smo bomo vrednosti parametrov določili na podlagi rezultatov poskusov, ki so opisani v naslednjem razdelku.

3 POSKUSI

3.1 Podatki

Za potrebe naše raziskave smo beležili čase vstopov treh različnih oseb. Za vsako smo zabeležili 40 regularnih vstopov, poleg tega pa še skupno 17 neregularnih vstopov vseh oseb, ki so posnemali "nenavadne" vstope. Med slednje spadajo igrane ugrabitve, poskusi vstopa z nenavadnimi predmeti ter t. i. smukanje (vstop več oseb naenkrat pri identifikacije ene same osebe).

Kot že rečeno, je vsak vstop definiran s tremi časi, ki se beležijo med vstopom. Tako lahko vsak vstop predstavimo s točko v tridimenzionalnem prostoru. Na sliki 2 predstavljamo regularne vstope vseh treh oseb. Hitro lahko opazimo dvoje: (1) časi vstopov treh oseb se mestoma prekrivajo ter (2) medtem ko so razlike med časi posameznih vstopov osebe 2 zelo majhne, to ne velja za osebi 1 in 3.



Slika 2: Vstopi treh različnih oseb kot točke v tridimenzionalnem prostoru (na oseh so predstavljeni posamezni časi vstopov v milisekundah).

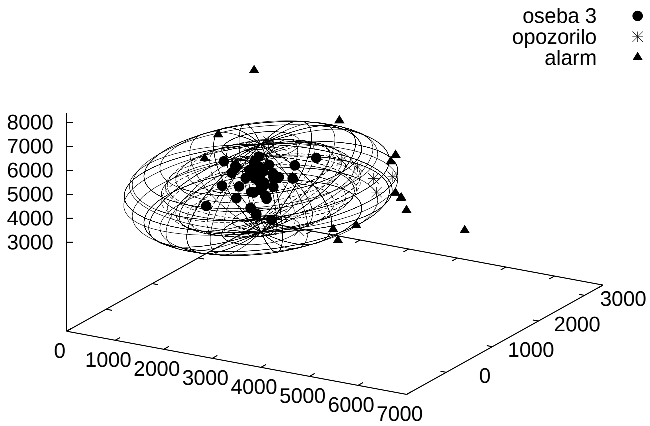
Za vsako osebo smo zbrane vstope razdelili na učno in testno množico na dva načina:

1. Vse regularne vstope obravnavane osebe smo (po vzoru 10-kratnega prečnega preverjanja) razdelili na 10 učnih in 10 testnih množic tako, da vsak vstop nastopa natanko enkrat v testni množici. Želimo si, da bi algoritem LOF za vse vstope iz testnih množic pravilno ugotovil, da niso izjemni.

2. Vse regularne vstope obravnavane osebe smo združili v učno množico, vse preostale vstope (80 regularnih vstopov drugih dveh oseb in vseh 17 neregularnih vstopov) pa v testno množico. Tu si želimo, da bi algoritem LOF znal pravilno razločevati med vstopi, ki so izjemni, in tistimi, ki (s stališča navad obravnavane osebe) to niso.

Torej moramo za vse vstope določiti želen izid (OK, opozorilo ali alarm) in parametre modula mikro učenja nastaviti tako, da se bodo tem izidom čim bolj približali.

Da bi se izognili ročnemu označevanju vstopov, smo si pomagali z elipsoidi. Okrog regularnih vstopov obravnavane osebe smo naredili osnovni elipsoid, ki ima središče v centru vseh teh vstopov in katerega polos r_i v smeri dimenzije i je enaka polovici razdalje med dvema najbolj skrajnima vstopoma v dimenziji i. Nato smo naredili še dva druga elipsoida – enega s polosmi enakimi $r_i^1 = 1.6r_i$ in drugega, katerega polosi so enake $r_i^2 = 2.2r_i$. Konstanti 1.6 in 2.2 smo določili eksperimentalno tako, da so v manjšem elipsoidu vsebovani vsi regularni vstopi osebe, med obema elipsoidoma vstopi, ki bi morali sprožiti opozorilo, ter zunaj večjega elipsoida vstopi, ki bi morali sprožiti alarm. Elipsoida torej označujeta mejo med vstopi OK/opozorilo ter opozorilo/alarm. Na sliki 3 lahko vidimo kako izgledata takšna elipsoida za osebo 3.



Slika 3: Elipsoida, ki označujeta mejo med vstopi OK/opozorilo ter opozorilo/alarm za osebo 3.

3.2 Prostor parametrov

S pomočjo elipsoidov smo označili vse vstope z želenim izidom. Želimo najti tiste nastavitve modula za mikro učenje, ki bodo vstope označile čim bolj podobno želenemu izidu. Za vsak parameter smo preizkusili naslednje nastavitve:

– število najbližjih sosedov $n_s \in \{3, 4, \ldots, 30\}$,

– mejna vrednost LOF za opozorilo $m_o \in \{1.1, 1.2, 1.3, 1.4, 1.5, 1.6\}$,

– mejna vrednost LOF za alarm $m_a \in \{1.6, 1.7, 1.8, 1.9, 2.0, 2.1\}$.

Vseh možnih nastavitev je 28 224.

3.3 Rezultati in diskusija

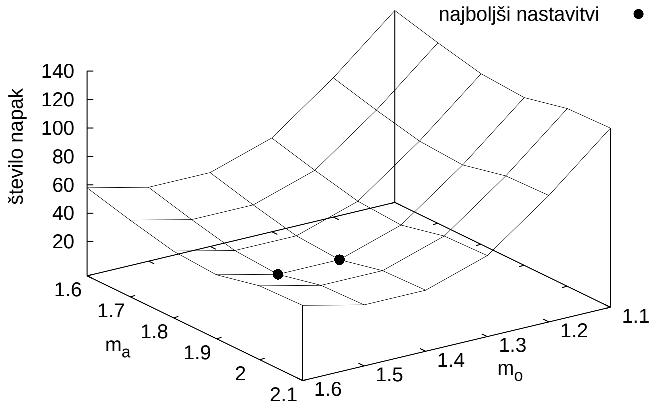
Za vsako nastavitev smo pognali modul mikro učenja za vsako osebo na obeh nalogah učenja in beležili, koliko napak je naredil modul glede na predhodno določene želene oznake. Vse napake smo sešteli in iskali nastavitev, pri kateri je skupna napaka najmanjša. Najmanjšo skupno napako, enako 31, smo dobili v dveh primerih:

– $n_s = 27$, $m_o = 1.4$, $m_a = 1.9$ in

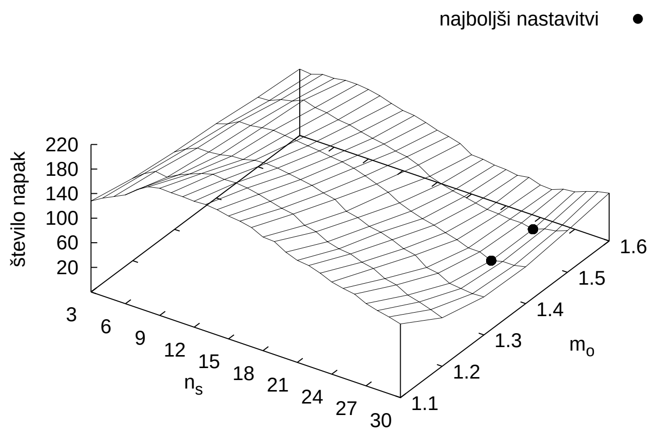
– $n_s = 27$, $m_o = 1.5$, $m_a = 1.9$.

V prvem primeru naredi modul mikro učenja eno napako na prvi nalogi in 30 napak na drugi nalogi, medtem ko so v drugem primeru vse napake narejene na drugi nalogi učenja. Ker si želimo, da bi bili vsi regularni vstopi označeni kot OK, bomo za praktično uporabo izbrali drugo nastavitev.

Vpliv posameznih parametrov na izvajanje modula mikro učenja si lahko pogledamo s pomočjo slik 4 in 5. Prva slika prikazuje kako se spreminja skupna napaka glede na izbrani mejni vrednosti LOF za opozorilo in alarm pri določenem številu najbližjih sosedov ($n_s = 27$), medtem ko druga kaže skupno napako pri izbrani mejni vrednosti LOF za alarm ($m_a = 1.9$).



Slika 4: Skupno število napak za $n_s = 27$ pri različnih vrednostih parametrov m_o in m_a.



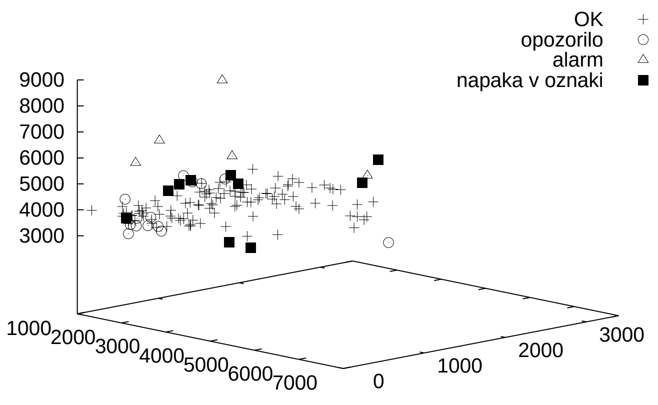
Slika 5: Skupno število napak za $m_a = 1.9$ pri različnih vrednostih parametrov n_s in m_o.

Kot priznavajo tudi avtorji algoritma LOF v [2], je zelo težko določiti pravo vrednost za število najbližjih sosedov n_s. Kot lahko vidimo s slike 5, v našem primeru prinesejo najboljše rezultate vrednosti okrog 27. Vendar pa je pri tem parametru potrebna pazljivost, saj je močno odvisen od števila obravnavanih točk. V našem primeru imamo v učni množici bodisi 36 bodisi 40 točk. Pri (bistveno) drugačnem številu točk, bi morali poskus ponoviti, saj bi vrednost $n_s = 27$ verjetno ne dala najboljših rezultatov. Preostala dva parametra modula mikro učenja sta skoraj neobčutljiva na velikost učne množice. Odvisna sta predvsem od tega, kako občutljiv modul želimo imeti.

Za konec si poglejmo še kako deluje modul pri izbranih vrednostih parametrov: $n_s = 27$, $m_o = 1.5$, $m_a = 1.9$. Kot že rečeno, je vseh napak 31, pri čemer ni nobena storjena na prvi nalogi učenja. Pri drugi nalogi pa so napake razdeljene po osebah tako, kot prikazuje tabela 1. Za posamezne osebe prikazujemo napake tudi na slikah 6, 7 in 8, iz katerih je razvidno, kateri vstopi so modulu povzročili največ težav. Poudariti je treba, da modul ni storil nobenih "dvakratnih" napak, pri katerih bi OK vstop označil za alarm oz. alarm označil kot OK. To je še posebej pomembno s praktičnega vidika, saj veča zaupanje nadzornika v pravilno delovanje modula.

napoved	pravilno	oseba 1	oseba 2	oseba 3	$\sum$
OK	opozorilo	6	4	3	13
OK	alarm	0	0	0	0
opozorilo	OK	3	1	0	4
opozorilo	alarm	1	2	8	11
alarm	OK	0	0	0	0
alarm	opozorilo	0	3	0	3
	$\sum$	10	10	11	31

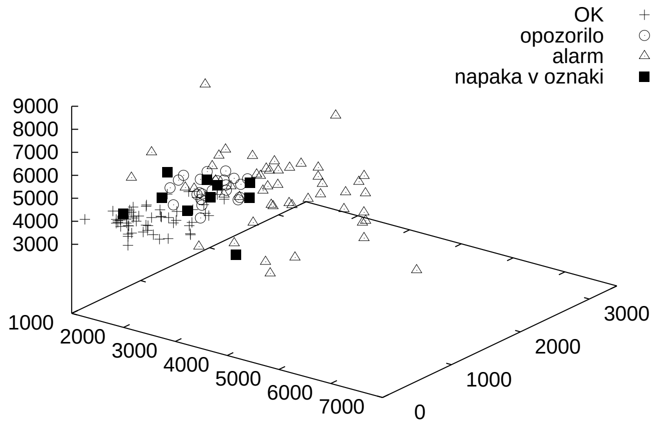
Tabela 1: Tipi napak za vsako osebo.



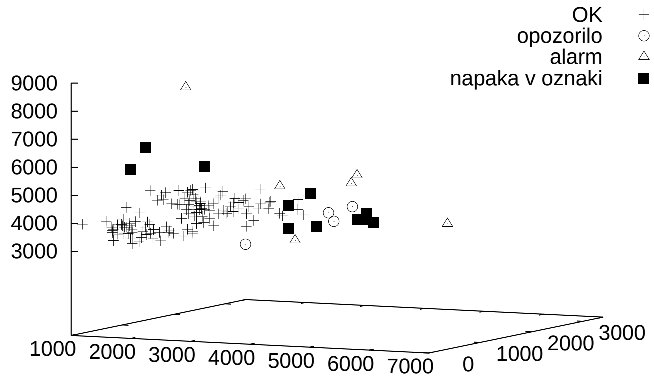
Slika 6: Izidi modula mikro učenja (s poudarjenimi napakami) za osebo 1.

4 ZAKLJUČEK

V prispevku smo predstavili modul za mikro učenje obnašanja uporabnika pred točkami vstopa, ki z upo-



Slika 7: Izidi modula mikro učenja (s poudarjenimi napakami) za osebo 2.



Slika 8: Izidi modula mikro učenja (s poudarjenimi napakami) za osebo 3.

rabo algoritma za odkrivanje izjem označuje vstope z oznakami OK, opozorilo ali alarm. Modul smo preizkusili na testni množici podatkov, ki smo jih prej označili z želenimi izidi. Na teh podatkih modul doseže 92.5% točnost. Posebej pomembno pa je to, da ne dela "dvakratnih" napak med vstopi OK/alarm.

Literatura

[1] M. M. Breunig. *Quality Driven Database Mining.* PhD thesis, University of Munich, 2001.

[2] M. M. Breunig, H.-P. Kriegel, R. T. Ng, and J. Sander. LOF: Identifying density-based local outliers. V *Proceedings of the International Conference on Management of Data (SIGMOD'00)*, strani 93–104, 2000.

[3] T. Tušar and M. Gams. Odkrivanje izjem na primeru inteligentnega sistema za kontrolo pristopa. V *Zbornik devete mednarodne multiconference Informacijska družba (IS 2006)*, zvezek B, strani 136–139, 2006.

THE IMPACT OF HIGH LEVEL KNOWLEDGE ON ECONOMIC WELFARE

Vedrana Vidulin[1], Matjaž Gams[2]

[1,2] Jožef Stefan Institute, Department of Intelligent Systems, Jamova cesta 39, 1000 Ljubljana, Slovenia
E-mail: vedrana.vidulin@ijs.si, matjaz.gams@ijs.si

Abstract. What is the relationship between the high level knowledge and economic welfare? This relationship was analyzed using the Weka, machine learning and data mining systems. Indicators describing tertiary education and research and development (R&D) sectors were collected from the statistical databases for the year 2001 and the decision trees describing the relationship were induced on them. Obtained tree showed the influence of the level of participation in tertiary education, mobility of the students and the investment in R&D on the economic development.

Keywords: high level knowledge, tertiary education, R&D, economic welfare, data mining, decision tree

1. Introduction

Modern society puts a lot of effort in analyzing how different social sectors impact on the economic welfare and those that have greater impact draw more attention on themselves and more money [1]. For the modern society we can also say that it is based on knowledge, therefore tertiary education and R&D should and does play an important role in it [6]. Hence, we asked question what are the common characteristics of the tertiary education and R&D sector of the countries with developed economies and that with undeveloped economies?

The question was answered through the data analysis using machine learning (ML) and data mining (DM) methods. DM is a process of analyzing data to identify patterns or relationships. It is about solving problems by analyzing data already present in databases [7].

The availability of statistical data on the Internet motivated us to apply ML and DM methods on the existing data seeking for a decision tree that will clearly and accurately describe the relationship between high level knowledge and economic welfare.

2. Data Set

The data was extracted from several statistical databases available on the Internet for the year 2001:

1. UNESCO Institute for Statistics - www.uis.unesco.org
2. WIPO - http://www.wipo.int/patentscope/en/
3. World Bank – www.worldbank.org

92 numeric indicators were selected and exported in the form of a spreadsheet table. Each country represents a row in the table and each indicator a column.

After preliminary overview of the data set some countries were removed due to unavailability of the data for all or almost all indicators. Hence, the data set consisted of 158 examples (countries) and 92 indicators, from which 48 tertiary education indicators (e.g. *Gross enrolment ratio. ISCED 5 and 6. Total*, *Gross outbound enrolment ratio*, *Gender parity index for gross enrolment ratio. Tertiary…*) and 44 R&D indicators (e.g. *Applications for patents*, *Grants of patents*, *GERD per capita (in PPP$)…*). The drawback of our data set is that in spite of the fact that countries with a lot of missing data were removed from the data set, we still needed to cope with the problem of missing data.

3. Indicator Construction and Selection

Several new indicators were constructed, two representing tertiary education and five R&D. Presented indicators are discrete except *Percentage of granted patents (%)* which is numeric. One of the values of all discrete indicators is N/A used for indicating that the data is missing.

The two indicators representing tertiary education are:

- *Field of study completed by the highest percentage of students* – Obtained through the comparison of eight indicators presenting the percentages of the tertiary graduates in the fields like education, humanities and arts etc. Indicator takes value of the name of field in which the highest percentage of students completed the programs.
- *Field of study completed by the lowest percentage of students* – Obtained by the comparison of the same eight indicators used for constructing the previous indicator. The only difference is in the choice of the value. Namely, indicator takes value of the name of the field in which the lowest percentage of students completed the programs.

The five indicators representing R&D are:

- *GERD per capita* – Obtained by the discretization of numeric indicator *GERD per capita (in PPP$)* into two categories: low and high. The threshold is 110.65 obtained through the use of the Weka supervised indicator filter Discretize.
- *Primary source of funds for R&D* – Obtained through the comparison of five indicators presenting the percentages of the funds which each of the five sectors invested in R&D (business, government etc.). The indicator takes

value of the name of sector that invests the most in R&D.

- *Sector employing the most researchers* – Obtained through the comparison of four indicators presenting the number of FTE researchers (FTE = full time equivalent – meaning if two researchers each work half of their working time in R&D, then the number of FTE researchers is one) in four sectors of employment (Business, Government etc.). The indicator takes value of the name of sector that employs the most researchers.
- *Sector employing the most R&D personnel* – The same as previous indicator. The only difference is in the type of population which indicator considers. While previous indicator deals only with the researchers, this one deals with all personnel working in R&D, including technicians and supporting staff.
- *Percentage of granted patents (%)* – Numeric indicator calculated by dividing *Grants of patents* with the *Applications for patents*.

Discrete indicator *GNI per capita* has been chosen for the class. "Gross National Income (GNI) prizes the total value of goods and services produced within a country (i.e. its Gross Domestic Product), together with its income received from other countries (notably interest and dividends), less similar payments made to other countries" (Wikipedia entry for "Gross National Income").

Indicator can take one of the three values, i.e. low, middle or high. This corresponds to official World Bank classification of economies [3] for the year 2001 with intervals:

1. low – $745 or less
2. middle – $746 – $9 205
3. high – $9 206 or more

Presented thresholds were based on the analysis of relation between summary measure of wellbeing (including e.g. poverty incidence and infant mortality) and GNI per capita based on the World Bank's Atlas method.

After adding seven new indicators we ended up with the data set consisted of 99 indicators. In the cases where the number of indicators is high in comparison with the number of examples, decision trees can overfit to the data. Overfitting means that the obtained model represents special cases and not the generalized relations between the key indicators. Hence, we conducted indicator selection to lower down the number of indicators.

Indicators were ranked using Ranker algorithm implemented in Weka and information gain (IG) evaluator [7]. The list of indicators together with IG values is presented in Table 1.

Table 1. Selected indicators with IG values

IG	Indicator
0.437	*GERD per capita*
0.284	Gross enrolment ratio. ISCED 5 and 6. Total
0.281	*Primary source of funds for R&D*
0.266	Gross enrolment ratio. ISCED 5 and 6. Male
0.261	*Sector employing the most researchers*
0.256	*Sector employing the most R&D personnel*
0.249	Gross enrolment ratio. ISCED 5 and 6. Female
0.231	*Field of study completed by the lowest percentage of students*
0.215	Applications for patents
0.213	Gross outbound enrolment ratio
0.194	Grants of patents
0.184	*Percentage of granted patents (%)*
0.174	Gender parity index for gross enrolment ratio. Tertiary
0.163	Percentage of female students. Total tertiary
0.147	GERD per capita (in PPP$)
0.142	*Field of study completed by the highest percentage of students*
0.126	Gross completion rate. ISCED 5A, first degree. Total
0.113	Percentage of female students. Tertiary ISCED 5A

Indicators with the measure of IG lower than 0.1 were excluded from the data set. Hence, the final data set is composed of 18 indicators, 11 base and 7 constructed (in Table 1 presented in italics). Although chosen indicators represented both the status and the investment in tertiary education and R&D, no indicator representing investment in tertiary education appeared in the list.

4. Machine Learning Results

From the ML methods available in Weka J48, the implementation of C4.5 [5] was chosen. It is a method used for the induction of decision trees. In Weka we can graphically represent the obtained trees thus gaining an easy comprehensive model representing relationship between high level knowledge sectors and economic welfare. J48 is appropriate in this case because it can deal with the numeric and missing data.

For building a decision tree default ML algorithm parameters set in Weka were used and for testing the 10-fold cross-validation [7]. The decision tree presented in Figure 1 was induced using the 18 tertiary education and R&D indicators.

Some notions demand clarification, like **GERD**. It is an abbreviation for Gross Domestic Expenditure on R&D and

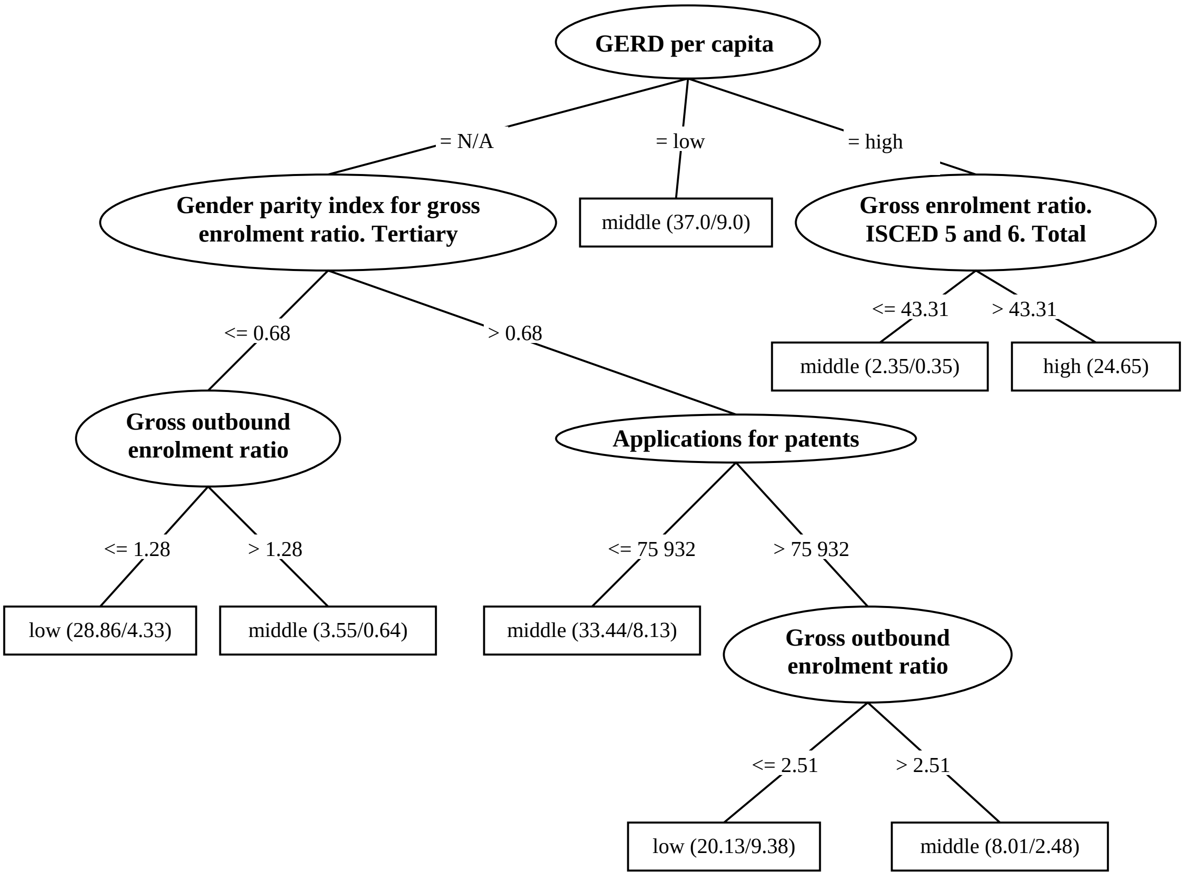


Figure 1. The decision tree built on 18 tertiary education and R&D indicators, 72% accurate

denotes expenditure on R&D performed on the national territory during a given period. Calculation also includes R&D performed within a country and funded from abroad and excludes payments made from abroad for R&D [4].

Gender parity index is ratio of female to male values of a given indicator. Value of 1 indicates parity between sexes [2].

Gross enrollment ratio is enrolment at a given level of education, regardless of age, expressed as a percentage of the population in the theoretical school-age group corresponding to this level of education. It is widely used to show the general level of participation in a given level of education indicating the capacity of the education system to enroll students of a particular age-group [2].

Gross outbound enrolment ratio presents mobile students coming from a country/region as a percentage of the population of tertiary student age in their home country [2].

The decision tree in Figure 1 presents several interesting relations. The success of high income countries is represented with the high level of investment in R&D and high level of participation in tertiary education (higher that 43%). In the case of low income countries the level of investment in R&D is not known, meaning that the data is unavailable. The information of gender parity index did not show informative enough, inadequately separating low and middle income countries. Other characteristics of low income countries are lower mobility of students (low number of students enrolling in foreign universities) and the higher number of applications for patents. Middle income countries can be generally described as countries which developed one or more sectors of tertiary education and R&D while others are still in the phase of development.

The strength of presented relations was examined by adding three indicators representing the level of development of communication infrastructure and information technology (see Table 2).

Table 2. Communication infrastructure and information technology indicators with IG values

IG	Indicator
1.0323	Fixed line and mobile phone subscribers (per 1000 people)
0.8324	Internet users (per 1000 people)
0.7853	Personal computers (per 1000 people)

From the IG values presented in Table 2 it can be seen that these indicators are more correlated with the class than the tertiary education and R&D indicators. It seems logical that the possession of good communication infrastructure and information technology is an important prerequisite for the development of tertiary education and R&D. However, in the case of indicators presented in Table 2 there are less missing data (on average 3%) in comparison to indicators presented in Table 1 (on average 45%). Hence, this could also play an important part in creating such differences in IG values.

The tree induced on the basis of 21 indicators presented in Table 1 and Table 2 is presented in Figure 2.

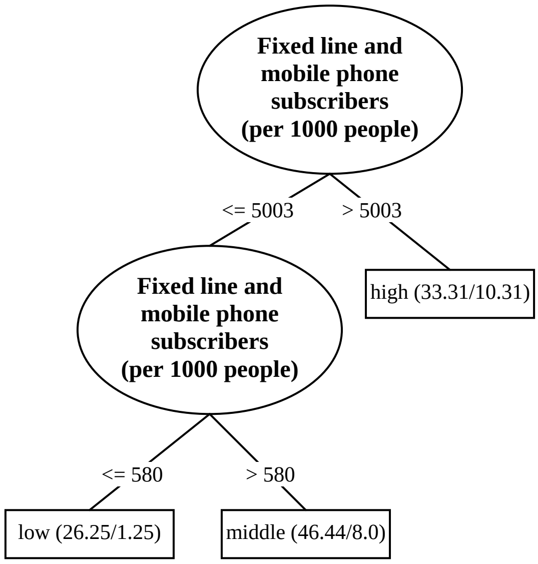


Figure 2. The decision tree built on 21 tertiary education, R&D and communication infrastructure and information technology indicators, 84% accurate

The tree was built using reduced error pruning and tested with 10-fold cross-validation.

Indicator *Fixed line and mobile phone subscribers (per 1000 people)* showed as the most important indicator confirming the results of the ranking.

5. Conclusion

In this paper ML and DM methods were used for the analysis of the relationship between high level knowledge and economic welfare. Various indicators were used presenting the status and the investment in tertiary education and R&D, together with three indicators presenting communication infrastructure and information technology.

It seems that in the case of tertiary education the level of investment is not the most important factor. Instead, the level of participation and the mobility of the students showed more important.

In the case of R&D situation is opposite making the high level of investment the key factor of the successful economy.

The level of the development of communication infrastructure and information technology has high impact on economic welfare, even higher than the high level knowledge sectors. For sure they represent important prerequisites for the successful development of the tertiary education and R&D. However, this result can just present the consequence of less amount of missing data in the cases of communication infrastructure and information technology indicators. Possible impacts of missing data on the obtained results will be examined in further work.

From the obtained results we can conclude that investing in R&D has an important impact on economic welfare, but if we do not stimulate people to educate, the progress of the economy will not be satisfactory.

Although the obtained trees just show relations from one point of view and are far from the final proof, the performed analyses clearly show the importance of high-level knowledge for economic welfare.

References

[1] B. Baumohl, *The Secrets of Economic Indicators: Hidden Clues to Future Economic Trends and Investment Opportunities*, Wharton School Publishing, 2004.

[2] *Global Education Digest 2006 – Comparing Education Statistics Across the World*, UNESCO Institute for Statistics, Montreal, 2006, http://www.uis.unesco.org/TEMPLATE/pdf/ged/2006/GED2006.pdf.

[3] *Human Development Report 2003 – Millennium Development Goals: A compact among nations to end human poverty*, pp. 362, New York, Oxford, Oxford University Press, 2003.

[4] *Manual for Statistics on Scientific and Technological Activities*, Division of Statistics on Science and Technology, Office of Statistics, UNESCO, Paris, June 1984, http://www.uis.unesco.org/template/pdf/s&t/STSManualMain.pdf.

[5] R. Quinlan, *C4.5: programs for machine learning*, Morgan Kaufmann Publishers Inc., San Francisco, 1993.

[6] V. Vidulin, M. Gams, Analyzing the impact of investment in education and R&D on economic welfare with data mining, *Electrotechnical Review*, 2006, vol. 73, no. 5, pp.285-290.

[7] I.H. Witten, E. Frank, *Data Mining – Practical Machine Learning Tools and Techniques*, Chapter 4: Algorithms: The basic methods, pp. 97-105, Elsevier Inc., 2005.

Zbornik 10. mednarodne multikonference

INFORMACIJSKA DRUŽBA - IS 2007

Proceedings of the 10th International Multiconference

INFORMATION SOCIEY - IS 2007

Vzgoja in izobraževanje v informacijski družbi

Education in Information Society

Uredili / Edited by

Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik

http://lopes1.fov.uni-mb.si

12. oktober 2007 / 12th October 2007
Ljubljana, Slovenia

PREDGOVOR

V tekstih, ki se ukvarjajo z napovedmi za pričujoče tisočletje, preberemo, da so temeljna znanja, ki jih bomo potrebovali, znanja matematike, računalništva in informatike. Na kaj se opirajo te za marsikoga drzne trditve? Predvsem na to, da ta znanja ne potrebujemo le za odkrivanje novega na področjih kot so npr. bioznanosti in astrofizika, ampak tudi za reševanje perečih vsakdanjih družbenih in ekoloških problemov. Gre za kvalitativen preskok od tehnoloških na znanstveno osnovane inovacije. V tem primeru računalnik presega okvire tehnološkega orodja, katerega uporabo običajno razumemo v okviru namizja osebnega računalnika in medmrežja. E-pismenost pomeni bistveno nove metode dela, ki omogočajo ta preskok.

Informatika in računalništvo sta dosegla raven, ko stojimo na pragu nove revolucije na področju znanja. Računalnik ni le pripomoček za »delo« z znanjem. Z novimi metodami, npr. analize podatkov, omogoča, da se ustvarjajo nova znanja in spoznanja, kar vodi v nova odkritja, do katerih brez tega ne bi prišli. Tak primer je razbitje genoma.

Revolucionarni preskoki na področju znanja v človeški zgodovini niso ravno pogosti. Do njih pride s temeljnimi konceptualnimi odkritji, med njimi algebra, ali tehnološkimi odkritji, primer le-teh je teleskop. Ko je leta 1202 Fibonacci z objavo Liber Abaci predstavil algebro kot novo vejo matematike, je matematika prešla iz opisne na simbolno raven. Tudi Galilejevo odkritje teleskopa leta 1604 in kasnejša odkritja tehnoloških pripomočkov, kot sta npr. mikroskop in rentgen, so pomembno vplivala na razvoj znanosti. Zahvaljujoč tem preskokom, je človek spremenil razumevanje samega sebe, sveta in vesolja. Pri tem pa nista bila brez pomena način in vsebina vzgoje in izobraževanja.

Težko je oceniti vso globino sprememb, ki jih v 21. stoletje prinašata računalništvo in informatika. Lahko pa rečemo, da gre za pomemben vpliv na to, na kakšen način in kako dolgo bomo živeli, kaj bomo vedeli o sebi in okolju ter kako bomo zaščitili sebe in življenje na Zemlji. Kakšen pa je in bo vpliv na procese vzgoje in izobraževanja? Zdi se, da vsaj primerjalno, bistveno večji kot kdajkoli doslej. Zakaj ta razlika? Predvsem so znanja informatike in računalništva tesno metodološko povezana s procesi vzgoje in izobraževanja. Pomembna razlika pa je tudi v tem, da izzivov, ki jih prinaša, ne moremo sprejeti, če je znanje le nekaj, kar je namenjeno ozkemu krogu elit. Tehnologija nam omogoča, da je znanje lahko dosegljivo vsakomur in vedno. To med drugim zahteva velik preskok na »šolskem« področju.

Prizadevanja za ustrezno vzgojo in izobraževanje so številna in različna. Od majhnih nasvetov, primerov dobrih praks, pa do konceptualnih premikov v miselnosti. Tako je marsikje že jasno, da mladine ne gre motivirati npr. za univerzitetni študij le s pričakovanji v zvezi z znanji, ki jim bodo predvidoma posredovana ali pa s »papirjem«, ki bo po možnosti priznan tudi izven naših meja. Tako so npr. univerze Velike Britanije skupaj izdale publikacijo s 100 največjimi odkritji na njihovih ustanovah, ki je namenjena predvsem srednješolcem in politikom. Politikom zato, da bi pokazali, da so naložbe v znanje in razvoj splačajo, čeprav so dolgoročne, srednješolcem pa zato, da bi videli, da vloga univerze ni samo posredovanje kodificiranega znanja, ampak da se do znanja pride tudi s sodelovanjem pri konkretnih projektih, ki lahko vodijo v nova odkritja in rešitve.

In kaj pričakujemo od 10. konference »Vzgoja in izobraževanje v informacijski družbi«, ki poteka v sklopu multikonference »Informacijska družba«? Prispevki predstavljajo nekatere rezultate raziskav in razvoja od predšolske vzgoje do univerze in vseživljenjskega učenja. S tem ne želimo le omogočiti pretoka znanja in idej, ampak tudi vzpodbuditi nadaljnje delo na področju raziskav in razvoja v procesih vzgoje in izobraževanja.

Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik

PREFACE

Texts discussing envisioned predictions for the present millennium uncover, that the basic types of knowledge needed in the future are those of mathematics, computing and informatics. What do these, for some rather daring, statements refer to? Most of all they point that knowledge is for example not key only for discoveries in the fields of bio-sciences and astrophysics, but also for solving current burning social and ecological issues. Basically it is about making the qualitative shift from technologically-based to science-based innovation. In this case the computer surpasses the boundaries of a technological tool, of which use is commonly limited to desktop applications and the Internet. Here e-literacy stands for significantly new methods of work than enable this leap.

Informatics and computing have reached a level that is a threshold of a new knowledge revolution. Besides being merely a tool for operating knowledge, the computers together with new methods, such as data mining, enable also the creation of new knowledge, what leads to new discoveries that would not be possible otherwise. An example of this is the decoding of a genome.

Revolutionary shifts in knowledge have not been very frequent throughout the history of the mankind. They were results of a basic conceptual discoveries, among them algebra, or technological discoveries, an example being the telescope. When in 1202 Fibonacci published Liber Abaci and introduced algebra as a new branch of mathematics, algebra enabled a shift from written to symbolic mathematics. Similarly, the invention of the telescope in 1604 by Galielo and later technological inventions such as microscope and X-rays, importantly influenced the development of science. Thanks to these shifts humans have changed the understanding of the humankind, the world and the universe. It goes without saying that the mode and content of the education played an important role in the process.

It is difficult to estimate the depth of the change that computing and informatics are bringing into the 21st century. We can say that there is an important influence on how we live, how long we live, what we know about ourselves and the world around us and on how to protect the entire life-support systems of the earth. What is the influence on the processes of education? It appears that it is essentially greater than ever before. What is the reason for this difference? Most of all the knowledge of informatics and computing is closely methodologically aligned with processes of education. Important difference comes also from the fact that new challenges cannot be tackled if knowledge is something that is meant only for the elites. The technology, however, enables the knowledge to be available to everyone at all times. Further, this means a big shift in learning.

Efforts for suitable education are numerous and varied, from small suggestions, examples of good practices to conceptual shifts in thinking. It is becoming clear that the way to motivate the youth, for example to obtain a University degree, cannot be carried out only by emphasizing the expectations regarding knowledge they will attain or the degree they will receive on paper that will be recognized outside our borders. Universities of the United Kingdom have therefore edited a publication on 100 greatest discoveries at their institutions that is intended most of all for high school students and politicians. For politicians in order to demonstrate to them that investments in knowledge and research pay despite their long term nature. To the target group of students, on the other hand, they wanted to show that the University is not only an intermediate for delivering codified knowledge but can also offer access to newly generated knowledge by participation in concrete projects leading to new discoveries and solutions.

And what lies in store for us at the 10th conference "Education in the information society" held in the frame of multiconference "Information society"? The contributions present some of the results of the research and development from the pre-school to the university level and lifelong learning. Our goal is to enable the flow of knowledge and ideas and more importantly to encourage future work in this field.

Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik

PROGRAMSKI ODBOR / PROGRAMME COMMITTEE

Peter Kokol
Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko

Alenka Krapež
Gimnazija Vič

Tanja Logar
Center za poklicno izobraževanje

Robert Marinšek
Center za mobilnost in evropske programe izobraževanja in usposabljanja

Gregor Mohorčič
Zavod RS za šolstvo

Mojca Orel
Gimnazija Moste

Milan Pagon
Univerza v Mariboru, Fakulteta za organizacijske vede

Jože Rugelj
Univerza v Ljubljani, Pedagoška fakulteta in Institut Jožef Stefan

Niko Schlamberger
Slovensko društvo Informatika

Tomaž Skulj
Zveza za tehnično kulturo Slovenije

Branislav Šmitek
Univerza v Mariboru, Fakulteta za organizacijske vede

Olga Šušteršič
Univerza v Ljubljani, Visoka šola za zdravstvo

Tanja Urbančič
Politehnika Nova Gorica in Institut Jožef Stefan

Margareta Vrtačnik
Univerza v Ljubljani, Naravoslovno tehniška fakulteta

Wechtersbach Rado
Zavod RS za šolstvo

Pregled stanja na področju e-izobraževanja v Sloveniji

Survey of the State of e-Learning in Slovenia

Tanja Arh[1], Rok Kokalj[2], Dejan Dinevski[3], Borka Jerman Blažič[1]

1 Institut "Jožef Stefan", Laboratorij za odprte sisteme in mreže, Jamova 39, 1000 Ljubljana, Slovenija
tanja@e5.ijs.si; borka@e5.ijs.si

2 Nevron d.o.o., Stegne 21c, 1000 Ljubljana, Slovenija
rok.kokalj@nevron.si

3 Univerza v Mariboru, Slomškov trg 15, 2000 Maribor, Slovenija
dejan.dinevski@uni.mb.si

Povzetek

Slovenija na področju uporabe informacijsko-komunikacijskih tehnologij v izobraževanju ter v zavedanju pomembnosti e-izobraževanja zaostaja za drugimi državami Evropske unije. Glede na raziskave, ki so bile v preteklosti pripravljene na tem področju znotraj različnih institucij, lahko povzamemo, da se v Sloveniji pravi razvoj in uporaba e-izobraževanja šele pričenja. V prispevku bodo prikazani dosedanji razvoj in pomembnejše iniciative na področju e-izobraževanja, stanje uporabe e-izobraževanja v slovenskih podjetjih ter visokošolskih in višješolskih institucijah ter trenutno stanje e-izobraževalne ponudbe na slovenskem trgu. Predstavljen bo osnutek Nacionalne strategije e-izobraževanja 2006-2010, katere glavna vizija je do leta 2013 vzpostaviti enega najučinkovitejših in v celoti informacijsko podprtih nacionalnih sistemov izobraževanja ter tako zagotoviti trajnostno gospodarsko rast, blaginjo in kakovost vseh državljanov RS, hkrati pa postati sinonim za eno najuspešnejših družb na svetu, temelječo na znanju, stalnih inovacijah in hitrem razvoju.

***Ključne besede**: informacijsko-komunikacijska tehnologija, e-izobraževanje, Nacionalna strategija e-izobraževanja 2006-2010*

Abstract

In comparison to the other European countries and the general status of the development of information-communication technology in education and training, Slovenia has been traditionally lagging behind. In the same sense, the awareness of the importance of e-learning has not been sufficiently recognized. With this in view we can summarize that the concrete activities on the implementation level on the national level started with the present period. The article thus focuses on the presentation of the past research activities and iniciatives dealing with the e-learning market structure in Slovenia and assesment of the current e-learning situation in Slovenian companies and high-education institutions. As well, the article indicates the background for setting up the guidelines for further development of e-learning in Slovenia. With this in view, the framework of the National E-learning Strategy 2006-2010 is presented, where special attention is given to that part of the strategy aimed at the establishing one of the most effective and ICT based national educational systems with the objective of increasing economic growth and the competitiveness of Slovenian society, as well as the quality of life of Slovenian citizens.

***Keywords:** information communication technology, e-learning, National E-learning Strategy 2006-2010*

Project CALIBRATE - Calibrating eLearning in Schools

Vladimir Batagelj, Iztok Kavkler, Matija Lokar

Univerza v Ljubljani, Fakulteta za matematiko in fiziko
Vladimir.Batagelj@fmf.uni-lj.si, Iztok.Kavkler@fmf.uni-lj.si, Matija.Lokar@fmf.uni-lj.si

Abstract

Exchange and collaborative use of learning resources is one of the main issues European Union supports through IST Programme. The CALIBRATE (Calibrating eLearning in Schools) brings together eight European countries to carry out a multi-level project designed to support the collaborative use and exchange of learning resources in schools. Its main aim is to provide brokerage system among national repositories of educational materials. The paper reports on main golas of this project, among which are to develop an open source technical architecture to support content exchange/collaboration between Ministries of Education and other owners of educational repositories, to develop an open source, learning toolbox that supports the collaborative use of learning resources, research and test new approaches that can improve semantic interoperability related to the discovery and evaluation of learning resources. One of the quite important issues developed through the project is the guidelines about the metadata resources in the repositories should be equipped with. We will report on two major guidelines the resources in Calibrate should follow. Also some practical examples of preliminary versions of tools are reported.

Keywords: *e-learning, metadata, repositories, learning resources*

E-izobraževanje z video vodiči

Borut Bencak[1], Branislav Šmitek[2]

[1] Jakobovo naselje 8, 9000 Murska Sobota
[2] Univerza v Mariboru, Fakulteta za organizacijske vede, Kidričeva cesta 55/a, 4000 Kranj

Povzetek

Dandanes je potreba po znanju iz dneva v dan večja. Veča se tudi potreba po čim lažji dostopnosti do potrebnih znanj. Zagotoviti je tudi potrebno da so učne vsebine dosegljive iz vsakega delovnega mesta in glede dostopnosti tudi časovno ne smemo biti omejeni. Zato se razvija nova veja izobraževanja, to je izobraževanje na daljavo. V tem projektu je prikazana ena izmed možnosti kako približati znanje o uporabi programskih orodij v pisarniškem poslovanju. Prikazujemo multimedijsko izobraževanje v smislu e-izobraževanja, z objavo vsebin na spletni učni portal Moodle, pa smo omogočili tudi izobraževanje na daljavo od kjerkoli in kadarkoli.

Ključne besede: *e-izobraževanje, multimedija, izobraževanje na daljavo, video vodiči*

Abstract:

Nowadays the need for knowledge grows everyday. Also the need after extremely easier accessibilities of necessary knowledge grows daily. It also needs to be assured that the didactic contents are approachable from every workplace and concerning the accessibility of these contents there can not be any timely restriction. That is why new branch of education is developing, this is education on distance. In this project is showed one of possibility how to approach knowledge concerning use of software tools in office business. Demonstrate multimedia education within the meaning of e-education, with publication of contents on web learning management system (LMS) Moodle, which allows also education on distance anywhere and anytime.

Keywords: *e-education, multimedia, distance education, video guides*

Medpredmetno povezovanja z uporabo spletnega dnevnika

Cross-curricular integration using the web diary (blog)

Jana Bizjak Bradeško

OŠ Ivana Cankarja, Lošca 1, 1360 Vrhnika
jana.bizjak-bradesko@guest.arnes.si

Primož Trček

OŠ Ivana Cankarja, Lošca 1, 1360 Vrhnika
primoz.trcek2@guest.arnes.si

Povzetek

Kompetenten učitelj potrebuje znanje, sposobnosti in vizijo za uresničitev zamisli v različnih situacijah. Ustvarjanje različnih, za učenca zanimivih situacij, je za učitelja v današnjem svetu težka naloga. Številne informacije , različni mediji in tehnologije so mu pri tem ustvarjanju v pomoč . Tako je potrebno v pouk vpeljati poleg frontalne oblike tudi druge oblike dela, ki zahtevajo učiteljevo znanje uporabe IKT. Zaželjene so tiste oblike, pri katerih je učenec aktiven soustvarjalec pouka. To dosežemo tudi s pravilno izbranimi metodami dela (pregledovanje, izbiranje literature in drugih virov, predstavitev, delo v skupinah idr.). Z načrtovanjem skupnega cilja med izbirnim predmetom računalniška omrežja (ROM) in geografijo je postal učenec aktiven oblikovalec pouka. Za izdelavo spletnega dnevnika (bloga) je potreboval znanja in spretnosti pridobljene pri obeh predmetih ter povratne informacije učitelja in sošolcev, ki so prispevale k dvigu kvalitete njegovega spletnega dnevnika.

Ključne besede: *medpredmetno povezovanje, aktivna vloga učenca, povratna informacija, blog – spletni dnevnik*

Abstract

A competent teacher needs knowledge, an ability and a vision for realization of different ideas in different situations. Nowadays it is difficult for a teacher to create different situations which are at the same time also interesting for students. Numerous pieces of information, different media and technology are very helpful. It is necessary to include other methods apart from face-to-face teaching. Such methods demand of teachers to be able to use IKT. Methods which include students as active participants in creating a lesson are especially welcome. They should be carefully chosen and include inspection and choosing of bibliography and other sources, presentation, group work and others. Students become active participants in creating lessons by planning a common goal between computer network (ROM) and Geography. If they want to create online personal journals (blogs), they need knowledge and abilities gained while studying both subjects. At the same time feedback from their teacher and schoolmates help them to achieve better quality of their blogs.

Keywords: *cross-curricular integration, students' active role, feedback, blog*

Raztezanje za računalnikom

Romina Bregant, Miran Štempihar

Srednja šola Jesenice, Ulica Bratov Rupar 2, 4270 Jesenice, Slovenija

Povzetek

V sodobnem času si težko predstavljamo življenje brez računalnikov, ki nam močno olajšajo delo, predvsem pa prihranijo veliko dragocenega časa. Kljub temu, da je elektronska revolucija pripomogla k skokovitemu napredku na različnih življenjskih področjih, pa je prinesla tudi negativne posledice. Človeško telo namreč ni ustvarjeno za sedenje, večurno mirovanje pa je za naše telo nenaravno in vodi v slabo počutje ter različne poškodbe. Relativno enostavno rešitev predstavljajo vaje za raztezanje (angl. »stretching«). Metoda se je razvila iz joge in je uveljavljena v vrhunskem in rekreativnem športu, v zadnjem času pa se raztezanje priporoča tudi kot aktivnost, ki naj bi jo redno izvajali vsi, ki delajo za pisalno mizo ali računalnikom. Gre za vadbo, ki je enostavna, ne zahteva veliko časa, niti prostora, izvajamo pa jo lahko praktično kjerkoli: za pisalno mizo, v avtu, na avtobusu, na sestankih,.... Vaj za raztezanje je ogromno, s pravilno izbiro pa lahko poskrbimo, za tisti del našega telesa, ki tovrstno pomoč najbolj potrebuje.

Ključne besede: elektronska revolucija, ergonomija, raztezanje

Abstract

These days it is difficult to imagine life without computers. They make our jobs much easier and save us a lot of precious time. In spite of the fact that electronic revolution helped to fast progress in different fields of life, it also has some negative effects. Human body is not formed to sit and being still for a long time leads to different injuries. Stretching exercises are relatively simple solution. The metod was developed from yoga and is well – established in professional as well as in recreative sport. Recently stretching has been recommended as an activity that should be done regularly by everyone who works at the desk or computer. It is an activity that is simple, doesn't take much time or space and can be done practically everywhere: at the desk, in the car, on the bus, in the meetings, etc. There are a lot of stretching exercises and with the right chioce we can provide for the part of the body which needs such help most.

Keywords: *electronic revolution, ergonomy, stretching*

Človeški kapital in e-učenje

Human capital and e-learning

Metod Černetič

Fakulteta za organizacijske vede, Kranj, Slovenia
metod.cernetic@fov.uni-mb.si

Povzetek

Prevladujoča doktrina v vzgoji in izobraževanju ima danes središče v teorijah o človeškem kapitalu. Te teorije, pa če so še tako polne ideoloških predsodkov, prikazujejo zelo resnično težnjo sodobnega kapitalizma k mobiliziranju čedalje številnejših vednosti z njihovim dvojnim aspektom produkcijskih dejavnikov in trgovskega blaga. Ekonomisti s človeškim kapitalom označujejo »zalogo znanj, ki jih je mogoče ekonomsko ovrednotiti in so jih posamezniki osvojili«. To so najprej kvalifikacije, pridobljene bodisi v sistemu usposabljanja bodisi s poklicnimi izkušnjami. V širšem pomenu lahko ta pojem zajame številne adute, ki jih lahko posameznik uveljavlja na trgu in jih delodajalcem prikaže kot potencialne vire vrednosti: denimo zunanji videz, olikanost, način življenja in razmišljanja ali zdravstveno stanje. Tako bi po mnenju OECD človeški kapital združeval »znanja, kvalifikacije, kompetence in individualne značilnosti, ki olajšujejo ustvarjanje osebne, družbene in ekonomske blaginje«. Koncepcija človeškega kapitala sicer ni povsem izvirna, vendar je v mednarodnih organih in med zahodnimi vladami doživela velikanski uspeh, pa ne zgolj zato, ker predlaga strategijo »trajne rasti«, kakor pravijo njeni zagovorniki, ampak zato, ker ekonomsko upravičuje stroške šolanja, kar je v očeh »odločujočih« danes edino veljavno upravičilo. Poleg tega ima pojem, kakor bomo videli, prednost, da prikazuje pešanje povezave med šolsko diplomo in zaposlitvijo ter upravičuje večjo selektivnost delodajalcev v času, ko se pomen »neformalnih« sestavin, predvsem tistih družbenega izvora, pri določanju »zaposljivosti« delavcev povečuje zaradi inflacije naslovov.

***Ključne besede**: človeški kapital, e-učenje, razcvet in omejitve e-tehnologij, globalizacija*

Abstract

With the term human capital different economists determine "stock of knowledge, which can be economically evaluated and has been captured by individuals." In the first place, these are qualifications, gained either in the system of qualification or either through professional experience. In the wider meaning this conception grasps numerous trumps, which can be carried into effect by individual in the marketplace and can be shown by employee as a potential sources of advantage: for example physical appearance, good manners, way of life and state of mind or even good medical condition. In such manner by the opinion of OECD human capital would unite "knowledge, qualifications, competence and individual characteristics, which relieve creation of personal, social and economic welfare." Conception of human capital is not entirely original, but it has achieved enormous success among international institutions and western governments, not only because it propose a strategy of permanent development as its advocates suggests, but because economical justifies education; what is in the eyes of decision makers only valid justification.

***Keywords:** human capital, stock of knowledge, permanent development, e-learning, high education*

Wiki in učna gradiva za matematiko

Wiki and Didactic Materials for Mathematics

Tadeja Cesar, Matija Lokar

Univerza v Ljubljani, Fakulteta za matematiko in fiziko
tadeja.cesar@student.fmf.uni-lj.si, matija.lokar@fmf.uni-lj.si

Povzetek

Wiki po eni strani razumemo kot sistem spletnih strani, ki omogoča vsakemu, da na spletnih straneh dodaja, briše in popravlja vsebino, po drugi strani pa s tem izrazom označujemo tudi poseben program, ki podpira urejanje spletnih strani s spletnim brskalnikom. Wikije lahko uporabimo tudi pri poučevanju. Zaradi enostavnosti, odprtosti in sodelovalnega dela ima uporaba sistemov wiki svetlo prihodnost pri poučevanju. Lotili smo se priprave spletnih strani s sistemom wiki, namenjenih zbiranju gradiv za učenje in poučevanje matematike s pomočjo različnih programov.

***Ključne besede**:Wiki, učna gradiva, Derive*

Abstract

On one side we understand under Wiki a system of web pages, who makes possible for everybody to add on web pages, wipes and correcting the content, on the other side we marking under this expression a special programme, that is supporting the arranging of web pages with web browser. We can use Wiki's also at teaching. Because of simplicity and opennesses has the system use of Wiki a failry future. We prepared web pages with Wiki system, intended for gathering of materials for teaching of mathematics with help of different programmes.

***Keywords:** Wiki, didactic materials, Derive*

Structuring Domain Knowledge by Semi-automatic Ontology Construction

Bojan Cestnik [1,3], Ingrid Petrič [2], Tanja Urbančič [2], Marta Macedoni-Lukšič [4]

[1] Jozef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

[2] University of Nova Gorica, Vipavska 13, 5000 Nova Gorica, Slovenia

[3] Temida, d.o.o., Dunajska cesta 51, 1000 Ljubljana, Slovenia

[4] University Children's Hospital, University Medical Center, Ljubljana, Slovenia

bojan.cestnik@temida.si, ingrid.petric@p-ng.si, tanja.urbancic@p-ng.si, marta.macedoni-luksic@mf.uni-lj.si

Abstract

In this paper we present a case in semi-automatic ontology construction from literature. In this case we concentrate on the articles about autism obtained from PubMed Central database. Our motivation was to investigate how separate parts of articles, such as titles, abstracts and full texts, influence the constructed ontology. Our results confirm the intuitive expectation that constructing ontologies from abstracts is a rational choice when uncovering the structure of a given scientific field. Also, when compared to the general autism knowledge, ontology concepts from abstracts show the highest resemblance.

Keywords: *Knowledge management, education, concept learning, ontologies, autism*

Boarding School's Students and Using of Internet – Reserach

Dijaki v dijaškem domu in uporaba interneta - raziskava

Lina Dečman[1], Ana Stare[2]

1 Iskraemeco, d.d., Savska loka 4, 4000 Kranj, Slovenija
e-mail: Lina.Decman@siol.net

2 Boarding School Ivana Cankarja, 1000 Ljubljana, Slovenija
e-mail: Ana.Stare@guest.arnes.si

Abstract

The information society and globalization have been introducing considerable changes into our lives on the level of our mutual relations. Generations of young people stay home and communicate with the outer world by computer and internet. We cannot designate the young people of today to be less sociable as past generations, only the way of communicating has changed. They socialize by means of internet and SMS – messages. We carried out a research among the pupils of high schools to find out how much time is spent daily on communicating via internet, which internet chat rooms they join, what communication methods they use, how many friends they make and how many acquaintances they meet in this way, how much e-mail is used and how much of their free time is spent for personal contacts.

Key words: *internet, students, boarding schools, communication, chat rooms, informations*

Povzetek

Informacijska in globalna družba spreminja naš način življenja na mnogih relacijah. Mladi vse bolj in pogosteje uporabljajo internet in SMS sporočila kot prioritetno komunikacijsko sredstvo. Dijaki uporabljajo internet doma, v šoli, v dijaških domovih, cyber kotičkih, knjižnicah. V raziskavi, ki smo jo izvedli v dijaškem domu, nas je zanimalo predvsem, kaj mlade privabi na internet, katere storitve uporabljajo, koliko prijateljev so spoznali preko interneta, katere komunikacijske metode uporabljajo ter kako pogosto uporabljajo email in koliko časa preživijo pred računalnikom.

Ključne besede: *internet, dijaki dijaški domovi, klepetalnice, informacije*

Knowledge, Skills and Using of ICT in Boarding Schools

Znanje, spretnosti in uporaba IKT v dijaških domovih

Olga Dečman Dobrnjič[1], Metod Černetič[2]

1 The National Education Institute, Poljanska 28, 1000 Ljubljana, Slovenija
olga.decman@zrss.si

2 Fakulteta za organizacijske vede, Kranj, Slovenia
metod.cernetic@fov.uni-mb.si

Abstract

Information technology has for some time now been an integral part of education and management processes in boarding schools. New contemporary work methods, used by tutors who are a motivated for introducing the necessary and inevitable novelties into the pedagogic practises, have been put into effect. In this artice we will list down some basic skills and knowledge that tutors and headmasters of boarding schools should know. Off course those skills and knowledge should have other teachers in schools and other institutes, but we will only mention boarding schools in this article, because they are the focus of our research.

A survey was carried out in boarding schools searching for the opinions of headmasters and tutors on the advantages and diadvantages of electronic diary of tutor's work. It searched for eventual weaknesses and strengths of the process which may be important for introducing and applying of the innovation in a pedagogic process. Simultaneously the attitudes of pedagogic staff on this novelty were checked.

Key words: *knowledge of ICT , tutors, headmasters, skills, pedagogic process, research, boarding schools*

Povzetek

Informacijska tehnologija je v sodobnem času sestavni del vzgoje, izobraževanja in menedžmenta v dijaških domovih. Vzgojitelji v dijaških domovih so motivirani, da nova znanja, ki jih ponuja sodobna tehnologija, vključujejo v vzgojno izobraževalni proces. V našem članku prikazujemo rezultate raziskave, s katero smo želeli izvedeti, koliko in katera znanja s področja informacijske tehnologije imajo vzgojitelji in ravnatelji dijaških domov v Sloveniji. Zanimalo nas je tudi, katere vsebine naj bi imel elektronski dnevnik vzgojiteljevega dela, ki se kot inovacija pojavlja v vse večjem številu dijaških domov. Da bi pridobili željene podatke, smo anketirali vzgojitelje in ravnatelje dijaških domov.

Ključne besede: *znanje s področja IKT, vzgojitelji, ravnatelji, pedagoški proces, raziskava, dijaški domovi*

E-učenje računalništva za srednje šole

E-learning in Computer Science for Secondary Schools

Saša Divjak

Faculty of Computer and Information Science, University of Ljubljana
Trzaska 25, 1000 Ljubljana
sasa.divjak@fri.uni-lj.si

Abstract

The paper presents the results of the Slovenian national project focused on development of SCORM compliant courseware for computer science teaching and learning. The requirements were that the teaching material should have integrated multimedia and interactive elements. This was achieved by introduction of flash based animations and also with several java applets. Following the experience with some other didactic applets the effort was focused on reusability of such interactive elements in different didactic scenarios. According to the basic aims of the project the developed materials cover most of the different curriculums of computer science teaching that are implemented in Slovenian schools. The developed courseware was tested on different learning platforms and checked by several 10 school teachers.

Keywords: *SCORM, e-learning, interactive examples*

Povzetek

Članek predstavlja rezultate slovenskega nacionalnega projekta, usmerjenega v razvoj SCORM kompatibilnih učnih gradiv za poučevanje in učenje računalništva in informatike. Zahteve projekta so bile, da mora imeti učno gradivo vgrajene multimedijske in interaktivne elemente. To smo dosegli z uvedbo animacij, temelječih na tehnologiji flash in z več javanskimi apleti. Na osnovi izkušenj z nekaterimi drugimi didaktičnimi apleti je bil podan poseben poudarek na ponovni uporabljivosti takih interaktivnih elementov v različnih didaktičnih scenarijih.V skladu z osnovnimi cilji projekta pokrivajo razvita gradiva večino različnih učnih načrtov poučevanja računalništva in informatike v slovenskih srednjih šolah. Razvita čna gradiva smo preskusili na različnih učnih platformah, preverilo pa jih je več 10 srednješolskih učiteljev.

Ključne besede: *SCORM, e-učenje, interaktivni primeri*

Izdelava pedagoškega poročila Gunzburg

Making Pedagogic Report Gunzburg

Simon Dolenec

simondolenec@yahoo.com

Povzetek

Ob zaključku šolskega leta je potrebno izdelati pedagoško poročilo za vsakega učenca na koncu šolskega leta. Za učence s posebnimi potrebami v duševnem razvoju je to poročilo Gunzburg in je posebne oblike. Izdelava poročil je specifična in odvisna od diagnoze učenca. V šolah za učence s posebnimi potrebami po Sloveniji, bi izdelovali Gunzburg poročila na nov, računalniško bolj preprost način.

Ključne besede: *pedagoško poročilo, Gunzburg, osebe z motnjami v duševnem razvoju, računalnik*

Abstract:

At the end of school year we need to make pedagogic report for each schoolable child. For pupils with developmental disabilities we make special report named Gunzburg. Makig of that report is specific and it depends of pupils diagnose. We will improve Gunzburg reports in similar schools for learners with special needs around Slovenia on new way, easily done with computer.

Key words: *pedagogue report, Gunzburg, person with developmental disabilities, computer*

Priprava in uporaba kvizov v okolju Moodle

Quizzes in Moodle Environment

Klaudija Gerenčer, Matija Lokar

Univerza v Ljubljani, Fakulteta za matematiko in fiziko
klaudija.gerencer@gmail.com, matija.lokar@fmf.uni-lj.si

Povzetek

E-izobraževanje spada med najsodobnejše načine prenosa znanja. Njegova priljubljenost iz leta v leto vedno bolj narašča. Eden izmed sistemov za izvajanje e-izobraževanja je Moodle. Moodle omogoča pripravo, upravljanje in izvedbo izobraževanja na daljavo. Pomembna sestavina vsakega izobraževanja je preverjanje znanja. Eden od popularnejših načinov preverjanja znanja, tako za učitelje kot tudi za študente, je uporaba kvizov. V prispevku bomo predstavili pripravo in uporabo kvizov v okolju Moodle na primeru izvedbe pri predmetu Podatkovne strukture in algoritmi (PSIA) v sklopu Dopolnilnega izobraževanja za učitelje računalništva in informatike na Fakulteti za matematiko in fiziko. Preko opisa načina sestavljanja in določenih nastavitev bomo predstavili predvsem določene poudarke in praktične izkušnje.

Ključne besede: kvizi, *Moodle, e-izobraževanje*

Abstract

E-learning is among somo of the most contemporary manners of transfering the knowledge. Its popularity is increasing from year to year. One of the systems of e-learning is Moodle. Moodle enables preparation, administration and realization of the distance education . One of the more important ingredient of every education is assesment. Quizzes are one of more popular ways os assesing the knowledge among teachers as well as among students. In the paper preparing and use of quizzes in Moodle environment will be introduced, following an example of their usage in the course Data structures and algorithms (PSIA) which is part of Supplementary education for computer science and informatics teachers in the Faculty of mathematics and physics. Through description of preparation and certain options mainly practical issues and experiences will be discussed.

Keywords: *Quizzes, Moodle, e-learning*

Distance Education Models and New Communication Trends in Education

Modeli izobraževanja na daljavo in novi komunikacijski trendi v poučevanju

Ivan Gerlič

Univerza v Mariboru, Fakulteta za naravoslovje in matematiko
Koroška160, 2000 Maribor, E-mail: ivan.gerlic@uni-mb.si

Abstract

Last decade's technological development in the field of information technology has boosted the range of varieties of its use in the distance education and given new dimensions to this type of education. Distance-learning nowadays is practised by several theory's, each differing from the other in its formal access, in the analyse of its teaching and learning materials, in its ways and range of counselling and the range of its communication with the participants, as well as in its didactic concept of preparing and forming learning materials, etc. Distance education is important criterion for new communication trends in education. Therefore it shall be covered more thoroughly in this work.

Key words: *Distance learning, distance education, distance teaching and learning models, didactic models, communication models, web based education, web-based learning material.*

Povzetek

V zadnjem desetletju je napredek na področju informacijsko-komunikacijskih tehnologij odprl nove možnosti poučevanja in učenja na daljavo in s tem dal temu področju nove dimenzije. Z izobraževanjem na daljavo se danes ukvarja množica teorij, ki se medsebojno razlikujejo po formalnem pristopu, po analizi gradiva, po obsegu in načinu svetovanja in komunikacije z učenci, po didaktičnem konceptu priprave in oblikovanja gradiv itd. Izobraževanje na daljavo pomeni tudi pomemben kriterij komunikacijsko – didaktičnih trendov v izobraževanju, ki jih bomo v tem prispevku analizirali.

Ključne besede: *Učenje na daljavo, izobraževanje na daljavo, modeli učenja in poučevanja na daljavo, didaktični modeli, komunikacijski modeli, spletno izobraževanje, spletno orientirani učni materiali,*

E- model uvajanja v uporabo in pripravo e-gradiv

Introduce E- Model For Use And Prepare E-Materials

Ivan Gerlič

Univerza v Mariboru, Fakulteta za naravoslovje in matematiko
Center za računalništvo, informatiko in multimedijo v izobraževanju
ivan.gerlic@uni-mb.si

Povzetek

V zadnjem desetletju je tehnološki napredek na področju informacijsko-komunikacijske tehnologije odprl nove možnosti učenju na daljavo in mu tudi odprl nove dimenzije. Izobraževanje na daljavo pomeni tudi pomemben kriterij kot za nove trende v izobraževanju. Izobraževalne ustanove so postavljene pred nove probleme, kako in na kakšen način pripraviti kvalitetna e-gradiva. V prispevku predstavljamo kako za pripravo e-gradiv uporabiti LMS Moodle.

Ključne besede: *Izobraževanje na daljavo, e-učenje, e-gradiva, računalniško podprto poučevanje, interaktivnost, izobraževanje, LMS – sistemi za upravljanje e-izobraževanja.*

Abstract

Last decade's technological development in the field of information technology has boosted the range of varieties of its use in the distance education and given new dimensions to this type of education. Distance education is important criterion for new communication trends in education. Educational institutions are put before new problems, how and on what kind of manner to prepare quality e-materials. In article we introduce how to use LMS Moodle for prepare e-materials.

Key words: *Distance learning, e-learning, e-materials, computer based learning, interactivity, education, LMS – Learning Management Systems.*

Informacijsko komunikacijske tehnologije za invalide –otroke s posebnomi potrebami

ITK for the Handicapped – Children with Prticular Needs

Vesna Gorjanc-Basaj, Metod Čufar

Srednja šola Jesenice, Ulica bratov Rupar 2, 4270 Jesenice, Slovenija
metod.cufar@guest.arnes.si

Povzetek

Smo v informacijski dobi in si brez sodobne informacijsko komunikacijske tehnologije številnih izobraževalnih procesov ne moremo več zamisliti. Hiter razvoj na področju računalništva in komunikacij pogosto povzroča težave uporabnikom, niti predstavljati pa si ne moremo, na koliko ovir pri tem naletijo osebe s posebnimi potrebami. Tudi od učiteljev zahteva poučevanje otrok s posebnimi potrebami veliko ustreznih znanj, poznavanja novosti na področju informacijsko komunikacijske tehnologije, motivacije in sposobnosti prilagajanja posamezniku. V prispevku je predstavljena problematika oseb s posebnimi potrebami v računalnici.

Ključne besede: *Komunikacijska tehnologija, osebe s posebnimi potrebami, računalnica*

Abstract

Nowadays, living in the information era, people can no longer imagine the process of learning without information and communication technology. Rapid development in the fields of computer science and communications often causes many problems to its users, but it can hardly be imagined how many problems people with special needs encounter. Teachers also have to be properly qualified when working with such people; they need to have the proper knowledge, they must be aware of novelties in the field of information and communication technology, they should be motivated and adaptable to individuals. The article presents the problems which people with special needs face when they want to gain some knowledge in computer science.

Key words: *Communication technology, special needs encounter, computer science*

Dropouts from E-Learning Courses and Students' Satisfaction with E-Learning

Alenka Gortan[1], Eva Jereb[2]

[1]Secondary School Velenje, Trg mladosti 3, 3320 Velenje, Slovenia, alenka.gortan@amis.net

[2]Faculty of Organisational Sciences, University of Maribor, Kidričeva 55a, 4000 Kranj, Slovenia, eva.jereb@fov.uni-mb.si

Abstract

The paper deals with dropout rate from e-learning academic courses in correlation with students' satisfaction with distance education. The study explores two main ideas: students' satisfaction with e-learning and locus of control. Results show that the main reason for persistence in e-learning academic courses is significantly high level of satisfaction with e-learning and satisfaction with students' own academic performance.

Key words: *e-learning, dropout rate, successfulness, satisfaction*

Didaktični pristopi v luči novih tehnologij

Didactic Perspectives in the Light of New Technologies

Boris Horvat, Matija Lokar, Primož Lukšič

Inštitut za matematiko, fiziko in mehaniko, Jadranska 19, 1000 Ljubljana
Boris.Horvat@fmf.uni-lj.si, Matija.Lokar@fmf.uni-lj.si, Primoz.Luksic@fmf.uni-lj.si

Povzetek

Sodobne multimedijsko podprte informacijske tehnologije vsebovane v učnem procesu spreminjajo obliko tako poučevanja, kot tudi učenja. Rešitve in pristopi omenjeni v prispevku so bile uporabljene predvsem pri predmetih, ki poučujejo računalniške vsebine na srednješolskem, visokošolskem in univerzitetnem nivoju. Predlagani koncepti in sistemi upravljanja z znanji omogočajo kvalitetnejše upravljanje z znanji, kvalitetnejše posredovanje znanj, in kar je najvažnejše - učeči se več naučijo.

Ključne besede: *e-izobraževanje, LMS, Moodle, MediaWiki, odprta koda, standardi e-izobraževanja, SCORM, računalniški predmeti*

Abstract

The modern multimedia supported IT included in the learning process is changing not only the teaching but also the learning. The article presents new didactic perspectives used when teaching computer oriented courses in high school and in undergraduate programs. The proposed concepts in systems of knowledge management provide higher knowledge quality and the most important of all – students learn more.

Keywords: *e-learning, LMS, Moodle, MediaWiki, open source, e-lerning standards, SCORM, computer science courses*

Uporaba IKT pri izvedbi večdnevne strokovne ekskurzije

Application of IKT at Realisation of More-day-lasting Professional Excursion

Vlasta Jemec

Tehniški šolski center Kranj, Kidričeva 55, 4000 Kranj

Povzetek

Strokovna gimnazija je ena od treh organizacijskih enot Tehniškega šolskega centra Kranj, ki že šestdeset let organizira tehnično izobraževanje. Vključevanje modernih informacijsko komunikacijskih tehnologij (IKT) v poučevanje in učenje obveznih in prostoizbirnih predmetov učnega načrta je in ostaja naš pomemben cilj.

Članek predstavlja primer, kako se didaktika in IKT lahko prepletata ob izvedbi petdnevne ekskurzije, ki je organizirana kot obvezni del učnega načrta gimnazije. V času ekskurzije imenovane Magistrala dijaki spoznavajo zgodovino, kulturo in znamenitosti naše skupne bivše države Jugoslavije. Táko projektno učenje nedvomno plemeniti tako učitelje kot dijake. Učitelji pridobivajo in uporabljajo nove didaktične pristope, dijaki pa razvijajo svoje raziskovalne spretnosti, znanja in spretnosti uporabe IKT, sodelovalne spretnosti ter medkulturne sporazumevalne in jezikovne zmožnosti.

Ključne besede: *IKT, e-učenje, učni načrt, ekskurzija, projektno učenje, didaktika*

Abstract

The Specialist Grammar School is one of the three organizational units within the Kranj Educational Centre for Technical Sciences, which for sixty years has offered technical and vocational education. The incorporation of information and communication technologies (ICT) into the national curriculum core subjects and at the same time offering these subjects as extra-curricular activities is one of our most important goals.

This article represents how didactics and ICT might be interwoven into the course of a five-day excursion organized as part of the Specialist Grammar School's syllabus. During the Magistrala excursion students are acquainted with the history, the culture, and also the sights of Yugoslavia, the state of which we were once part. The added value of such project-based learning is that the activities undoubtedly enrich both teachers and students alike. Teachers learn and use new didactical approaches, and students are encouraged to develop their individual research skills, ICT skills, collaboration skills, cross-cultural communication skills, and language skills.

Key words: *ICT, e-learning, curriculum, excursion, project-based learning, didactics*

Informacijski sistem dijaškega doma

Information System of Boarding School

Bojan Jeram

Dijaški dom Vič, Gerbičeva ulica 51a, 1000 Ljubljana, Slovenija

Povzetek

Prispevek opisuje stanje v dijaških domovih (vzgojno izobraževalnih ustanovah) pred in po uvedbi informacijskega sistema. Prikazana je organiziranost, delovni proces ustanove in potek informacijskih tokov, ter pretekli poizkusi reševanja problema sodobnejšega načina vodenja pedagoške dokumentacije in pretoka informacij.

V nadaljevanju je opisana programska rešitev, ki omogoča računalniško izmenjavo podatkov, avtomatizira določene procese in predstavlja celovit informacijski sistem dijaškega doma.

Na koncu so navedeni še primeri kjer informatizacija (tudi zaradi zunanjih dejavnikov) še ni popolna, kar pa tudi omejuje uporabnost obstoječega informacijskega sistema.

Ključne besede: *dijaški dom, informacijski sistem, podatkovna baza, izmenjava podatkov*

Abstract

Contribution is describing condition in boarding schools (educationally educational institutions) before and after introduction of information system. Then is showed organization, working process of institution and flow of informations. Follows former attempts rescuing problems of more up-to-date manner guidances pedagogic documentation and flow of informations.

In continuation is described software solution that is allowing computer exchange of data, automates certain processes and presents complete information system of boarding school.

At last are listed examples where informatisation (also because of outside factors) still isn't complete, which also limiting usability of existent information system.

Key words: *boarding school, information system, data bases, exchange of data*

Spletni portal didaktične programske opreme v osnovni šoli

Didactic Software Web Portal in Elementary School

Alenka Jurančič

Osnovna šola Matije Valjavca Preddvor, Šolska ulica 9, 4205 Preddvor

Povzetek

V osnovni šoli uporabljamo vedno več didaktične programske opreme pri pouku. Za uporabo le-te se lahko udeležimo seminarjev. Praktično pa bi bilo tudi, ko bi lahko čim več informacij o posameznem programu dobili na spletnih straneh. V prispevku bo predstavljen spletni portal, na katerem so predstavljeni didaktični programi, ki jih uporabljamo v osnovni šoli. Namenjen je tako učiteljem posameznih predmetov kot tudi učiteljem računalnikarjem, ki te programe nameščajo. Učitelji lahko te vsebine dopolnjujejo, izmenjavajo izkušnje, sprašujejo po nasvetih ipd. Portal je izdelan z odprtokodnim programom Joomla!.

Ključne besede*: didaktična programska oprema, osnovna šola, sistemi za upravljanje vsebin, Joomla!*

Abstract

Nowadays, more and more didactic software is used in classroom in elementary school. To know how to deal with the software there are seminars at our disposal. It would be of great significance to get as many information about certain programme as possible on the web pages. A portal with didactic programmes will be presented in this article. It is supposed for teachers of special subjects and for computer science teachers who install the programmes. The contents can be supplemented, experiences exchaged and advice given etc. The portal is made with the help of open source programme Joomla!.

Keywords: *didactic software, elementary school, content management systems, Joomla!*

Metadata for Electronic Learning Resources

Metapodatki pri elektronskih učnih virih

Jernej Južna, Alenka Kavčič, Saša Divjak

University of Ljubljana, Faculty of Computer and Information Science
jernej.juzna@fri.uni-lj.si, alenka.kavcic@fri.uni-lj.si, sasa.divjak@fri.uni-lj.si

Abstract

Over the last decades, extensive catalogues and large repositories of educational content have been made available to schools, teachers and students. As the number of resources in these repositories continues to grow, the demand for better identification of resources is increasing: more precise and detailed tagging of resources is needed in order to enable teachers and learners quickly and easily search, find and access the needed learning materials.

The problem of identification of resources and consequently more accurate search can be solved by using better and richer metadata. Since creation of needed metadata is long-lasting and complex procedure, approaches how to deal with this issue are presented in this article. Social tagging and automated metadata generation are examples of such approaches.

The number of repositories that offer these resources is increasing as well, so extra attention is given to metadata exchange that provides a way to perform federated search. Since exchange between different systems can be made only by using standard formats, an insight of common standards is given as well.

Keywords: *metadata, creating metadata, social tagging, metadata standards, metadata exchange*

Povzetek

Šolam, učiteljem in učencem so na spletu na voljo obsežni katalogi in zbirke elektronskih učnih virov. Medtem ko se število virov v teh zbirkah neprestano veča, narašča tudi potreba po natančnejši identifikaciji teh virov, da lahko omogočimo uporabnikom hitro in enostavno preiskovanje, odkrivanje in dostop do potrebnih učnih materialov.

Problem identifikacije in natančnejšega iskanja rešujejo boljši in kvalitetnejši metapodatki učnih virov. Pridobivanje metapodatkov ni enostavno, saj so običajni postopki kompleksni in dolgotrajni. V članku je tako predstavljenih nekaj novih načinov, kako se omenjenim problemom izogniti, kot sta na primer: družbeno označevanje in avtomatsko pridobivanje metapodatkov.

Hkrati s številom učnih virov raste tudi število ponudnikov teh virov. Problem dostopnosti istega vira pri večih ponudnikih rešuje izmenjava metapodatkov, ki omogoča združeno iskanje. Predstavili smo tudi najpogostejše načine izmenjave metapodatkov in standardne formate zapisov, ki tako izmenjavo omogočajo.

Ključne besede: *metapodatki, pridobivanje metapodatkov, družbeno označevanje, standardi metapodatkov, izmenjava metapodatkov*

Simulation Based Group Learning

Učenje, podprto s simulacijskim modelom

Mirjana Kljajić Borštnar, Andrej Škraba, Vladislav Rajkovič, Miroljub Kljajić

University of Maribor, Faculty of Organizational Sciences, Kidriceva 55a, SI – 4000 Kranj, Slovenia
e-mail: {mirjana.kljajic, andrej.skraba, miroljub.kljajic, davorin.kofjac}@fov.uni-mb.si

Abstract

This article describes an experiment investigating simulation based group learning. For this purpose we have conducted a four-group Solomon experiment under four conditions: a_1) determination of strategy with application of the system dynamics (SD) model without group interaction with pretest, a_2) determination of strategy with application of the SD model and group information feedback with pretest, a_3) determination of strategy with application of SD model without pretest, and a_4) strategy determination with application of SD model and group information feedback without pretest. The observed variables were the criteria function values and frequency of simulation runs. The hypothesis that simulation model application and group feedback information positively influence the convergence of the decision process and contribute to faster decision-making was confirmed. A model of learning during the decision-making process was developed. Students' opinions were analyzed as well. The results show that management students thought that application of the simulation model do contributes to a greater understanding of the problem, faster finding of solutions and greater confidence in participants. All participants agree that clear presentation of the problem motivates participants to find the solution.

Ključne besede: *skupinsko odločanje, model učenja, sistemska dinamika, povratna zanka, načrt poskusa*

Povzetek

V prispevku so raziskani principi učenja, podprtega s simulacijskim modelom. V ta namen smo izvedli Solomonov poskus štirih skupin pod naslednjimi pogoji: a_1) definiranje strategije, podprto s simulacijskim modelom brez sodelovanja skupine s predtestom, a_2) definiranje strategije, podprto s simulacijskim modelom s sodelovanjem skupine s predtestom, a_3) definiranje strategije, podprto s simulacijskim modelom brez sodelovanja skupine brez pretesta (v zveznem času) ter a_4) definiranje strategije, podprto s simulacijskim modelom s sodelovanjem skupine brez pretesta (v zveznem času). Pri tem smo opazovali spremenljivki: vrednost kriterijske funkcije (kvaliteta odločitve) in pogostost simulacijskih tekov (dinamika iskanja rešitve). Domneva, da simulacijski model in sodelovanje skupine pozitivno vplivata na enostnost skupine in prispevata k hitrejšemu odločanju je bila potrjena. Razvili smo model, ki ponazarja učenje v procesu odločanja. Izvedli smo tudi mnenjsko anketo udeležencev poskusa. Rezultati ankete kažejo, da se študentje managementa strinjajo s trditvami, da uporaba siulacijskega modela v podporo odločanju pripomore k boljšemu razumevanju problema, hitrejšemu odločanju ter večjemu zaupanju udeležencev. Udeleženci so si enotni, da jasna predstavitev motivira udeležence k reševanju problema.

Keywords: *group decision, learning model, system dynamics, feedback, experiment design*

Narteh - E-učbeniki za izbrane naravoslovno-tehniške predmete

Narteh - E-Books for Selected Natural Science and Technical Subjects

Slavko Kocjančič

Pedagoška fakulteta, Univerza v Ljubljani, Kardeljeva Ploščad 16, 1000 Ljubljana
slavko.kocijancic@pef.uni-lj.si

Franc Vrbančič

ŠC Ptuj, Poklicna in tehniška elektro šola, Volmerjeva cesta 19, 2250 Ptuj
franc.vrbancic@guest.arnes.si,

Povzetek

V prispevku je pozornost usmerjena v opis, načrtovanje in pripravo e-gradiv z naravoslovnega področja pri dveh izbirnih predmetih v osnovni šoli (Robotika v tehniki, Elektronika z robotiko), enega obveznega predmeta v poklicnih šolah (Naravoslovje) ter povezovalnega e-učbenika temelječega na računalniško podprtem laboratoriju pri temah iz elektrotehnike in elektronike na srednjih tehniških šolah.

Podajanje informacij na daljavo predstavlja izziv tako za učitelje kot tudi za slušatelje, ki pri takem načinu pridobivanja znanja pomembno sooblikujejo ta proces. Pomembna cilja e-gradiv sta predvsem samostojno učenje in povečanje učinkovitosti vseh udeleženih v projektu.

Ključne besede: *e-vsebina, e-izobraževanje, naravoslovje, tehnika*

Summary

The paper outlines planning, development and contents of e-material for science and technology subjects; two optional subjects in primary school (Robotics and Electronics), one compulsory subject in vocational schools (Science) and e-material with a selection of computerised laboratory exercises developed for various subjects on electricity and electronics for secondary technical schools.

Providing educational material trough internet is a challenge both for teachers as well as for students who need to take their active role. The main goal is to promote autonomous learning and to increase efficiency of all participants in the project.

Key words: *e-contents, e-learning, science, technology*

Eksplozija živih distribucij

Live Linux distributions explosion

Andrej Kološvari

Aljaževa 6, 4248 Lesce, Slovenia
andrej.kolozvari@guest.arnes.si

Povzetek

Žive Linux distribucije lahko pomembno vplivajo na razvoj in uporabo IKT. V tem članku so preverjene njihove lastnosti. Open Source razvijalci so uspeli razviti množico kvalitetnih programskih rešitev in operacijski sistem, ki za uporabo ne potrebujejo zahtevne strojne opreme. Žive distribucije ustvarjajo tudi učinke javnega dobra in pomembno vplivajo na evolucijo celotne informacijske družbe.

Ključne besede: *Odprta koda, Linux, živa Linux distribucija, operacijski sistem, javno dobro*

Abstract

Live Linux Distributions has significantly affect on the IKT development and usage. This paper examines his properties. The Open Source developing group has managed to find a quality software solutions and an operating systems, that don't need powerfull hardware for its use. Some bootable Live Linux systems also affect as National Assets and have influence on evolution of information society.

Keywords: *Open Source, Linux, bootable Live Linux system, operating system, national assets*

Inovativni video snemalni sistem za osebe s posebnimi potrebami

An Innovative Video Recording System for Persons with Special Needs

Primož Kosec, Matjaž Debevc

Povzetek

Proizvodi informacijske in komunikacijske tehnologije so v vse večji meri posebej prilagojeni tudi za osebe s posebnimi potrebami. Prilagojena tehnologija običajno predstavlja del strojne opreme ali pa je to programska oprema, ki je namenjena temu, da se poveča, vzdržuje ali podpira funkcionalne zmožnosti oseb s posebnimi potrebami. To je lahko vsaka naprava ali tehnika, ki služi posameznikom, da lažje premostijo vsakdanje težave, ki so posledica njihove motnje, okvare oziroma prizadetosti. Iz tega razloga smo na inovativen način zasnovali video snemalni sistem, ki pravtako podpira elemente namenjene osebam s posebnimi potrebami. V pričujočem članku bo predstavljena struktura avtomatiziranega video snemalnega sistema, njegove lastnosti ter sam princip delovanja

***Ključne besede**: gluhi in naglušni, slepi in slabovidni, izobraževanje na daljavo, e-izobraževanje, informacijske in komunikacijske tehnologije, pretočni video, internet.*

Abstract

Products of information and communication technology that are adapted for persons with special needs can be seen more and more in everyday life. This technology adaptation is usually manifesting as a part of a hardware or as a software, designed to increase, maintain and support all features dedicated to persons with special needs. It could be a device or a technique for helping individuals to cross daily obstacles, which are a consequence of their disturbance or malfunction. For that reason, we have designed and built an innovative video recording system, which enables elements meant for persons with special needs. This paper presents the structure of our automatic video recording system, its functionalities and working scenarios.

***Keywords:** deaf and hard of hearing people, blind and hard of seeing people, distance learning, e-learning, information and communication technology, streaming video, Internet.*

Naj bo slika vredna tisoč besed?

Should a Picture Worth a Thousand Words?

Julija Lapuh Bele, Darko Bele, David Rozman

B2 d.o.o., Višja strokovna šola, Tržaška cesta 42, 1000 Ljubljana, Slovenija

julija.bele@b2.eu, darko.bele@b2.eu, david.rozman@b2.eu

Povzetek

Spletna učna gradiva postajajo vse pomembnejši učni viri. Tehnologija je danes že tako razvita, da se ne smemo zadovoljiti zgolj s prenosom klasičnih dokumentov v e-obliko. S pomočjo interaktivnosti in večpredstavnosti lahko učencem omogočimo boljšo učno izkušnjo in učinkovitejše učenje. Vendar pa tehnologija sama zase ne omogoča niti učinkovitejšega učenja, niti dobre učne izkušnje. Pri kreiranju spletnih izobraževalnih programov in spletnih učnih gradiv je zato potrebno upoštevati priporočila, ki so zasnovana na teoretičnih izhodiščih konstruktivizma in kognitivne teorije večpredstavnostnega učenja. Namen tega članka je podati priporočila, kako izdelati ustrezno večpredstavnostno gradivo in podati znanje za presojo, če je določeno večpredstavnostno gradivo ustrezno.

Ključne besede: *multimedija, večpredstavnost, spletno učenje, spletno učno gradivo, e-gradivo, eCampus*

Abstract

Web-Based Learning Contents (WBLCs) are becoming increasingly important learning sources. They should not be just transpositions of traditional learning materials into electronic formats. Constructivist theories of learning and cognitive theory of multimedia learning should be implemented to enhance learning and to ensure the learner a meaningful learning experience. WBLCs should be interactive and appropriately designed. The intention of this article is to give advice on how to create efficient WBLCs.

Keywords: *multimedia, web-based learning, web-based learning content, eCampus*

Model odličnosti za zviševanje ravni pismenosti ali kako smo v mreži SIMOS opismenjevali učence?

Model of Perfection Used for Increasing Literacy Level – SIMOS' Influence in Increasing Pupils' Literacy Level

Marija Lubšina Novak

Osnovna šola Brežice, Levstikova 18, 8250 Brežice
marija.lupsina@guest.arnes.si

Povzetek

Model odličnosti za zviševanje ravni pismenosti s pomočjo orodij informacijsko-telekomunikacijske tehnologije, imenovanega Od kakovosti k odličnosti predstavlja nadgradnjo modela Pot od kakovosti k odličnosti, ki ga že nekaj let izvajamo na Osnovni šoli Brežice, in sicer v tistem njegovem delu, ki se skriva pod »klobukom« Knjiga plus, kot delovno imenujemo podprojekt. (Lubšina Novak, 2005, 123)

Nadgradnjo pomeni zato, ker je dobil aprila 2006 na javnem razpisu Ministrstva RS za šolstvo in šport za sofinanciranje mrež vzgojno-izobraževalnih organizacij na področju ugotavljanja in razvijanja kakovosti v letih 2006 in 2007 možnost in priložnost, da skupaj s še šestimi osnovnimi šolami iz različnih slovenskih regij ter z zunanjimi sodelavci, drugimi javnimi zavodi (ZRSŠ), podjetji oplemeniti in razvija osnovno idejo nenehnega izboljševanja nivoja vseh vrst pismenosti pri osnovnošolcih - www.simos.si.

V model smo strnili vrsto ločenih pobud: od vseživljenjskega učenja in uveljavljanja kompetenčnega pristopa do razvoja vseh vrst pismenosti s pomočjo orodij informacijsko- telekomunikacijske tehnologije ter Evropskega modela odličnosti kot filozofije nenehne rasti in izboljševanja ter kot orodja za evalvacijo in samoevalvacijo.

Delo mreže SIMOS je delno sofinancirano iz Evropskih socialnih skladov, delno pa je podprto s sredstvi Ministrstva za šolstvo in šport Republike Slovenije.

***Ključne besede**: pismenost, orodja informacijsko-telekomunikacijske tehnologije, kakovost, odličnost, vseživljenjsko učenje, kompetenčni pristop, model odličnosti, mreža šol.*

Abstract

Model of perfection used for increasing literacy level in cooperation with ICT tools termed "From quality to excellence" presents the upgraded model of the "The path from quality to excellence" project which has already been carried out by Brežice Elementary School for several years. Its presence can be found amid the subproject called "Book Plus". (Lubšina Novak, 2005, 123)

In April 2006 the Slovenian Ministry of Education and Sport published a public tender for co-financing the educational organization network in the field of ascertaining and developing quality in the years 2006 and 2007 giving Brežice Elementary School an opportunity to co-operate with six other elementary schools from various Slovenian districts and other public institutions, firms, publishing houses…The principal idea of the project is to refine and develop all literacy levels in elementary schools – www.simos.si.

The model of perfection combines different strategies including long life learning, competency approach, literacy development with IKT and the use of the European model of perfection as a philosophy of constant growth and improvement and as an instrument for appraisement and self-evaluation.

The project is partially financed by the European Social Funds and the Slovenian Ministry of Education and Sport.

Keywords: *Literacy, ICT devices, quality, excellence, long life learning, competency approach, the model of perfection, school network*

Teaching Information Systems Technology in Partnership with IT Companies

Poučevanje tehnologije informacijskih sistemov v sodelovanju z računalniškimi podjetji

Viljan Mahnič

Univerza v Ljubljani, Fakulteta za računalništvo in informatiko
viljan.mahnic@fri.uni-lj.si

Abstract

We describe an example of partnership between university and some major IT companies – IBM and Microsoft – in teaching a course on information systems technology. The course is taught in the fifth (final) year of the university undergraduate program when students have already mastered the basic theoretical knowledge of information systems development. For this reason the course content was restructured in order to pay more attention to practical experience and learning opportunities available within the environment of professional industry. During the course, students get acquainted with IBM and Microsoft products and tools that support the development of Web-based information systems. Special attention is devoted to group project work, which is not only intended for the improvement of technical skills, but also for the aqusition of transferrable skills like teamwork, management/leadership, planning and organizing, presentation and documentation, information search, etc. We describe our experience after teaching the course in the academic years 2005/06 and 2006/07. A description of the course content is given and the results of a survey among students are presented. Students responded favourably to the new approach and found the course very useful and interesting.

Keywords: *computer engineering education, university-industry co-operation, group project work, information systems technology*

Povzetek

Prispevek opisuje primer sodelovanja med Fakulteto za računalništvo in informatiko in podjetjema IBM in Microsoft pri izvajanju predmeta Tehnologija informacijskih sistemov. Predmet je na programu v petem (zadnjem) letniku univerzitetnega študija, ko študenti že obvladajo temeljna teoretična znanja o razvoju informacijskih sistemov. Zato smo prilagodili njegovo vsebino tako, da je večji poudarek namenjen pridobivanju praktičnih izkušenj v profesionalnem delovnem okolju. V okviru predmeta se študenti seznanijo z orodji in rešitvami, ki jih za razvoj spletnih informacijskih sistemov ponujata IBM in Microsoft. Posebna pozornost pa je namenjena delu na projektih, katerih namen ni samo poglabljanje tehničnega znanja, ampak tudi pridobivanje sposobnosti za skupinsko delo, vodenje, načrtovanje in organizacijo, pripravo predstavitev in medosebno komuniciranje, iskanje informacij ipd. V prispevku so opisane naše izkušnje s poučevanjem nove vsebine predmeta v študijskih letih 2005/06 in 2006/07. Predstavljena je vsebina predmeta in rezultati ankete, ki smo jo izvedli med študenti. Študenti se strinjajo z novim pristopom in ocenjujejo, da je tako zasnovan predmet zanimiv in koristen.

Ključne besede: *izobraževanje inženirjev računalništva, sodelovanje univerze z gospodarstvom, skupinsko delo na projektih, tehnologija informacijskih sistemov*

Nekateri vidiki priprave e-učnih gradiv - primer projekta Rural-eGov

Marjeta Marolt, Gregor Skumavc

marjeta.marolt@fov.uni-mb.si, gregor.skumavc@email.si

Povzetek

Vseživljenjsko izobraževanje je ključnega pomena za uspešnost in konkurenčnost tako podjetij kot tudi posameznikov. Z vedno hitrejšim tempom življenja je pomembno, da je podajanje znanj in novih spretnosti učinkovito. Z vpeljavo e-izobraževanja se potreba po fizični in časovni prisotnosti zmanjšuje, vendar se s tem sorazmerno povečuje potreba po kakovostnih in učinkovitih e-učnih gradivih. V pričujočem članku so predstavljene konfiguracije e-izobraževalnih proizvodov za pripravo in posredovanje e-učnih gradiv, glavni del pa je namenjen predstavitvi nekaterih smernic za pripravo e-učnih gradiv, da bodo v kar največji meri lahko ustrezali pedagoškim in tehnološkim načelom. Obravnavana tematika je predstavljena na primeru projekta Rural-eGov.

Ključne besede: *e-učno gradivo, e-izobraževanje, e-izobraževalne tehnologije*

Abstract

Lifelong learning is of key importance for companies' and individuals' success and competitive position. Because our life tempo is rapidly getting faster, it is more and more important that teaching new skills and knowledge is efficient. With e-learning, the need for learner's physical and time presence has become obsolete, though the need for quality and efficient e-learning materials has become more apparent. In the following article some of the products for authoring and distribution of e-learning materials are presented. The main part is focused on different guidelines for e-learning materials, so that they can meet the demands of pedagogical and technological principles. The above mentioned topics are presented through Rural-eGov project.

Keywords: *e-learning material, e-learning, e-learning technologies*

Spodbujanje ustvarjalnosti v izobraževalnem procesu

Stimulation of Creativity in Educational Process

Janez Mayer, Neja Zupan

Univerza v Mariboru, Fakulteta za organizacijske vede

Povzetek

V prispevku prikazujemo rezultate anketiranja absolventov univerzitetnega in visokošolskega strokovnega študija na Fakulteti za organizacijske vede. Mnenja kažejo, da naš izobraževalni sistem ne spodbuja ustvarjalnosti in ne izobražuje za ustvarjalnost, marveč celo proti njej. Izkazalo se je, da nagrajevanje ustvarjalnih dosežkov drastično pada od osnovne preko srednje šole do fakultete, kjer pade celo pod povprečno vrednost. Rezultati so zaskrbljujoči, zaradi rastoče potrebe inovativnosti, ki je danes predpogoj za uspešno in rastoče gospodarstvo, s tem pa tudi uspešno družbo. V prispevku so podane smernice razvoja izobraževalnega sistema v smeri spodbujanja ustvarjalnosti, ki je v vsakem človeku.

Ključne besede: *ustvarjalnost, izobraževanje, starši, osnovna šola, srednja šola, fakulteta*

Abstract

In this paper results of the survey on creativity stimulation in educational process are presented. The survey was conducted at the Faculty of organizational sciences University of Maribor. Results show that our educational system does not encourage creativity but also influence against creativity. Rewarding results of creativity drastically decrease from primary school to faculty. At the faculty results showed the lower values according to rewarding creativity. Results are of a big concern while today's economy is based on innovativeness and creativity. In this paper we recommend directions for development of educational system that support and reward creativity.

Keywords: *creativity, education, parents, primary school, secondary school, faculty*

Možnosti uporabe spletnih simulacij pri pouku fizike

Robert Murko

Osnovna šola Videm, Videm pri Ptuju 47, 2284 Videm pri Ptuju
robert.murko2@guest.arnes.si

Povzetek

V članku bom nakazal nekaj novih možnosti uporabe spletnih simulacij pri pouku fizike. Možnosti in prednosti, ki nam jih nudijo simulacijski modeli. V želji po novih simulacijah, ki bi jih uspešno uporabili pri pouku fizike in s tem prispevali k višjemu nivoju znanja in lažjega razumevanja sem na spletni strani Physics Education Technology (http://phet.colorado.edu) poiskal nekaj primernih simulacij za pouk fizike. Njihova spletna stran omogoča brezplačen dostop do simulacij, ki so v večini narejene v javi in flashu. Omogočeno je tudi tako imenovano »off« delovanje. Instalacija je enostavna in uporabniku prijazna. Zato se lahko vsi učitelji in učenci poslužujejo obeh načinov uporabe. Opisal sem simulacije in navedel kaj nam simulacije vse omogočajo ter pri kateri učni temi jih lahko uporabimo pri pouku fizike. Uporaba je razdeljena po sklopih v osmem in devetem razredu.

Ključne besede: *fizika, simulacije, pouk, računalnik, vzgojno-izobraževalni proces*

Abstract

The article is going to point out some of the new possibilities of using simulations in teaching Physics. Possibilities and advantages offered by simulation models. In the desire for new simulations that could be successfully used in teaching Physics and could by that contribute to a higher level of knowledge and better understanding I have found quite a few appropriate simulations for teaching Physics on the web site Physics Education Technology http://phet.colorado.edu/. Their site enables a free access to simulations that are mostly made in java and flash. A function called "off" function is also possible. Installation is simple and user friendly therefore all teachers and students can use both ways of usage. I have described the simulations and add what do the simulations enable us and also at what stage or topic in teaching Physics they can they be used. The use is divided by chunks in the 8th and 9th grade.

Keywords: *Physics, simulations, teaching, a computer, the educational process*

Večparametrski hierarhičen model za svetovanje pri izbiri izbirnega predmeta

Hierarchical multiattribute model for giving advice your optional subject

Robert Murko

Osnovna šola Videm, Videm pri Ptuju 47, 2284 Videm pri Ptuju
robert.murko2@guest.arnes.si

Povzetek

V prispevku želim s pomočjo metod umetne inteligence iz baze podatkov o uspehu pri posameznih predmetih ugotoviti pravila za uspešno izbiro izbirnih predmetov v tretji triadi. Postaviti želim večparametrski hierarhičen model za izbor izbirnega predmeta glede na dosežen uspeh pri posameznih predmetih in zaključni uspeh v prejšnjem razredu. Osredotočil se bom na tri predmete, in sicer iz družboslovnega sklopa bo to drugi tuji jezik nemščina in vzgoja za medije, iz naravoslovno-tehničnega sklopa pa izbirni predmet obdelava gradiv. Iz baze podatkov o uspehu v drugi triadi bom poiskal kriterije, ki so glavni prediktorji za uspeh pri izbirnem predmetu. Z metodo odkrivanja znanja iz podatkov bom poiskal te povezave. V prispevku se bom zaenkrat omejil na matično šolo. Bazo znanja si bom zagotovil s pomočjo strojnega učenja in ostalih postopkov rudarjenja na bazi podatkov o učencih in izbirnih predmetih. Prispevek je pripravljen kot začetek dela na tem področju in zaradi večje preglednosti ter lažjega razumevanja osnovne ideje so zajeti samo nekateri podatki in ne vsi, ki so na razpolago in omogočajo še kvalitetnejše rezultate. Cilj je olajšati izbiro izbirnega predmeta učencem in jim tako zagotoviti najvišjo kvaliteto izobraževanja.

Ključne besede: *umetne inteligence, izbirni predmeti, devetletka, izbira, odločitveno drevo*

Abstract

The aim of the project is to determine the rules for a successful choice of elective subjects in the third triad of primary school by the use of artificial intellect methods and by taking data from achievements at different subjects. Another aim is to set up hierarchical multiattribute model for choosing an elective subject according to achievements in certain subjects and final achievement mark in last period primary school. The focus of the project are three subjects, second foreign language German and Media education from the social-humanistic complex and Material handling from natural-technical complex. The data about achievements in the second triad are the basis for establishing criteria that are the main predictors for being successful at certain elective subject. These relations are found by using a method where knowledge is detected from data. The project is limited to the central school. The base of attainments is going to be assured by using machine learning and other mining procedures on the basis of students' and elective subjects' data. The project is prepared as a starting point in this field therefore to get a clearer view and for the sake of better understanding of the principals not all but only a few available data is included that enable better quality results. The purpose is to alleviate the choice of choosing an elective subject and assure the students the best possible quality of education.

Keywords: *artificial intellect, an elective subject, 9-year primary school, a choice, a decision making tree*

Sodobna podružnična šola v luči informatizacije

Contemporary Branch School in a Light of ICT

Fani Nolimal

Zavodu RS za šolstvo

Povzetek:

O sodobni podružnični šoli govorimo, kadar je le-ta demokratično vodena, izpolnjuje številne materialne, organizacijske in strokovne pogoje ter s poučevanjem in učenjem zagotavlja kakovostno znanje. Eden pomembnih kazalcev kakovosti je opremljenost s sodobno IKT in funkcionalna raba le-te. Glede na to, da so bile podružnične šole v svoji zgodovini na področju materialne opreme večinoma zapostavljene, smo z empirično raziskavo, predstavljeno v prispevku, ugotavljali opremljenost tovrstnih šol z IKT, strokovno usposobljenost učiteljev in funkcionalno uporabo navedene opreme. Rezultati so spodbudni – razvoj podružnic na področju IKT je bil v zadnjih treh letih velik, prav tako tudi trendi razvoja, kar sledi iz primerjave rezultatov iz leta 2003 in 2007. Tako ugotavljamo, da je bilo opremljanje podružnic in usposabljanje učiteljev v številnih delavnicah uspešno in da je tem trendom razvoja potrebno slediti tudi v bodoče, kajti le tako bodo tovrstne šole v mreži vseh osnovnih šol konkurenčne.

Ključne besede: *sodobna podružnična šola, kazalci kakovosti, IKT (informacijska komunikacijska tehnologija), opremljenost podružnic, trendi razvoja, funkcionalna raba IKT*

Abstract

A local branch school can be called contemporary when it is managed in a democratic way, has adequate material basis, highly qualified professional staff and also assures acquisition of qualitative knowledge. One of the important indicators of quality of schools is the ICT equipment and its use. Due to the fact that branch schools have often been neglected in the past decades in terms of quality ICT and other equipment, we conducted an empirical study which is presented in this paper. We studied the technical equipment of branch schools, in particular the ICT, professional qualifications and skills of teachers and their use of ICT. From the comparison of years 2003 and 2007 we can conclude that the results are optimistic. Therefore we can ascertain that the investment into the improvement of school material conditions and teacher development and training have been successful. Needless to say, these trends of development should be followed also in the future.

Keywords: *contemporary branch school, indicators of quality , ICT (information and communication technology), material conditions of branch schools, trends of development , functional use of ICT*

Robotki za osnovnošolce

Lego Robots for Pupils in Primary Schools

Sergeja Osredkar

Osnovna šola Tržič, Šolska ulica 7, 4290 Tržič
sergeja.osredkar@guest.arnes.si

Povzetek

Živimo v družbi, ki se zaradi stalne potrebe po še boljšem razvija z enormno hitrostjo. V zadnjih desetletjih se je v številnih industrijskih procesih utrdila nova veda – robotika.

Robotika uporablja znanja številnih področij, kot so senzorji, merjenja, regulacije, računalniška simulacija, mikroračunalništva, proizvodnih sistemov, umetna inteligenca. To je nova vrsta znanja, tako imenovana mehatronika.

Učenci bi se zato morali z robotiko začeti spoznavati že zelo zgodaj. Vsled temu se v osnovne šole počasi prebijajo posebne vrste robotov - Lego roboti. Gre za iz kock sestavljene različne vrste vozil (lahko tudi robotek v obliki človeka), ki se premikajo po predhodno sestavljenem programu. Programiranje je prav tako podobno sestavljanju kock. Za otroke taki robotki pomenijo združeno spoznavanje izdelave tehničnih elementov kakor tudi enostavno programiranje. V članku sta opisani dve vrsti Lego robotkov, prav tako tudi način programiranja le-teh.

Ključne besede*: robotika, mehatronika, Lego Mindstorms, RCX, NXT, robot*

Abstract

Our society is becoming more and more technologically developed. During the past decades, robotics has gained its place in many industrial processes. In robotics a lot of knowledges from many different areas are used, such as sensors, measurements, regulations, computer simulations, microcomputering, product systems, artificial intelligence. This is so called mechatronics.

That's why it is necessary to make sure that the basics of robotics are included in curriculums in primary schools. There is a special kind of robots, the so-called Lego robots, which are well adjusted to children's developing level. There are cars and other shapes, made of bricks, moving by the previously made program. The programming is also similar to assembly of bricks. To children, Lego robots represent an interesting way of familiarization with the making of technical elements, as well as with the simple programming. In this article there are two different systems of Lego Mindstorms described.

Keywords: *robotics, mechatronics, Lego Mindstorms, RCX, NXT, robot*

Uporaba informacijske tehnologije pri poučevanju zdravstvene nege

Using of Information Technology in Nursing Care Education

Elizabeta Pikovnik

Srednja zdravstvena šola Ljubljana,Poljanska cesta 61, 1000 Ljubljana, Slovenija
elizabeta.pikovnik@guest.arnes.si

Povzetek

Danes je že splošno znano dejstvo, da učitelji vedno bolj uporabljajo informacijsko-komunikacijsko tehnologijo v izobraževanju. V članku avtorica prikaz uporabo avdiovizualnih sredstev pri pouku zdravstvena nega iz didaktičnega vidika. Prikazani so tudi

simulatorji negovalnih intervencij zdravstvene nege ter nekateri primeri uporabe poučevanja informacijske tehnologije v tujini. V nadaljevanju je prikazan izobraževalni film Zdravstvena nega, ki je nastal v sodelovanju Centrom za poklicno izobraževanje. Izobraževalni film vsebuje prikaz negovalnih intervencij zdravstvene nege, ki jih poučujemo pri pouku Zdravstvena nega ter Pomoč in oskrba v izobraževalnem programu tehnik zdravstvene nege in bolničar negovalec.

Ključne besede*: zdravstvena nega, poučevanje, učna gradiva, informacijska komunikacijska tehnologija*

Summary

Today, the application of information-communication technology by teachers is a generally known fact. The authors of the article present the didactic viewpoints of the application of audio-visual means in nursing care training. Simulators of nursing interventions are discussed together with some examples of information technology teaching in different countries. The educational movie »Nursing care«, produced in collaboration with The Center for Vocational Training is also presented. The movie presents the nursing interventions that are being taught in the programs Medical nursing care and Assisstance and care in the educational program Medical Health technician and Medical care assistant.

Keywords: *nursing care, teaching, learnig materials, information and communication technology*

Games for Learning and Learning from Games

Igre za učenje in učenje iz iger

Maja Pivec[1], Paul Kearney[2]

1 Information Design, FH JOANNEUM, University of Applied Sciences, Graz, Austria,
maja.pivec@fh-joanneum.at

2 Deakin University/UNITEC School of Information Technology, Auckland, New Zealand,
pkearney@unitec.ac.nz

Abstract

This paper details a model of game-based learning and suggests how this can be applied to both the playing of computer games and learning within the classroom environment. The authors document the results from a University level course, created in the form of a role-play for designing educational games, and highlight the student's attitudes and beliefs towards game design as a career. They also suggest that educational games can be used successfully for the transference of knowledge to domains outside the world of computer games, and highlights several case studies in the area of health and medicine.

Keywords: *game-based learning, recursive loops of learning, games for learning*

Povzetek

V prispevku je predstavljen model učenja na osnovi iger in možnosti uporabe modela v različnih okoljih: pri igranju iger kakor tudi pri uporabi iger za učenje v razredu. Opisane so izkušnje in rezultati tečaja na univerzitetni ravni, ki je bil zasnovan kot role-play igra, ter mnenja študentov o poklicni karieri na področju koncepcije iger za učenje. Znanje, pridobljeno s pomočjo iger za učenje, je moč uspešno uporabljati in prenesti v različne domene izven računalniških iger, kar je prikazano na primerih in študijah iz zdravstva.

Ključne besede: *učenje na osnovi iger, rekurzivne zanke učenja, igre za učenje*

Educational Challenges of E-representation of International Classification of Nursing Practice

Izobraževalni izzivi e-predstavitve Mednarodne klasifikacije prakse zdravstvene nege

Uros Rajkovič[1], Olga Šušteršič[2], Vladislav Rajkovič[1,] Darja Cibic[3]

1 University of Maribor, Faculty of Organizational Sciences, Kidričeva cesta 55/a, SI-4000 Kranj, Slovenia
uros.rajkovic@fov.uni-mb.si, vladislav.rajkovic@fov.uni-mb.si

2 University of Ljubljana, College of Health Studies, Poljanska cesta 26/a, SI-1000 Ljubljana, Slovenia
olga.sustersic@vsz.uni-lj.si

3 Ministry of Health of Republic of Slovenia, Štefanova 5, SI-1000 Ljubljana, Slovenia
darja.cibic@gov.si

Abstract

Teaching about classifications plays an important role also in nursing education. International Classification for Nursing Practice is a unified professional language devoted to nurses, other health workers and broader. In the paper the e-version of classification is presented as a challenge for efficient educational practice searching for new information solutions in different environments using information and communication technology. Browsers on personal computer, internet and PDA-hand-held computers are presented. Combination of those browsers in education in health-care is analyzed.

Keywords: *education, health care, nursing, classifications, information technology*

Povzetek

Klasifikacije zasedajo pomembno mesto v izobraževanju zdravstvenih delavcev. Mednarodna klasifikacija zdravstvene nege je poenoten profesionalni jezik namenjen medicinskim sestram, drugim zdravstvenim delavcem in pa tudi laikom. V članku je predstavljena e-oblika klasifikacije kot izziv za učinkovito izobraževanje z uporabo sodobne informacijske in komunikacijske tehnologije. Predstavljene so rešitve za osebne računalnike, na spletu in za dlančne računalnike. Analizirana je kombinacija treh predlaganih rešitev kot možnost za uspešno izobraževanje v zdravstvu.

Ključne besede: *izobraževanje, zdravstvo, zdravstvena nega, klasifikacije, informacijska tehnologija*

Odločitveni model za pomoč pri izbiri dobavitelja igral v vrtcu

Ribič Marko

Žiče 98, 3215 Loče, Slovenia, 031-336-315
ribic23@yahoo.com

Povzetek

Več vrtcev v Sloveniji se ubada s problemom slabega stanja ali celo pomanjkanja zunanjih igral za otroke . Zaradi tega je vse večji pritisk na občine, ki financirajo vrtce. Zato smo se odločili, da predstavimo možnosti odločanja pri takih nakupih z večparametrskim odločitvenim modelom. S pomočjo le-tega smo izbrali najboljšega dobavitelja zunanjih igral, ki glede na kriterije najbolj ustreza zahtevam vrtca. Največ pozornosti in časa pri odločitvenem modelu smo posvetili smotrnosti in pravilnosti kriterijev, saj je od njih najbolj odvisna pravilna izbira.

Na splošno je predstavljen pomen vrtcev in gibanja otrok ter s tem razjasnjen pomen zunanjih igral in upoštevanje predpisanih standardov za zunanja igrala. Program DEXi smo uporabili pri izdelavi modela za ocenjevanje ponudbe dobaviteljev zunanjih igral za vrtec. Rezultate smo analizirali in vrednotili tudi v programu Vredana, kjer smo naredili tudi primerjalno analizo Kaj – če.

Ključne besede: *DEXi, večparametrski odločitveni model, odločanje, vrtci.*

Abstract

Many kindergartens in Slovenia are affected by the problem of bad conditions or even insufficiency regarding outside toys for children. As consequence, there is greater pressure on municipalities that finance kindergartens. This is why we decided to introduce possibilities of decision-making by means of multi-attribute decision making at such buyings. With its help the best supplier of outside toys that suited to kindergarten demands, was chosen. Attention and time were dedicated to decision making model and to the regularities of criteria because the correct choice mainly depends on these criteria.

The importance of kindergarten and children`s exercise are generally presented and the necessity of outside toys is clarified. The fulfilment of current standards for outside toys was included. In the process of model making assessment for the suppliers of outdoor toys for kindergarten we used the DEXi program. The results were also analysed and evaluated by the Vredana program enabling us to carry out also a comparative analysis What – if.

Keywords: *DEXi, multi-attribute decision making, decision making, kindergarten*

Matura iz matematike v luči tehnologije

Final External Examination - Matura in the View of Technology

Katarina Roškar, Matija Lokar

Univerza v Ljubljani, Fakulteta za matematiko in fiziko
katarina.roskar@student.fmf.uni-lj.si, matija.lokar@fmf.uni-lj.si

Povzetek

Razvoj informacijske tehnologije in še posebej programov oziroma sistemov za simbolno računanje (SSR) ponuja nova orodja in neizogibno vpliva na metode in cilje matematičnega izobraževanja. SSR spreminjajo matematični svet in te spremembe je potrebno ustrezno vključiti tudi v matematični izobraževalni sistem. V zvezi s tem se poraja veliko pomembnih vprašanj. Eno ključnih je vpliv na preverjanje znanja. Trenutno so na maturitetnem pisnem izpitu iz matematike dovoljena le standardna (znanstvena) računala. V luči naraščajoče uporabe SSR si bomo pogledali izbrane maturitetne naloge in jih uvrstili v razrede petih različnih razvrstitev, ki merijo koristnost in vpliv sistemov za simbolno računanje na izpitna vprašanja. Predstavili bomo tudi sistem spletnih strani, zasnovan kot wiki, kjer se zbirajo pričujoče analize, ki bodo v pomoč pri uvajanju tehnologije v učni proces.

Ključne besede: *Matura, tehnologija, preverjanje znanja, sistemi za simbolno računanje, SSR*

Abstract

The development of information technology and, especially, programs or computer algebra systems (CAS) o_ers new tools and inevitably influences the methods and goals of mathematical teaching and learning. CAS are reshaping the mathematical landscape and the mathematical education system should reflect these changes. Many questions arise concerning this fact. One of the key questions is the influence on assessment. At the moment only standard (scientific) calculators are allowed during the Matura examination. In the view of emerging usage of CAS, we will take a look at couple of exam questions and classify them according to five di_erent schemes which measure the usefulness and the impact of computer algebra systems on exam questions. We shall also present the wiki based pages, where analyses as this one accumulate and shall serve as a helpful tool in introducing technology into the teaching process.

Keywords: *Matura, external examination, technology, assessment, Computer Algebra Systems, CAS*

Spletno projektno delo

Web Project Work

Sašo Stanojev

Srednja trgovska šola Kranj, Župančičeva 22, 4000 Kranj
saso.stanojev@guest.arnes.si

Povzetek

IKT ponuja veliko priložnosti za izboljšanje procesa učenja in poučevanja. Cilj uvedbe spletnega projektnega dela je omogočiti dijaku zbiranje znanja z različnih področij in pridobivanje izkušenj, kot so sodelovanje, komuniciranje in samostojno učenje.

Aplikacija Webcollab je enostavna za uporabo in spodbuja uporabnike k skupnemu delu. Je funkcionalno ustrezna in nezahtevna za uporabnike. Dijakom omogoča ustvarjanje, vzdrževanje in upravljanje njihovih nalog, različnih dokumentov in delo v skupini.

***Ključne besede**: Projektno delo, sodelovanje, Webcollab, odprta koda*

Abstract

ICT offers many opportunities to improve process of learning and theaching. Implementing Web project work is a learning experience, which aims to provide pupils with the opportunity to synthesise knowledge from various areas of learning. This process enables them to acquire skills like collaboration, communication and independent learning.

WebCollab is easy to use, and encourages users to work together. The software is functionally elegant, without being cumbersome for users. Pupils have chance to create, maintain and manage their tasks, arhive different documents and work as a group.

***Keywords:** Project work, collaboration, Webcollab, open source*

Spletne strani ─ ogledalo življenja in delovanja dijaške skupnosti

Websites ─ The Mirror of Pupils Community Life and Activities

Polona Tomac Stanojev

Ekonomska šola Kranj (Srednja poklicna in strokovna šola), Kidričeva cesta 65, 4000 Kranj
polona.tomac@guest.arnes.si

Povzetek

Povezanost med šolo in njenimi dijaki poteka na različnih področjih, med katerimi je tudi šolska dijaška skupnost. Ker so dijaki vsakodnevno vključeni v različne dejavnosti in dogodke, jim postavitev spletne strani dijaške skupnosti pomaga zlasti pri tem, da si lahko posredujejo ter izmenjujejo različne informacije in izkušnje, vnašajo spletne vsebine, sodelujejo v forumih in izražajo svoja mnenja.

Joomla je namreč aplikacija, ki omogoča upravljanje spletnih vsebin brez potrebnega znanja o spletnem programiranju.

Prihodnost načrtovanja in izvajanja različnih šolskih dejavnosti je povezana z njihovo spletno predstavitvijo, s čimer se šola, ki skuša to uvajati in uresničevati, promovira kot moderna, dijakom, staršem in učiteljem prijazna ustanova.

Ključne besede: *dijaška skupnost, spletna stran, Slojoomla*

Abstract

Connection between school and pupils takes place in different areas. One of them is certainly school pupils community. Pupils are involved in many different activities and events on a daily basis. The best way of sharing their information and experiences is setting up a website and enable them to write web contents, take part in forums and to express their own opinions.

Joomla content management system is a great application, that can be used for managing website contents without knowing anything about programming.

The future of school activity is connected with their web presentations, so it shows the school as a modern, student, parents and teacher friendly institution.

Keywords: *pupils community, website, Slojoomla*

Učni cilji pouka računalništva v osnovni šoli – *slovenski in ACM K12 kurikulum*

Learning Aims for Computer Science in the Elementary School – Slovenian and ACM K12 Curriculum

Matejka Tomazin[1], Andrej Brodnik[2]

Škocjan 45/a, 6000 Koper

2 Univerza na Primorskem, Pedagoška fakulteta, Cankarjeva 5, 6000 Koper,
andrej.brodnik@upr.si

Povzetek

Z uvedbo devetletke, je računalništvo kot izbirni predmet spet ugledalo luč sveta. Kurikulum za pouk Računalništva še ni bil opredeljen, učbenikov ali delovnih zvezkov za računalništvo ni bilo. V ospredje je prišla ideja o vključevanju informacijsko komunikacijske tehnologije v osnovno šolo, zaradi vedno večje odvisnosti človeka od njene uporabe. Nezadostno poučeni in nepripravljeni učitelji so morali pogosto prirediti učne cilje pomanjkljivim učnim sredstvom in svojemu pomanjkljivemu znanju.

Ker je računalništvo še vedno le izbirni predmet in se ga učenci udeležijo le po lastni izbiri, ga tako površno zastavljen šolski sistem še vedno zadržuje na stopnji krožka in ne priznava nepogrešljive vloge, ki jo ima v današnji družbi.

Medtem je vodilna svetovna strokovna organizacija za področje računalništva in informatike ACM (Association for a Computing Machinery) pričela oblikovati navodila za poučevanje računalništva in informatike od vrtca do konca srednje šole, ki so jih tudi pričeli uporabljati v vrsti držav. Priporočila bi lahko uporabili tudi za opredelitev in prenovo učnih ciljev za poučevanje predmeta v Sloveniji. Postavlja se osnovno vprašanje: »Ali je slovenski kurikulum za Računalništvo sploh dobro oblikovan?«

Ključne besede: *kurikulum, K12, IKT, primerjava, prenova*

Abstract

With the nine-year elementary school, Computer Science re-appeared as an elective subject. However, there was virtually no curriculum for Computer Science to be used, no textbook, no exercise book. There was only an idea to include information and communication technology in the elementary school, because of society's growing dependence on it. Not properly trained and severely underprepared teachers had to adapt competency goals to the inappropriate teaching equipment.

Because Computer Science is still only an elective subject and hence students attend it at their own will, the quality and importance of the subject is still at the level of an out-of-class activity not recognizing its indispensable role in the modern society.

Meanwhile, the leading international professional society ACM (Association for a Computing Machinery) started forming guidelines for teaching curriculum for Computer and Information Science from Kindergarten to Grade 12 (K12) that are already used in several countries. The guidelines could be also used as a reference to define and renew competency goals for teaching in Slovenia. There appears a fundamental question: "Is the Slovenian curriculum for Computer Science well designed?"

Keywords: *curriculum, K12, ICT, comparison, renewal*

Sistem za podporo e-izobraževanju na Višji strokovni šoli

Vocational College Learning Management System

Janko Uhan

Tehniški šolski center Kranj, Kidričeva 55, 4000 Kranj
janko.uhan@guest.arnes.si

Povzetek

Višja strokovna šola za mehatroniko je kot ena od enot Tehniškega šolske centra Kranj pričela z izvajanjem izobraževalnih programov v študijskem letu 2005/2006. V letošnjem študijskem letu je vpisanih 280 študentov, za izvajanje programa skrbi 23 predavateljev. Za podporo e-izobraževanju smo izdelali spletno aplikacijo, namenjeno študentom, predavateljem in vodstvu šole. V prispevku so opisani razlogi, zaradi katerih smo se odločili za izdelavo lastne rešitve, sama izvedba ter izkušnje, ki smo jih pridobili pri tem obsežnem projektu.

Ključne besede: *IKT, informacijski sistem, spletna aplikacija, e-izobraževanje, sistem za podporo e-izobraževanju, komunikacija, sistem za upravljanje z vsebinami, gradiva, internet*

Abstract

The Vocational College of Mechatronics was established as a department within the Kranj Educational Centre for Technical Sciences and started its education programme in the school year 2005/2006. During the current study year 280 students have enrolled, and their training programme is overseen by 23 lecturers. A special web application was created in order to enable the IT support of the students, as well as the teaching and non-teaching staff of the Vocational College. This paper explains the reasons for creating our own information system, focusing on its realisation and the experience we have gained in this vast project so far.

Keywords: *ICT, information system, web application, e-learning, learning management system, communication, content management system, e-content, internet*

Lojze Spacal: virtualne razstave ob 100 letnici rojstva

Lojze Spacal: Virtual Exhibitions Celebrating the Centenary of His Birth

Janko Uhan, Marko Arnež

Tehniški šolski center Kranj, Slovenija

Povzetek

V počastitev stoletnice rojstva Lojzeta Spacala, eminentnega in mednarodno uveljavljenega slovenskega umetnika, se bo v letošnjem letu zvrstil niz obsežnih preglednih likovnih razstav. Z namenom približati delo umetnika širšemu krogu ljubiteljev umetnosti, vzbuditi zanimanje za obisk razstav, predvsem pa ohraniti v elektronski obliki serijo razstav, ki tako po vsebini kot po obsegu predstavljajo enega večjih projektov na področju umetnosti v Sloveniji v zadnjih letih, smo se odločili pripraviti obsežno tematsko zasnovano spletno stran, na kateri bo predstavljen umetnik, njegovo delo in predvsem dogodki, ki se bodo odvijali v letu 2007. V prispevku bomo predstavili, kako smo uspešno realizirali ta obsežen projekt.

Ključne besede: *Spletne strani, elektronska predstavitev, internet, galerija, umetnost*

Abstract

To mark the centenary of the birth of Lojze Spacal, and also to honour the eminent and internationally recognised Slovene artist, a series of extensive survey art exhibitions are being held this year. In order to raise the interest of an even wider audience of art lovers in the artist's work and exhibitions of his works of art, and in order to preserve the series of this year's exhibitions, which is one of the largest Slovene art's projects of the past few years, electronically, a special Web site has been created. The Web site presents the artist, his work and the unique events taking place in 2007. This paper presents how this demanding and vast project has been accomplished.

Keywords: *Web sites, electronic presentation, Internet, gallery, art*

Robotika za vsakogar

Robotics for Everybody

Suzana Uran[1], Franc Vrbančič[2]

1 Univerza v Mariboru, FERI, Smetanova ulica 17, 2000 Maribor
suzana.uran@uni-mb.si

2 ŠC Ptuj, Poklicna in tehiška elektro šola, Volmerjeva cesta 19, 2250 Ptuj
franc.vrbancic@guest.arnes.si

Povzetek

V pričujočem sestavku smo predstavili kako IKT tehnologije pomagajo pri širjenju znanja kot pomoč pri izbirnih predmetih Robotika v tehniki in Elektronika z robotiko. Pri tem smo uporabili sistem Legomindstorms, ki je didaktično in cenovna ugodna rešitev. Sistem sestavljajo lego kocke, s pomočjo katerih lahko sestavimo »robote«. Najvažnejši del je mini računalnik RCX s senzorji, s pomočjo katerih robot zaznava okolje. Računalnik lahko programiramo v preprostem SimBot programskem sistemu ali pa v zahtevnejšem programskem orodju. Učitelje, mladostnike ter njihove starše smo k sodelovanju pritegnili z organizacijo šolskih, regijskih ter državnih tekmovanj Legobum, problemsko usmerjenimi tehničnimi dnevi ter seminarji in srečanji za odrasle in mladino. V projektu smo dodali vsebinam, ki se nahajajo v učbenikih, podporo na spletnem mediju, ki nosi dodatna in specialna znanja. Nekatere srednje šole omenjeno spletno stran in Legomindstorms komplete uporabljajo tudi za promocijo poklicev s področja tehnike kakor tudi pri pouku mehatronike, kar je celo preseglo zastavljene cilje projekta. V naslednjih dveh letih nameravamo razširiti tekmovanja iz Legobuma tudi na na pete in šeste razrede, organizirati posebno »low cost« robotsko tekmovanje ter plesno tekmovanje robotov. Spletni naslov projekta: http://hl1.uni-mb.si/Suphp/ROBOTIKA za VSAKOGAR.htm

Ključne besede: *robot, mladostnik, tehnika, izobraževanje*

Abstract

In this article the information communication technology is presented that helps spreading knowledge of optional subjects Robotics in technics and Electronics with robotics. Legomindstorms system was used that is didactically a good solution. At the same time the Lego system has an affordable price. At the heart of Legomindstorms system is a mini computer called RCX. This is the brain of the Legomindstorms system. Using RCX and sensors a robot could be build that reacts to the environment. RCX could be programmed with SIMBot or any other more demanding programming environment. Teachers, pupils and their parents were asked to participate in school, regional and state competitions called LegoBum, problem oriented technical days and seminars for young people and adults. In the project topics covered in the text-books as well as additional and special knowledge was supported by the Web. Some secondary schools use mentioned web page and the Legomindstorms system use to promote technical professions as well as to support learning of Mechatronics. Due to these facts the project was very successful. In the next two years it is desired that Legobum competitions would be extended and would include pupils from the 5th and 6th class of primary school, and that a special »low cost« robot competition and a robot dancing competition would be organised.

Keywords*: robot, adolescent, technics, learning*

From Pieces of Knowledge towards a Bigger Picture: How Can the Process be Supported

Tanja Urbančič [1,2]

[1] University of Nova Gorica, Vipavska 13, 5000 Nova Gorica, Slovenia

[2] Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia

tanja.urbancic@p-ng.si

Abstract

In this paper we deal with the problem of information that is dispersed and is growing so fast that it is difficult to connect it into a coherent picture as needed for complex problem solving. We present two examples and some methods that have potential to contribute towards putting pieces of knowledge together. The first one is finding complementary pieces of knowledge from literature which supports hypothesis generation by a well-definde computer supported method. The second one is sharing and upgrading knowledge in collaborative settings, which. although well elaborated in technical aspects, still has many non-tecnical issues to be solved.

Keywords: *knowledge management, education, data mining, networked organizations*

Povzetek

V članku je obravnavan problem hitrega naraščanja in raztresenosti informacij, kar otežkoča njihovo povezovanje v smiselno celoto, potrebno za reševanje zahtevnih problemov. Predstavljamo dva primera, ki prinašata obete v tej smeri. Prvi je iskanje komplementarnih kosov znanja iz literature, kar podpira generiranje novih hipotez z dobro definirano računalniško metodo. Drugi je izmenjava in nadgrajevanje znanja v sodelovalnih okoljih, kar je tehnično sicer že zelo dobro podprto, vendar pa prinaša s sabo še veliko nerešenih, predvsem netehničnih vprašanj.

Ključne besede: *upravljanje znanja, izobraževanje, rudarjenje podatkov, mrežne organizacije*

E- Learning in Chemistry: To Use It or Not to Use It?

Margareta Vrtačnik[1], Rahela Čemažar[2]

1 University of Ljubljana, Faculty of Natural Sciences and Engineering

2 University of Ljubljana, Faculty of Education

Abstract

The paper presents the results of a study on the impacts of e-learning chemistry concepts. The purpose was to find out whether students are able to learn new chemistry concepts using e-learning exclusively and later apply newly acquired knowledge, and what are their attitudes towards e-learning. Specially designed learning objects (LOs) were prepared and students were working in Moodle e-learning environment. Prior to the experiment students' pre-knowledge was tested, followed by post-knowledge test and a structured interview, where also their performance and feelings were tested. The results were analysed quantitatively and qualitatively. The study shows that learning chemistry by using technology may result in actual learning of new and difficult concepts, however the learning effect primarily depends on student prior knowledge. On the other hand student attitudes towards e-learning are positive.

Keywords: *e-learning, learning objects (LOs), chemistry, students' attitude, chemistry knowledge*

Povzetek

Članek obravnava raziskavo o vplivih e-učenja na razumevanje zahtevnih kemijskih pojmov. Namen študije je bil dobiti odgovore na vprašanja:ali so učenci sposobni razumeti in naučiti se zahtevnih kemijskih pojmov ter kasneje to znanje tudi pravilno uporabiti ter ugotoviti njihove občutke pri tovrstnem učenju. Učenje je potekalo v učnem okolju Moodle s posebej izdelanimi učnimi objekti. Rezultate smo merili s primerjavo rezultatov pred-testa in po-testa, odgovore pa smo preverjali tudi prek strukturiranega intervjuja. Kvalitativna in kvantitativna analiza rezultatov kaže, da so učenci sposobni usvojiti novo znanje dokaj težkih kemijskih pojmov izključno s pomočjo e- tehnologije uspešno le ob pogoju, da imajo ustrezno predznanje. Delo v e-učnem okolju so učenci pozitivno sprejeli.

Ključne besede: *e-učenje, učni objekti (UO), kemija, odnos dijakov, znanje kemije*

Spletne učilnice predmetnih komisij za razvoj kurikula na ZRSŠ

Virtual Classrooms of the Groups for the Development of Curriculum with The National Education Institute

Alenka Zabukovec[1], Janko Harej[2], Andrej Bagon[2]

1 Srednja ekonomska šola Ljubljana, Roška 2, 1000 Ljubljana
alenka.zabukovec@guest.arnes.si

2 TŠC Nova Gorica, Cankarjeva 10, 5000 Nova Gorica
janko.harej@gmail.com, andrej.bagon@gmail.com

Povzetek

Skupine za razvoj kurikula so na Zavodu RS za šolstvo organizirane po predmetnih področjih. V letu 2007 so se na ZRSŠ odločili, da bo delo skupin, t. j. prenova učnih načrtov potekala v virtualem okolju. Izbran je bil način dela prek spletnih učilnic, ki omogoča vse dejavnosti, ki naj bi jih delo skupin obsegalo. Skupina strokovnjakov je postavila sistem Moodle in ga prilagodila potrebam dela skupin. Spletni naslov spletnih učilnic predmetnih podskupin je http://info.edus.si/studijsk/. V prispevku je opisano delo skupine: od priprave, tehničnega dela zasnove, postavitve sistema do dela z uporabniki in svetovanja za potrebe dela skupin. Na koncu je predstavljeno nekaj najbolj zanimivih statističnih podatkov dela na spletišču.

Ključne besede: *spletne učilnice, e-študijske skupine, ZRSŠ, moodle, razvoj kurikula, prenova učnih načrtov, delo na daljavo.*

Abstract

Groups for the development of curriculum with the National Education Institute (ZRSŠ) are organized according to subjects. In the year 2007 the ZRSŠ decided that special groups should carry out the renovation of curricula in virtual space. It was chosen to work in virtual classrooms, since they enable all activities a certain group should perform. Web address of virtual classrooms is the following http://info.edus.si/studijske. The text discusses the activities of a single group: preparation, technical planning, setting up the system, cooperation with users, consulting groups and others. In the end there are some most interesting statistical data about the work on the website.

Keywords: *virtual classrooms, e-study groups, The National Education Institute (ZRSŠ), Moodle, development of curriculum, renovation of syllabus, teleworking*

Živ projekt – sodelovanje in učenje

Living project – cooperation and learning

Tina Žagar Pernar, Tatjana Lotrič

Osnovna šola Naklo, Glavna cesta 47, 4202 Naklo, Slovenija
tina.zagar1@guest.arnes.si; tatjana.lotric@guest.arnes.si

Povzetek

V sodobnem svetu se človek na vsakem koraku srečuje z najrazličnejšo digitalno tehnologijo, zato je logično, da rabo le-te učitelji izkoriščamo v učnem procesu.

Kot učiteljici slovenščine spoznavava, da IKT omogoča ažurnejše, preglednejše, enostavnejše in privlačnejše sodelovanje tudi pri šolskem glasilu. Prav zato sva se odločili za uporabo finskega elektronskega učnega okolja eJournal, ki uporabniku ponuja možnost skupnega oblikovanja člankov (besedil, fotografij, slik, videoposnetkov, dokumentov in spletnih povezav), možnost izmenjave, spreminjanja in komentiranja le-teh. Tovrstno sodelovanje je temeljna dodana vrednost omenjenega delovnega okolja, ki je spletna stran ali elektronska pošta ne omogočata.

Prepričani sva, da tudi s tem vzgajamo kompetentnejšega uporabnika spletnih vsebin / storitev, a le, če se ga pravočasno opozori na zadrege, povezane z anonimnostjo, trivialnostjo vsebine in komentarjev ter s pretirano liberalizacijo pri jezikovni normativnosti.

Ključne besede: *elektronsko učno okolje (EUO) eJournal, sodelovalno učenje, slovenščina, obravnava umetnostnih in neumetnostnih besedil pri pouku slovenščine, šolski časopis, medpredmetno povezovanje, kritičen uporabnik spletnih gradiv*

Abstract

In the context of using digital technology every day it is only logical step for teachers to include it into school learning process.

As the teachers of Slovene language we realised that ICT enables more accurate, more easily scanned, easier and more attractive cooperation at the school gazette. That is why we decided to use Finnish electronic learning environment (ELO) eJournal which gives editors (pupils) the opportunity to publish an article (text, pictures, photos, video clips, documents, links to websites) together, to share, change, and comment it. This cooperation is an added value as it is no need to create any other website as a source for materials.

We believe that with this attitude we bring up more competent user of web materials / service. But nevertheless, the user has to be warned on problems, connected with anonymousness, triviality of the context and of the comments and with excessive liberalisation on language norm.

Key words: *electronic learning environment (ELO) eJournal, cooperative learning, Slovene language, fiction and non-fiction text, school gazette, interdisciplinary connection, critical user of web materials*

Konceptualni pouk v osnovni šoli pri obravnavi tlaka plina

Conceptually Based Learning in Primary School Presenting the Topic Gas Pressure

Mihael Zaletel

Osnovna šola Bistrica, Begunjska c. 2, 4290 Tržič
mihael.zaletel@guest.arnes.si

Povzetek

Informacijsko komunikacijska tehnologija omogoča številne nove pristope pri organizaciji vzgojno-izobraževalnega dela. Poučevanje fizike temelji na eksperimentalnem delu in problemsko zasnovanem pouku. Konceptualni pristop k pouku fizike združuje eksperimentalno delo učencev, problemsko naravnan pouk in uporabo informacijsko komunikacijske tehnologije v celoto s ciljem uspešnejšega učenja in ustreznega motiviranja učencev na vseh ravneh poučevanja. V prispevku predstavljam primer konceptualnega pristopa pri pouku fizike pri obravnavi teme tlak plina v osmem razredu osnovne šole. Simulaciji, s pomočjo informacijske komunikacijske tehnologije, sem v tem primeru dal prednost pred klasičnim eksperimentalnim delom, saj tema posega na področje, kjer samega dogajanja ne moremo opazovati v realnem svetu, opazimo le posledice.

Ključne besede: *fizika, eksperimentalno delo, problemski pouk, simulacije, konceptualni pouk, informacijsko komunikacijska tehnologija, e-izobraževanje*

Abstract

Information communication technology offers numerous new approaches to the organisation of a teaching process. Teaching Physics is based upon experimental work and problem-based learning. Conceptually based approach to teaching Physics incorporates experimental work of students, problem-based learning and the use of information communication technology, to achieve successful learning and appropriate motivation of students at all levels of teaching. In my paper I have presented a pattern of conceptual approach to teaching Physics, presenting the topic gas pressure, in the 8th class of primary school. I chose simulation, presented by means of information technology, instead of conventional experimental method, because in this situation the activity itself cannot be observed in real life, we can only detect its effects.

Keywords: *Physics, experimental work, problem-based learning, simulations, conceptually based learning, information communication technology, e-learning*

Računalniške didaktične igre kot pripomoček pri premagovanju težav zaznavanja

Computer Didactic Games as a Tool to Overcome the Problems of Perception

Neža A. Zelinka

Osnovna šola Staneta Žagarja Kranj, Cesta 1. maja 10 a, 4000 KRANJ
neza.zelinka@guest.arnes.si

Povzetek

V pomoč pri širjenju znanja učencev so specifične računalniške didaktične igre, ki v veliki meri pomagajo pri urjenju in razvijanju številnih predstav in logičnih misli; slušnih in vidnih zaznavanj, orientaciji in koordinaciji.

Zaradi velike motivacije, ki jo računalnik vzbuja pri otrocih, ima kot učni pripomoček še večjo vrednost, ker krepi samopodobo, kar omogoča uspešno delo tudi na drugih področjih učenja.

Pomembno je, da bi bili vsi otroci, v procesu učenja, deležni računalniških didaktičnih iger zaznavanja in tako pridobili spretnosti, pomembne za njihov celostni razvoj.

Ključne besede: *računalniške didaktične igre, razvoj zaznavanja*

Abstract

Computer didactic games are considered to be of a great assistance when it comes to broadening pupils' knowledge, because of their ability to invigorate listening comprehension, visual perception, the sense of orientation and coordination…

Computers used as a learning device motivate the children and enhance their self-confidence, which presents an important factor in enabling pupils to be successful in various fields of learning.

It is important for all the children involved in the learning process to get acquainted with didactic games involving computer skills in order to gain additional skillfulness and knowledge needed for their further development as whole human beings.

Keywords: *computer didactic games, development of perception*

Kompetence in učni uspeh

Neja Zupan, Janez Mayer

Univerza v Mariboru, Fakulteta v Mariboru

Povzetek

V članku so predstavljene kompetence in pomen kompetenc v današnjem svetu. Predstavljeni so rezultati raziskave, ki je bila izvedena na Fakulteti za organizacijske vede Univerze v Mariboru, na podlagi intervjujev in dveh anket. Vzorec je bil sestavljen iz 200 študentov, vpisanih v drugi, tretji in četrti letnik. Končna analiza je podala štiri kompetence, ki so najbolj prisotne in tudi najbolj pomembne za uspešen študij, te pa so: organiziranost, motivacija, delavnost in koncentracija. Prisotnost kompetenc se statistično pomembno razlikuje med skupinami študentov glede na njihov študijski uspeh.

Ključne besede: *kompetence, uspeh, študij*

Abstract

This paper discusses important competences for study. The study was conducted in three phases. The research sample consisted of 200 students of different study year at the Faculty of organisational Systems University of Maribor. Analysis showed that there are four most important competences for successful study: self-organisation, self-motivation, diligence and concentration. These competences have statistically values by students with higher study success.

Keywords: *study, competence, success*

Zbornik 10. mednarodne multikonference

INFORMACIJSKA DRUŽBA - IS 2007

Proceedings of the 10th International Multiconference

INFORMATION SOCIEY - IS 2007

Izkopavanje znanja in podatkovna skladišča

Data Mining and Data Warehouses

Uredila / Edited by

Dunja Mladenić, Marko Grobelnik

http://is.ijs.si

12. oktober 2007 / 12th October 2007

Ljubljana, Slovenia

PREDGOVOR

Tehnologije, ki se ukvarjajo s podatki so v zadnjem desetletju (devetdeseta leta) močno napredovale. Iz prve faze, kjer je šlo predvsem zato kako podatke shraniti in kako do njih učinkovito dostopati, se je razvila industrija za izdelavo orodij za delo s podatkovnimi bazami, prišlo je do standardizacije procesov, povpraševalnih jezikov itd. Ko shranjevanje podatkov ni bil več poseben problem se je pojavila potreba po bolj urejenih podatkovnih bazah, ki bi služile ne le transakcijskem procesiranju ampak tudi bolj analitskim pogledom v podatke – pojavilo se je skladiščenje podatkov (data warehousing), ki postaja vse bolj standarden del informacijskih sistemov v podjetjih. Paradigma OLAP (On-Line-Analytical-Processing) zahteva od uporabnika, da še vedno sam postavlja sistemu vprašanja in dobiva nanje odgovore in na vizualen način preverja in išče izstopajoče situacije. Ker seveda to vedno ni mogoče, se je pojavila potreba po avtomatski analizi teh podatkov oz. z drugimi besedami to, da tehnologija sama pove, kaj bi utegnilo biti zanimivo za človeka – to prinašajo tehnike izkopavanja znanja (data mining), ki iz podatkov, ki ze nekje obstajajo, skušajo pridobiti novo znanje, ki uporabniku ponudi novo razumevanje svojih lastnih procesov.

Slovenska KDD konferenca ponuja nekaj predstavitev, ki se ukvarjajo z modernejšimi pogledi na delo s podatki – predvsem poslovno analitske poglede: pristope, orodja, probleme in rešitve.

PREFACE

Data handling technologies have significantly progressed in the 90's. The first phases mainly dealing with storing and efficiently accessing the data, resulted in the development of industry delivering tools for handling large databases, standardization of related processes, queering languages, etc. When the data storage was not a primary problem any more the need for improving the database organization resulted in the databases supporting not only transactions but also analytical views of the data. At this point data warehousing with OLAP (On-Line-Analytical-Processing) entered as a usual part of a company information system. The OLAP paradigme stil requires from the user to set well defined questions which is not always easy and possible. This led to the development of Data Mining offering automatic data analysis trying to obtain some new information from the existing data and enabling the user some new insights in the data. The Slovenian KDD conference covers a broad area including Statistical Data Analysis, Data/Text and Web Mining, Semantic Web, Link Detection and Link Analysis, Data Warehouses.

Urednika/Editors and Program Chairs

- Marko Grobelnik
- Dunja Mladenič

MINING WIKIPEDIA AND RELATING NAMED ENTITIES OVER TIME

*Abhijit Bhole**, *Blaž Fortuna*[#], *Marko Grobelnik*[#], *Dunja Mladenić*[#]
* Department of Computer Science and Engineering, Indian Institute of Technology,
Bombay, Mumbai - 400076, India
[#]Department of Knowledge Technologies, Jozef Stefan Institute,
Jamova 39, 1000 Ljubljana, Slovenia
tel: +386 1 477 3127; fax: +386 1 477 3315
e-mail: abhijit.bhole@cse.iitb.ac.in, blaz.fortuna@ijs.si, marko.grobelnik@ijs.si, dunja.mladenic@ijs.si

ABSTRACT

In this paper we present an approach to mining information relating people, places, organizations and events extracted from Wikipedia and linking them on a time scale. The approach consists of two phases: categorizing the articles as containing people, places or organizations; linking the named entities and extracting events and their time frame. We illustrate the approach on 1.7 million Wikipedia articles describing some unique concept.

1 INTRODUCTION

Wikipedia is an abundant and valuable source of information manually constructed and mainly targeting human readers, and hence remains unfriendly towards automatic information extraction and mining. The text in Wikipedia is written using a special markup which is mainly aimed towards formatting the text and to a limited extent standardizing pages belonging to same categories. In this paper we propose an approach to extracting information from Wikipedia based on a standard method of first identifying pages that are relevant for the information extraction task and then extracting the desired information as illustrated in Figure 1. We use machine learning methods to identify pages belonging to the same category (in our case person, place or organization) and then proceed with text mining of articles to get links and time line information on named entities. The result of our approach is a collection of pages belonging to the predefined categories and a dynamic graph showing named entities (people, places and organizations) and relations between them. For instance, for each person we have important dates from his/her life (birthday, …) and some events including places and organizations possibly associated with some dates.

Our work is based on standard machine learning and text mining methods [7], in particular for document categorization we use linear support vector machine (SVM) [4], as it is currently considered the state-of-the-art algorithm in text categorization. We used binary linear SVM, the implementation from TextGarden [5]. The main novelty in this work is in extracting dynamic graph relating named entities based on Wikipedia. The closely related work is on semantically annotated snapshot of the English Wikipedia [1]. However that approach is based on natural language processing, while we are using machine learning and mining the extracted data in order to connect the extracted named entities. Another related work is on extracting structured information from Wikipedia mainly by using the existing structured information, such as Wikipedia *infobox templates* and by making this information available on the Semantic Web which is known as dbPedia [3]. The task of building timelines from Wikipedia data was first pioneered by the project Wikistory [9], a project which creates a dynamic timeline of scientists based on the data obtained from dbPedia. Somewhat related is also work on Semantic MediaWiki which introduces some additional markup into the wiki-text which allows users to manually add "semantic annotations" to the Wiki [2].

The rest of the paper is structured as follows. Section 2 describes the proposed approach. Section 3 gives experimental results and illustrative example of the obtained dynamic graph. Section 4 concludes with discussion.

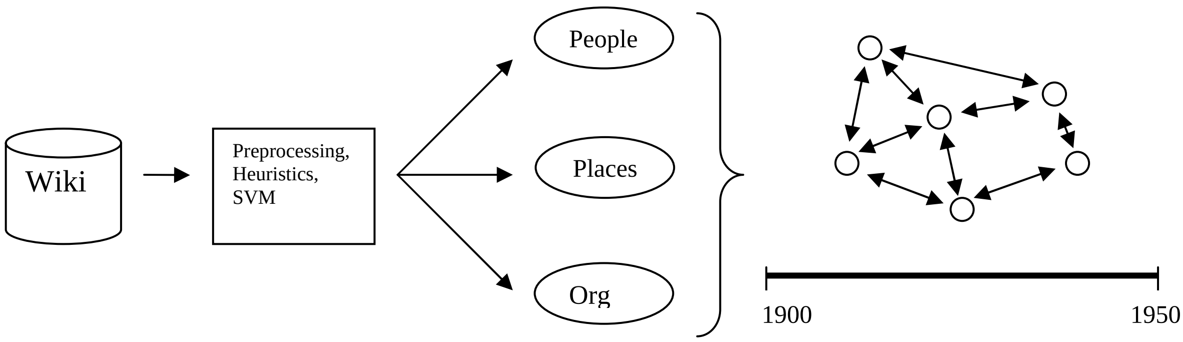


Figure 1. Illustration of the approach consisting of two phases: identifying pages containing named entities and generating timeline.

2 APPROACH DESCRIPTION

Our goal is to generate a dynamic graph with named entities and relations between them, such as; a person was born at date X at city of Y, in year Z he/she lived in city W. In order to extract named entities we use Wikipedia and first categorize all its pages to find those containing the targeted named entities. We use two approaches to categorizing the pages: one based on manually constructed heuristic rules and the other based on labeling some of the examples and training an SVM classifier.

As Wikipedia pages contain articles with text and some markup information, there are two ways of approaching categorization of documents using heuristics: based on markup and based on text. We can analyze Wiki markup in the articles which can lead to clues for document categorization. However, we should be aware of the fact that the Wiki markup is not semantic annotation and is not uniformly and strictly enforced across the whole Wikipedia. The other approach is to extract plain text from Wiki and then search for particular phrases. We use regular expression based search and replace method throughout for parsing the Wiki markup, obtaining plain text as well as searching for heuristics.

Categorization of Wikipedia pages can be realized either by using index pages on Wikipedia or by classifying each individual articles. Our preliminary experiments using index pages show that it is not a reliable and consistent method over the long term since the index pages are not automatically generated but are maintained by the users themselves. We also tried with filtering some page titles based on tagged word corpuses, but the results were of limited value. Our current strategy involves analyzing individual articles by first using heuristic-based categorization of articles and then, once we have a sufficient number of articles, applying machine learning techniques. A brief description of these heuristics is given along with the experimental results in Section 3.

Once we have categorized Wikipedia pages as describing people, place or organization getting the corresponding named entities is trivial from the Web page URL (e.g., Wikipedia page describing Abraham Lincoln is on URL http://en.wikipedia.org/wiki/Abraham_lincoln). Once we have a collection of articles describing named entities we apply mining for relations between the extracted named entities. We define relation between two entities as follows. An entity is related to other if it has a certain probability of reaching that entity using the Wikipedia hyperlink structure. This usually reflects real life relationships, but inevitably with some difference. The approach we use for finding relations is to build a matrix based on out-links and in-links from a Web page and then searching for two named entities occurring together in the text of other articles.

There are two possible ways of realizing events: one is to identifying articles belonging to events and other is to apply text mining on article texts searching for sentences having mention of dates in them. The task here involves first sentence boundary disambiguation, then extracting dates from these sentences and also linking them to the corresponding named entities.

3 EXPERIMENTS

3.1 Overview

The entire Wikipedia consists of 5 million entries including redirections, list pages and namespace pages (“Category:”, “Template:” etc), out of which about 1.7 million can be considered as articles describing some unique concept. These 1.7 million articles can be obtained by simple heuristic filtering, which forms our main corpus. Out of that corpus, we selected a random sample of 1000 articles and manually labeled them with three categories (describing people, place, and organization) and left the rest unlabeled. In that sample of articles we found 260 people, 184 places and 118 organizations. We used that for evaluating our approach and estimating the total number of named entities present in the corpus. Although the size of the manually labeled test sample is very small, it is our hypothesis that it represents the diversity of the source.

Our preliminary experiments identifying named entities through index pages was made by crawling pages with titles similar to “list of people” resulting in about 130K hits which is estimated to result in about 30% recall and about 85% precision. An effort to filter out titles using word corpus failed to have any significant impact on accuracy due to the fact that many persons have fairly common words in their names while some non-person articles may have uncommon words. Similar was true for the other two categories (places, organizations).

3.2 Heuristic based identification

We use parts of Wiki markup known as “Infobox” for identifying some people, places and organizations. We then search for co-ordinates and name them as place while we use the first paragraph from the extracted plain text from the article to search for keywords and dates for identifying people. In this was we labeled 285.000 articles as people, 150.000 as places and 26.000 as organizations. We have evaluated the proposed heuristic approach on our manually labeled sample of 1000 articles. The results are summarized in Table 1.

	Precision	Recall
People	100%	62.4%
Places	95.7%	48.9%
Organizations	100%	10.16%

Table 1: Evaluation of heuristics based classification of Wikipedia articles.

More detailed analysis of the obtained results shows several common sources of error. Many people left out by our heuristic do not have indicative dates in sufficient proximity of the beginning of article. Also the heuristic takes into account most common formats of date, but is conservative enough not to include irrelevant text such as ISBN numbers to maintain its precision. After all, the goal is to apply machine learning with sufficient labeled data rather than to rely entirely on heuristic. When identifying places, several articles on military vehicles or asteroids may have co-ordinates in them but do not qualify for this category which leads to the error. An organization is a loosely defined term, can be any entity which links people (company, university, school or even a rock band). Hence they lack any such indicative text and remain difficult to be found simply by this technique. Some examples of successfully identified named entities are given in Figure 2.

```
"Aristotle (Greek: Ἀριστοτέλης Aristotélēs) (384 BC – 322 BC) was a Greek philosopher, a student…"
```

Example 1: The article describing Aristotle which belongs to category person having birth dates at the beginning of article.

```
{{Infobox Philosopher
| me = {{polytonic|Ἀριστοτέλης}} ''Aristotélēs''
| image_name = Aristoteles Louvre.jpg
| color = #B0C4DE
| region = Western philosophy
| era = [[Ancient philosophy]]
| name = [[Aristotle]]
| birth = [[384 BC]]
```

Example 2: The article describing Aristotle has a specific Wiki markup indicating him to be a philosopher and thus classifiable as a person.

```
The coordinates of the nominal centre of London
(traditionally considered to be the original
[[Eleanor Cross]] at [[Charing Cross]], near the
junction of [[Trafalgar Square]] and
[[Whitehall]]) are approximately {{coor
dms|51|30|29|N|00|07|29|W|type:city(7,000,000)_reg
ion:GB}}.
```

Example 3: A co-ordinate header in the article describing London.

Figure 2. Examples of Wikipedia text of some identified named entities for category person (Examples 1 and 2) and place (Example 3).

3.3 Support Vector Machine based identification

In order to apply machine learning, text of the documents to be classified was preprocessed by removing stop-words applying stemming and representing each document using the standard bag-of-words approach containing individual words. Representation of each document was further enriched by frequent phrases, which were considered to be those consisting of up to two consecutive words [6] and occurring at least fifty times in the data collection. The binary classification model was automatically constructed for each of the three classes, taking the training documents of the class as positive and the training documents of other classes as negative. The classification model was trained on one part of the data collection, leaving the other part to be classified using the standard statistical method called cross validation. In other words, the data collection was randomly divided into several disjoint parts (in our case three) of approximately equal size. Then three classification models were generated, each taking one of the three parts as testing and the remaining two parts as training documents. We report average performance (precision, recall) over the three models. We first ran 3-fold cross validation on manually labeled dataset, using only the first paragraph from the article text (Table 2a) and using the plain text from the entire article (Table 2b).

	Precision	Recall	F1	BEP
People	92.81%	49.20%	64.22%	60.40%
Places	73.14%	54.46%	62.03%	64.88%
Org.*	25.96%	49.17%	33.91%	28.05%

Table 2a: Results from cross validation on sample set using only first paragraphs of article text.

	Precision	Recall	F1	BEP
People	85.18%	63.38%	72.67%	75.57%
Places	85.31%	60.29%	70.46%	77.02%
Org.*	47.63%	37.73%	41.59%	43.11%

Table 2b: Results from cross validation on sample set using plain text from entire article.

*Since the sample set was too unbalanced in this category, the cross validation was run with bias misclassification cost (SVM parameter j=5).

The text extracted from the first paragraph of the articles was used in all subsequent classification experiments presented in this paper since it is significantly computationally less expensive. However, the results obtained using the entire text of the articles (Table 2b) are better than the results of using the first paragraph only (Table 2a). We also tried to use the text including the Wiki markup and it produced results that are a few percent better than those in Table 2b, but this needs further analysis.

The diversity of the sample set can be explained to be a cause of the low recall in case of people and places, where the SVM may have misclassified some article alien to it. However, the precision of people and places was encouraging considered the small size of the sample set as the SVM succeeded in picking up most of the entities which were sufficiently represented in this training data. The poor results with organizations can be explained either by insufficiency of the sample set to capture the diversity of the category or by inability of the text to capture all the features to classify an organization.

We also ran 3-fold cross validation using only the first paragraphs on the whole corpus, which was labeled solely by our heuristics. In the first experiment we use a binary SVM to train the classification model (Table 3a) and in the second experiment we use one class SVM (Table 3b).

	Precision	Recall	F1	BEP
People	83.59%	79.72%	81.61%	82.30%
Places	83.58%	72.19%	77.47%	78.58%
Org.	38.85%	58.28%	46.62%	45.66%

Table 3a: Results of cross validation using binary SVM on the whole corpus

The experiments show that binary SVM is much more successful than one class SVM in partitioning our data. Also, we can assert that our hypothesis that the features present in the text are good enough to enable automatic classification of named entities is correct to a large extent.

	Precision	Recall	F1	BEP
People	46.66%	89.50%	61.34%	63.74%
Places	38.01%	89.39%	53.34%	51.88%
Org.	9.41%	86.32%	16.97%	23.72%

Table 3b: Results of cross validation using one class SVM on the whole corpus.

When running binary SVM on the entire text of articles, we didn't observe considerable improvements over the results given in Table 3a. Namely, we got F1 of 79.37%, 78.79% and 37.09% for people, places and organizations respectively and BEP of 80.14%, 80.05% and 52.01%.

3.4 Analyzing Relations

We analyzed relationships between people for three different kinds of clues relating people: in-links, out-links occurring in the article pages and people occurring in the same paragraph of a text of another article or a list. All three clues were given different weights based on some trial and error and in the end an adjacency matrix ("to-from") of a graph with persons as nodes was constructed and the end result was obtained by sorting the edges by weight. Further extension is possible by recursively multiplying the matrix in order to consider paths having length more than one [8]. Example is given in Figure 3.

Aristotle is related to:

Plato	(25.217420)
Thomas Aquinas	(4.700384)
Socrates	(4.536786)
Cicero	(3.608422)
Alexander the Great	(3.017379)
Plutarch	(3.011533)
Averroes	(3.000203)
Demosthenes	(2.028392)
Ptolemy	(1.938013)
Aristophanes	(1.848224)
Avicenna	(1.823166)
Galileo Galilei	(1.714287)
Hippocrates	(1.688921)
Euclid	(1.670485)
Homer	(1.659085)

Figure 3: Here the first 15 persons related to Aristotle are shown along with the weights calculated by our algorithm

Also, further association is also possible by finding overlaps between time lines of two people. Although a quantitative analysis of these results is a big task, an overview of the results obtained was quite satisfactory.

3.5 Events extraction

To extract events, we used heuristic-based sentence boundary disambiguation after extracting plain text from Wiki markup and then picked up sentences containing dates. The extracted sentences are regarded as events and are linked to the article in which they were found (see Figure 4 for an example). Other named entities are searched for in the extracted sentences. However the task of incorporating these entities into relationships was already accomplished previously.

We also extracted the birth and death dates for many of the people and for the rest we used an average of the dates occurring in these events to estimate the time period of the person. This heuristics makes possible the association based on time lines.

0/0/-323 - Upon Alexander's death in 323 BC, anti-Macedonian feelings in Athens once again flared.
0/0/-86 - When Lucius Cornelius Sulla occupied Athens in 86 BC, he carried off the library of Appellicon to Rome, where they were first published in 60 BC by the grammarian Tyrranion of Amisus and then by philosopher Andronicus of Rhodes.

Figure 4: An event extracted from article describing Aristotle

4 CONCLUSIONS

In this paper we outlined how heuristic based approaches can be used for extracting high quality annotations of Wikipedia articles and that SVM based text categorization is a viable way of generalizing the heuristics. As a part of future work we are planning to further extend the number of extraction classes, detail level of extracted data from the articles (e.g. type of place, profession of a person, etc.) and investigate integration of the extracted facts into a knowledge base, such as Cyc [10].

Acknowledgement

This work was supported by the Slovenian Research Agency and the IST Programme of the EC under NeOn (IST-4-027595-IP), and PASCAL (IST-2002-506778).

References

[1] H. Zaragoza and J. Atserias and M. Ciaramita and G. Attardi. Semantically Annotated Snapshot of the English Wikipedia v.0 (SW0), http://www.yr-bcn.es/semanticWikipedia, 2007

[2] Semantic MediaWiki, http://ontoworld.org/wiki/Semantic_MediaWiki, 2007

[3] DBpedia.org, http://dbpedia.org/docs, 2007

[4] Joachims, T. Making large-scale svm learning practical. In B. Scholkopf, C. Burges, and A. Smola, editors, Advances in Kernel Methods, Support Vector Learning, MIT-Press, 1999.

[5] Grobelnik, M., Mladenic, D. 2007. Text Mining Recipes. Berlin, Heidelberg, New York: Springer. Accompanying software available at: http://www.textmining.net.

[6] Mladenic, D., Grobelnik, M. 2003. Feature selection on hierarchy of web documents. Journal of Decision Support Systems, 35. 45-87.

[7] Sebastiani, F. 2002. Machine learning in automated text categorization. ACM Computing Surveys, 34(1). 1–47.

[8] Olston, C., Chi, H. E. (2003). ScentTrails: Integrating browsing and searching on the Web. In ACM Transactions on Computer-Human Interaction (TOCHI), Volume 10, Issue 3, Pages: 177–197, ACM Press, New York, NY, USA.

[9] Wikistory, http://www.urbigene.com/wikistory/

PREDICTING THE ADDITION OF NEW CONCEPTS IN A TOPIC HIERARCHY

Janez Brank, Dunja Mladenić, Marko Grobelnik
Department of Knowledge Technologies, Jozef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773778; fax: +386 1 4251038
e-mail: {janez.brank,dunja.mladenic,marko.grobelnik}@ijs.si

ABSTRACT

Ontologies often change through time, a process largely done manually by human editors. We discuss the task of automatically predicting when structural changes will occur in a given ontology. We first analyze the frequency of different types of structural changes in a large real-world ontology and then focus on the problem of predicting one specific type of structural change, namely the addition of a new category as a subcategory of an existing category, from which some of the existing instances are transferred into the new category. We show how the prediction of this type of structural change can be seen as a machine learning problem; the main challenge is to define a useful set of features. Experimental evaluation on a subset of the Open Directory Project hierarchy is provided.

1 INTRODUCTION

An ontology may need to change through time, because the domain modelled by the ontology changes, or because the needs of its users change. Thus it is natural to ask whether such changes in an ontology can be predicted automatically as an aid to the people maintaining the ontology.

In this paper we will limit ourselves to a simple class of lightweight ontologies, namely topic hierarchies. In these ontologies, the concepts are really topical categories and the only relationship between them is the *is-a* (parent-child) relationship which connects the categories into a tree. In addition, we assume that the ontology contains instances and that these instances are actually textual documents. Each document belongs to one or possibly several categories.

A well-known example of such an ontology from the real world is the topic hierarchy of the Open Directory Project (ODP) web directory (available from *http://www.dmoz.org*). It currently contains more than 700,000 categories and several millions of documents. Each document consists of a URL to an external web page and a short textual description of the page (approx. one or two sentences). The ontology is continuously updated by human editors, and snapshots of its past state are available. Thus it is a suitable dataset for our research, and we will focus on it throughout the rest of this paper, although the techniques presented are applicable to any topic hierarchy, as long as it contains instances and as long as a similarity measure over these instances can be defined.

2 RELATED WORK

[12] and [10] defined three types of change discovery in ontologies: structure-driven (where suggested changes are deduced from analyzing the ontology structure itself), usage-driven (changes are recommended by observing the usage patterns over time [9]) and data-driven (which is based on changes in the underlying data that describes the domain of interest [8]). For a recent overview of the area of ontology change, and its relationship with ontology evolution, merging, and integration, see the survey by Flouris et al. [13].

Maynard et al. [14] defined a detailed typology of ontology change operations. However, these operations are relatively low-level, whereas we will focus on slightly higher-level operations which are more amenable to automatic prediction and which we believe to correspond more closely to the way the ODP editors actually conceptualize their work.

3 AN ANALYSIS OF STRUCTURAL CHANGES IN THE ODP ONTOLOGY

The development of the ODP ontology through time can be observed by examining approx. 50 of the ODP. From July 2003 onwards, there is one snapshot per month.

One problem with this dataset is that any two consequent snapshots are approximately a month apart and many structural changes can take place during that time period. Sometimes several of them affect the same part of the ontology, and it isn't possible to uniquely determine the exact sequence of structural changes that took place. We developed a set of heuristics to compare two snapshots of the ontology and output a set of operations that could change the earlier snapshot into the later one. (Of course, this is not necessarily the same sequence of operations that was used by the human editors of the ODP.)

Low-level structural changes. In principle, one snapshot of the ontology can always be transformed into another one by a sequence of two elementary structural operations: addition and deletion of categories. (Other operations would involve only the documents, which we won't deal with here as we focus on structural changes only.) Here is an example of a few changes from April to May 2007 in the *Top/Computers* (abbreviated to "T/C") subtree:

```
DEL T/C/Open_Source/Software/Games/FPS
DEL T/C/Software/Internet/Servers/Directory/LDAP
DEL T/C/Software/Internet/Servers/Directory/LDAP/Products
DEL T/C/Software/Internet/Servers/Directory/LDAP/Standards_and_Organizations
DEL T/C/Software/Internet/Servers/Directory/LDAP/Products/Related_Middleware
DEL T/C/Software/Internet/Servers/Directory/LDAP/Products/Related_Client_Apps
ADD T/C/Open_Source/Software/Games/Shooter
ADD T/C/Programming/Languages/Smalltalk/Squeak/Croquet
ADD T/C/Programming/Languages/Smalltalk/Squeak/Croquet/News_and_Media
ADD T/C/Internet/Protocols/LDAP
ADD T/C/Internet/Protocols/LDAP/Standards_and_Organizations
ADD T/C/Internet/Protocols/LDAP/Software/Client
ADD T/C/Internet/Protocols/LDAP/Software/Server
ADD T/C/Internet/Protocols/LDAP/Software
```

As we can see from this list, it is unsatisfactory to describe the transformation of one snapshot to another solely through these two types of low-level operations. The human editors of the ODP clearly conceptualized their work as a sequence of more abstract operations. *FPS* was renamed into into *Shooter*. The *LDAP* subtree was moved from *Internet/Servers/Directory* to *Internet/Protocols*. Additionally, the *Products* subtree has been renamed into *Software* and rearranged somewhat, while the *Standards_and_Organization* subtree has remained unchanged. Finally, *Squeak/Croquet* is a genuinely new subtree, in which (as it turns out) not only the categories themselves are new but the documents therein as well.

There also exist other types of structural changes not shown above. Often, many empty subcategories are added, e.g. one for each letter of the alphabet; or corresponding to taxonomical units from zoology and botany, or geographical terms such as U.S. states. We consider such changes to be too dependent on background knowledge to be predictable by a computer. We will try to predict structural changes only in cases when a new category is added and some documents from previously existing categories transferred into it; this suggests that the structural change in question was genuinely an editor's response to the available data (e.g. the editor notices that the category's documents are too diverse and must be divided into narrower subtopics), and it may therefore be predicted automatically given the same data.

Heuristics for the identification of higher-level structural changes. We will briefly present a set of heuristics comparing two snapshots of the ontology and proposes a set of higher-level operations that transform one into the other.

Consider two categories, C from the old snapshot and C' from the new one. By comparing the sets of documents in their subtrees, we can compute precision, recall and then F_1, as usually done in information retrieval [2]. For each deleted category from the old snapshot, we then find its best match (i.e. the one with maximal F_1) in the new snapshot. To detect the renaming and moving of categories, we consider only matches with a recall of at least 90%. We will refer to these as "strong matches". The next step is to combine the matches on the level of categories into matches on the level of entire subtrees. We say that a strong match between subtrees (one from the old snapshot and one from the new snapshot) exists in cases when a strong match in the new subtree exists for each category in the old subtree and the matches preserve the parent-child relationships.

The strong matches between entire subtrees, once they have been identified, are a good first step towards the identification of several types of higher-level structural changes. – If the subtree of C (in the old snapshot) strongly matches the subtree of C' (in the new snapshot), and C' did not exist in the old snapshot, and no other subtree of the old snapshot strongly matches that of C', then we say that C has been renamed or moved into C' (renamed if they have the same parents, moved otherwise). – If, on the other hand, C' has already existed in the old snapshot or it is new but some other subtree besides that of C has strongly matched the subtree of C', then we say that C has merged into C'. A category may merge into its parent or a more distant relative, and several categories may merge into one.

As an example, the chart in Figure 1 shows the frequency of these various types of higher-level ontology changes within the *Top/Computers* subtree of the ODP ontology, over three years. As described above, all the category deletions have now been explained as either renames, moves, or merges, with merges further divided into many-to-one merges, merges into parent and merges into nonparent categories. What remains are the additions of genuinely new categories. Note that additions are by far the most frequent structural changes, followed by renames and moves. Merges are comparatively rare. Thus, we will focus on the prediction of additions as they are the most important and most frequently occurring type of structural change in the ODP ontology.

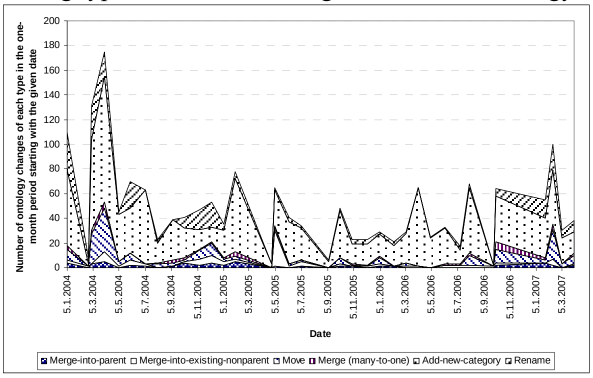


Figure 1: Frequency of various types of ontology changes.

Different types of category additions. As we saw on Figure 1, the addition of new categories is the most common type of structural change, even after we exclude the categories that seem to be new but are really just old categories that have been renamed, moved or merged. In the *Top/Computers* subtree, there were a total of 1115 category additions in the three-year period covered by Figure 1. Figure 2 shows how these additions can be divided into several kinds.

First of all, sometimes a new category has a parent that is also new (i.e. a whole subtree was added); this accounts for about 20% of all additions. We will not attempt to predict these, as it is challenging enough to predict the addition of an individual category, much less of a whole subtree.

Approximately 10% of the new categories contained no documents. Another 20% contain only documents that did not exist in the ontology in the previous snapshot. We will not work with these types of additions either as predicting them requires knowledge external to the ontology.

Approx. 44% of the new categories could reasonably be said to have been obtained by splitting a previously existing parent category. This means that the new category is a child of an existing parent P, and most of its documents (excluding those that are completely new to the ontology) have been taken from P or its desendants (rather than from other parts of the old ontology). This is the type of additions that our prediction efforts will chiefly focus on. Unfortunately it turns out that most of the categories added in this way are fairly small; only approx. a third of them (16% of all additions) contain at least 5 documents from P.

Finally, the remaining additions result in categories that contain some mixture of old documents from P, old documents from other parts of the ontology, and entirely new documents. It is not clear that they can be characterized in any unified way.

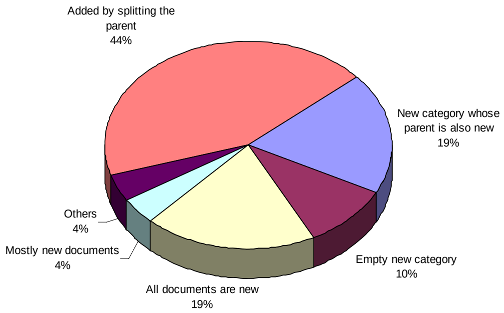


Figure 2: Frequency of various types of category additions.

4 PREDICTION OF CATEGORY ADDITIONS AS A LEARNING PROBLEM

One can treat the problem of predicting category additions as a machine learning problem. Each example of the learning problem consists of a category and a point in time; the example is positive iff a new subcategory should be created below the given category at the given point in time. The challenge is how to describe each example by a set of features (or attributes) such that the resulting representation will be suitable as an input for a machine learning algorithm.

Our approach is based on the idea that the human editors of the ODP probably suggest the addition of a new subcategory when they notice, within an existing category C, a few documents dealing with a reasonably well-defined narrower subtopic of the general topic of C. In this case a new subcategory would be added as a child of C, and the documents dealing with the subtopic thus identified would be moved into the new subcategory (whereas they had previously resided in C or possibly in one of its descendants). Since these documents all deal with a relatively narrow subtopic, we would expect them to form a cluster within the set of all documents of the parent C. Thus, we turn to clustering to assess whether such subsets of tightly related documents actually exist.

First, we represent each document by a vector using the usual bag-of-words model, with TF-IDF weighting and each vector normalized to a length of 1. The cosine of the angle betwen two vectors can be used as a measure of similarity between the corresponding documents.

Now consider the set of all documents that have been assigned to a category C or any of its descendants. This is the set within which we would like to find any tightly coupled cluster. We will use the well-known bisecting k-means [7] (a.k.a. hierarchical 2-means) algorithm, which begins by treating the whole set of documents as a single cluster; at each step, it selects a cluster and splits it into two. We stop when there are 10 clusters, we do not split clusters containing less than 5 documents or if one of the resulting subclusters would contain just one document.

Let A be the initial set of all documents in the category C (and its descendants), and let P be the partition of A into k disjoint clusters obtained using the hierarchical 2-means algorithm. We describe P using the following features:

(1) One feature is the average cosine between each document and the cluster to which it belongs.

(2) We find the cluster B maximizing the avg. cosine between each document in that B and its centroid. We use, as features, the following properties of this cluster: (a) The size of this cluster; not $|B|$ but log $|B|$, to prevent large clusters from having too much influence. (b) The relative size, $|B|$ / $|A|$. (c) The avg. cos. to centroid for the cluster B. (d) The avg. cos. to centroid for B, relative to that for the whole set A.

(3) We find the cluster B with the maximum average intra-cluster similarity (i.e. the cosine between two documents, averaged over all pairs of documents in B). For this B, we use 4 features analogous to those described in (2).

Thus we have described the partition P by nine features. Every time a cluster is split, we obtain nine features for the new partition. When the clustering stops at 10 clusters, we have a 90-dimensional feature vector.

5 EXPERIMENTAL EVALUATION

The dataset. We used the *Computers* subtree of the Open Directory Project ontology. From January 2004 through October 2006, this subtree had around 8,000 categories and 140,000 documents. There were 964 category additions, 198 renames, 134 moves, and 153 merges of various types. See Figure 1 for a chart on a monthly basis.

Of the category additions, 482 were such that the new category is added as the child of a previously existing parent category and more documents have been moved into the new category from the parent (or its previously existing descendants) than from other parts of the hierarchy. This, as described in Sec. 3, is the type of additions we will be trying to predict. We limit ourselves to additions in which at least five documents were moved from the parent category into the new child, which leaves us with 107 category additions.

A category at a given point in time is a positive example if some children (matching the criteria described above) have indeed been added to it between that point and the next available ontology snapshot (i.e. a month later). According to this definition, the 107 additions give rise to 98 positive examples (because sometimes several children are added to the same parent in a certain month).

To avoid having an excessively wide definition of the negative set, we declare a category to be negative at a certain point in time only if no suitable children have been added to it at that point or in the preceding or following three months. Despite this, since category additions are rare relative to the total number of categories, there are more than 168,000 negative examples. To speed up the experiments and to prevent the positive examples from being completely overwhelmed by the negative ones during the training process, we randomly selected three times as many negative examples as there are positive examples. We use the years 2004-5 as a training set (74 positive + 222 negative examples) and 2006 as a test set (24 pos.+ 72 neg.).

Experimental setup. We will use the SVM algorithm (the SVM^{light} implementation [5]) to train classifiers. Since our dataset is relatively unbalanced (i.e. there are many more negative examples than there are positive ones), we will distinguish between the error cost on negative examples (denoted C) and the error cost on positive examples (which will be set to $j \cdot C$, depending on a second parameter, j).

Since the number of features in our data is relatively modest (90) while the number of training examples is large, we will use the RBF kernel, $K(\mathbf{x}, \mathbf{z}) = \exp[-\gamma \, \|\mathbf{x} - \mathrm{z}\|^2]$. This introduces another tunable parameter, namely γ, the width of the Gaussian functions in the kernel.

We tested the following parameter values: $C \in \{0.1, 1, 10, 100, 1000\}$; $j \in \{1, 2, 3, 5, 10, 20, 50, 100\}$; and $\gamma \in \{0.0001, 0.0002, 0.0005, 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5\}$. For most combinations of these parameter settings, training a model costs less than a second.

For evaluation, we will compute standard evaluation measures from fields of information retrieval [2] and text categorization: the precision-recall breakeven point (BEP) [3] and the area under the ROC curve [1]. Both measures have values from the range [0, 1], higher values being better. A model that ranks all positive examples higher than all negative ones would achieve a score of 1 on both measures.

Results. We used stratified 5-fold cross-validation (CV) on the training set. As described above, we investigated 5 values of C, 8 values of j and 15 values of γ. This results in 600 combinations of parameter settings. We then select the combination that performed the best during cross-validation on the training set; using this combination of parameter settings, we train the final model on the entire training set, and this model would then be evaluated on the test set. The results are summarized in the following table:

Model selection crterion	Performance on the validation set during 5-fold cross-validation		Performance on the test set (after training on the full training set)	
	BEP	A. u. ROC	BEP	A. u. ROC
Highest BEP during CV	0.5148	0.7796	0.7083	0.8893
Highest a.u.ROC during CV	0.5021	0.7850	0.6667	0.8738
Highest BEP on the test set	0.4717	0.7436	0.7500	0.9011
Highest a.u.ROC on the test set	0.4768	0.7495	0.7500	0.9155
Random ranking	0.2500	0.5000	0.2500	0.5000

The rows referring to the highest BEP/a.u.ROC on test set indicate what the best models among those tested here are capable of, but we aren't able to identify these models without peeking at the test data. It is encouraging to see that one does not do much worse by honestly selecting the models through CV. For comparison, the last row of the table also shows the performance of a hypothetical model that doesn't learn anything and instead just outputs random scores for all the examples. (The fact that the performance on the test set is better than the one during cross-validation is probably due to the fact that only 80% of the training set are used to train each model during cross-validation.)

It turns out that in general, the best performance is achieved at $j = 3$, which is reasonable as there are exactly 3 times as many negative examples as there are positive ones in our dataset. With C and γ, there is a fairly wide range of values where performance is close to the best.

6 CONCLUSIONS AND FUTURE WORK

We described an approach for predicting a subset of structural changes in an ontology. Our approach aims to predict the addition of categories within a hierarchy of documents, under the assumption that the new category is a child of an existing parent category and that it contains at least a few documents that were formerly members of the parent category. We have described how this task can be formulated as a machine learning problem and presented experiments that show that the prediction of this type of changes is feasible.

There are several directions for future work. More features could be devised, especially to take the presence of the existing subcategories (if any) into account. One could try predicting not just whether a new category should be added, but also which documents it should include, and perhaps which keywords it should be described by.

One could also address other types of ontology changes, such as moves, merges, and renamings. The problem with renames is that a category name often includes abstract terms that are not necessarily prominent in the documents from that category (or its subtree). One could also consider the problem of structural change prediction in semantically richer ontologies.

Acknowledgments

This work was supported by the Slovenian Research Agency and the IST Programme of the EC under NeOn (IST-2004-27595-IP).

References

[1] F. Provost, T. Fawcett. Robust classification for imprecise environments. *Machine Learning*, 42(3):203-231, March 2001.

[2] C. J. van Rijsbergen. *Information Retrieval*. Butterworth, 1979

[3] D. D. Lewis. *Representation and Learning in Information Retrieval*. Ph.D. Thesis, U. of Massachusetts, Amherst, USA, 1991.

[4] C. Cortes, V. Vapnik. Support-Vector Networks. *Machine Learning* 20(3):273-297, September 1995.

[5] T. Joachims. Text categorization with support vector machines: Learning with many relevant features. *Proc. ECML 1998*.

[6] T. Su, J. G. Dy. In search of deterministic methods for initializing K-means and Gaussian mixture clustering. *Intelligent Data Analysis* 11(4):319-338, 2007.

[7] M. Steinbach, G. Karypis, V. Kumar. A comparison of document clustering techniques. *Proc. KDD Text Mining Workshop,* 2000.

[8] P. Cimiano, J. Völker. Text2onto - a framework for ontology learning and data-driven change discovery. *Proc. NLDB'2005*.

[9] P. Haase, Y. Sure, J. Völker. Management of dynamic knowledge. *Journal of Knowledge Management*, 9(5):97-107, 2005.

[10] L. Stojanović. *Methods and Tools for Ontology Evolution*. PhD thesis, University of Karlsruhe, 2004.

[11] J. Völker, Y. Sure. *Data-driven change discovery*. Deliverable 3.3.1, SEKT Project (EU IST-2003-506826). July 22, 2005.

[12] A. Maedche et al. Ontologies for Enterprise Knowledge Management. *IEEE Intelligent Systems*, January/February 2003.

[13] G. Flouris, D. Plexousakis, G. Anto. A Classification of Ontology

Change. *Proc. 3rd Italian Semantic Web Workshop*, 2006.
[14] D. Maynard, W. Peters, M. d'Aquin, M. Sabou, N. Aswani. *Dynamics of Metadata*. Deliverable 1.5.1, NeOn Project. 2007.

LEARNING GENERIC MODELS OF DYNAMIC SYSTEMS

Darko Čerepnalkoski[1], Sašo Džeroski[1], Katerina Taškova[2], Ljupčo Todorovski[3]

[1]Department of Knowledge Technologies,

[2]Department of Computer Systems,

Jozef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

[3] Faculty of Administration, University of Ljubljana, Gosarjeva ul. 5, 1000 Ljubljana, Slovenia

Darko.Cerepnalkoski@gmail.com,{Saso.Dzeroski, Katerina.Taskova}@ijs.si,

Ljupco.Todorovski@fu.uni-lj.si

ABSTRACT

This paper concentrates on the use of Ordinary Differential Equations (ODEs) as models for describing dynamic system's behavior. The LAGRAMGE algorithm can construct such a model from experimental or observational data. Based on domain knowledge in the form of a context-free grammar (CFG), LAGRAMGE finds the most suitable structure of ODEs and fits the constant parameters of those equations to the given data set. One generalization of this problem is to find a generic model, i.e., an ODE structure that can be applied to several different datasets and fits them all well by tailoring the values of constant parameters to each dataset. In this paper, we modify the original LAGRAMGE algorithm, so we can use it to construct such generic models. Initial experiments were performed in modeling algal growth at four locations in the Lagoon of Venice. The generic models for all four locations fit the individual datasets less well, as compared to the specific models for individual locations. However, they have a wider range of validity and are likely to overfit less. They describe several similar dynamic systems in a uniform manner.

1 INTRODUCTION

Describing processes and systems in the form of models is one of the central areas of scientific research. Models are specifications in some well established mathematical formalism and when it comes to dynamic systems, differential equations are often used for specifying the model.

Differential equations are frequently used to model dynamic systems i.e. systems that change their state over time. This type of equations is good in capturing the nature of the change of the system. ODEs can be used to study a real system, e.g. an ecosystem such as a lake and can produce a simulation of anticipated results [4, 7].

The process of formulating ODEs for a given system involves two tasks. First, the structure of the differential equation has to be identified, and second, the constant parameters of the equation have to be estimated with an acceptable accuracy. The identification of the structure involves a certain amount of domain knowledge. In LAGRAMGE [3] the domain knowledge is formulated in a context-free grammar which describes the structure of the equation. Actually, the differential equation can have any of a number of, potentially infinite, concrete forms that the context-free grammar describes. For each of the equation structures the values of the constant parameters are estimated with fitting of the dataset and for each of the equation structure a certain degree of adequacy is evaluated with a certain heuristic function. The context-free grammar defines the search space of all possible structures. In order to find the most suitable equation, LAGRAMGE uses two search strategies. The first one is exhaustive search (with the possible constraint of a maximum depth) which traverses the whole search space to a certain depth. Depth refers to the depth of the parse tree with which the equation is constructed. The second one is beam search which doesn't traverse the whole search space but instead uses directed search. With beam search a beam, which is an array of the best equations found is kept at all times. In each iteration all possible refinements of the equations in the current beam are constructed and evaluated. The beam in the next iteration consists of the best equations from the previous beam equations and their refinements. The LAGRAMGE algorithm uses one dataset to fit the constant parameters. In each step when an equation with a specific structure is used the same dataset is used. The dataset is a set of tuples of measurements of the variables used in the equations.

The key concept Generic Models is presented in Section 2. Outline of the modified LAGRAMGE algorithm used for construction of generic models is covered in Section 3. In brief about the implementation of the modified algorithm is discussed in Section 4. Evaluation results are presented in Section 5. And finally, conclusions and further work are discussed in Section 6 and Section 7 respectively.

2 GENERIC MODELS

A generic model is a system of ODEs with generic constant parameters. A generic model can be applied to several different real systems by selecting different values for the generic constant parameters. Given several datasets with data that refers to several measurements to similar but not identical systems, the generic model represents a model that defines a series of equations with the same structure which only differ in the choice of constant parameters. The values of the parameters for each equation depend on the specific dataset. For example, if we have datasets with measurements for several very similar ecosystems, say several similar lakes that reside in vicinity, with the standard approach we can find ODEs for each lake which fits its data best, and these ODEs will most probably differ amongst not only in parameters but also in structure. With the approach of generic models we can construct a family of models (ODEs) with the same structure that differ in the constant parameters for each lake. This approach can be used for constructing ODEs for the same real system but with measurements taken at different times, for example, datasets with measurements for the same lake but taken at successive years.

```
procedure LAGRAMGE(D, G, h_max, S, w_b, F, H, C)
  switch (S)
  case exhaustive:
    let T be the shallowest derivation tree
    Q := <empty set>
    repeat
      fit the constant parameter values of expression E,
          generated by T, with F
      evaluate expression E according to H
      Q := Q U {T}
      retain the w_b best derivation trees in Q
      T := next enumerated derivation tree in G
    until all derivation trees enumerated or C
  case beam_search:
    let T_0 be the shallowest derivation tree
    Q := {T_0}
    repeat
     Q_1 := Q
     R := set of all refinements of derivation trees in Q
     fit the constant parameter values of expressions,
          generated by trees in R with F
     evaluate expressions, generated by trees in R,
          according to H
     Q := Q_1 U R
     retain the w_b best derivation trees in Q
    until Q = Q_1 or C
  end switch
  print out expressions generated by trees in Q
```

Figure 1: *The original LAGRAMGE algorithm.*

3 MODIFICATION OF THE LAGRAMGE ALGORITHM

The equation discovery system LAGRAMGE, using context-free grammar heuristically searches through the space of candidate equations, matches them against data, and finds the best fitting one. Figure 1 presents a high-level outline of the algorithm, where D is the dataset, G is the context-free grammar, h_{max} is the maximum height of the parsing trees, S the search strategy, w_b the beam width, F a fitting method, H a heuristic function (typically Mean Square Error-MSE or alternative heuristic function MDL that takes into account the complexity of the model and guides the search towards simpler models [3]) and C is a stopping criterion. The two search strategies of the algorithm are presented as two separate cases.

```
procedure LAGRAMGE(D, G, h_max, S, w_b, F, H, C)
  switch (S)
  case exhaustive:
    let T be the shallowest derivation tree
    Q := <empty set>
    total_error = 0;
    repeat
      for i := 1 to  length(D) do
        fit the constant parameter values of
        expression E_i, generated by T, with F,
        using data D_i
        error_i  = evaluate expression E_i according to H
        total_error = total_error +  error_i
      end for
      Q := Q U {T}
      retain the w_b best derivation trees in Q according
        to total_error
      T := next enumerated derivation tree in G
    until all derivation trees enumerated or C
  case beam_search:
    let T_0 be the shallowest derivation tree
    Q := {T_0}
    repeat
     Q_1 := Q
     R := set of all refinements of derivation trees in Q
      for each tree T in R do
        total_error = 0;
        for i := 1 to length(D) do
          fit the constant parameter values of
          expression E_i, generated by T with F
          using data D_i
          error_i  = evaluate expression E_i,
                according to H
          total_error = total_error +  error_i
        end for
      end for
      Q := Q_1 U R
      retain the w_b best derivation trees in Q according
        to total_error
    until Q = Q_1 or C
  end switch
  print out expressions generated by trees in Q
```

Figure 2: *The modified LAGRAMGE algorithm*

The modified LAGRAMGE algorithm for learning generic models is presented in Figure 2. In both search strategies whenever a parse tree is constructed, instead of fitting one data set and thus producing one set of constant parameters, all datasets are fitted one by one on the same equation structure and for each dataset a different set of values for the constant parameters is produced. Instead of assigning the adequacy of a given model structure by evaluating the heuristic function on the data and resulting equation, the adequacy of a given model structure is computed as the

sum of the values of the heuristic function for all the actual equation and their corresponding datasets.
The implementation of the modification in the case of exhaustive search is pretty much straight forward since essentially the original algorithm is performed for all the datasets and the errors of all the equations computed by the heuristic functions are summed up.
The beam search on the other hand is a directed search and unlike the exhaustive search does not traverse the whole search space. It keeps a list of the best equations found up until that moment, called a beam (Q) and in each iteration it constructs the refinements (R) of all the equations in the beam. Then for each refinement, which is an equation structure with unfitted parameters, it performs the fitting procedure against all datasets. Again, the new heuristic value of the equation structure is the sum of errors of all the particular fittings.

4 IMPLEMENTATION

The original implementation of the LAGRAMAGE algorithm was written in the C programming language and compiled using the Gnu gcc compiler. This implementation was used as a starting point. In order to encompass the modifications made to the original algorithm, appropriate changes were made to this implementation.
Learning generic models with the exhaustive search strategy was implemented as a first step modification of the original implementation of the algorithm. The second step includes implementation of the beam search strategy and this is a task on which we work in the moment.

5 EXPERIMENTAL EVALUATIONS

To test the modified LAGRAMGE algorithm for learning generic models we made experiments using the dataset for the Lagoon of Venice. The task is to model the algal growth in the Lagoon of Venice.
The Lagoon of Venice measures 550 km^2, but it is very shallow, with an average depth of less than 1 m. It is heavily influenced by anthropogenic inflow of nutrients – 7 [mio kg/year] of nitrogen and 1.4 [mio kg/year] of phosphorus. These (mainly nitrogen) loads are above the Lagoon's admissible trophic limit and generate its dystrophic behavior, which is characterized by excessive growth of algae, mainly Ulva rigida.
Four sets of measured data [5] were available for modeling the growth of algae in the Lagoon. The data were sampled weekly for slightly more than one year at four different locations in the Lagoon. Location 0 was sampled in 1985/86, locations 1, 2 and 3 in 1990/91. The sampled quantities are nitrogen in ammonia NH_3, nitrogen in nitrate NO_3, phosphorus in orthophosphate PO_4 (all in [μg/l]), dissolved in oxygen DO (in percentage of saturation), temperature T ([degrees C]), and algal biomass B (dry weight in [g/m^2]).
The addressed modeling problem is defined by 7 system variables: time, temp, dox, nitroh, nitroox, phospox and biomass. The "time" variable is the variable on which the derivation is applied. The biomass is the dependent variable whose first derivative "$\mathrm{biomass}'$" is the target variable.
From the domain knowledge about modeling population dynamics described in [7], an (almost) context-free grammar was constructed and supplied to the algorithm. Based on this grammar and the additional constraint of the depth of the derivation trees set to 5, 32 model structure-trees were generated and evaluated every time the algorithm was run.
The best equations (according to the MSE and MDL heuristics) discovered by the algorithm when trying to fit every dataset separately are presented below ordered by the location where data were sampled.

Model for dataset 0 (Location 0):

$$\begin{aligned} \mathrm{biomass}' &= 5.7 \cdot 10^{-7} \cdot \mathrm{biomass} \cdot \frac{1-\mathrm{biomass}}{0.2} + \\ &+ 0.09 \cdot \mathrm{biomass} \cdot (1 - e^{-0.006 \cdot \mathrm{dox}}) \cdot \frac{\mathrm{nitroox}^2}{\mathrm{nitroox}^2 + 5.58} \\ &- 0.05 \cdot \mathrm{biomass} \end{aligned} \quad (1)$$

Model for dataset 1 (Location 1):

$$\begin{aligned} \mathrm{biomass}' &= 0.017 \cdot \mathrm{biomass} + \\ &+ 0.45 \cdot \mathrm{biomass} \cdot (1 - e^{-2.17 \cdot \mathrm{dox}}) \cdot (1 - e^{-0.01 \cdot \mathrm{nitroox}}) \\ &- 0.2 \cdot \mathrm{biomass} \end{aligned} \quad (2)$$

Model for dataset 2 (Location 2):

$$\begin{aligned} \mathrm{biomass}' &= -0.38 \cdot \mathrm{biomass} + \\ &+ 0.39 \cdot \mathrm{biomass} \cdot (1 - e^{-0.68 \cdot \mathrm{dox}}) \cdot (1 - e^{-0.26 \cdot \mathrm{nitroox}}) \end{aligned} \quad (3)$$

Model for dataset 3 (Location 3):

$$\begin{aligned} \mathrm{biomass}' &= -0.2 \cdot \mathrm{biomass} + \\ &+ 0.2 \cdot \mathrm{biomass} \cdot \frac{\mathrm{dox}}{\mathrm{dox} + 4.3} \cdot (1 - e^{-0.55 \cdot \mathrm{nitroox}}) \end{aligned} \quad (4)$$

The values of the heuristics functions which determine the level of adequacy of the equations (1) to (4) to the given data are presented in Table 1.

Equation for	MSE	MDL
Dataset 0	5980.3	6697.01
Dataset 1	32730.1	36019.7
Dataset 2	10105.3	12995.5
Dataset 3	2249.82	2465.49

Table 1: *Error estimations*

Results obtained by running the modified algorithm across all four datasets are presented in Table 2.
As can be seen from Table 2, the sum heuristics are considered for evaluating the adequacy of a generic models. In order to be able to compare the obtained generic models to the predicted models in the individual cases we considered the average heuristics as well. From the results

presented in both tables, one can notice that the individual models are undoubtedly better in describing the individual datasets than the generic model. However, the benefit from using a generic model is in the uniformity of the solution, since one generic equation, with generic constant parameters is returned as a result.

Equation rank	Sum MSE	Sum MDL	Average MSE	Average MDL
1	73857.4	76724.2	18464.4	19181.1
2	75867.9	78734.7	18966.9	19683.7
3	75941.4	78610.5	18985.4	19652.6

Table 2: *Best generic models.*

The best three generic model structures (for which the heuristics are listed in Table 2) obtained are:

$$\text{biomass}' = -cons_1 \cdot \text{biomass} + \\ + cons_2 \cdot \text{biomass} \cdot (1 - e^{-cons_3 \cdot \text{dox}}) \cdot (1 - e^{-cons_4 \cdot \text{nitroox}}) \quad (5)$$

$$\text{biomass}' = \text{const}_1 \cdot \text{biomass} \cdot \frac{1 - \text{biomass}}{\text{const}_2} \\ + \text{const}_3 \cdot \text{biomass} \cdot (1 - e^{-\text{const}_4 \cdot \text{dox}}) \cdot \frac{\text{nitrox}^2}{\text{nitrox}^2 + \text{const}_5} \\ - \text{const}_6 \cdot \text{biomass} \quad (6)$$

$$\text{biomass}' = \text{const}_1 \cdot \text{biomass} \cdot (1 - e^{-\text{const}_2 \cdot \text{dox}}) \cdot \frac{\text{nitrox}}{\text{nitrox} + \text{const}_3} \\ - \text{const}_4 \cdot \text{biomass} \quad (7)$$

Dataset	const_1	const_2	const_3	const_4	MSE
Dataset 0	0.059	0.079	0.064	0.103	8018
Dataset 1	0.212	0.454	1.933	0.016	40850
Dataset 2	1.530	0.419	0.458	0.130	22059
Dataset 3	0.055	0.056	0.061	0.102	2660

Table 3: *Constant parameters' values across the four datasets*

The specific values of the generic parameters in the best generic model (5) for each of the four concrete equations describing the four datasets along with the corresponding MSE values are given in Table 3. It is evident that there are noticeable differences in the values of the constant parameters for the different datasets. It is obvious that the best generic model fits best to the dataset 3 (smallest MSE value) compared to the rest of the datasets.

5 CONCLUSIONS

In this work we have presented a way of extending LAGRAMGE to learn generic models of dynamic systems expressed as systems of Ordinary Differential Equations. We have applied our modified method to real world data about the Lagoon of Venice.

The equations obtained from the generic model by substituting the specific values of the parameters fit the individual datasets less well as compared to the equations obtained directly from each dataset. This, however, is not surprising, as we are talking about accuracy on the training data. The generic models have a wider range of validity and are allowed to overfit less. The generic models describe several similar dynamic systems in a uniform manner.

6 FURTHER WORK

Evaluations with beam search strategy implemented in the proposed algorithm are next step in our work.

This algorithm has so far been tested on only one collection of datasets, the Lagoon of Venice, so further testing and evaluation of different datasets is needed. One particular area is datasets from the same physical system which are gathered at different points in time.

For accurate evaluation of given models, the most suitable approach is applying cross-dataset validation. That means learning generic model on one of the given dataset (training set) and test the one on the rest of the available datasets that describe the same physical system. And the same procedure is performed across all given datasets.

Another direction for further research is parallelization of the modified LAGRAMGE algorithm, topic on which some work has already been done with the original algorithm [6].

References

[1] Dzeroski, S., & Todorovski, L. (1993). Discovering dynamics. Proceedings of Tenth International Conference on Machine Learning (pp. 97–103). San Mateo, CA: Morgan Kaufmann...

[2] Dzeroski, S., & Todorovski, L. (1995). Discovering dynamics: From inductive logic programming to machine discovery. Journal of Intelligent Information Systems, 4, 89–108.

[3] Todorovski, L., & Dzeroski, S. (1997). Declarative bias in equation discovery. Proceedings of Fourteenth International Conference on Machine Learning (pp. 376–384). San Mateo, CA: Morgan Kaufmann.

[4] Todorovski, L., & Dzeroski, S. (2003). Using domain specific knowledge for automated modeling. Proceedings of Fifth International Conference on Intelligent Data Analysis (pp. 48–59).

[5] Coffaro G., Carrer G. and Bendoricchio G. (1993). Model for Ulva Rigida growth in the Lagoon of Venice.Technical report, UNESCO MURST Project: Venice Lagoon Ecosystem, University of Padova, Padova, Italy.

[6] Gjorgjioski, V, Todorovski L. & Dzeroski S. (2007). A Parallel Implementation of the LAGRAMGE Approach to Process-Based Modeling. International Conference on Machine Learning

[7] Todorovski, L., & Džeroski, S., (2006). Integrating knowledge-driven and data-driven approaches to modeling. Ecological Modelling, 194(1-3): 3-13.

ANOMALY DETECTION IN COMPUTER NETWORKS USING LINEAR SVMs

Carolina Fortuna, Blaž Fortuna[#], Mihael Mohorčič**
* Department of Communication Systems, Jožef Stefan Institute,
Jamova 39, 1000 Ljubljana, Slovenia
[#]Department of Knowledge Technologies, Jožef Stefan Institute,
Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 4773900; e-mail: carolina.fortuna@ijs.si

ABSTRACT

Modern computer networks are subject to various malicious attacks. Since attacks are becoming more sophisticated and networks are becoming larger there is a need for an efficient intrusion detection systems (IDSs) that can distinguish between legitimate and illegitimate traffic and be able to signal attacks in real time, before serious damages are produced. In this paper we use linear support vector machines (SVMs) for detecting abnormal traffic patterns in the KDD Cup 1999 data. The IDS system is supposed to distinguish normal traffic from intrusions and to classify the intrusions into four classes: DoS, probe, R2L and U2R. The dataset is quite unbalanced, with 79% of the traffic belonging to the DoS category, 19% is normal traffic and less than 2% constitute the other three categories. This paper studies the performance of IDSs based on linear multi-class SVMs with highest confidence (one-to-all), majority (one-to-one) and two level (one-to-all-3categ) voting on this particular dataset. The one-to-all-3categ IDS is tailored to perform well on the unbalanced dataset but it proves to be less efficient when trained on large datasets. The one-to-one IDS turns to perform the best on larger training dataset. The best performing IDS has a 90.9% intrusion detection rate, 90.7% intrusion diagnosis rate and 0.2479 average cost per test example (ACTE).

1 INTRODUCTION

A computer network can be the target of attacks both from the intra and extra domain. The critical nodes of such a network need to be monitored from a centralized location in such way as to prevent potential damages. Since computer networks increase their size and attacks are evolving continuously, it is hard for a human system engineer to efficiently combat intrusions. A machine learning software can alert in real time both known and unknown attack types. The intrusion detector learning task is to build a predictive model (i.e. a classifier) capable of distinguishing between ``bad" connections, called intrusions or attacks, and ``good" normal connections [1].

The winner of the KDD Cup 1999 used a mixture of bagging and boosting taking into consideration asymmetric error costs by minimizing the so called initial costs [2]. The competitors ranked on the second and third place used decision trees and tailored their methods on the nature of the dataset [3][4]. Recently, a three tier IDS using multi-class SVM with Gaussian kernel was used to produce better results than the KDD Cup 1999 winner. Their approach is to combine the strength of the classical signature based detection to the more recent anomaly detectors, since the first one performs well on known attacks and the second performs well on novel attacks. In their approach, they use a three tier IDS: on the first tier a black list is built that is able to filter out probe, DoS, R2L and U2R attacks based on signature. The normal and unknown attacks that pass the filters in the first tier are passed to the second tier. Here a white list is used to filter normal traffic from the unknown attacks. Finally, on the third tier, Smooth SVM [12] is used to determine the category the unknown attacks belong to [5].

In our approach we study the performance of IDSs based on linear multi-class SVM with highest confidence (one-to-all IDS) and majority voting (one-to-one IDS) respectively and propose a simple and rapid IDS that uses multi-class SVM with linear kernel and two level voting (one-to-all-3categ). In the first step of the approach, SVMs are trained on subsets of the 10% training dataset and a subset of the full dataset, according to the IDS architecture. The models built by SVM are used to classify new instances and three voting types are used to decide the final class the new instance belongs to. We expect that the one-to-all-3categ IDS performs better then the other two IDSs given the nature of the training dataset but this proves to hold only for small training datasets. On the 10% training dataset, the one-to-one IDS yields the best results, outperforming the one-to-all-3categ IDS. It seems that R2L connections are spread across the space and linear SVM is not able to build a model that can classify them accurately, especially that these instances appear in small number in the training dataset. In the testing dataset, their number increases dramatically and the misclassification cost is high. R2L connections are misclassified as normal connection most of the times.

The rest of the paper is structured as follows. Section 2 describes the criteria for evaluating IDSs, Section 3 describes the dataset, Section 4 details the experiments focusing on the data preprocessing, the machine learning method used and the three IDS architectures and discusses the results. Finally, Section 5 concludes the paper.

2 EVALUATION CRITERIA

Several metrics are used to evaluate and compare the performance of Intrusion Detection Systems (IDSs). The most basic metrics are the detection and false alarm rates. The detection rate is equal to the number of intrusions detected divided by the total number of intrusions in a data set, while the false alarm rate is equal to the number of normal instances detected as intrusions divided by the number of normal instances in a data set. False alarms are also referred to as false positives [7]. The diagnosis rate (or recall), meaning the number of correctly classified intrusions divided by the total number of intrusions, is also a relevant metric and we refer to it across this paper.

In the KDD Cup 1999 the criteria used for evaluation of the participant entries is the ACTE computed using the confusion matrix and a given cost matrix. The confusion matrix is obtained while classifying the instances in the test dataset. Each column of the confusion matrix represents the instances in a predicted class, while each row represents the instances in an actual class. The cost matrix is given in Table 1.

	normal	Probe	DOS	U2R	R2L
normal	0	1	2	2	2
probe	1	0	2	2	2
DOS	2	1	0	2	2
U2R	3	2	2	0	2
R2L	4	2	2	2	0

Table 1 Cost matrix

From the table above, it can be noticed that the most expensive is misclassifying U2R and R2L instances as normal instances.

3 DATASET

The KDD Cup 1999 uses a version of the data on which the 1998 DARPA Intrusion Detection Evaluation Program was performed. The training dataset was acquired in a seven week time frame of monitoring the network and was processed into almost 5 million instances. The test dataset was acquired during a two week time frame and contains 311029 instances. Both training and test datasets are labeled with the name of the attack type or as being normal traffic [1]. There are 38 different attack types in training and test data together and these attack types fall into four main categories: probe, denial of service (DoS), remote to local (R2L) and user to root (U2R) [2].

The dataset is extremely unbalanced; most instances are DoS traffic (79%), while the other three attack types together make less than 2% of the instances. Around 19% of the instances correspond to normal traffic. The test dataset has different distribution than the training dataset and contains several new attacks (17 new attacks out of 38 possible attacks). Figure 1 depicts the distribution of the full training dataset, 10% of the full training dataset and of the testing dataset. It can be noticed that the normal, probe and DoS connections keep their distribution across the three datasets while the same is not valid for U2R and R2L connections. For U2R connections a slight increase in number of instances in the test dataset versus the training dataset can be noticed. U2R instances represent 0.01% of the 10% training dataset and 0.2% of the test dataset. On th other hand, the proportion of the R2L connections dramatically increases in the test dataset (5.2%) comparing to the training one (0.2%). Furthermore, the R2L connections are spread in space posing real challenge for determining an accurate model for classification.

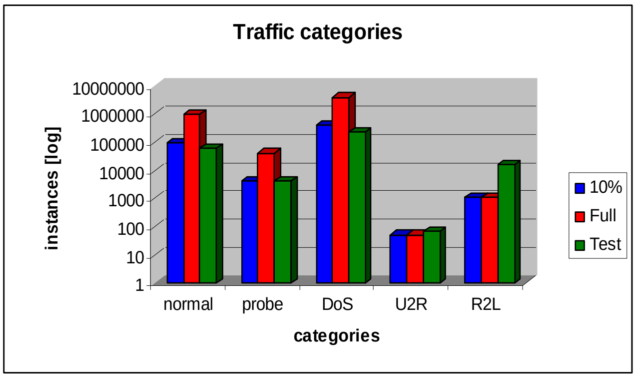


Figure 1 Traffic distribution in KDD Cup 1999 dataset

4 EXPERIMENTS

4.1 Data preprocessing

Each instance in the KDD Cup 1999 datasets contains 41 features that describe a connection. Features 1-9 stand for the basic features of a packet, 10-22 for content features, 23-31 for traffic features and 32-41 for host based features [6]. There are 7 nominal and 34 continuous features. Since SVM does not take as input nominal values, the 7 nominal features had to be transformed so that the resulting datasets had 108 features for each instance. Given the large dimension of the full dataset (around 5 million instances), we used only 10% of it (494021 instances) in most of the experiments. However, the first experiments were performed on a smaller dataset (100.000 instances) sampled from the 10% dataset in such way that the three minority classes were kept unchanged. This approach is expected to be faster (since the dimension of the training data is smaller) and build a better model for the three minority classes (as their weight in the dataset has been artificially increased).

4.2 SVM

The machine learning method used in this paper is the support vector machines (SVMs) [11]. SVMs are a set of related supervised learning methods used for classification and regression. The experiments in this paper use linear SVM as implemented in TextGarden [10].

4.3 One-to-all, one-to-one and one-to-all-3categ IDSs

The one-to-all IDS uses the 10% training dataset and preprocesses it as described in Section 4.1. After preprocessing, five training files are created. In each of the files, one attack type represents the positive class and all the other attacks represent the negative class. The SVM is trained on these five files and for each input file, it builds an output model that distinguishes between the positive class and all the other classes in the input, this is why the name one-to-all. Each connection in the test data is then fed to the models, each model decides if the connection belongs or not to a class with a certain degree of confidence. The connection is classified as belonging to the class that classified it with highest confidence. Figure 2 presents the workflow of the one-to-all IDS. The outcome of the voting is summarized into a confusion matrix and finally the average cost per text example is computed.

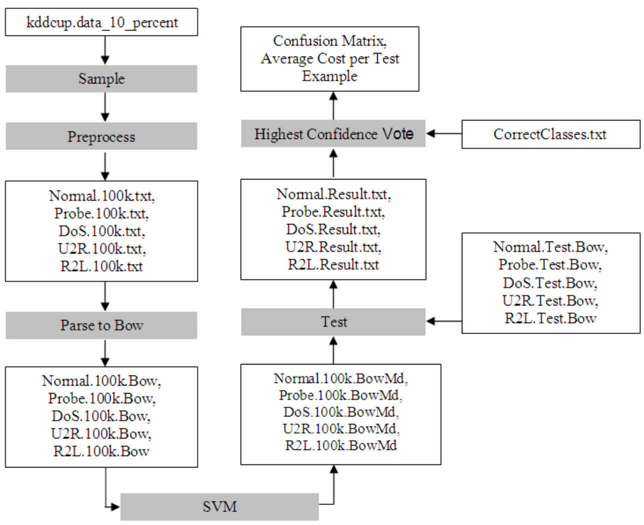


Figure 2 One-to-all IDS

The one-to-one IDS works similarly as the one-to-all IDS with two exceptions: the training files and the voting method. Each training files contains only two types of attacks: one represents the positive class and the other represents the negative class. This way 10 training files are prepared and 10 models are built. When a new connection has to be classified, each model decides for one of the two classes the connection belongs to. The connection is classified as belonging to the class to which the majority of the models assigned it to.

Figure 3 presents the workflow of the one-to-one IDS.

The third IDS tries to adapt to the nature of the training data. Given the unbalanced nature of the data, it attempts to build a better model for classifying minority classes. In order to achieve this, two sets of one-to-all training files are used. The first set is formed of two files in which the positive class is represented by normal and DoS connections respectively, and the negative class is represented by all other types of connections (one-to-all test files). The second set of training files contains only three types of connections: probe, R2L and U2R filtered from the full dataset, resulting in three one-to-all files (one-to-all-3categ files since the "all" stands for the other two minority categories). SVM is trained on all five files and a two level voting is applied to the new instances. In the first level, the system determines if the connection belongs to any of the two majority classes, DoS or normal, based on a highest confidence voting. If the connection does not belong to any of the two classes, it goes to the second level where the system determines if it belongs to probe, R2L or U2R classes also based on a highest confidence vote.

Figure 4 presents the workflow of the one-to-all-3categ IDS.

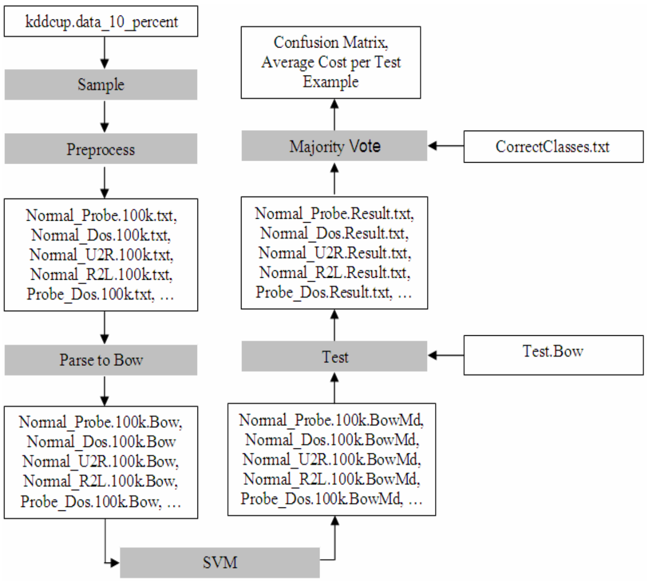


Figure 3 One-to-one IDS

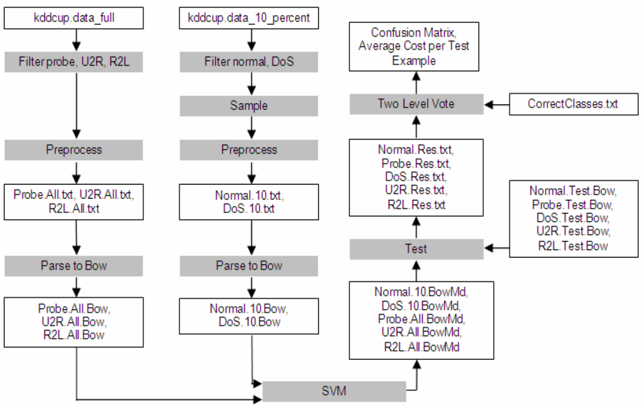


Figure 4 One-to-all-3categ IDS

4.4 Experimental Results

When dealing with such large and unbalanced datasets as the one provided for the KDD Cup 1999, an important step is to understand the data and find a suitable model for it. Our approach was to build models on a 100.000 instance dataset obtained as explained in Section 4.1 and classify the test dataset using the three IDSs described in Section 4.3. Table 2 presents the results obtained at this stage. The one-to-one IDS has the poorest ACTE, the one-to-all-3categ

IDS has the best ACTE while the results for one-to-all IDS are somewhere in between. The one-to-all IDS has a high detection rate, a good diagnosis rate but a very high false alarm rate meaning that it classifies most of the normal traffic as intrusion. This system doesn't detect probe, R2L and U2R intrusions at all. All the traffic is classified as DoS or normal, but it seems that it confuses DoS with normal quite often. This might be due to the SVM cost parameters that are not optimized for this dataset or to the nature of the dataset. The one-to-one scenario has lower false alarm rate, but has poor diagnosis performance, meaning that it detects most of the alarms, but it doesn't classify them correctly. The high ACTE seems to come from misclassifying DoS attacks (over 220.000 instances out of 311.000) for R2L attacks. Finally, the one-to-all-3categ IDS gives the best results: good ACTE, good detection and diagnosis rates and low false alarm rate. However, this result might be further improved by parameter tuning or increasing the size of the training dataset.

	One-to-all	One-to-one	One-to-all-3categ
ACTE	0.5306	1.6656	0.2641
Detection rate	99.2%	95.0%	90.3%
Diagnosis rate	91.3%	3.3%	90.1%
False alarm rate	99.6%	12.8%	1.6%

Table 2 Results for 100.000 instance training set

The next step in the approach was to tune SVM parameters in order to build more accurate models. The 10% training dataset (494021 instances) with 10 fold cross validation were used to build the models and the three resulting IDSs were then tested. The results are listed in Table 3.

	One-to-all	One-to-one	One-to-all-3categ
ACTE	0.2625	0.2479	0.2653
Detection rate	90.2%	90.9%	90.3%
Diagnosis rate	90.1%	90.7%	90.1%
False alarm rate	1.6%	2.02%	1.6%

Table 3 Results for 10% training set

The one-to-all IDS improved the overall performance as well as the detection, diagnosis and false alarm rates. Both detection and diagnosis rates are quite good and false alarm rate is low, meaning the system detects and correctly determines the class of over 90% of connections and has a small false alarm rate (1.6%). The one-to-one IDS also improved: it has the smallest ACTE and good detection and diagnosis rate. The false alarm rate is slightly higher than for the one-to-all IDS. The most unexpected result comes from the one-to-all-3categ IDS: there is no improvement in the detection, diagnosis and false alarm rates. The ACTE slightly increases, due to more expensive (see the cost matrix) misclassifications.

We can go more into detail with the analysis of the performance of the three IDSs by comparing the output confusion matrices listed in Table 4, Table 5 and Table 6. Rows represent the labels of the connections and columns represent the class attributed by the IDS. The last row displays the rate of true positives (e.g. 71.0% of the connections classified as normal are normal) and the last column displays the accuracy (e.g. 98.3% of normal traffic was classified as normal).

	normal	probe	DOS	U2R	R2L	%
normal	59611	300	678	4	0	98.3
probe	1053	2922	191	0	0	70.1
DOS	7242	22	222589	0	0	96.8
U2R	54	0	0	11	5	15.7
R2L	15959	16	2	2	368	2.2
%	71.0	89.6	99.6	64.7	98.6	

Table 4 One-to-all confusion matrix (ACTE = 0.2625)

	normal	probe	DOS	U2R	R2L	%
normal	59367	211	818	12	185	97.9
probe	901	3002	148	0	115	72.0
DOS	7047	52	222754	0	0	96.9
U2R	32	0	0	32	6	45.7
R2L	14791	11	2	11	1532	9.3
%	72.2	91.6	99.5	58.1	83.3	

Table 5 One-to-one confusion matrix (ACTE = 0.2479)

	normal	probe	DOS	U2R	R2L	%
Normal	59593	313	672	5	10	98.3
probe	767	3120	181	6	92	74.8
DOS	7113	324	222406	0	10	96.7
U2R	60	0	0	5	5	7.1
R2L	16186	11	2	1	147	0.8
%	71.1	82.8	99.6	29.4	55.6	

Table 6 One-to-one-3categ confusion matrix (ACTE = 0.2653)

It can be seen in Table 4 that the one-to-all IDS performs well on normal and DoS connections, on probe it has a rather poor performance (70.1% diagnosis) and misclassifies most of U2R (15.7% diagnosis) and R2L (2.2% diagnosis) connections. Most of the misclassified probe, U2R and R2L connections are classified as normal. The models for normal and DoS traffic are fairly accurate since they had a large set of training instances to build on.

The one-to-one IDS performs better than one-to-all IDS as can be seen in Table 5. This IDS performs significantly better than one-to-all IDS on classifying U2R and R2L connections: it classifies 45.7% of U2R connections and 9.3% of R2L connections. The R2L connections are spread in space so that linear SVM proves to be inefficient for building a good model for classifying these instances. We noticed a tradeoff: the more accurate the SVM model for classifying R2L connections, the poorest in classifying normal connections and the other way around.

The one-to-all-3categ IDS performs worse than the other two IDSs in classifying R2L and U2R attacks, and performs slightly better on classifying probe attacks. It seems indeed that linear SVM is limited in building a good model for separating normal traffic from R2L due to the spread of these connections. Even though we introduced the one-to-all-3categ IDS in order to perform better at separating the three minority classes from the two major ones (normal and DoS), it seems like the model built using SVM is not accurate enough so that this voting system proves efficient. Most of the R2L connections do not pass the first level voting, being classified as normal.

Comparing to relevant results in the literature, the IDSs studied in the paper are less accurate. The one-to-one IDS with 0.2479 ACTE would rank 8^{th} in the KDD Cup 1999 contest. Higher accuracy can be obtained by increasing the complexity of the system. SVMs with different kernels can be used for building better models, but with this approach, classification speed would decrease [11], this is undesired in real time IDSs. Hybrid systems that combine several machine learning methods or that combine machine learning methods with the more classical ones based on signatures could be used.

4 CONCLUSIONS

In this paper we studied the performance of linear SVM in classifying normal and attack connections sniffed from a computer network. We proposed a two level voting IDS that proved to perform well on a small training set but performed relatively poor when the training dataset increased. In the context of intrusion detection in a computer network, attacks such as R2L and U2R that result in small number of traffic packets seem to pose a real challenge for detection and diagnosis. A good, simple and fast classifier that is able to detect novel attacks is hard to build. Usually simplicity and speed are traded for accuracy and machine learning methods are complemented by traditional signature based methods.

Acknowledgement

This work was supported by the Slovenian Research Agency and the IST Programme of the EC under NeOn (IST-4-027595-IP) and PASCAL (IST-2002-506778).

References

[1] KDD Cup 1999 Task Description, http://kdd.ics.uci.edu/databases/kddcup99/task.html

[2] Bernhard Pfahringer, Winning the KDD99 Classification Cup: Bagged Boosting, *ACM SIGKDD Explorations Newsletter*, Volume 1, Issue 2, p. 65-66 January 2000.

[3] Itzhak Levin, KDD-99 Classifier Learning Contest LLSoft's Results Overview, *ACM SIGKDD Explorations Newsletter*, Volume 1, Issue 2, p. 67-75 January 2000.

[4] Vladimir Miheev, Alexei Vopilov, Ivan Shabalin, The MP13 Approach to the KDD'99 Classifier Learning Contest, *SIGKDD Explorations Newsletter*, Volume 1, Issue 2, p76-77 January 2000.

[5] Tsong Song Hwang, Tsung-Ju Lee, Yuh-Jye Lee, A Three-tier IDS via Data Mining Approach, *MineNet'07*, June 12, 2007, San Diego, California, USA

[6] W. Lee. A Data Mining Framework for Constructing Features and Models for Intrusion Detection Systems. PhD thesis, Columbia University, 1999.

[7] Computer Security and Intrusion Detection, http://www.acm.org/crossroads/xrds11-1/csid.html

[8] H. Gunes Kayacik, Nur Zincir-Heywood, Malcolm I. Heywood, Selecting Features for Intrusion Detection: A Feature Relevance Analysis on KDD '99 Benchmark, http://www.unb.ca/pstnet/pst2005/Shaughnessy%20Room/Oct13/GK_FeatRelevance.ppt#256,1,Selecting Features for Intrusion Detection: A Feature Relevance Analysis on KDD 99 Benchmark

[9] Results of the KDD Cup 1999 Classifier Learning Contest, http://www-cse.ucsd.edu/users/elkan/clresults.html

[10] TextGarden – Text Mining Tools, http://kt.ijs.si/Dunja/textgarden/

[11] C. Cortes and V. Vapnik, Support-Vector Networks, Machine Learning, 20(3):273-297, September 1995.

[12] Y.-J. Lee and O. L. Mangasarian. SSVM: A smooth support vector machine. Computational Optimization and Applications, 20:5–22, 2001. Data Mining Institute, University of Wisconsin, Technical Report 99-03.

ADVANCING TOPIC ONTOLOGY LEARNING THROUGH TERM EXTRACTION

Blaž Fortuna (1), Nada Lavrač (1, 2), Paola Velardi (3)
(1) Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia
(2) University of Nova Gorica, Vipavska 13, 5000 Nova Gorica, Slovenia
(3) Universita di Roma "La Sapienza", 113 Via Salaria, Roma RM 00198, Italy
Tel: +386 1 4773900; e-mail: Blaz.Fortuna@ijs.si

ABSTRACT

This paper presents a novel methodology for topic ontology learning from text documents. The proposed methodology, named OntoTermExtraction is based on OntoGen, a semi-automated tool for topic ontology construction, upgraded by using and an advanced terminology extraction tool in an iterative, semi-automated ontology construction process. This process consists of (a) document clustering to find the nodes in the topic ontology, (b) term extraction from document clusters, (c) populating the term vocabulary and keyword extraction, and (d) choosing the concept names by comparing the best ranked terms with the extracted keywords. The approach is illustrated on a case study analysis of the ILPNet2 publications data.

1 Introduction

OntoGen [1, 2] is a semi-automated, data-driven ontology construction tool, focused on the construction and editing of topic ontologies. In a topic ontology, each node is a cluster of documents, represented by keywords (topics), and nodes are connected by relations (typically, the the SubConcept-Of relation). The system combines text mining techniques with an efficient user interface aimed to reduce user's time and the complexity of ontology construction. In this way it presents a significant improvement in comparison with present manual, and relatively complex ontology editing tools, such as Protégé [3], whose use is hindered by the lack of ontology engineering skills of domain experts constructing the ontology.

Concept naming suggestion (i.e. description of a document cluster through a set of relevant terms) plays a central part of the OntoGen system. Concept naming helps the user at evaluating clusters and organizing them hierarchically. This facility is provided by employing unsupervised and supervised methods for generating the suggestions. Despite the well-elaborated and user-friendly approach to concept naming, as currently provided by OntoGen, the approach was limited to single-word keyword suggestions, and by the use of very basic text lemmatization in the OntoGen text preprocessing phase.

This paper aims at improving the ontology construction process through improved concept naming, using terminology extraction as implemented in the advanced TermExtractor tool [4,5]. The improved ontology construction process, proposed in this paper, consists of the following steps:

- document clustering to find the nodes in the topic ontology,
- terminology extraction from document clusters,
- population of the terminology vocabulary and keyword extraction, and
- choice of concept names by comparing the best-ranked terms with the extracted keywords.

The proposed approach is illustrated on a case study analysis of the ILPNet2 publications database [4,5], a database of publications in the area of Inductive Logic Programming, extensively gathered for the period of about 20 years.

The paper is structured as follows. Section 2 describes the ILPNet2 domain used to illustrate the proposed approach to ontology construction. Section 3 describes the background technologies, as implemented in the OntoGen and TermExtractor tools. Section 4 presents the proposed methodology, through a detailed description of the individual steps of the advanced ontology construction process, illustrated by the results achieved in the analysis of the ILPNet2 database.

2 The ILPnet2 database

The domain we analized is the scientific publications database of the ILPnet2 Network of Excellence in Inductive Logic Programming [4]. ILPNet2 consisted of 37 project partners composed mainly of universities and research institutes. Our entity for the analysis are ILP publictions. The ILPnet2 database is publicly available on the Web and contains information about ILP publications between years 1971 and 2003. The data about publications in the BibTeX format, available in files at http://www.cs.bris.ac.uk/~ILPnet2/Tools/Reports/Bibtexs/2003, ..., (one file for each year 2003, 2002, …).

The first stage of the data-driven ontology construction process is data acquisition and preprocessing. The data was acquired with the *wget* utility and converted into the XML format. For easier data management in exploratory analysis of the social network of authors of ILP publications [5], it was convenient to put the data into a relational database format, using the Microsoft SQL Sever. One of the tasks accompanying the database population was the normalization of authors' names. While this was crucially needed for social network analysis(described in [5]), this step is not needed for the experiments in ontology construction described in this paper, as ontology construction uses only document titles and abstracts, preprocessed using a predefined list of stop-words and the Porter stemmer.

3 Background technologies

3.1 OntoGen

The two main characteristics of the OntoGen system [1,2,6] are the following.

- *Semi-Automatic.* The system is an interactive tool that aids the user during the ontology construction process. It suggests concepts, relations between the concepts, and concept names, automatically assigns instances to the concepts, visualizes instances within a concept and provides a good overview of the ontology to the user through concept browsing and various kinds of visualizations. At the same time the user is always in full control of the system and can affect the ontology construction by accepting or rejecting the system's suggestions or manually editing the ontology.
- *Data-Driven.* Most of the aid provided by the system is based on the underlying data, provided by the user typically at the beginning of the ontology construction process. The data affects the structure of the domain for which the user is building the ontology. The data is usually a document corpus, where ontological instances are either documents themselves or named entities occurring in the documents. The system supports automated extraction of instances (used for learning concepts) and co-occurrences of instances (used for learning relations between the concepts) from the data.

Major features of the system serve one or both of the two major design goals of OntoGen: (1) visualization and exploration of existing concepts from the ontology, and (2) addition of new concepts or modification of existing concept using simple and straightforward machine learning and text mining algorithms.

The main window of the system (see Figure 1) provides multiple views on the ontology. A tree-based view on the ontology, as it is intuitive for most users, presents a natural way to represent a concept hierarchy. This view is used to show the folder structure and as a visualization offering a one-glance view of the whole ontology. Each concept from the ontology is further explained by the most informative keywords describing the target concept, automatically extracted by employing unsupervised and supervised learning methods.

A sample ontology in the form of a tree-based concept hierarchy is shown in Figure 2. Both the first and the second level of the concept hierarchy were constructed using the k-means clustering algorithm, where the first level was split into 7 concepts and each of these concepts was than further split into three sub-concepts. The hierarchical structuring is user-triggered. At each single level, k-means is invoked for various user-defined values of k, then selecting the preferred k and dividing all the documents into k-subclusters, as a consequence.

While this procedure of ontology construction is elegant and simple for the user, quite some effort is needed to understand the content and the meaning of the selected concepts. This is especially striking when comparing the second level concepts, for example the sub-concepts of the concept named *logic_program, program,* and *inductive_logic* in Figure 2 with the sub-concepts of the concept *logic program* in Figure 3, which shows the concept hierarchy developed by the novel concept naming methodology based on TermExtractor.

3.2 TermExtractor

The TermExtractor tool [7,8] for automatic extraction of terms (possibly consisting of several words, as opposed to single keywords) from documents works as follows.

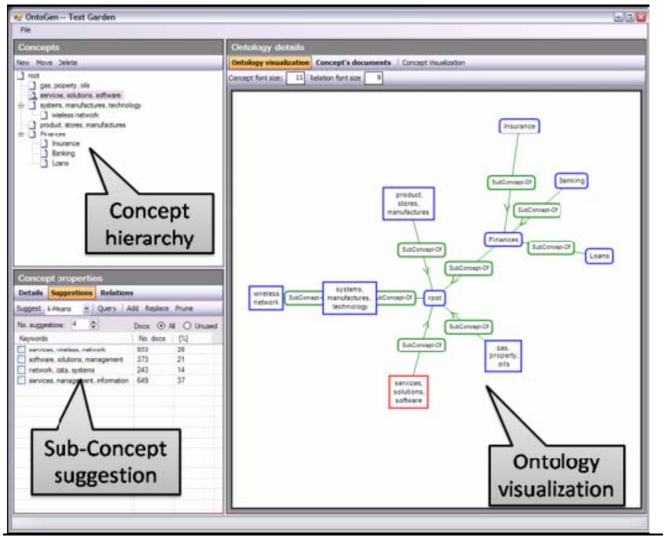


Figure 1. The user gets suggestions for the sub-concepts of the selected concept (left bottom part); the ontology is visualized as a tree-based concept hierarchy in a textual mode (left upper part) and in a graphical mode (right part).

Given a collection of documents from the desired domain, TermExtractor first extracts a list of candidate terms (frequent multi-word expressions). In the second step it evaluates each of the candidate terms using several scores which are then combined and the candidates are ranked according to the combined score. The output is a set of candidates whose score excides a given threshold. Documents from contrast domains are used as extra input for term evaluation and serve as a control group for measuring the term significance. The following scores are used to evaluate candidate terms in the second step (normalized score values are in the [0,1] interval):

- *Domain Relevance* is high if the term is significantly more frequent in the domain of interest than in other domains.
- *Domain consensus* is high if the term is used consistently across the documents from the domain.
- *Lexical cohesion* is high if the words composing the term are more frequently found with the term than alone in the documents.
- *Structural Relevance* is high for terms that are emphasized in the documents (e.g. appear in the title).
- *Miscellaneous* set of heuristics is used to remove generic modifiers (e.g. large knowledge base).

The combined score is a weighted convex combination of the individual scores.

4 OntoTermExtraction methodology

4.1 Motivation

There are several ways in which a vocabulary can be acquired. In some domains there already exist established vocabularies (e.g. EUROVOC used for annotating European legislation, AGROVOC used for annotating agricultural documents, ASFA used within UN FAO, DMOZ created collaboratively to categorize web pages, etc.). Another option is automatic extraction of terms from documents, which is especially attractive for the domains where there is no established vocabulary.

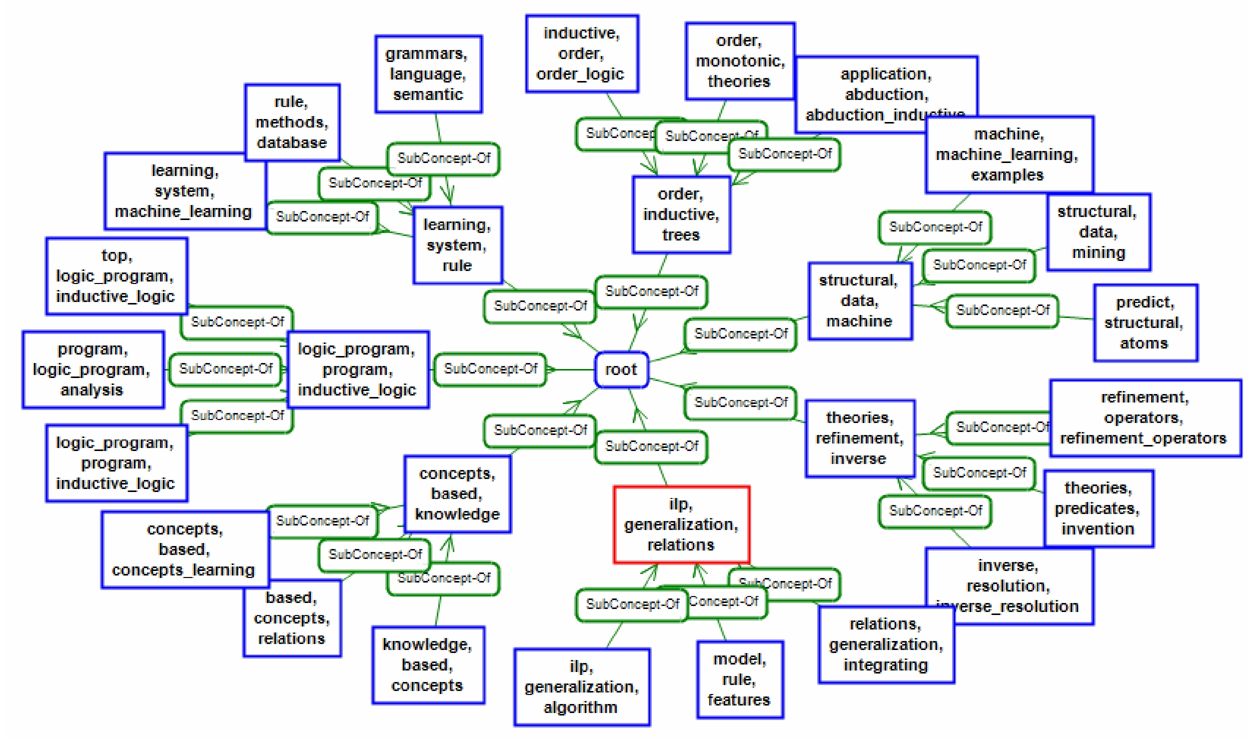


Figure 2 Ontology constructed by the standard OntoGen approach, constructed from ILPnet2 publications data, using the k-means clustering algorithm without any help from the pre-calculated vocabulary extracted by TermExtractor.

Concept and concept name suggestions play a central part in every ontology construction system. OntoGen provides unsupervised and supervised methods for generating such suggestions [1,2,6]. Unsupervised learning methods automatically generate a list of sub-concepts for a currently selected concept by using k-means clustering and latent semantic indexing (LSI) techniques to generate a list of possible sub-concepts. On the other hand, supervised learning methods require the user to have a rough idea about a new topic[1] – this is identified through a query returning the documents. The system automatically identifies the documents that correspond to the topic and the selection can be further refined by the user-computer interaction through an active learning loop using a machine learning technique for semi-automatic acquisition of the user's knowledge.

While OntoGen originally used only the input documents for proposing concept suggestions and term extraction techniques for providing help at naming the concepts, it should be noted that the whole process can be significantly improved by constructing a predefined vocabulary from the domain of the ontology under construction. The vocabulary can be used to support the user during hierarchical ordering of concepts, and to create concept descriptions, thus helping concept evaluation.

4.2 Steps in the proposed OntoTermExtraction methodology for concept naming

The advanced ontology construction process, proposed in this paper, consists of the following steps:

(a) document clustering to find the nodes in the ontology (described in Section 3.1),
(b) terminology extraction from document clusters (described in Section 3.2), using TermExtractor
(c) populating the term vocabulary and keyword extraction (described in Section 4.3),
(d) choosing the concept name (topic) by comparing the best-ranked terms with the extracted keywords (described in the ILPNet2 application in Section 5).

4.3 Populating the terms and keyword extraction

For each term from the vocabulary, a classification model is need which can predict if the term is relevant for a given document cluster. In this paper we use a centroid based nearest neighbor classifier [6] which was developed for fast classification of documents into taxonomies. We use this approach since it can scale well to larger collections of terms (hundreds of thousands of terms). A training set of

1 Hereafter we name *concepts* the document clusters generated by the k-means clustering algorithm, while a *topic* is a description of the concept, e.g. a term of a set of terms that best identify the document cluster.

documents is needed to generate a classification model. In some cases vocabularies already come with a set of documents annotated by the terms. In this case these documents can be used for training the term models. When no annotated documents are available, information retrieval can be applied for finding documents to populate the terms.
In this paper we propose using two different techniques to populate terms extracted by TermExtractor.
Let T be the set of terms automatically extracted from document clusters:

- The first technique uses the ILPnet2 collection. Each term $t \in T$ was issued in turn as a query and the top ranked documents (according to cosine similarity, using TFIDF word weighting) were used to populate the term.
- The second technique did not use the ILPnet2 collection and relied on Google web search instead [9]. A query was generated from each term *t* by taking its words and attaching an extra keyword "ILP" to limit the search to ILP related web pages. For example, if *t* is *inductive logic programming*, the query is *ILP inductive logic programming*. The query is then sent to Google and snippets of the returned search results are used to populate the term.

The ILP vocabulary prepared in this way was used as an extra input to OntoGen, besides the collection of the articles. We tried both approaches but in this report we only show the results of the second technique, because retrieval from the whole web turned out to be a richer resource than just the ILPnet2 collection. Details on how the vocabulary looked and how it was applied in the ILP ontology construction are described in Section 5.

5 ILPnet2 vocabulary and ontology construction

5.1 Vocabulary extraction

As described in the previous section, we used TermExtractor to automatically extract the vocabulary for the ILP domain from the ILPnet2 collection of ILP publications. Table 1 shows the 11 top-ranked terms (out of 97) extracted from ILPNet2 documents.

Table 1: Top-10 terms extracted from ILPNet2	Term Weight	Domain Relevance	Domain Consensus	Lexical Cohesion
inductive logic	0.928	1.000	0.968	0.557
logic programming	0.924	1.000	0.988	0.293
inductive logic programming	0.893	1.000	0.966	0.181
background knowledge	0.825	1.000	0.737	0.835
logic program	0.824	1.000	0.867	0.203
machine learning	0.785	1.000	0.777	0.221
data mining	0.776	1.000	0.691	0.672
refinement operator	0.757	1.000	0.572	1.000
decision tree	0.742	1.000	0.613	0.714
inverse resolution	0.722	1.000	0.557	0.894
experimental result	0.718	1.000	0.594	0.684

All the terms were populated using Google web search. As an example, here are the top 5 snippets that were returned for the query "ILP predictive accuracy":

- Boosting Descriptive ILP for Predictive Learning in Bioinformatics -- general, this means that a higher predictive accuracy can be achieved. Thirdly, although some predictive ILP systems may produce multiple classification ...
- Imperial College Computational Bioinformatics Laboratory (CBL) -- Results on scientific discovery applications of ILP are separated below ... Progol's predictive accuracy was equivalent to regression on the main set of 188 ...
- Evolving Logic Programs to Classify Chess-Endgame Positions -- indicate that in the cases where the ILP algorithm performs badly, the introduc-. tion of either union or crossover increases predictive accuracy. ...
- Estimating the Predictive Accuracy of a Classifier -- the predictive accuracy of a classifier. We present a scenario where meta- ..... Workshop on Data Mining, Decision Support, Meta-Learning and ILP, 2000. ...
- -*-BibTeX ... -- An outline of the theory of ILP is given, together with a description of Golem .... Performance is measured using both predictive accuracy and a new cost ...

For each query the snippets of the first 1000 results were used. The snippets served as input for term modeling, described in Section 4.3. The models generated for each term, using this data, were then used for generating the concept suggestions and name suggestions in OntoGen.

5.2 Ontology learning

First the ILPnet2 collection and vocabulary were loaded into the program. The collection was imported in OntoGen as a directory of files, where each document was a separate ASCII text file (File -> New ontology -> Folder). The vocabulary was loaded using the Tools -> Context menu.
After experimenting with different numbers and with the help of concept visualization, a partition into seven concepts using the k-means clustering algorithm was chosen. For all the seven concepts the first-ranked term suggested from the vocabulary suggested by TermExtractor was selected. This means that the term extraction and population have indeed succeeded to rank the terms in a meaningful way. This is illustrated also by the following list of discovered concepts, with best-ranked concept names proposed by TermExtractor, followed by the second best-ranked concept name (in parantheses), and the list of most important keywords, as chosen originally by OntoGen:

- Learning system (learning algorithm) -- learning, system, rule, language, methods, machine_learning, machine, approach, ilp, grammars
- Decision tree (logical decision tree) -- order, inductive, trees, order_logic, discovery, decision, application, decision_trees, database, experiments
- Structured data (chemical structure) -- structural, data, machine, predict, examples, relations, machine_learning, mining, definitions, knowledge
- Clausal theory (theory revision) -- theories, refinement, inverse, resolution, predicates, operators, inverse_resolution, invention, refinement_operators, revision

- Relational database (inductive learning) -- ilp, generalization, relations, model, algorithm, constraints, integrating, rule, agent, evaluation

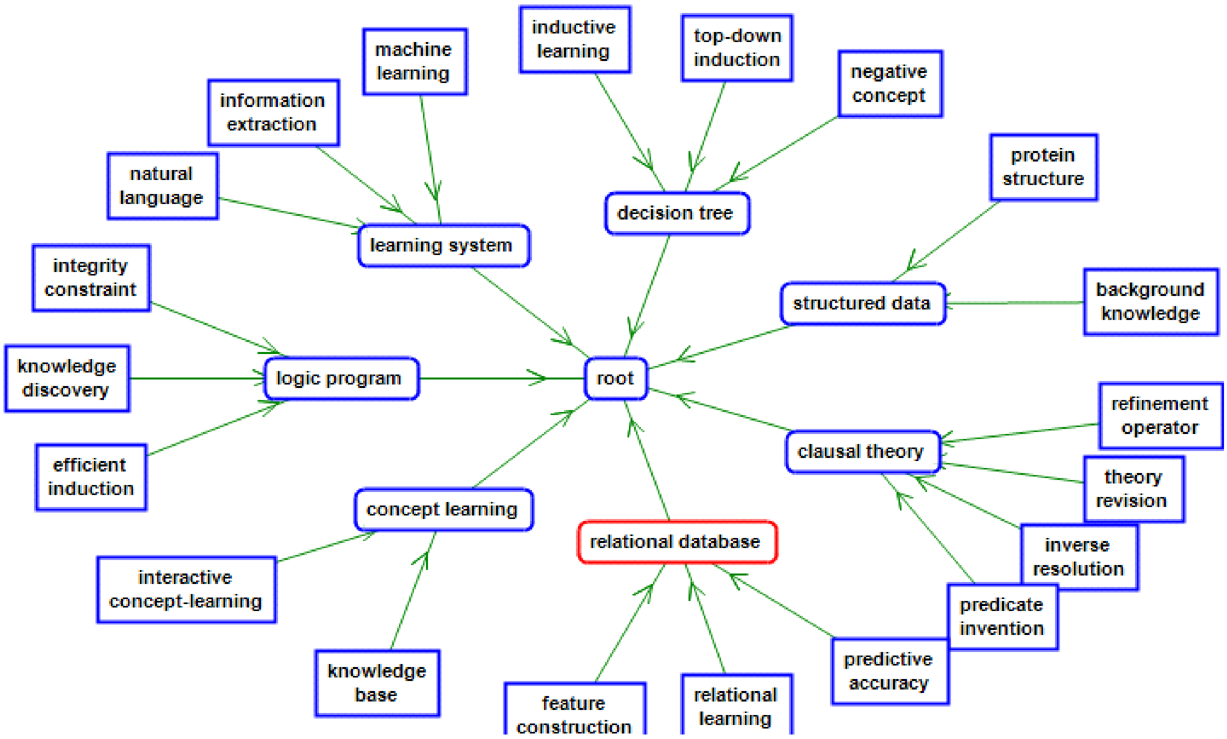


Figure 3 Ontology constructed on top of ILPnet2 dataset using the pre-calculated terminology.

By checking the publication years of articles from different concepts it was possible to analyse the *evolution* of topics. For example, we can notice that most frequent years in concepts clausal theory, concept learning and logic program were around 1994, concepts structured data and learning system were most frequent around year 2000, and concepts decision tree and relational database appear to be most recent in years following 2000. Each of the concepts was further split into sub-concepts using suggestions from the vocabulary which resulted in the two-level taxonomy shown in Figure 3.

5 Conclusions

We presented a novel concept naming methodology applicable in advanced ontology construction, and illustrated the improved concept naming facility on the ontology of topics, extracted from the ILPNet2 scientific publications database. Concept naming supports the user in the task of concept discovery, concept naming and keeps the constructed ontology more consistent and aligned with the established terminology in the domain.

Acknowledgement This work was supported by the Slovenian Research Agency and the IST Programme of the EC under NeOn (IST-4-027595-IP), PASCAL (IST-2002-506778) and ECOLEAD.

References

[1] B. Fortuna, D. Mladenić, M. Grobelnik. Semi-automatic construction of topic ontologies. In: Ackermann et al. (eds.) Semantics, Web and Mining. LNCS (LNAI), vol. 4289, pp. 121–131. Springer, 2006.

[2] B. Fortuna, M. Grobelnik, and D. Mladenić. Semi-automatic Data-driven Ontology Construction System. In: Proc. of the 9th International multi-conference Information Society IS-2006, Ljubljana, Slovenia, 2006.

[3] The Protégé project 2000. Available online at http://protege.stanford.edu.

[4] ILPNet2 publications database. Available online at http://www.cs.bris.ac.uk/~ILPnet2/

[5] S. Sabo, M. Grčar, D.A. Fabjan, P. Ljubič, N. Lavrač. Exploratory analysis of the ILPnet2 social network. In Proc. of the 10th International multi-conference Information Society IS-2006, Ljubljana, Slovenia, 2007.

[6] M. Grobelnik, D. Mladenić. Simple classification into large topic ontology of web documents. In Proc. of the 27th International Conference Information Technology Interfaces, Dubrovnik, Croatia, pp.188–193, 2005

[7] The TermExtractor tool. Available online through a Web interface at http://lcl2.uniroma1.it/termextractor,

[8] F. Sclano and P. Velardi "TermExtractor: A Web application to learn the common terminology of interest groups and research communities. In Proc. of the 9th Conf. on Terminology and Artificial Intelligence (TIA 2007), Sophia Antinopolis, France, 2007.

[9] M. Grcar, E. Klien. Using Term-matching Algorithms for the Annotation of Geo-services. Web Mining 2.0, Workshop at ECML 2007.

CONTEXTUALIZING ONTOLOGIES WITH ONTOLIGHT: A PRAGMATIC APPROACH

Marko Grobelnik, Janez Brank, Blaž Fortuna, Igor Mozetič

Department of Knowledge Technologies, Jozef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
e-mail: {marko.grobelnik, janez.brank, blaz.fortuna, igor.mozetic}@ijs.si

ABSTRACT

We present a pragmatic approach to using large-scale ontologies as contexts. The approach is based on a light-weight ontology model and grounding of the ontology concepts in textual documents. These assumptions allow for efficient implementation of the basic operations (classification, population and mappings between ontologies), and, as a consequence, exploitation of several large-scale ontologies as background, contextual knowledge. We demonstrate one possible scenario how contextual information can be exploited during semi-automatic ontology construction from text corpora.

1 INTRODUCTION

Ontologies represent isolated pieces of knowledge. By networking them, one can explore their interrelations. One form of networked ontologies are contextualized ontologies. In this case, one ontology represents a context of the other and its constituent ingredients (concepts and relations). So, for a given ontology, its ingredients can be interpreted in different contexts by selecting appropriate ontologies which represent appropriate contexts.

In this paper we describe OntoLight which implements basic reasoning functionalities for contextualized ontologies. It is limited to light-weight ontologies which are grounded with appropriate text corpora. The representation and reasoning scales to the largest currently available ontologies, comprising up to one million concepts. In particular, OntoLight currently incorporates the following five ontologies: AgroVoc and ASFA (relevant for the Food and Agricultural Organization of UN), EuroVoc (EU legislation), Cyc (common-sense knowledge) and DMoz (WWW directory).

There are two basic reasoning mechanisms implemented in OntoLight. First, new textual instances without known class can be classified into the selected ontology. Second, soft (probabilistic) mappings between a pair of selected ontologies can be computed, thus providing contextual relationship between the ontologies.

We are using OntoLight as a basic building block for extensions to OntoGen [1], where contextual mappings are used to improve semi-automatic construction of light-weight ontologies from text corpora. The same mechanism of contextual reasoning will be used to extend OntoGen to support simultaneous, collaborative development of an ontology. Our soft mappings between grounded ontologies also complement methods for ontology alignment, where mappings are computed on the basis of common, background ontologies (as provided by Swoogle, for example) [2], [3].

The paper presents the software package OntoLight consisting of several executable modules and data library of ontologies. The main functionality we cover is contextualization of ontologies through generation of soft mappings between ontologies, thus enabling to view concepts of one ontology through the perspective of another one. The second goal was achieving scalability needed for large case studies – i.e. being able to deal with large ontologies such as AgroVoc and ASFA. To achieve this we constrained the representation to a light-weight ontology model which covers targeted functionality needed in case studies. Finally, we took care of the software engineering aspects of the result – namely, the software package is built on top of an existing Text-Garden software library [4]. It is written in C++ with proper API and accessible through several development platforms (Java, Python, Matlab, Mathematica, Prolog).

In the next Section we first present the ontology model used in OntoLight. Next, in Section 3 we present the library of ontologies already incorporated in OntoLight – each ontology is presented through its main features. In Section 4, the software package is presented by describing each module separately and through possible integration of the modules which could be used in a pipeline. Finally, in Section 5, we show an integration of OntoLight with OntoGen, where light-weight ontologies are used as background, contextual knowledge which helps the users during the process of semi-automatic ontology construction from text corpora.

2 THE ONTOLOGY MODEL

The ontology model used in OntoLight is a relatively simple model which covers most of the well known light-weight ontologies. The model we use is a subset of richer ontology formalisms (such as OWL) in the sense that richer ontologies could be imported but not all their expressiveness can be used. Informally, the light-weight ontology model is defined by:

- A list of languages used for lexical terms.

- A list of class-types used for representing different types of nodes in the ontology structure.
- A list of classes where each class can have several lexical representations in one or several languages. One class represents one node in the graph.
- A list of relation-types used to label relations (links) between classes in the ontology graph.
- A list of relations connecting classes in the ontology graph.
- Each ontology can have one or several grounding models. Each grounding model is a function which proposes zero, one or more classes for a given instance. This corresponds to a classification /categorization model in machine learning terminology.

The above model has a one-to-one mapping into C++ classes in the OntoLight module of the Text-Garden library [4].

3 LIBRARY OF ONTOLOGIES

To perform experiments on real data, we had to import several ontologies into the OntoLight framework. Since most of the larger real life ontologies are still in non-standard formats we needed to develop specialized filters for pre-processing the available data into the common ".OntoLight" format used by the rest of the OntoLight package. In the first version of the software we decided to prepare filters for importing five medium to large scale ontologies. They are all used on a daily basis in real life applications. They model different types of knowledge – from relatively specific ones (AgroVoc, ASFA), a general one with legal bias (EuroVoc) to generic ones for Web contents (DMoz) and common sense (Cyc).

3.1 AgroVoc

AgroVoc is a multilingual structured thesaurus of all subject fields in Agriculture, Forestry, Fisheries, Food security and related domains (e.g. Sustainable Development, Nutrition, etc). It consists of words or expressions (terms) in different languages and is organized in the thesaurus relationships (e.g. "broader", "narrower", and "related") used to identify or search resources. Its main role is to standardize the indexing process in order to make search simpler and more efficient, and to provide users with the most relevant resources.

The AgroVoc thesaurus was developed by the Food and Agriculture Organization of the United Nations (FAO) and the Commission of the European Communities, in the early 1980s. It is updated by FAO roughly every three months and users can see the specific changes on the AgroVoc website [5]. AgroVoc is available in the five official languages of FAO, which are English, French, Spanish, Chinese and Arabic. Additionally, it is also available in Czech, German, Japanese, Portuguese, Slovak and Thai. Other translations, such as Hindi, Hungarian, Italian and Korean are currently underway or being revised.

AgroVoc is downloadable in several formats – we used the MS Access package which includes several tables with all the data about the ontology. Specifically, AgroVoc includes 12 languages, 65 relation-types, and 47101 classes. AgroVoc classes were grounded with text abstracts from ASFA document corpus (see below) which are close to AgroVoc terms.

3.2 ASFA

ASFA (Aquatic Sciences and Fisheries Abstracts) is a thesaurus used for the Aquatic Sciences and Fisheries Information System (ASFIS), an international co-operative information system for the collection and dissemination of information covering the science, technology and management of marine, brackish water, and freshwater environments. It contains approximately 1 million bibliographic references to the world's aquatic science literature accessioned since 1971 (for some journals and/or subject areas the coverage precedes 1971). All references are machine readable.

ASFA is produced as a cooperative effort by the international network of ASFA partners [6] which consists of: United Nations Co-sponsoring Partners, National and International Partners, and the Publishing Partner. The objective is to disseminate bibliographic information to the relevant research community. A good description of several aspects of ASFA is available at [7].

In our case we extracted the ASFA thesaurus and abstracts by crawling the web search interface. The extracted data were all in the English language. The thesaurus structure included two types of classes (descriptor and non-descriptor), 5 link types, and 9882 classes. ASFA classes were grounded with text abstracts available within the records of the crawled data (over 360.000 abstracts).

3.3 EuroVoc

EuroVoc is a multilingual thesaurus covering the fields in which the European Communities are active – it provides a means of indexing the documents in the documentation syste?ms of the European institutions and of their users. The European Parliament, the Office for Official Publications of the European Communities, the national and regional parliaments in Europe, some national government departments and European organizations are currently using this controlled vocabulary. The recent version EuroVoc 4.2 exists in 21 official languages of the European Union (Bulgarian, Spanish, Czech, Danish, German, Estonian, Greek, English, French, Italian, Latvian, Lithuanian, Hungarian, Dutch, Polish, Portuguese, Romanian, Slovak, Slovene, Finnish and Swedish), and one other language (Croatian). In addition to these versions, it has been translated by the Parliaments of several other countries: Albania, Russia and Ukraine.

The data of the thesaurus are available from [8] where we extracted the thesaurus structure by crawling the html pages (since the officially proposed way of getting the data was non-functioning) while the multilingual part (without the structure) was downloadable from the web site as an MS Excel file. The extracted data is available in 21 languages, it has two types of nodes (descriptors and non-descriptors), 5 relation types, and 13416 nodes (out of which 6645 are descriptors). We grounded the EuroVoc classes with the documents from Acquis Communitarian, the corpus of European legislation indexed with EuroVoc descriptors.

3.4 Cyc

The Cyc [9] knowledge base (KB) is a formalized representation of a vast quantity of fundamental human knowledge: facts, rules of thumb, and heuristics for reasoning about the objects and events of everyday life. The original form of representation is a formal language CycL. The KB consists of terms which constitute the vocabulary of CycL and assertions which relate those terms. These assertions include both simple ground facts and rules with variables.

Cyc KB is available for researchers from the Cycorp company homepage [10] in two different forms – OpenCyc (vocabulary only) and ResearchCyc (full version). In our case, we are using the data retrieved directly from the company under the ResearchCyc license. Since Cyc KB is very rich (it includes ~50.000 first order logic rules) we decided to deal only with the static part of the KB. It is written only in English, it has two types of classes (concepts and lexical nodes), it has 3295 relations, and 464.988 concepts.

Since Cyc has only structure (concepts and facts) we grounded each Cyc's concept by querying Google with lexical representation for that class.

3.5 DMoz/Open Directory Project

The Open Directory Project (ODP), also known as DMoz, is the largest multilingual open content directory of World Wide Web links that is constructed and maintained by a community of volunteer editors. The browsing and search service is accessible from [11].

The directory data (structure and content) are available from [12] in the RDF format. The version we are using here uses only the English part of the directory, it has 3 types of relations, and 642.995 concepts.

The taxonomic part was grounded with the content which is available within the downloadable data. The main data source for grounding were short textual descriptions of the manually categorized web sites within each DMoz category.

4 SOFTWARE MODULES

In the following subsections we present each of the OntoLight modules (or module groups) dealing with ontology data – from raw data to classification models and mappings. The software is available from [13].

4.1 Ontology data transformation utilities

The function of the ontology data transformation utilities is to process specific formats of each of the selected ontologies for the ontology library. The result of all the utilities is saving the ontology data in the unifying binary format with the file-extension ".OntoLight" and its textual counterpart with the file extension ".OntoLight.Txt". As described in section 3, the ontology library consists of five ontologies – therefore we prepared five command line utilities for processing the data:

- AgroVoc2OntoLight.Exe
- Asfa2OntoLight.Exe
- Cyc2OntoLight.Exe
- DMoz2OntoLight.Exe
- EuroVoc2OntoLight.Exe

Each of the utilities takes on the input file name or file path to the data and produces binary file (".OntoLight") and textual file (".OntoLight.Txt"). An example run of the transformation of the EuroVoc is the following:

```
[d:\textgarden\eurovoc2ontolight]
EuroVoc2OntoLight.exe
EuroVoc To Ontology-Light [Feb 12 2007]
========================================
Input-EuroVoc-FilePath (-i:)=f:/data/EuroVoc/
Output-OntoLight-FileName (-
o:)=f:/Data/OntoLight/EuroVoc.OntoLight
Output-Text-FileName (-
ot:)=f:/Data/OntoLight/EuroVoc.OntoLight.Txt
========================
Loading 'f:/data/EuroVoc/listMultiLg_All.txt'
... 6645/6646
Done. (6645)
Loading 'f:/data/EuroVoc/eurovoc.txt' ...
Done. (48044)
Saving OntoLight to
'f:/Data/OntoLight/EuroVoc.OntoLight' ...
Done.
Saving Text to
'f:/Data/OntoLight/EuroVoc.OntoLight.Txt' ...
Done.
```

4.2 Ontology grounding module

The ontology grounding module OntoLight2OntoCfier.exe creates from an ontology stored in the ".OntoLight" format an additional file with the extension ".OntoCfier" (and its textual representation ".OntoCfier.Txt"). This file includes a classification model which is used by OntoClassify module (next subsection) for classification of new instances in the ontology classes. The current version uses a centroid-based classifier which calculates a centroid vector for each class in the ontology. It takes into account data used for grounding and the hierarchical part of the ontology structure. The actual classification is performed with the kNN (k-nearest-neighbour) algorithm [14].

Here is an example run of the OntoLight2OntoCfier.exe module for ontology grounding. On the input the utility takes ".OntoLight" data and a pre-processed Bag-Of-Words file with the text documents and the descriptors from the ontology. On the output the system creates ".OntoCfier" file with a classifier and its textual representation (".OntoCfier.Txt"). With additional parameters we specify the language we are using for grounding (in the case when data exists in several languages), to see whether the document's category equals descriptors in the ontology and the threshold for writing weighted words in the textual output.

```
[d:\textgarden\ontolight2ontocfier]OntoLight2
OntoCfier.exe
Ontology-Light To Ontology-Classifier [Feb 12
2007]
=============================================
======
Input-OntoLight-FileName (-
iol:)=f:/Data/OntoLight/EuroVoc.OntoLight
Input-BagOfWords-FileName (-
ibow:)=f:/Data/OntoLight/Acquis.Bow
Output-OntoClassifier-FileName (-
oom:)=f:/Data/OntoLight/EuroVoc.OntoCfier
Output-OntoClassifier-Text-FileName (-
oom:)=f:/Data/OntoLight/EuroVoc.OntoCf
Language-Name (-lang:)=EN
DocumentCategory-Is-TermId (-catisid:)=Yes
Cut-Word-Weight-Sum-Percent (-cwwprc:)=0.33
====================================
Loading Onto-Light from
'f:/Data/OntoLight/EuroVoc.OntoLight' ...
Done.
Loading Bag-Of-Words from
'f:/Data/OntoLight/Acquis.Bow' ... Done.
Generating Ontology-Classifier...
  Creating BowDocWgtBs ... Done.
  Collecting documents per ontology-term ...
    Docs:7972/7972 Pos:26915 Neg:149
  Done.
  Creating sub-terms & up-terms vectors ...
Done.
  Creating centroids ...
    Active-Terms:1399
    Active-Terms:441
    Active-Terms:85
    Active-Terms:7
    Active-Terms:0
    Active-Terms:0
  Done.
Done.
Saving Onto-Classifier to
'f:/Data/OntoLight/EuroVoc.OntoCfier' ...
Done.
Saving Text to
'f:/Data/OntoLight/EuroVoc.OntoCfier.Txt' ...
Done.
```

4.3 Ontology population module

The ontology population module OntoClassify.Exe takes as input a grounded ontology in the ".OntoCfier" format and instance data (in various textual formats) and produces XML and textual file with the possible categories for the given instance.

In the following example we take a grounded version of the EuroVoc and the query "Slovenia and Croatia are having a fishing industry". The result is in the files OntoCfy.Xml and OntoCfy.Txt.

```
[d:\textgarden\ontoclassify]OntoClassify.exe
Ontology-Classify [Feb 12 2007]
===============================
Input-OntoClassifier-FileName (-
ioc:)=f:/Data/OntoLight/EuroVoc.OntoCfier
Input-Query-String (-qs:)=Slovenia and
Croatia are having a fishing industry.
Input-Query-Html-File (-qh:)=
Input-Query-CompactDocument-FileName (-
qcpd:)=
Input-Query-Url (-qu:)=
Input-Query-URL-Vector-FileName (-quf:)=
Output-Classification-Xml-File (-
ox:)=OntoCfy.Xml
Output-Classification-Txt-File (-
ot:)=OntoCfy.Txt
=================
Loading Onto-Classifier from
'f:/Data/OntoLight/EuroVoc.OntoCfier' ...
Done.
```

The resulting textual file lists classes from the EuroVoc grounded ontology to which the query should belong with the highest confidence. Each line of the file OntoCfy.Txt includes the following three fields: rank, confidence, and class name:

```
 1. 0.201 Croatia
 2. 0.171 fisheries policy
 3. 0.162 Slovenia
 4. 0.161 fishing area
 5. 0.159 national independence
 6. 0.159 fishing regulations
 7. 0.156 fishery management
 8. 0.147 fisheries structure
 9. 0.147 fishing fleet
10. 0.144 Community fisheries
```

4.4 Ontology mapping module

The last module in the pipeline of utilities is the utility OntoJoint.exe which takes as an input two grounded ontologies in the ".OntoCfier" format and creates soft mappings between the classes of both ontologies. This is done in the following way: first, by aligning vocabularies of grounded ontologies (this typically means aligning words from respective bag-of-words representations), and second, by classifying centroid vectors from the first ontology into the classes of the second one.

In the following example we take as an input the EuroVoc and ASFA ontologies and store mapping results into XML and textual files, OntoJoint.XML and OntoJoint.Txt, respectively:

```
[d:\textgarden\ontojoint]OntoJoint.exe
Join-Ontologies [Mar 12 2007]
=============================
```

```
Input-OntoClassifier-FileName-1 (-
ioc1:)=f:/Data/OntoLight/EuroVoc.OntoCfier
Input-OntoClassifier-FileName-2 (-
ioc2:)=f:/Data/OntoLight/Asfa.OntoCfier
Output-OntologyJoin-Xml-File (-
ox:)=OntoJoint.Xml
Output-OntologyJoin-Txt-File (-
ot:)=OntoJoint.Txt
==============
Loading Onto-Classifier-1 from
'f:/Data/OntoLight/EuroVoc.OntoCfier' ...
Done.
Loading Onto-Classifier-2 from
'f:/Data/OntoLight/Asfa.OntoCfier' ... Done.
```

The following is an example mapping from the resulting OntoJoint.Txt file where we see a mapping from the ASFA "fishing licence" class to 10 related classes from the EuroVoc ontology.

```
'fishing licence' →
    1. 'Legal aspects' (0.003)
    2. 'Ships' (0.003)
    3. 'Disputes' (0.002)
    4. 'Ecology' (0.002)
    5. 'Military operations' (0.001)
    6. 'Rare species' (0.001)
    7. 'Public health' (0.001)
    8. 'Fish culture' (0.001)
    9. 'Commercial fishing' (0.001)
   10. 'Resource development' (0.001)
```

5 CONTEXUALIZED ONTOLOGY GENERATION WITH OntoGen

OntoGen [1] is a software tool for semi-automatic, data-driven ontology construction. It incorporates methods for discovering concepts from a collection of documents. Documents are represented by the well known bag-of-words representation, where each document is encoded as a vector of term frequencies. The similarity of a pair of documents is calculated by the number and weights of the words that these documents share. The weights of the words are usually calculated by the so called TFIDF weighting, but there are other alternatives.

OntoGen implements two methods for concept discovery: Latent Semantic Indexing (LSI) [15] and k-means clustering [16]. LSI is a method for linear dimensionality reduction by learning an optimal sub-basis which approximates documents' bag-of-words vectors. The sub-basis vectors are proposed as concepts. The k-means method discovers concepts by clustering the documents' bag-of-words vectors into k clusters where each cluster is a proposed concept.

We have extended OntoGen with OntoLight, specifically with five general-purpose light-weight ontologies: AgroVoc, ASFA, EuroVoc, DMoz and Cyc. These ontologies provide contexts to the user during the user-guided, data-driven generation of an ontology from a corpus of documents. OntoGen structures the documents into concepts and subconcepts, but, until now, has used only extracted keywords to suggest concept names. With contextual ontologies available, OntoGen is now able to provide much better suggestions for concept names based on the similarity between structured documents and grounded concepts from the selected contexts. As a consequence, the user can view each concept suggested by OntoGen through different "sematic lenses": each view corresponds to a different context as implemented by a different light-weight ontology. Figure 1 gives an example.

6 CONCLUSION

In the paper we describe OntoLight, a set of software modules for:

- transforming raw ontology data for several ontologies from their specific formats into a unifying light-weight ontology format,
- grounding the ontology and storing it into grounded ontology format,
- populating grounded ontologies with new instance data, and
- creating mappings between grounded ontologies.

As a part of OntoLight we already prepared the ontology library consisting of five different ontologies: AgroVoc, ASFA, Cyc, DMoz, and EuroVoc. Additional ontologies (e.g., WordNet) will be incorporated in the future.

We will be using OntoLight as a basic building block for extensions to OntoGen, where contextual mappings are used to improve semi-automatic construction of light-weight ontologies from text corpora. The same mechanism of contextual reasoning will be used to extend OntoGen to support simultaneous, collaborative development of an ontology. Our soft mappings between grounded ontologies also complement methods for ontology alignment, where mappings are computed on the basis of common, background ontologies. We plan to integrate our approach to mappings with the mechanisms for ontology alignments.

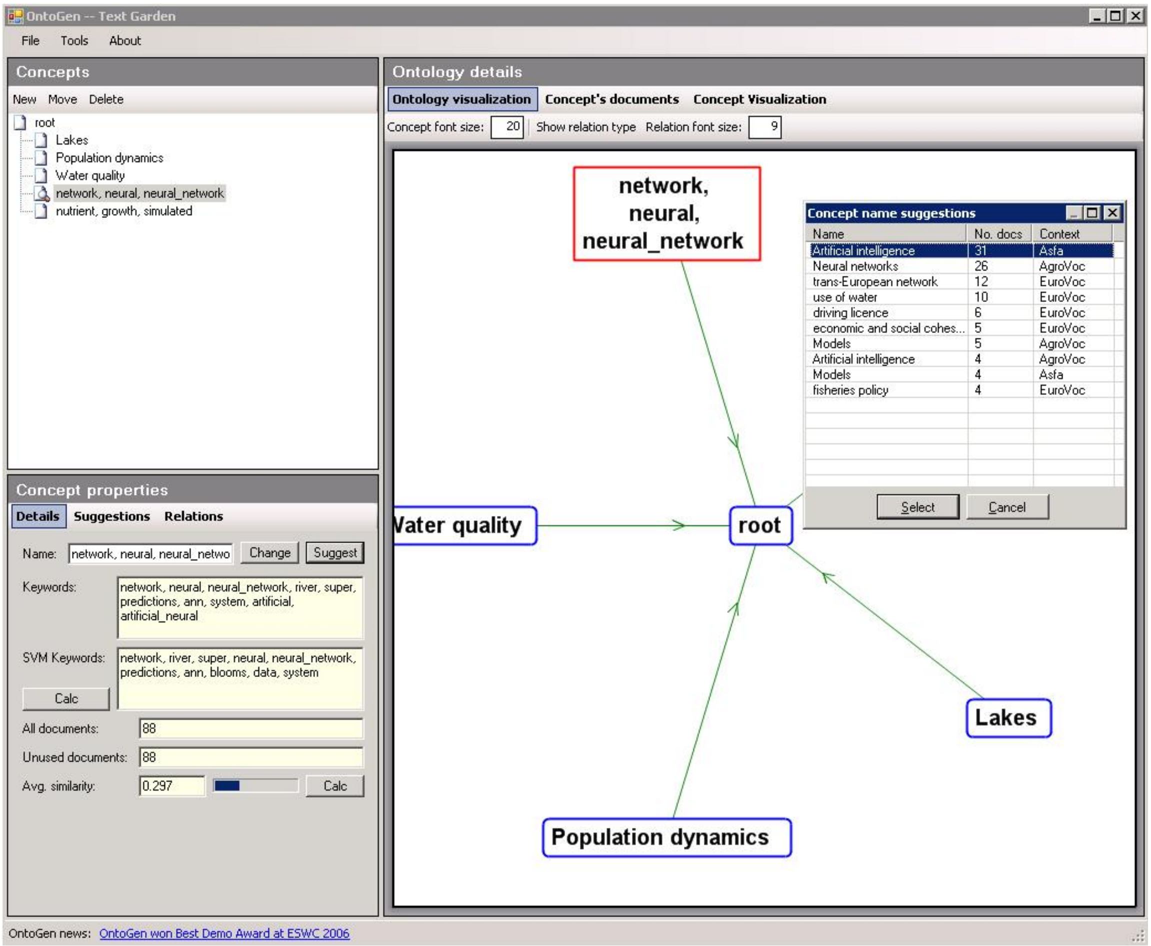


Figure 1: *A screenshot of OntoGen when used to structure the abstracts of recent issues of the Ecological Modelling journal. Contexts are provided by three ontologies: AgroVoc, ASFA, and EuroVoc. Some concept names were already derived from contextual suggestions (Water quality, Population dynamics, Lakes) and the user inspects current suggestions for the top node (network, neural, neural_network). The system provides two sensible suggestions: Artificial Intelligence (from ASFA) and Neural networks (from AgroVoc), while the third suggestion: trans-European network (from EuroVoc) probably makes less sense.*

Acknowledgement

This work was supported by the Slovenian Research Agency and the IST Programme of the EC under NeOn (IST-2004-27595-IP) and PASCAL (IST-2002-506778).

References

1. B. Fortuna, M. Grobelnik, D. Mladenic: Semi-automatic Construction of Topic Ontology. Semantics, Web and Mining, Joint International Workshop, EWMF 2005 and KDO 2005, Porto, Portugal, October 3-7, 2005.
2. M. Sabou, M. d'Aquin, and E. Motta: Using the Semantic Web as Background Knowledge for Ontology Mapping, In Proceedings of the International Workshop on Ontology Matching (OM-2006), collocated with ISWC-06.
3. M. Sabou, M. d'Aquin, W. R. van Hage and E. Motta: Improving Ontology Matching by Dynamically Exploring Online Knowledge. Submitted for review, 2007.
4. TextGarden: http://kt.ijs.si/Dunja/textgarden/
5. AgroVoc: http://www.fao.org/aims/ag_intro.htm
6. ASFA: http://www.fao.org/fi/asfa/partners.asp
7. ASFA: http://www.fao.org/fi/website/FIRetrieveAction.do?dom=org &xml=asfa_prog.xml&xp_nav=2
8. EuroVoc: http://europa.eu/eurovoc/
9. Douglas B. Lenat. Cyc: A Large-Scale Investment in Knowledge Infrastructure. Comm. ACM 38, no. 11, November 1995.
10. Cyc: http://www.cyc.com/
11. DMoz: http://dmoz.org/
12. DMoz: http://rdf.dmoz.org/
13. OntoLight: http://analytics.ijs.si/Projects/NEON/OntoLight.Zip
14. Shakhnarovish, Darrell, Indyk (Eds.): Nearest-Neighbor Methods in Learning and Vision, The MIT Press, 2005.
15. S. Deerwester, S. Dumais, G. Furnas, T. Landauer, R. Harshman: Indexing by Latent Semantic Analysis, Journal of the American Society of Information Science, vol. 41, no. 6, 391-407, 1990.
16. Jain, Murty, Flynn: Data Clustering: A Review, ACM Comp. Survey, 1999.

LEARNING RIPPLE DOWN RULES FOR EFFICIENT LEMMATIZATION

Matjaž Juršič, Igor Mozetič, Nada Lavrač
Department of Knowledge Technologies, Jožef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
e-mail: matjaz@gmail.com, {igor.mozetic, nada.lavrac}@ijs.si

ABSTRACT

The paper presents a system, LemmaGen, for learning Ripple Down Rules specialized for automatic generation of lemmatizers. The system was applied to 14 different lexicons and produced efficient lemmatizers for the corresponding languages. Its evaluation on the 14 lexicons shows that LemmaGen considerably outperforms the lemmatizers generated by the original RDR learning algorithm, both in terms of accuracy and efficiency.

1 INTRODUCTION

Lemmatization is the process of determining the canonical form of a word, called *lemma*, from its inflectional variants. Lemmas correspond to headwords in a dictionary. An alternative approach to abstract the variability of word-forms is *stemming* which reduces the word to its root or stem. For example, in Slovene, the word-forms *pisati, pišem, pišeš, pišemo* have a common lemma *pisati*, and a common stem *pi*. For text analysis and knowledge discovery applications, lemmatization yields more informative results then stemming. However, both problems are closely related and the approach described here can be applied to stemming as well.

The difficulty of lemmatization depends on the language. In languages with heavy inflection, such as the Slavic languages, stems can combine with many different suffixes, and the selection of appropriate ending and its combination with the stem depends on morphological, phonological and semantic factors. As a consequence, lemmatization of highly inflectional languages is considerably more difficult then the lemmatization of 'simple' languages, such as English.

In computer science, the problem of stemming and lemmatization was addressed already in 1968 [1]. For English, the problem is considered solved by the Porter stemmer [12]. However, the Porter stemmer was hand crafted specifically for English and is not applicable to other languages, specially those with heavy inflection. Manual development of a lemmatizer requires involvement of a linguistic expert, and is an impractical and expensive undertaking. An alternative is to use machine learning tools for automatic generation of lemmatization rules. There have already been several approaches to learning lemmatization rules:

- 1993-2002: A rule induction system ATRIS [8,9]
- 2002: If-then classification rules [7]
- 2002: Naïve Bayes [7]
- 2004: A first-order rule learning system CLog [3]
- 2004: Ripple Down Rule (RDR) learning [10, 11].

This paper is focused on Ripple Down Rule (RDR) learning. The RDR learning approach was originally proposed as a methodology for the GARVAN-ES1 expert system maintenance [2]. The idea is that the rules are incrementally added to the system. When new examples of decisions are available, new rules are constructed and added to the system. However, already existing rules might contradict some new examples, therefore exceptions to the original rules have to be added as well.

In this paper we describe an improved Ripple Down Rule (RDR) learning system called LemmaGen [6], especially tailored to the problem of word lemmatization. In Section 2 we describe the RDR format, how the rules can be applied to lemmatization and how is the RDR structure automatically constructed from the lemmatization examples by LemmaGen. In Section 3 we describe the application of LemmaGen to 14 different language lexicons, compare the results with an alternative RDR implementation, and evaluate the performance in terms of lemmatization accuracy, efficiency, and applicability of the approach to different languages.

2 LEARNING RIPPLE DOWN RULES

RDR rules form a tree-like decision structure with an obvious interpretation:

```
if A then C
   except if B then E
   except if D then F
else if G then H
```

Rules and their exceptions are ordered, and the first condition that is satisfied fires the corresponding rule. In addition, explanation is also provided. Every \`if-then' rule is augmented by its explanation in terms of the \`because of' appendix, which lists one or more training examples covered by the rule (examples which \`fire' for the given rule), which – in the process of learning - caused the individual rule to appear in the rule list.

In the case of lemmatization, general concepts that appear in RDR rules are instantiated to domain specific terms:

- Training examples are pairs *(word-form, lemma).*
- A rule condition is a *suffix* of the word-form which ends the word that fires the rule.

```
`---> RULE:( suffix("") transform(""-->"") except(3) );
       |---> RULE:( suffix("i") transform("i"-->"o") except(4) );
       |      |---> RULE:( suffix("li") transform("li"-->"ti") );
       |      |---> RULE:( suffix("ni") transform("ni"-->"ti") );
       |      |---> RULE:( suffix("ti") transform(""-->"") );
       |      `---> RULE:( suffix("ši") transform("ši"-->"sati") );
       |---> RULE:( suffix("l") transform("l"-->"ti") );
       `---> RULE:( suffix("mo") transform(""-->"") except(2) );
              |---> RULE:( suffix("šemo") transform("šemo"-->"sati") );
              `---> RULE:( suffix("šimo") transform("šimo"-->"sati") );
```

Figure 1: *A part of the RDR tree structure, constructed by LemmaGen for the lemmatization of Slovenian words.*

- A rule consequent is a transformation which replaces the word-form suffix by a new suffix, thus forming the lemma. The transformation is written as *{word-form suffix} -> {lemma suffix}*.

Some example RDR rules for the lemmatization of Slovenian are given in Figure 1.

The original RDR learning algorithm, adapted to learn the lemmatization rules, and applied and evaluated on the Slovenian lexicon is described in [10, 11]. We have applied this RDR algorithm to several additional language lexicons and investigated the means of possible improvements. The new algorithm, LemmaGen, implements the following improvements:

- The original RDR algorithm processes training examples sequentially and does not take into account the number of examples covered by individual rules and their exceptions. As a consequence, a rule high in the RDR hierarchy ('default rule') might cover just a small fraction of examples with a non-typical transformation, and have a large number of exceptions itself. LemmaGen performs lexicographical ordering of training examples (starting from the end of words) and orders rules and exceptions by the frequency of examples.
- As there are identical word-forms with different lemmas, the nodes in the RDR tree cannot distinguish between different transformations. The original RDR algorithm simply selected the first transformation it encountered, while LemmaGen selects the most frequent transformation.
- The LemmaGen learning algorithm is considerably faster then the original RDR. It achieves speedups between factors 2 and 10, depending on the lexicon used for learning. Due to more compact RDR trees produced, the lemmatization is also considerably faster, between 10 and 40 fold. Improvements in the efficiency of learning and lemmatization are in Figure 4.

If N is the number of training examples, and M is the length of the longest word in the lexicon, then the time-complexity of our learning algorithm is $O(2*N*M)$. The worst-case time complexity is therefore linear in the number of examples.

3 APPLICATIONS ON THE MULTEXT-EAST AND MULTEXT LEXICONS

We have applied LemmaGen on two sets of lexicons, namely Multext-East [4] and Multext [5] (Multilingual Text Tools and Corpora) to automatically learn lemmatizers for different languages. There are altogether 14 lexicons for 12

	Language	No. of records	No. of different				
			Morph.forms	Lemmas	Morph.specs	Morph.forms per lemma	Lemmas per morph.form
MULTEXT- EAST	Slovenian	557.970	198.507	16.389	2.083	12,63	1,0430
	Serbian	20.294	16.907	8.392	906	2,07	1,0285
	Bulgarian	55.200	40.910	22.982	338	1,95	1,1002
	Czech	184.628	57.391	23.435	1.428	2,55	1,0441
	English	71.784	48.460	27.467	135	1,80	1,0206
	Estonski	135.094	89.591	46.933	643	2,19	1,1507
	French	306.795	232.079	29.446	380	8,01	1,0164
	Hungarian	64.042	51.095	28.090	619	2,03	1,1209
	Romanian	428.194	352.279	39.359	616	9,35	1,0447
MULTEXT	English	66.216	43.371	22.874	133	1,93	1,0182
	French	306.795	232.079	29.446	380	8,01	1,0164
	German	233.858	51.010	10.655	227	4,87	1,0174
	Italian	145.530	115.614	8.877	247	13,85	1,0636
	Spanish	510.709	474.158	13.236	264	36,07	1,0069

Figure 2: *Sizes and basic properties of the MULTEXT-EAST and MULTEXT training sets.*

East and West European languages (see Figure 2). Each lexicon contains records of the form *(word-form, lemma, morphological form)*. The last column (morph. form) was not used in our experiments, but nevertheless it indicates the complexity of different languages. One can speculate that the higher number of morphological forms per lemma indicates a more complex language. On the other hand, a higher fraction of lemmas per morphological form (e.g., Bulgarian, Estonian, Hungarian) will probably prove to be more difficult for learning and will result in lower accuracies. 'Simpler' languages with lower number of lemmas per morphological form (e.g., Spanish, German, French, English) will likely have better lemmatizers with higher accuracy. The available number of training examples and how representative the training examples are will also affect the accuracy (e.g., there are relatively few training examples for Serbian).

For learning and testing experiments we used 5-fold cross validation. For each language, cross validation was performed 10 times. Both, the original RDR algorithm and our improved LemmaGen were applied. Results are given in Figure 3:

- Accuracy – Lemmatization assigns a transformation (class) to a word-form. If there are *P* correctly lemmatized word-forms, and *N* is the total number of word-forms, then *Acc = P/N*.
- Accuracy was tested on the training set (yielding an optimistic accuracy prediction), testing set ('realistic' prediction) and on unknown words from the testing set (pessimistic prediction). In the last case we made sure that no two words with the same lemma appear in both, training and testing set in the same validation step.
- Standard deviation is averaged over all three sets above. Lower values indicate higher stability of the learning algorithm.
- Error is a relative decrease of the number of incorrectly classified examples of LemmaGen relative to the original RDR. *Error = (Acc(RDR) - Acc(LemmaGen)) / (1 – Acc(RDR))*. An Error of -25 means that LemmaGen commits 25% less incorrect classifications then RDR.

The results indicate that LemmaGen outperformed the original RDR in most of the cases, primarily due to the improvements described in Section 2.

The (reverse) lexicographical ordering of examples and subsequent use of example frequencies results in the highest improvement of accuracy on the training set. This might seem irrelevant since generally we are mostly concerned with the accuracy on new, unknown examples. However, in the case of lemmatization and lexicons provided, it turns out that they mostly cover a typical text corpora. Therefore, training examples cover most of the domain, and accuracy on the training set is very relevant for practical applications of lemmatizers.

We did test this hypothesis on a Slovene corpus of news agencies texts which comprises almost 900.000 words [6]. It turned out that 84% of the words were covered by the lexicon used for learning the lemmatizer. Therefore, the expected accuracy is best computed by using the accuracy on the training set in 84%, and accuracy on the unknown words in 16% of the cases. If *p* is the fraction of words covered by the learning lexicon then a realistic estimate of the expected accuracy is: Acc = p*Acc(optimistic) + (1-p)*Acc(pessimistic). In the case of Slovenian, we get: Acc = 84%*97.61% + 16%*82.12% = 95.13%. This is slightly above the actual accuracy on the testing set.

	Language	Accuracy (%)									Standard deviation (%)		
		Learning set (optimistic)			Test set (realistic)			Unkown words (pessimistic)					
		RDR	LemmaGen	Errors	RDR	LemmaGen	Errors	RDR	LemmaGen	Errors	RDR	LemmaGen	Errors
MULTEXT- EAST	Slovenian	95,35	97,61	-48,6	92,59	94,38	-24,1	80,68	82,12	-7,5	0,029	0,015	-47,88
	Serbian	94,36	97,86	-62,1	70,34	73,49	-10,6	64,26	65,85	-4,5	0,150	0,059	-60,44
	Bulgarian	91,22	93,68	-28,0	74,52	76,10	-6,2	69,29	71,52	-7,2	0,107	0,074	-30,29
	Czech	96,61	97,89	-37,8	92,77	93,66	-12,3	78,09	81,13	-13,9	0,040	0,023	-41,02
	English	97,75	98,84	-48,3	92,05	93,07	-12,8	89,27	91,03	-16,4	0,038	0,021	-45,27
	Estonian	86,81	89,51	-20,5	73,52	73,93	-1,6	66,69	66,54	0,5	0,066	0,049	-25,83
	French	96,72	98,80	-63,5	91,78	92,94	-14,1	86,80	88,22	-10,8	0,032	0,015	-54,19
	Hungarian	90,23	91,88	-16,9	74,82	74,33	2,0	72,73	72,86	-0,5	0,091	0,072	-21,03
	Romanian	94,96	96,75	-35,6	78,16	79,17	-4,6	73,48	74,14	-2,5	0,036	0,033	-7,27
MULTEXT	English	98,20	99,00	-44,5	93,29	94,14	-12,7	90,82	92,48	-18,1	0,052	0,029	-45,17
	French	96,72	98,80	-63,5	91,79	92,95	-14,2	86,85	88,25	-10,7	0,034	0,012	-63,71
	German	95,88	98,70	-68,5	95,06	97,13	-41,9	79,56	84,15	-22,4	0,062	0,026	-58,54
	Italian	93,75	95,58	-29,2	85,87	86,08	-1,5	82,05	82,11	-0,3	0,041	0,040	-3,26
	Spanish	99,10	99,48	-42,1	94,65	95,73	-20,1	94,32	95,45	-19,9	0,007	0,008	7,42

Figure 3: *Comparison of accuracy between the original RDR lemmatizer and the improved LemmaGen.*

Results in Figure 3 also enable the analysis of different languages. The actual accuracies are mostly as expected, except for Hungarian and Estonian. It turns out that the two languages are not Indo-European, but belong to the Finno-Ugric language group (along with Finnish). In these languages words can be composed from morphemes in a large number of ways. Consequently, lemmatization by suffix transformation only appears to be of limited value and a more expressive transformation language is needed. Figure 4 gives the efficiency comparison.

	Language	Learning					Lemmatization				
		RDR		LemmaGen		Speedup	RDR		LemmaGen		Speedup
		sec	ms/rec	sec	ms/rec	factor	sec	ns/rec	sec	ns/rec	factor
MULTEXT- EAST	Slovenian	26,80	60,0	3,02	6,8	8,9	2,53	22.633	0,10	867	26,1
	Serbian	0,23	14,4	0,09	5,4	2,7	0,03	8.089	0,00	643	12,6
	Bulgarian	2,03	46,0	0,32	7,2	6,4	0,30	26.958	0,01	670	40,2
	Czech	4,42	29,9	0,56	3,8	7,9	0,42	11.279	0,03	722	15,6
	English	0,43	7,5	0,23	4,0	1,9	0,10	6.946	0,01	752	9,2
	Estonian	4,15	38,4	0,68	6,3	6,1	0,41	15.226	0,02	800	19,0
	French	6,46	26,3	1,72	7,0	3,7	1,35	21.995	0,06	898	24,5
	Hungarian	0,99	19,4	0,23	4,5	4,3	0,12	9.575	0,01	718	13,3
	Romanian	183,12	534,6	7,23	21,1	25,3	43,51	508.043	0,08	911	557,7
MULTEXT	English	0,37	6,9	0,21	3,9	1,8	0,08	6.017	0,01	724	8,3
	French	7,02	28,6	1,56	6,3	4,5	1,34	21.819	0,05	877	24,9
	German	10,22	54,6	0,80	4,3	12,9	0,60	12.857	0,04	788	16,3
	Italian	1,18	10,1	0,80	6,9	1,5	0,26	8.821	0,03	860	10,3
	Spanish	22,97	56,2	3,88	9,5	5,9	3,57	34.923	0,09	894	39,1

Figure 4: *Comparison of the learning and lemmatization efficiency between the original RDR and LemmaGen.*

6 CONCLUSION

We have developed an improved learning algorithm for automatic generation of lemmatization rules in the form of a RDR tree, named LemmaGen. The algorithm has linear time complexity, is very efficient, and can produce very accurate lemmatizers from sufficiently large lexicons. The whole LemmaGen system is freely available under the GNU open source license from http://kt.ijs.si/software/LemmaGen .

References

[1] Beth, L.J. Development of a stemming algorithm. *Mechanical Translation and Computational Linguistic* 11, pp. 22–31, 1968.

[2] Compton, P., Jansen, R. Knowledge in Context: a strategy for expert system maintenance. *Proc. 2nd Australian Joint Artificial Intelligence Conference,* pp. 292–306, 1988.

[3] Erjavec, T. Džeroski, S. Machine Learning of Morphosyntactic Structure: Lemmatising Unknown Slovene Words. *Applied Artificial Intelligence* 18(1), pp. 17-40, 2004.

[4] Erjavec, T. MULTEXT-East Version 3: Multilingual Morphosyntactic Specifications, Lexicons and Corpora. *Proc. 4th International Conference on Language Resources and Evaluation LREC-2004,* pp. 1535-1538, 2004.

[5] Ide, N., Véronis, J. MULTEXT: Multilingual Text Tools and Corpora. *Proc. 15th Conference on Computational Linguistics* 1, pp. 588-592, 1994.

[6] Juršič, M. Efficient Implementation of a system for Construction, Application and Evaluation of RDR Type Lemmatizers. Diploma Thesis, Faculty of Computer and Information Science , University of Ljubljana, 2007.

[7] Mladenić, D. Automatic Word Lemmatization. *Proc. 5th International Multi-Conference Information Society IS-2002* B, pp.153-159, 2002.

[8] Mladenić, D. Combinatorial Optimization in Inductive Concept Learning. *Proc. 10th International Conference on Machine Learning ICML-1993, pp.* 205-211, 1993.

[9] Mladenić, D. Learning Word Noramlization Using Word Suffix and Context from Unlabeled Data. *Proc. 19th International Conference on Machine Learning ICML-2002, pp.* 427-434, 2002.

[10] Plisson, J., Lavrač, N., Mladenić, D. A rule based approach to word lemmatization. *Proc. 7th International Multi-Conference Information Society IS-2004* C, pp. 83-86, 2004.

[11] Plisson, J., Lavrač, N., Mladenić, D., Erjavec, T. Ripple Down Rule Learning for Automated Word Lemmatisation. *AI Comm.,* in press, 2007.

[12] Porter, M.F. An Algorithm for Suffix Stripping. *Program* 14(3), str. 130–137, 1980.

ENSEMBLES OF MULTI-OBJECTIVE REGRESSION TREES: A CASE STUDY FOR PREDICTING THE CONDITION OF REMNANT INDIGENOUS VEGETATION

Dragi Kocev[1], *Sašo Džeroski*[1], *Matt D. White*[2], *Graeme R. Newell*[2], *Peter Griffioen*[3]
[1]Department of Knowledge Technologies, Jozef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia. {Dragi.Kocev, Saso.Dzeroski}@ijs.si
[2]Department of Sustainability and Environment, Arthur Rylah Institute for Environmental Research, 123 Brown Street, Heidelberg, Victoria 3084, Australia. {Matt.White, Graeme.Newell}@dse.vic.gov.au
[3]Acromap, Pty. Ltd.,37 Gloucester Drive, Heidelberg, Victoria 3084, Australia. pgriffioen@acromap.com

ABSTRACT

In this paper, we show the application of Multi-Objective Decision Trees (MODTs) and Ensembles of MODTs to environmental modelling. MODTs have ability to make simultaneous prediction of several target attributes. One essential component of ecological studies and planning processes is the assessment of quality, condition or status of stands of the native vegetation or habitat. Recently, 'Habitat Hectares' was proposed as an approach for vegetation quality assessment. Habitat Hectares method includes assessments of the retention of characteristics within a site (site condition components) and the nature of the landscape surrounding the site (landscape context components). The data for this study consists of 16967 'homogenous' sites that are described with a total of 40 variables (GIS and remote-sensed data) that include biophysical and spectral data. The data were analyzed using multi-objective regression trees (MORTs) and ensembles of MORTs. The results show that ensembles have better predictive performance than the single MORT or single-objective regression tree (SORTs). Ensembles of MORTs and ensembles of SORTs have approximately equal performance, but ensembles of MORTs are faster to learn. Additionally, we learned predictive models (pruned trees) that can be used to better understand the resilience of indigenous vegetation and landscapes.

1 INTRODUCTION

Multi-Objective Regression Trees (MORTs) are decision trees capable of predicting several target attributes simultaneously [1]. The main advantages of this approach (over building a separate model for each target attribute) are: (1) a multi-objective model is smaller than the total size of the individual models for all target attributes, and (2) such a multi-objective model explicates dependencies between the different target attributes.

Ensembles of MORTs can be used to lift the predictive performance of the MORTs [2]. Ensemble methods construct a set of classifiers for a given prediction task and classify new data instances by taking a vote over their predictions. Ensemble methods improve the predictive performance of their base classifier when used in a single target setting (learn an ensemble for each target attribute separately) [3]. In [2], it is shown that this applies also for the multi-target setting (learn one ensemble for all target attributes). In addition, the ensembles for multi-target predictions should be preferred because they are faster to learn.

In this paper, we apply MORTs and ensembles of MORTs on environmental modelling dataset – modelling of remnant indigenous vegetation.

Governments and other agencies (within Australia) are required to demonstrate their compliance with the policies and legislation that are related to remnant indigenous vegetation [4]. These policies may extend the requisite knowledge base and representation of vegetation beyond just 'extent' and 'type', to incorporate the notion of 'condition' or 'quality'. Concepts of vegetation condition are typically idiosyncratic and/or context-specific. Recent attempts have been made to clarify these concepts, and develop general and widely applicable metrics and indices for assessing vegetation condition. Recently the habitat hectares approach, a rapid assessment technique, was proposed [5]. The 'vegetation quality' in the 'habitat hectares' approach is defined as the degree to which the current vegetation differs from a 'benchmark' that represents the average characteristics of a mature and long-undisturbed stand of the same plant community. Therefore dissimilar community assemblages such as rainforests and savannah can be compared by employing the same general index. The overall 'habitat hectares' index comprises 10 components. Seven of these are related to site characteristics (including structural, compositional and other ecological features). The remaining three components are related to the landscape characteristics (patch size, neighborhood and distance to core area).

Employing the 'habitat hectares' approach, 16967 'homogenous' sites within the study area were sampled. Each sampling point was described with a total of 40 variables (GIS and remote-sensed data) that include biophysical and spectral data.

For building predictive models from the data (the descriptions and 'habitat hectares' scores for the sampling sites) we used, both MORTs and ensembles of MORTs. MORTs were used in order to obtain models that can explain the problem at hand, while ensembles of MORTs to obtain models that have better predictive performance.

The development of predictive models of condition will contribute towards an understanding of the resilience of indigenous vegetation types and landscapes and the relative importance of biophysical and landscape attributes that influence observed condition states. In addition, spatially explicit models of condition, could when used in conjunction with other data, inform natural resource investment decisions, statutory protection and reserve design, while providing a basis for new forms of environmental accounting.

2 METHODOLOGY

2.1 Multi-Objective Regression Trees

Multi-Objective Regression Trees (MORTs) [1] are regression trees that can predict several numeric target variables at once (Figure 1 depicts a MORT). MORTs are a special instantiation of predictive clustering trees (PCTs) [6]. In the PCTs framework, the tree is viewed as a hierarchy of clusters: the top-node corresponds to one cluster containing all data, which is recursively partitioned into smaller clusters while moving down the tree. MORTs are constructed with a standard top-down induction algorithm. This algorithm uses heuristic that minimizes the intra-cluster variation to select an attribute test in the internal nodes. The heuristic score is calculated as sum over the subsets that are induces by the test. Minimization of the intra-cluster variation results in homogeneous leaves, which in turn results in accurate predictions. The predicted vector (that contains predictions for each target attribute) is the vector mean of the target vectors of the training examples belonging to it. More detailed explanations for MORTs can be found in [1,6].

2.2 Ensemble Methods

Ensemble methods are learning algorithms that construct a set of classifiers (called ensembles) [7]. Each new data instance is classified by combining the prediction of each classifier from the ensemble. For regression tasks, the predictions can be combined using average, while for classification tasks using majority vote. Also, more complex combinations of the predictions can be used [8,9].

A condition for an ensemble to be more accurate than any of its individual members is that the individual classifiers are accurate and diverse [10]. An accurate classifier is one that does better than random guessing on new examples. Two classifiers are diverse if they make different errors on new examples. The diversity can be introduced in several ways: by manipulating the training set (changing the weight of examples [3,11] or changing the weight of attributes[12,13]) or by manipulating the learning algorithm itself [11].

Bagging [3] is an ensemble method that constructs the different classifiers by making bootstrap replicates of the training set that are used to construct individual classifiers. Each bootstrap sample is obtained by randomly sampling training instances, with replacement, from the original training set. The bootstrap sample and the training set have an equal number of instances. Bagging can give substantial gains in predictive performance, when applied to an unstable learner (i.e., a learner for which small changes in the training set result in large changes in the predictions), such as classification and regression tree learners [3].

Random Forest [11] is an ensemble method for trees, where the diversity among the individual classifiers is obtained from two sources: (1) by using bagging and (2) changing the feature set during learning. At each node in the decision tree, a random subset of the input features is taken and the best split is selected from this subset. The size of the random subset is given by a function *f* of the number of descriptive attributes *x* (e.g. $f(x)=1$, $f(x)=\sqrt{x}$, $f(x)=\lfloor \log_2 x+1 \rfloor$, $f(x)=\frac{x}{2}$ …). If $f(x)=x$, then random forests are equal to bagging.

The diversity between the individual classifiers, when using **Random Subspaces** [12] method, is obtained with random sampling of the feature space (each individual classifier is learned over randomly chosen feature subspace). The number of retained features is given by the function *f* of the number of descriptive attributes *x* as given above.

Recently, combination of Bagging and Random Subspaces (**SubBag** algorithm) was proposed [13]. This method takes bootstrap replicates of the training set and randomly selects feature subspaces. The difference between this approach and random forests is that here feature subspace is used to learn the whole model (while in Random Forests feature subset is selected at each node). In addition, this method can use variety of learning algorithms as individual classifiers, and Random Forests can be constructed only with trees.

The ensemble methods for multi-objective regression trees are obtained using MORT as a individual classifier. More detailed description can be found in [2].

3 DATA DESCRIPTION

The dataset contains 16967 samples. Each sample is described with a total of 40 independent variables (GIS and remote-sensed data) and 7 dependant variables (the 'habitat hectares' score). The 'habitat hectares' score was represented with the following components: Large Trees, Tree (canopy) cover, Understorey (non-tree) strata, Lack of weeds, Recruitment, Organic litter and Logs. Each score was calculated comparing the current status of the vegetation with the benchmark (average characteristics of a mature and long-undisturbed stand of the same vegetation community).

The large tree score represents the number of large trees (both living and dead) that are present at the measuring site. Tree canopy score assesses the projective foliage cover of canopy trees in the stand, while the understorey score assesses the abundance of various shrubs and forb/herb strata of a community. The understorey assessment includes only indigenous plant species. The lack of (indigenous) weeds score is calculated from the coverage of non-indigenous and native weed plant species. The recruitment score gives the potential for the recruitment of plant species (that is essential part of the long-term site viability). Litter represents both fine and coarse plant debris less than 10 cm diameter, while logs represent the fallen timber or branches of trees that are substantially detached from the parent tree. More detailed description of the 'habitat hectares' scores can be found in [5].

4 EXPERIMENT SETUP

Two sets of experiments were performed. With the first set of experiments we opted for interpretability of the models, so we learned highly pruned MORT (for prediction of all target variables simultaneously) and regression trees (for prediction of each target attribute separately). The pruning was controlled with setting the parameter minimum instances in a leaf to 2048. The second set of experiments consists of un-pruned MORTs, ensembles of MORTs, regression trees and ensembles of regression trees. With this experimental setting the goal was to obtain models that are as accurate as possible, so later on can be used for drawing maps of the quality of remnant indigenous vegetation.

For combination of the predictions output (voting scheme) of the base classifiers from the ensemble, average was used. The ensembles consisted of 100 un-pruned trees. For building Random Forests, Random Subspaces and SubBag the parameter $f(x)$ was set to $f(x) = \lfloor \log_2 x + 1 \rfloor$ as suggested in [11].

The obtained models were validated using 10-fold cross-validation. For assessing the predictive performance of the obtained models we report the correlation coefficient and root mean squared error (RMSE) in the next section.

5 RESULTS AND DISCUSSION

Table 1 shows the predictive performance of the pruned models. From these results we can note that the MORT has comparable performance with the regression trees for each target attribute. Note that, MORT is smaller than all models together and is faster to learn. The size (sum of internal nodes and leafs) of obtained MORT was 11, while the size of each SORT was 11(except the SORT for LargeTreeScore that had size 13).

Table 1: *Correlation coefficient and RMSE (MORT – Multi-Objective Regression Tree, SORT – Single-Objective Regression Tree)*

Target	Correlation		RMSE	
	MORT	**SORT**	**MORT**	**SORT**
LargeTreeScore	0.502	0.520	2.905	2.871
TreeCanopyScore	0.671	0.677	1.665	1.652
UnderstoreyScore	0.702	0.707	5.103	5.064
LitterScore	0.715	0.699	1.428	1.461
LogsScore	0.698	0.712	1.491	1.461
WeedsScore	0.784	0.789	3.811	3.773
RecruitmentScore	0.607	0.614	2.592	2.574

Figure 1 depicts the pruned MORT. The predictions for the target attributes are the vectors at each leaf. The ordering of the target attributes in the vector of predictions is given in Table 1.

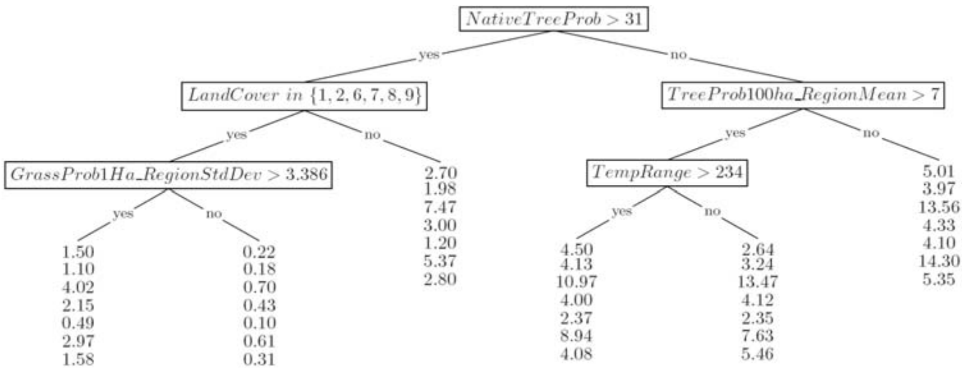


Figure 1: *Pruned MORT*

Tables 2 and 3 show the correlation coefficients and RMSEs of the obtained models. The ensemble methods show better predictive performance than the MORT and SORTs. All ensemble methods have comparable predictive performance, but Random Forests are fastest to learn. Additionally, Random Forests of Multi-Objective Regression Trees are faster to learn, compared to the time needed for learning ensemble for each target attribute separately.

6 CONCLUSIONS

Traditionally most people have thought of native vegetation in terms of extent and type, with relatively few considering its condition or quality. However, the new Government policies (in Australia) increasingly require environmental managers to also consider native vegetation condition. As a result of these policies new ways of measuring the condition of native vegetation have been developed (e.g. Habitat Hectares). These metrics provide simple methods to obtain a score for a site, and to enable comparisons of condition between locations in different vegetation communities.

While this point-based data provides a useful tool for land managers, maps of the condition of native vegetation are an obvious extension to assist identifying the priority areas for restoration and conservation activities. With the modeling approach it is possible to extrapolate point-based native vegetation condition data into a map of remnant native vegetation condition.

Different modeling techniques were used, and their performances were compared. In terms of predictive performances, the ensembles produced approximately equal results. But, Random Forests with multi-objective regression trees should be preferred because they are faster to learn.

Also, in this study interpretable models were learned (pruned trees). These models will be used to further understand the resilience of indigenous vegetation and landscapes.

Table 2. *Correlation Coefficients of the obtained models (MO – Multi-Objective, SO – Single-Objective; RT – Regression Trees, Bag – Bagging, RF – Random Forests, RSub – Random Subspaces, BSub – Bagging and Random Subspaces – SubBag)*

Target	MORT	SORT	MOBag	SOBag	MORF	SORF	MORSub	SORSub	MOBSub	SOBSub
LargeTreeScore	0.627	0.601	0.685	0.684	0.690	0.690	0.669	0.667	0.686	0.684
TreeCanopyScore	0.754	0.728	0.798	0.802	0.802	0.803	0.788	0.788	0.798	0.801
UnderstoreyScore	0.779	0.765	0.827	0.826	0.827	0.828	0.812	0.812	0.827	0.826
LitterScore	0.768	0.753	0.812	0.815	0.816	0.815	0.802	0.801	0.812	0.814
LogsScore	0.765	0.744	0.802	0.798	0.800	0.801	0.788	0.786	0.801	0.798
WeedsScore	0.830	0.824	0.872	0.871	0.872	0.873	0.860	0.861	0.872	0.871
RecruitmentScore	0.692	0.677	0.743	0.744	0.744	0.748	0.728	0.728	0.743	0.745

Table 3. *RMSEs of the obtained models (MO – Multi-Objective, SO – Single-Objective; RT – Regression Trees, Bag – Bagging, RF – Random Forests, RSub – Random Subspaces, BSub – Bagging and Random Subspaces – SubBag)*

Target	MORT	SORT	MOBag	SOBag	MORF	SORF	MORSub	SORSub	MOBSub	SOBSub
LargeTreeScore	2.618	2.718	2.448	2.451	2.439	2.437	2.527	2.530	2.445	2.451
TreeCanopyScore	1.476	1.563	1.355	1.343	1.344	1.342	1.405	1.407	1.355	1.344
UnderstoreyScore	4.492	4.649	4.034	4.040	4.040	4.023	4.255	4.257	4.033	4.034
LitterScore	1.310	1.352	1.195	1.185	1.186	1.186	1.242	1.244	1.194	1.188
LogsScore	1.340	1.399	1.245	1.256	1.249	1.247	1.290	1.294	1.247	1.255
WeedsScore	3.426	3.506	3.011	3.015	3.013	2.999	3.196	3.181	3.009	3.017
RecruitmentScore	2.357	2.423	2.184	2.180	2.183	2.170	2.262	2.262	2.184	2.176

References

[1] J. Struyf, and S. Dzeroski. Constraint based induction of multi-objective regression trees, Knowledge Discovery in Inductive Databases, 4th International Workshop, KDID'05, LNCS vol. 3933, pp. 222-233, 2006

[2] D. Kocev, C. Vens, J. Struyf, and S. Dzeroski. Ensembles of multi-objective decision trees, Proceedings of 18th ECML, Warsaw, Poland, 2007, LNAI vol.4701, pp. 624-631, 2007 (to appear)

[3] L. Breiman. Bagging predictors, Machine Learning **24** (2), 123–140, 1996

[4] D. Parkes, and P. Lyon. Towards a national approach to vegetation condition assessment that meets government investors' needs: A policy perspective. Ecological Management and Restoration **7**, S3-S5, 2006

[5] D. Parkes, G. Newell, and D. Cheal. Assessing the quality of native vegetation: The 'habitat hectares' approach. Ecological Management and Restoration **4**, S29-S38, 2003

[6] H. Blockeel, L. De Raedt, and J. Ramon. Top-down induction of clustering trees, In Proceedings of the 15th ICML, p. 55–63, 1998

[7] T. Dietterich. Ensemble methods in machine learning, In: J. Kittler, F. Roli (Eds.) MCS 2000. LNCS vol. 1857, p.1-15. Springer, Heidelberg, 2000

[8] T. Ho, J. Hull, and S. Srihari. Decision combination in multiple classifier systems, IEEE Trans. on Pattern Anal. and Mach. Intell. **16**(1), p.66–75, 1994

[9] J. Kittler, M. Hatef, R. Duin, and J. Matas. On combining classifiers, IEEE Trans. on Pattern Anal. and Mach. Intell. **20**(3), 226–239, 1998

[10] L. Hansen, and P. Salamon. Neural Networks ensembles. IEEE Trans. on Pattern Anal. and Mach. Intell. **12**, 993–1001, 1990

[11] L. Breiman. Random forests, Machine Learning **45**(1), 5–32, 2001

[12] T. Ho. The random subspace method for constructing decision forests, IEEE Trans. on Pattern Anal. and Mach. Intell. **20**(8), 832–844, 1998

[13] P. Panov, and S. Dzeroski. Combining bagging and random subspaces to create better ensembles, In: Advances in Intelligent Data Analysis VII - 7th Int'l Symposium on Intelligent Data Analysis, IDA 2007. Ljubljana, Slovenia. Proceedings. LNCS Vol. 4723. Springer

A PROTOTYPE DECISION SUPPORT SYSTEM FOR GMO TRACEABILITY

Petra Kralj(1), Nada Lavrač(1,2),
Kristina Gruden(3), Ana Rotter(3), Dejan Štebih(3), Dany Morisset(3), Jana Žel(3)
(1) Jožef Stefan Institute, Jamova 39, Ljubljana, Slovenia
(2) University of Nova Gorica, Vipavska 13, Nova Gorica, Slovenia
(3) National Institute of Biology, Večna pot 111, Ljubljana, Slovenia
e-mail: petra.kralj@ijs.si

ABSTRACT

The problem of traceability of genetically modified organisms (GMOs) addresses the detection, identification and quantification of GMOs in food, feed and seed samples. Due to a large number of GMOs in the market, a system for reliable and affordable traceability of GMOs, optimizing the price of testing for a given sample, has to be established. We have defined the input to the future decision support system for assay selection to be of a tabular form, with rows corresponding to GMOs, and columns corresponding to assays they react to. In this paper we present a prototype decision support system for GMO detection and identification.

1 INTRODUCTION

A genetically modified organism (GMO) is an organism whose genetic material (Figure 1) has been altered using modern genetic engineering techniques (known as recombinant DNA technology). The general principle of producing a GMO is to artificially modify the genetic material of an organism's genome in order to give it a new property (a plant's resistance to a disease or insect, improvement of the nutritional value, increased crop productivity, a plant's tolerance to a herbicide, etc.)

Modern biotechnology has many applications in the pharmaceutical and agri-food industries. One example is the use of GMOs in the food production chain. In order to ensure that this development of modern biotechnology, specifically of GMOs, takes place in accordance with precautionary principle [1], the European Union has established a legal framework comprising various acts [1, 2, 3, 4, 5, 6]. In this paper we focus on [4] and [6] on GMO traceability and labeling of food and feed produced from GMOs.

The growing number of GMO allowed in the European Union and in the rest of the world and the need of inspection services to be able to effectively assess whether the regulatives and directives are being respected have lead to a problem of minimizing laboratory costs for testing samples of food or feed for GMO presence, GMO identification and GMO quantification.

In this paper we present a prototype decision support system [7] called GMOtrack. The goal of GMOtrack is to support laboratory work on GMO traceability. It evaluates possible assay sets for a given sample of food of feed and suggesting those that would minimize the cost of testing for GMO presence and GMO identification. It also allows "what if" analysis.

This paper is organized as follows: Section 2 presents the biological background necessary to understand the data and the GMO traceability problem. Section 3 is dedicated to the description of the GMO traceability problem. In Section 5 we present the prototype of the decision support system for GMO traceability. It is followed by conclusions and further work in Section 5.

2 BIOLOGICAL BACKGROUND

Deoxyribonucleic acid, or DNA, is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms. The main role of DNA molecules is the long-term storage of information, since it contains the instructions needed to construct other components of cells, such as proteins and RNA molecules. The DNA segments that carry this genetic information are called genes, but other DNA sequences have structural purposes, or are involved in regulating the use of this genetic information. Since DNA is a very stable molecule, it can be detected in processed food and other products of biological origin.

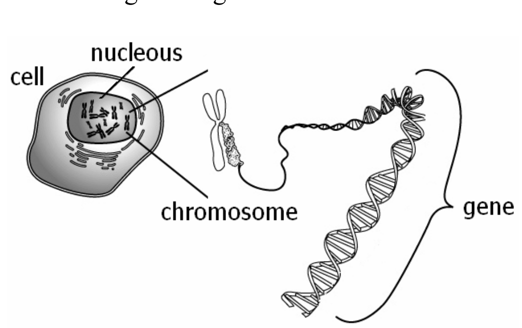


Figure 1: *Schematic representation of a genome in a cell.*

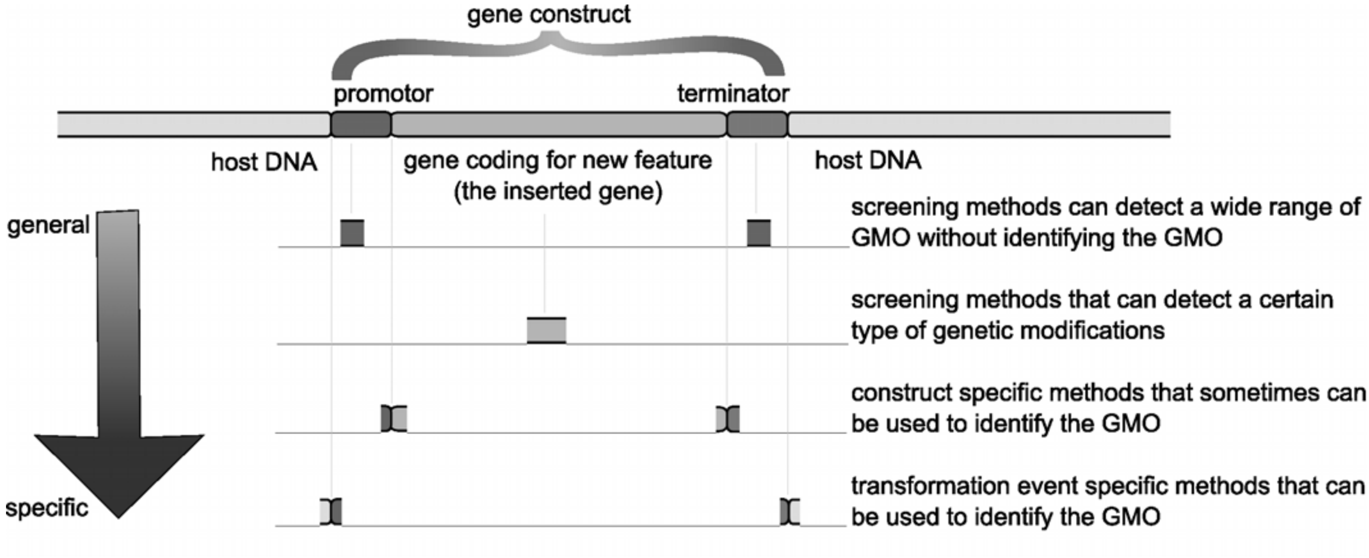


Figure 2: *Targets for PCR based detection of genetic modifications, ordered according to specificity.*

A gene construct is a functional unit necessary for the expression of a gene of interest. Apart from the gene of interest itself, a so-called promoter ("starter") and a terminator ("stop signal") are required for expression. In most cases, additional sequences are included, e.g. marker genes, which are also accompanied by a promoter and a terminator. The name "construct" is used because the sequences normally do not exist in this combination, but must be "put together" (constructed). A schematic representation of a gene construct is depicted in the upper part of Figure 2.

Detection of a GMO or a derivative of a GMO can be done by detecting a DNA molecule that is specifically associated with or derived from the genetic modification of interest. DNA can be purified and multiplied in billions of copies in a few hours with a technique called PCR (polymerase chain reaction) [8]. There is normally a linear correlation between the quantity of GMO and DNA.

The specificity of currently available DNA based methods can be divided into four categories (Figure 2): 1) screening methods that can detect a wide range of GMO without identifying the GMO, 2) screening methods that can detect a certain type of genetic modifications, 3) construct specific methods that sometimes can be used to identify the GMO, 4) transformation event specific methods that can be used to identify the GMO. In addition PCR-based GMO analyses usually include testing for presence of DNA from the particular species of interest, e.g. soybean DNA.

3 THE GMO TRACEABILITY PROBLEM

All foods and feed produced from GMOs, including products that no longer contain detectable traces of genetic modification must be labeled. The threshold for adventitious presence for EU-approved varieties of GMOs for use in food and feed is set at 0.9 percent [4]. Above this level, all products must be labeled.

GMO tracking is a several steps process. After the inspector has acquired the sample and has brought it to a certified laboratory for testing, grinding, homogenization, DNA isolation and DNA quantification need to be done before applying a real-time PCR to qualitatively detect GMO presence and identify the present GMOs. If the presence of GMOs is confirmed, the quantification step is required to ascertain if GMO content is above the allowable adventitious presence level of 0.9 percent. The qualitative detection of GMO presence and identification of the present GMOs are the most expensive steps in the GMO traceability process. The identification of GMOs presence is becoming extremely expensive with increasing number of GMOs on the market. We believe it can be improved (lowered costs) by acquiring and systemizing the data about GMOs gene constructs and by using this data as the basis for an intelligent decision support system.

The decision support system GMOtrack, presented in this paper, helps the user to select a set of assays (real-time PCR tests) to be done for a specific sample. We believe that, by selecting the right set of tests according to the sample, we can lower the cost of the entire analysis.

There are several sources of data about GMOs that are on the market in the European Union and in the rest of the world [9, 10], but there is no unified database describing the gene constructs of these GMOs. We are gathering data about GMOs in a unified table (A small part of this table is shown in Figure 3).

The first line of our unified table is reserved for DNA elements and corresponding assays to detect them. Each following line is one GMO. In the first column we have the GMO names. The second column denotes the species. The following columns are “1” if the corresponding GMO contains the element and “0” if it does not.

Since real-time PCR is time consuming and due to the available technology, one sample is preferably tested for presence of several elements in parallel (at the same time).

In routine practice at most two iterations of assays are required. Our goal is to support the decision making process of deciding which assays to perform in each iteration depending on the sample in order to detect and identify GMOs.

GMOname	species	P35S	P-ract	P-4AS1	P-ubiZM1	P-TA29	P-NOS	P-CMoVb	P-FMV	P-PEPC	PSsuAra	P-PCDK
MON810	maize	1	0	0	0	0	0	0	0	0	0	0
MON 863	maize	1	0	1	0	0	0	0	0	0	0	0
RRS	soja	1	0	0	0	0	0	0	0	0	0	0
NK 603	maize	1	1	0	0	0	0	0	0	0	0	0
DAS1507	maize	1	0	0	1	0	0	0	0	0	0	0
GT 73 / RT	oilseed	0	0	0	0	0	0	0	1	0	0	0
Mon 1445	cotton	1	0	0	0	0	0	1	0	0	0	0
MON 531	cotton	1	0	0	0	0	1	0	0	0	0	0
T25	maize	1	0	0	0	0	0	0	0	0	0	0
GA 21	maize	0	1	0	0	0	0	0	0	0	0	0
Bt 11	maize	1	0	0	0	0	0	0	0	0	0	0
Bt176	maize	1	0	0	0	0	0	0	0	1	0	1
MS8	oilseed	0	0	0	0	1	0	0	0	0	1	0
RF3	oilseed	0	0	0	0	1	0	0	0	0	1	0
MS1	oilseed	0	0	0	0	1	1	0	0	0	1	0
RF1	oilseed	0	0	0	0	1	1	0	0	0	1	0

Figure 3: *A part of the unified GMO table.*

The cost is defined as follows: all the assays have the same price. Doing more assays in parallel lowers the costs. The chart depicting cost grows related to the number of assays is presented in Figure 4.

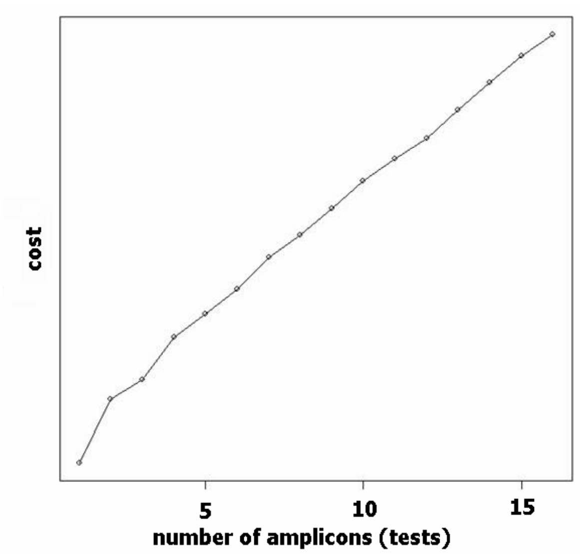


Figure 4: *A chart depicting costs relative to the number of assays.*

4 A PROTOTYPE DECISION SUPPORT SYSTEM FOR GMO TRACEABILITY

We have implemented a prototype decision support system program for GMO traceability called GMOtrack. After loading the data, the user selects the species contained in his sample. In the screenshot in Figure 5, oilseed rape and potato are the selected species. The minimum coverage constraint is by default set to 100 percent meaning that the user is interested in only those assay sets that detect the presence of all GMOs of the selected species. The user could also set a lower coverage constraint. The user then sets the maximum number of assays at the first level constraint and starts the computation by pressing the “Compute” button. In the screenshot in Figure 5 this constraint is set to 4. The program generates assay sets and evaluates them according to their GMO detection and GMO identification power. It then outputs the assay tests sorted from the best to the worst.

The user can then browse through the proposed assay sets. In Figure 5 the user has chosen the assay set {P35S, PSsuAra, gox247 and EH92-527-1} (highlighted). The program then shows what different outcomes of these assays would mean.

Example 1:

- The outcome P35S=0, PSsuAra=0, gox247=0 and EH92-527-1=0 would mean that the analyzed sample does not contain any GMO. No further analysis is needed.

Example 2:

- The outcome P35S=0, PSsuAra=0, gox247=1 and EH92-527-1=0 would mean that the sample contains exactly one GMO which has been identified. No further analysis is needed.

Example 3:

- The outcome P35S=1, PSsuAra=0, gox247=1 and EH92-527-1=1 would mean that two GMOs have been identified in the sample and that seven other GMOs could be present in the sample. In this case, further analysis is needed to asses the presence of other GMOs.

The user could then further investigate which GMOs are identified with every outcome of and which tests, if any, need to be done in the second phase.

5 CONCLUSIONS AND FURTHER WORK

GMO traceability is a very important issue in the modern world. Besides allowing the consumer to choose the products based on GMO content, there are several other applications of GMO traceability, like environmental impact.

In this paper we have presented a prototype program GMOtrack which is a decision support system for optimization of two of the most expensive steps in GMO tracking - GMO detection and GMO identification.

Acknowledgement

This work was supported by Slovenian Ministry of Higher Education, Science and Technology projects "Knowledge Technologies", “Rastlinska fiziologija in biotehnologija”, “Harmonization of technologies for tracking genetically modified organisms in agricultural production of harvest and provisions and their coexistence with conventional and ecological farming” and EU FP6 project "Co-Extra: GM and

non-GM suppy chains: their CO-EXistence and TRAceability".

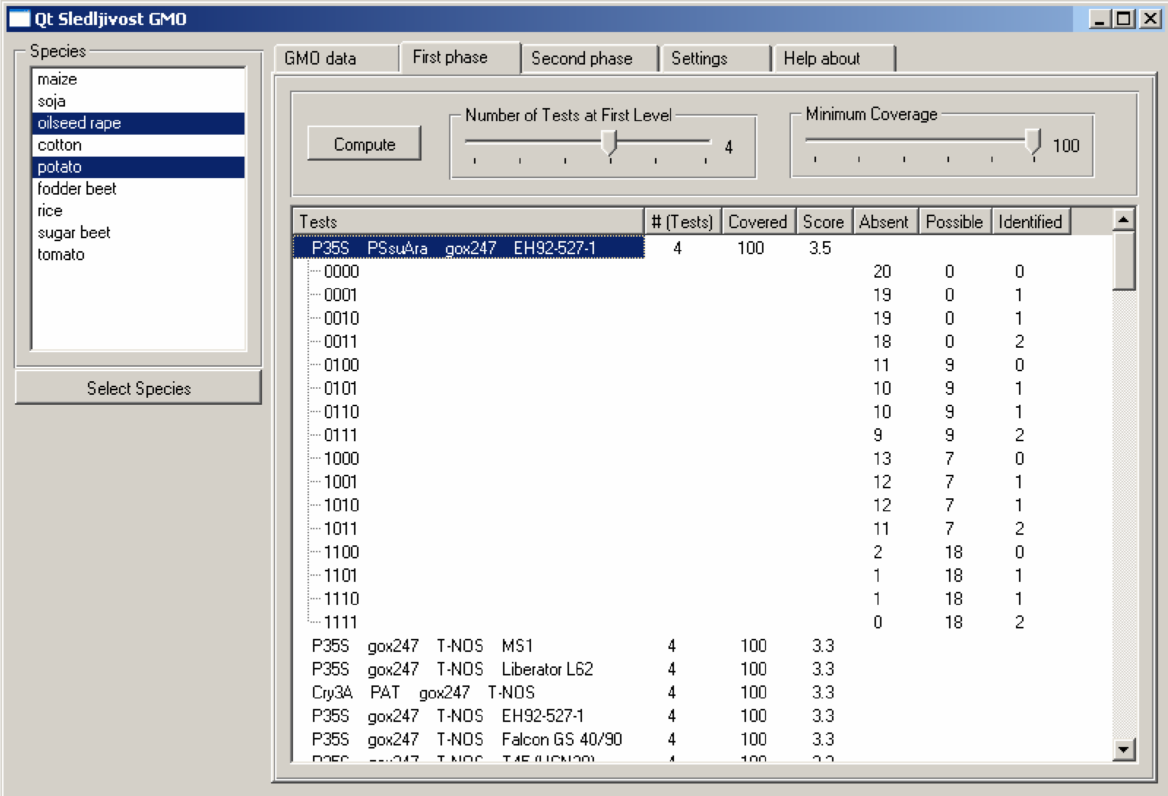


Figure 5: *Screenshot of the GMOtrack prototype decision support system program.*

References

[1] A. Holst Jensen, M. De Loose, G. Van Den Eede: Coherence between legal requirements and approaches for detection of genetically modified organisms (GMOs) and their derived products. J. Agric. Food Chem. 54. 2799-2809. 2006.

[2] EU Commission Directive 90/219/EC on the contained use of genetically modified micro-organisms, Official Journal L 239 (1991).

[3] EU Commission Directive 2001/18/EC on the deliberate release of genetically modified organisms into the environment, regulating placing products containing or consisting of GMOs on the market, Official Journal L 7, 38 (1991).

[4] EU Commission Regulation (EC) 1829/2003 on genetically modified food and feed, Official Journal L 268, 1–23 (2003).

[5] EU Commission Regulation (EC) No 1946/2003 on transboundary movements of genetically modified organisms, Official Journal L 287, 1-10 (2003).

[6] EU Commission Regulation (EC) 1830/2003 on traceability and labeling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms, Official Journal L 268, 24-28 (2003).

[7] M. Bohanec. Odločanje in večparametrsko modeliranje. M. Vintar, J. Grad (ur.). *E-uprava : izbrane razvojne perspektive, (Upravna misel, 1, 04).* V Ljubljani: Fakulteta za upravo, 2004, str. 205-219. In Slovenian.

[8] S. A. Bustin. A-Z of Quantitative PCR. International University Line. La Jolla. USA. 2004.

[9] ABIGOS database: http://www.agbios.com/main.php

[10] GMO compass: http://www.gmo-compass.org/eng/home/

TRIPLET EXTRACTION FROM SENTENCES

Delia Rusu, Lorand Dali*, Blaž Fortuna°, Marko Grobelnik°, Dunja Mladenić°*
* Technical University of Cluj-Napoca, Faculty of Automation and Computer Science
G. Barițiu 26-28, 400027 Cluj-Napoca, Romania
° Department of Knowledge Technologies, Jožef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 477 3127; fax: +386 1 477 3315
E-mail: delia.rusu@gmail.com, loranddali@yahoo.com
{blaz.fortuna, marko.grobelnik, dunja.mladenic}@ijs.si

ABSTRACT

In this paper we present an approach to extracting subject-predicate-object triplets from English sentences. To begin with, four different well known syntactical parsers for English are used for generating parse trees from the sentences, followed by extraction of triplets from the parse trees using parser dependent techniques.

1. INTRODUCTION

According to the approach presented in [13], we define a triplet in a sentence as a relation between subject and object, the relation being the predicate. The aim here is to extract sets of the form {subject, predicate, object} out of syntactically parsed sentences, with four parsers, namely Stanford Parser, OpenNLP, Link Parser and Minipar. The work presented in [13] used proprietary parser that already provided the logical form of a sentence including subject, object, predicate information, while our work is based on using publicly available parsers. Stanford Parser and OpenNLP both generate a treebank structure, and therefore will be discussed together. Furthermore, we present the results obtained using the Link Parser application, which is based on the link grammar. Finally, we describe the triplet extraction algorithm for the parse tree given by Minipar.

The performance of the applications was measured using a system with CPU 2.80 GHz and 2.00 GB RAM. We used the same data for all measurements, meaning 100 sentences extracted from news articles.

2. TREEBANK PARSERS

A treebank is a text corpus where each sentence belonging to the corpus has a syntactic structure added to it.

Because of the common outputted parse tree of Stanford Parser and OpenNLP, we developed a similar algorithm for triplet extraction for the two parsers. In this section the algorithm will be presented in more detail

2.1. Triplet Extraction Algorithm for Treebank Parsers

A sentence (S) is represented by the parser as a tree having three children: a noun phrase (NP), a verbal phrase (VP) and the full stop (.). The root of the tree will be S.

Firstly we intend to find the subject of the sentence. In order to find it, we are going to search in the NP subtree. The subject will be found by performing breadth first search and selecting the first descendent of NP that is a noun. Nouns are found in the following subtrees:

Subtree	The type of noun found
NN	noun, common, singular or mass
NNP	noun, proper, singular
NNPS	noun, proper, plural
NNS	noun, common, plural

Secondly, for determining the predicate of the sentence, a search will be performed in the VP subtree. The deepest verb descendent of the verb phrase will give the second element of the triplet. Verbs are found in the following subtrees:

Subtree	The type of verb found
VB	verb, base form
VBD	verb, past tense
VBG	verb, present participle or gerund
VBN	verb, past participle
VBP	verb, present tense, not 3rd person singular
VBZ	verb, present tense, 3rd person singular

Thirdly, we look for objects. These can be found in three different subtrees, all siblings of the VP subtree containing the predicate. The subtrees are: PP (prepositional phrase), NP and ADJP (adjective phrase). In NP and PP we search for the first noun, while in ADJP we find the first adjective. Adjectives are found in the following subtrees:

Subtree	The type of adjective found
JJ	adjective or numeral, ordinal
JJR	adjective, comparative

JJS	adjective, superlative

```
function TRIPLET-EXTRACTION(sentence) returns a solution, or failure

        result ← EXTRACT-SUBJECT(NP_subtree)
                ∪ EXTRACT-PREDICATE(VP_subtree)
                ∪ EXTRACT-OBJECT(VP_siblings)
        if result ≠ failure then return result
        else return failure

function EXTRACT-ATTRIBUTES(word) returns a solution, or failure
        // search among the word's siblings
        if adjective(word)
                result ← all RB siblings
        else
                if noun(word)
                        result ← all DT, PRP$, POS, JJ,
                        CD, ADJP, QP, NP siblings
                else
                        if verb(word)
                                result ← all ADVP
                                siblings
        // search among the word's uncles
        if noun(word) or adjective(word)
                if uncle = PP
                        result ← uncle subtree
        else
                if verb(word) and (uncle = verb)
                        result ← uncle subtree
        if result ≠ failure then return result
        else return failure

function EXTRACT-SUBJECT(NP_subtree) returns a solution, or failure
        subject ← first noun found in NP_subtree
        subjectAttributes ←
                EXTRACT-ATTRIBUTES(subject)
        result ← subject ∪ subjectAttributes
        if result ≠ failure then return result
        else return failure

function EXTRACT-PREDICATE(VP_subtree) returns a solution, or failure
        predicate ← deepest verb found in VP_subtree
        predicateAttributes ←
                EXTRACT-ATTRIBUTES(predicate)
        result ← predicate ∪ predicateAttributes
        if result ≠ failure then return result
        else return failure

function EXTRACT-OBJECT(VP_sbtree) returns a solution, or failure
        siblings ← find NP, PP and ADJP siblings of
                VP_subtree
        for each value in siblings do
                if value = NP or PP
                        object ← first noun in value
                else
                        object ← first adjective in value
                objectAttributes ←
                        EXTRACT-ATTRIBUTES(object)
        result ← object ∪ objectAttributes
        if result ≠ failure then return result
        else return failure
```

Figure 1: *The algorithm for extracting triplets in treebank output.*

Moreover, for each element composing the triplet, we find its attributes (modifiers). For example, the attributes of a noun are mainly adjectives, the attributes of a verb are adverbs. Figure 1 presents the algorithm for extracting triplets of the form **subject – predicate – object**.

2.2. Stanford Parser and OpenNLP

2.2.1. Description

Stanford Parser is a natural language parser developed by Dan Klein and Christopher D. Manning from The Stanford Natural Language Processing Group [1, 2]. The package contains a Java implementation of probabilistic natural language parsers; a graphical user interface is also available, for parse tree visualization. The application we developed uses version 1.5.1, released on 11.06.2006. The software is available at [3].

OpenNLP is a collection of projects for natural language processing. We used SharpNLP, which is the C# variant. SharpNLP is distributed with the GNU lesser general public license and can be downloaded from [4].

2.2.2. Stanford Parser and OpenNLP Parse Trees

Stanford Parser generates a Treebank parse tree for the input sentence. Figure 2 depicts the parse tree for the sentence "*A rare black squirrel has become a regular visitor to a suburban garden"*. The triplet extracted out of this sentence is **squirrel – become – visitor**, as shown in Figure 2.

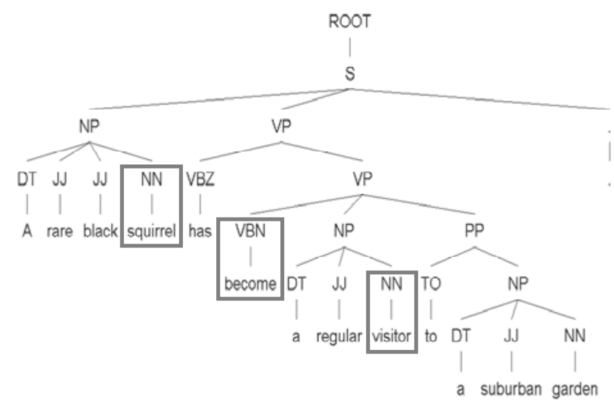


Figure 2: *The parse tree generated by Stanford Parser, when the input sentence is "A rare black squirrel has become a regular visitor to a suburban garden." The triplet extracted out of this sentence is* ***squirrel – become – visitor.***

After applying the triplet extraction algorithm presented in Figure 1, we obtain the result presented in Figure 3.

The subject *squirrel* has as attributes the adjectives *rare, black* and the article *a;* the word *become* has as attributes its auxiliary *has* and the object *visitor* has as attributes the adjective *regular*, the article *a* and the noun *garden* with its attributes: preposition *to*, article *a* and adjective *suburban*.

OpenNLP's parse tree is similar to that of Stanford Parser, thus we will not discuss it separately.

2.2.3. Performance

The application using Stanford Parser was written in Java. It parsed the sentences in 178.1 seconds, generating 118 triples.

The application using OpenNLP was written in C#. It parsed the sentences in 29.95 seconds, generating 168 triples.

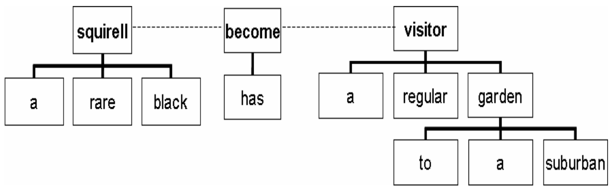


Figure 3: *The triplet structure containing the triplet elements together with their attributes.*

3. LINK PARSER

3.1. Description

This application uses the link grammar, generating a linkage after parsing a sentence [7, 8, 9, 10]. It can be downloaded from the web site [5].

For the sentence given as an example in the case of Stanford Parser, the output of Link Parser is presented in Figure 4.

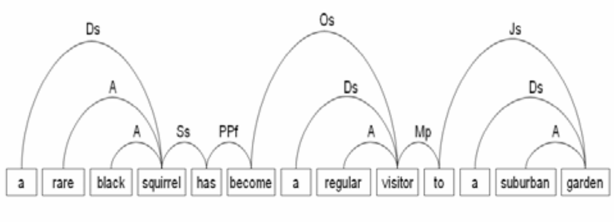


Figure 4: *The linkage obtained by parsing the sentence "A rare black squirrel has become a regular visitor to a suburban garden."*

Detailed explanations of what the different link labels mean are available at [6].

For a sentence many possible linkages can be found. A

```
function EXTRACT-ATTRIBUTES(word) returns a solution, or failure
    // search among the word's siblings
    if verb(word)
        result ← all the words which have been visited on the way from the right word of the S_link to the predicatePivot ∪ adverbs connected by E_link to the left or {EBm*, N}_links to the right
    else
        if noun (word)
            result ← all words connected by {D*, J*, A*}_links to the left and {Mp, NI*, TM, TY}_links to the right
    if result ≠ failure then return result
    else return failure

function TRIPLET-EXTRACTION(sentence) returns a solution, or failure
    determine S_link
    subjectPivot ← word left of S_link
    subjectAttributes ←
        EXTRACT-ATTRIBUTES (subjectPivot)

    currentWord ← first word right of S_link
    do
        predicatePivot ← currentWord
        currentWord ← next word to the right
    while link from predicatePivot to the right ∈ {Pv*[1], Pg*, PP*, I*, TO, MVi*}
    // if the verb is a phrasal verb
    if predicatePivot has a K_link to the right
        predicatePivot ← predicatePivot + word corresponding to the link
    predicateAttributes ←
        EXTRACT-ATTRIBUTES (predicatePivot)

    if link from predicatePivot ∈ {O, Os*, Op*, MVpn*}
        // noun objects
        objectPivot ← objectPivot + word corresponding to the link
    else
        if link from predicatePivot ∈ {Pa*, MVa*}.
            // adjective objects
            objectPivot ← objectPivot + word corresponding to the link
    // find objects connected to the predicate by prepositions
    if link from predicatePivot ∈ {MVp*, Pp*, OF, TO}
        //link from predicate to preposition
        preposition ← word corresponding to the link
        if link from preposition ∈ {J*, TI, I*, ON}
            objectPivot ← objectPivot + word corresponding to the link
    for each value in objectPivot do
        objectAttributes ← objectAttributes + EXTRACT-ATTRIBUTES (value)

    result ← subjectPivot ∪ subjectAttributes ∪ predicatePivot ∪ predicateAttributes ∪ objectPivot ∪ objectAttributes
    if result ≠ failure then return result
    else return failure
```

Figure 5: *The algorithm for extracting triplets using Link Parser*

linkage is composed of one or more sublinkages.

If the sentence is a compound sentence with two simple sentences, then the linkage will contain two sublinkages, one for each sentence. There can also be more sublinkages if in place of some part of speech there is a list of words separated by conjunctions. For example for the sentence *"The squirrel and the elephant are in the garden."* there will be two sublinkages, one for *"The squirrel is in the garden",* and one for *"The elephant is in the garden".*

3.2. Triplet Extraction Algorithm

In each sublinkage there is exactly one link which begins with an 'S'. This link connects the subject to the predicate.

The left of the S link is the subject pivot (squirrel). If the subject pivot is linked to other words on its left by G (names of persons) or NN (parts of numerals) links, then these words will be added to the subject word (e.g. Sergio Ricardo Gomez, one hundred million). From the right of the S link the predicate will be obtained. Once the predicate is found, objects can be determined as well by following several links, as shown in Figure 5, where a pseudocode version of the algorithm is given.

The EXTRACT-ATTRIBUTES function searches for attributes of verbs and nouns. Attributes of nouns (the subject and some objects) can be to the left or to the right. In the case of the Mp link to the right, a link to a preposition is made, and from that preposition to a noun by {J*[1], I*}. The attribute will be this noun, not the preposition to which Mp links. This attribute noun will have its own attributes, one of them being the preposition which connects it to the noun it determines by the Mp link.

3.3. Performance

The application was written in C++. It parsed the sentences in 271 seconds, generating 110 triples.

4. MINIPAR

4.1. Description

Minipar is a parser developed by Dekang Lin. In the application we developed, version 0.5 for Windows was used.

4.2. Minipar Parse Tree

The parse tree generated by Minipar for the sentence given as an example for the previous parsers is described in Figure 6. *E<number>* is a label used to describe the root of a new clause. The information that one node of the parse tree contains is the following: a label that uniquely identifies the node, the word, its root form, its grammatical category and its grammatical relation.

[1] The * means that the link has to start with the letters left to the * and can end at the * or continue with any letters.

4.3. Triplet Extraction Algorithm

In order to find the subject element of the triplet, we look for nodes in the tree having the grammatical relation *s*. The predicates will be found by identifying the nodes with grammatical relation *i* and the objects will be nodes having grammatical relation *pcomp*. In addition, attributes will be determined by examining the subtree of each of the triplet elements.

4.4. Performance

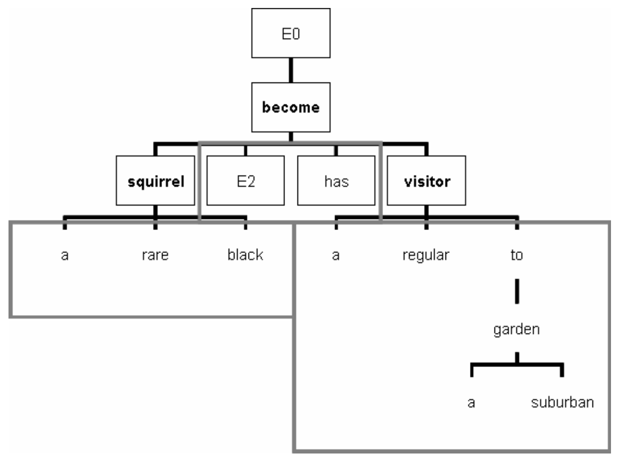


Figure 6: *The parse tree generated by Minipar for the sentence "A rare black squirrel has become a regular visitor to a suburban garden." The attributes of the triplet elements are also marked.*

The application was written in C++. It parsed the sentences in 104 seconds, generating 153 triples.

5. CONCLUSION

In this paper we presented algorithms for extracting of {subject, predicate, object} triplets from a given parse tree of a sentence.

As part of the future work we plan to use the triplets as an input for applications such as text summarization [13, 14], fact extraction [15] and *template induction* (discovering event templates in news articles) with the purpose of extracting facts for Cyc [12].

Acknowledgement

This work was supported by the Slovenian Research Agency and the IST Programme of the EC under NeOn (IST-4-027595-IP) and PASCAL (IST-2002-506778).

References

[1] D. Klein, C. D. Manning. 2003. *Fast Exact Inference with a Factored Model for Natural Language Parsing*. In *Advances in Neural Information Processing Systems 15 (NIPS 2002)*, Cambridge, MA: MIT Press, pp. 3-10, 2003.

[2] D. Klein, C. D. Manning. *Accurate Unlexicalized Parsing*. *Proceedings of the 41st Meeting of the Association for Computational Linguistics*, pp. 423-430, 2003.

[3] Stanford Parser web page: http://nlp.stanford.edu/software/lex-parser.shtml

[4] SharpNLP: http://www.codeplex.com/sharpnlp

[5] Link Parser web page: http://www.link.cs.cmu.edu/link/.

[6] Link labels web page: http://www.link.cs.cmu.edu/link/dict/summarize-links.html

[7] D. Sleator and D. Temperley. *Parsing English with a Link Grammar*. Carnegie Mellon University Computer Science technical report CMU-CS-91-196, October 1991.

[8] D. Sleator and D. Temperley. *Parsing English with a Link Grammar. Third International Workshop on Parsing Technologies*, 1993.

[9] J. Lafferty, D. Sleator, and D. Temperley. *Grammatical Trigrams: A Probabilistic Model of Link Grammar*. *Proceedings of the AAAI Conference on Probabilistic Approaches to Natural Language*, October, 1992.

[10] D. Grinberg, J. Lafferty and D. Sleator. *A robust parsing algorithm for link grammars*. Carnegie Mellon University Computer Science technical report CMU-CS-95-125, and *Proceedings of the Fourth International Workshop on Parsing Technologies*, Prague, September, 1995.

[11] D. Lin, P. Pantel. *DIRT - Discovery of Inference Rules from Text*. In *Proceedings of ACM SIGKDD Conference on Knowledge Discovery and Data Mining 2001*. pp. 323-328, 2001.

[12] Cyc project: http://www.cyc.com/

[13] J. Leskovec, M. Grobelnik, N. Milic-Frayling. *Learning Sub-structures of Document Semantic Graphs for Document Summarization*. In *Proceedings of the 7th International Multi-Conference Information Society IS 2004, Volume B*. pp. 18-25, 2004.

[14] J. Leskovec, N. Milic-Frayling, M. Grobelnik. Impact of Linguistic Analysis on the Semantic Graph Coverage and Learning of Document Extracts, *National Conference on Artificial Intelligence*, 2005.

[15] O. Etzioni, M. Cafarella, D. Downey, A. M. Popescu, T. Shaked, S. Soderland, D. S. Weld, A.Yates. *Unsupervised named-entity extraction from the Web: An experimental study*. Artificial Intelligence, Volume 165, Issue 1, June 2005, Pages 91-134.

EXPLORATORY ANALISYSIS OF THE ILPnet2 SOCIAL NETWORK

Sergeja Sabo, Miha Grčar, David A. Fabjan, Peter Ljubič, Nada Lavrač
Jožef Stefan Institute and Jožef Stefan International Postgraduate School
Jamova 39, 1000 Ljubljana, Slovenia

ABSTRACT

In this paper we present techniques for social network analysis and interpret the results of the analysis of the ILPnet2 scientific publications database. The analysis was performed with the Pajek software for large (social) network analyses. The central entity of our analysis is the author, related to other authors by co-authorship links. The author is weighted by the number of his/her publications (registered in ILPnet2). In this paper we present cohesion, brokerage and ranking techniques used in social network analysis, illustrated by examples from the ILPnet2 domain.

1 Introduction

In social sciences, social network analysis has become a powerful methodology, complementing standard statistical approaches. Network concepts have been defined, tested, and applied in research traditions throughout the social sciences, ranging from anthropology to business administration and history [3].

Social network analysis focuses on interpreting patterns of social ties among people, groups of people, organizations, or countries. A typical domain is a group of individuals and their characteristics and the structure of their ties. For the analysis we used Pajek [2], a specialized professional tool for social network analysis.

The domain we analized was the scientific publications database of the ILPnet2 Network of Excellence in Inductive Logic Programming [1]. ILPNet2 consisted of 37 project partners composed mainly of universities and research institutes. Our main entity for the analysis are individual authors, related to other authors by co-authorship relationships. The dataset includes 589 authors, 1046 co-authorships and most ILP-related publictions published in 1970-2003. Through our analysis we tried to answer some questions like: Who are the most important authors in the area? Are there any closed groups of authors? Is there any person in-between most of these groups? Is this person also very important?

The paper presents the ILPNet2 domain and data preprocessing in Sections 2 and 3, the cohesion (density, degree, components), brokerage (degree, closeness, betweenness), and ranking (prestige, acyclic decomposition) techniques used for ILPNet2 analysis in Section 4, and finally some conclusions.

2 The ILPnet2 database

The first stage of every data mining process is data acquisition and preprocessing. The ILPnet2 database is publicly available on the Web and contains information about publications on the ILP domain between the years 1971 and 2003. The data about publications is available in the BibTeX format and can be accessed at: http://www.cs.bris.ac.uk/~ILPnet2/Tools/Reports/Bibtexs/2003, ..., (one file for each year 2003, 2002, …).

The data was acquired with the wget utility and converted into the XML format. For this purpose we implemented a shell script which we do not present herein in full. The part of the script that collects the data from the Web is as follows:

```
$ for((i=1971;i<2004;i++)); do
wget
http://www.cs.bris.ac.uk/~ILPnet2/Tools/Reports/Bibtexs/$;
done
```

For easier data management it was convenient to put the data into a relational database format, using the Microsoft SQL Sever. The resulting ILPnet2 database (see its database schema in Figure 1) contains the following tables:

- **Authors**: ID (key), name of the author
- **AuthorOf** (relates authors to publications with a many-to-many relation): ID (key), ID of the author, ID of the publication
- **Publications**: ID (key), title, abstract, institution, year, month
- **KeywordIn** (related keywords to publications with a many-to-many relation): ID (key), ID of the keyword, ID of the publication
- **Keywords**: ID (key), keyword

One of the tasks accompanying the database population was the normalization of authors' names. Due to the simplicity of our heuristics, some names were not normalized correctly hence the same author was given several different identifiers. Such false normalizations were corrected manually by reviewing the table of mappings between authors' names and their identifiers.

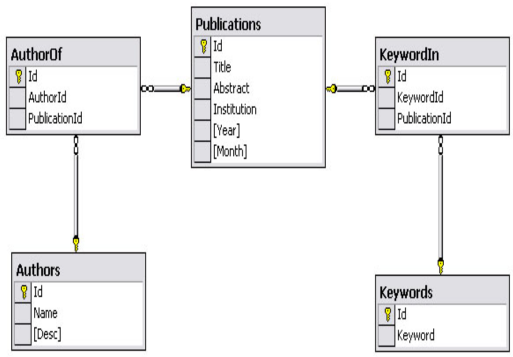


Figure 1: The ILPnet2 database schema.

3 Data preprocessing

We converted the data into the Pajek compatible input file (.net) which contains the following mandatory elements:

- Vertices. Each vertex represents an author and is described with an ID (in our case this is the sequential number of the author in the Authors table), a short string (in our case this is the normalized name of the author), and some other parameters. We have also set the vertex size (parameters x fact and y fact) which denote the author's productivity.
- Edges. Each edge is described with two IDs corresponding to the two vertices that define the edge (i.e. the two vertices connected by this edge). Furthermore, each edge is characterized with a weight that corresponds to the degree of collaboration (i.e. co-authorship) between the two authors.

For certain types of analyses, our undirected social network of authors was converted to a directed network, using *bond by co-authorship*. We first created a *complete directed network* (i.e. a network based on a graph containing no loops and multiple arcs but connecting each and every pair of vertices both ways) based on the vertices representing the authors. We weighted each arc according to the *trust* of the source author in the target author. As suggested in [3], trust is modeled as a linear combination of the number of joint publications and the number of the target author's publications as illustrated in Figure 2.

Figure 2: A network converted to bond by co-authorship.

In our application we applied the logarithm to the number of individual's publications and the number of joint publications (i.e. w_A and $w_{A\&B}$ in Figure 2) when calculating arc weights. With the logarithm we achieved a near-linear growth in the "logarithmized" productivity from the least to the most productive author. This in effect prevented the few hyper-productive authors from getting all the highest in-arc weights as soon as α was set to somewhat less than 1. The values of the number of joint publications were treated equally. Furthermore, both types of values were normalized with respect to their corresponding maximum value so that "high productivity" was able to compete with "high level of collaboration" (both were represented with a value close to 1 after the normalization).

The next step was to remove some of the arcs from our complete directed network. We decided to allow each author to keep at most k outgoing arcs – the ones with the highest weights. With the so obtained directed network (directed graph to be more specific) we were able to calculate the structural prestige of authors (in Section 4.3).

4 Techniques

Several techniques for social network analyses on ILPnet2 database were used: cohesion, brokerage, and ranking.

4.1 Cohesion

Cohesion is an attractive force between the individuals (network nodes). Solidarity, shared norms, identity, collective behavior, and social cohesion are considered to emerge from social relations. Therefore, the first concern of social network analysis is to investigate which individuals are related and which are not. A general hypothesis is that people who match on social characteristics will interact more often and people who interact regularly will foster a common attitude or identity. The ultimate goal is to test whether structurally delineated subgroups differ with respect to other social characteristics, for instance, norms, behavior, or identity. For the purpose of our analysis we used the following techniques to detect cohesive subgroups in our ILPnet2 network: density, degree and components.

Density. In network analysis density represents the number of lines in a simple network, expressed as a proportion of the maximum possible number of lines. It is inversely related to network size: the larger the social network, the lower the density because the number of possible lines increases rapidly with the number of vertices, whereas the number of ties which each person can maintain is limited.

Degree. The degree of a vertex is the number of lines incident with the vertex. Degree is a discrete attribute of a vertex (it is always an integer).

Figure 3 shows the distribution of the degree of co-authorships ILPnet2. Almost 150 authors have two co-authorships and only few authors have more than ten.

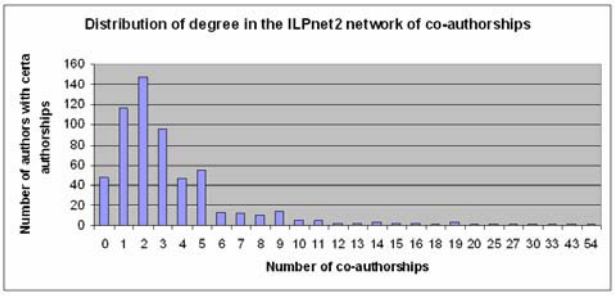


Figure 3: The distribution of the degree of co-authorships.

Since the visualization of our network (Figure 4) showed no specific characteristics, we looked for vertices with the highest degree. The removal of the lines with value less than 10 and the reduction of the vertices with degree less than 1 resulted in the visualization shown in Figure 5. Note that 24 authors which have more than 10 co-authorships are grouped together in seven subgroups, mostly consisting of researchers from the same country.

Figure 4: Connections in ILPnet2, visualized by Pajek.

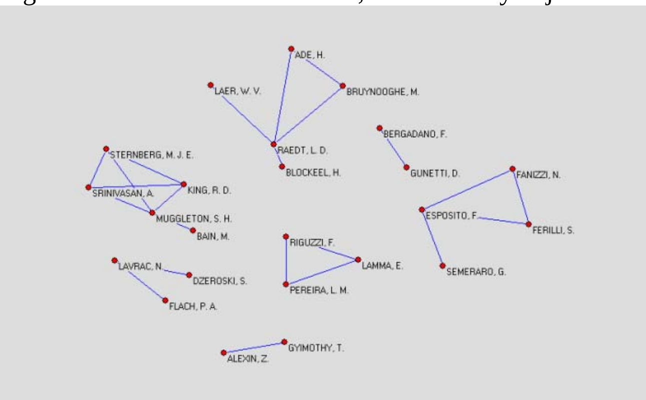


Figure 5: Visualization of the ILPnet2 network after removal of the lines with value less than 10 and the reduction of the vertices with degree less than one.

Components. Components identify cohesive subgroups in a straightforward manner: each vertex belongs to exactly one component. Networks are connected weakly or strongly. A network is weakly connected if all vertices are connected by a semi-path. A semi-path is a semi-walk in which no vertex in between the first and last vertex of the semi-walk occurs more than once. A semi-walk from vertex u to vertex v is a sequence of lines such that the end of one line is the starting vertex of the next line and the sequence starts at vertex u and ends at vertex v. Figure 6 shows 110 components of the ILPnet2 network. Having analyzed the individual components we have observed that the individuals in smaller components are mostly grouped according to the country, whereas the biggest component includes different individuals connected with each other.

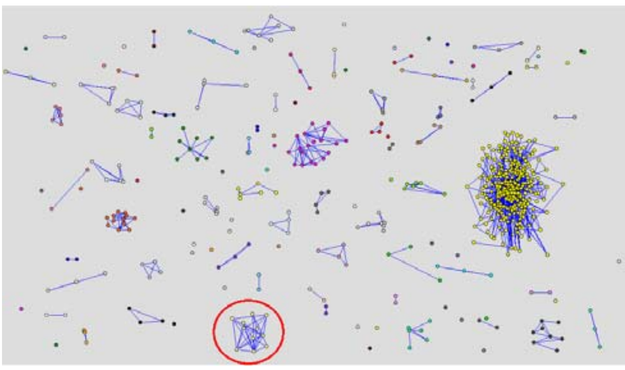


Figure 6: Visualization of the ILPnet2 network using the algorithm for discovering components in Pajek.

4.2 Brokerage

The notion of brokerage is based on the notions of centrality and betweenness.

Centrality. When talking about center and periphery in social networks we want to discover who has a better access to information or a better opportunity to spread the information. Term *centrality* is used to refer to the position of individual vertices within the observed non-directed network where we assume that the flow of information may be exchanged both ways between people or organizations that are linked. A network is highly centralized if there are clear boundaries between the center and the periphery, which means that information can be distributed very quickly between the center and the subjects (non-central nodes), which is indispensable for the transition of information. The vertices vary with respect to their centrality. The *degree of centrality* of a vertex is its degree, and its *closeness centrality* is the number of other vertices divided by the sum of all distances between the vertex and all others.

Betweenness. Degree and closeness centrality are based on the reachability of a vertex within a network. Other approach to centrality and centralization is based on an idea that vertex is more important as an intermediary in the communication network. This approach is based on the notion *betweeness*, where *betweeness centrality* of a vertex is measured by the proportion of all shortest path between pairs of other vertices that include the given vertex. See the visualization of this notion in Figure 7.

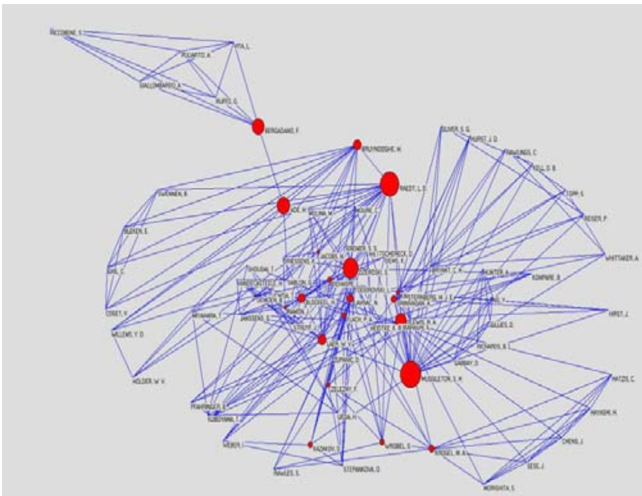


Figure 7: Betweenness in ILPnet2 shown in Pajek, where larger vertices represent people that have more direct or indirect connections (i.e. have a better ability to disperse information).

4.3 Ranking

Ranking deals with the notions prestige and ranking through acyclic decomposition.

Prestige. In social networks there are many techniques to calculate the so called *structural prestige* of a person. Note, however, that structural prestige is not identical to the concept of *social prestige* (or *social status*), but depends on the data from which we are able to infer a structure so that the structural prestige of a person only reflects his/her actual social prestige.

- The *in-degree* of a vertex represents the *popularity* of the person represented by the vertex. To measure popularity, we need to have a directed network.
- *Domains* represent extend prestige to indirect in-links so that the overall structure of the network is taken into account. The *input domain* of a vertex is defined as the number or percentage of all other vertices that are connected by a path to this vertex. A *restricted input domain* restricts the maximum paths length. In well-connected networks it is recommended to limit the input domain to direct neighbors (i.e. to use popularity instead) or to those at a predefined maximum distance (e.g. 2).
- *Proximity prestige* of a vertex is defined as the proportion of all vertices (except itself) in its input domain divided by the mean distance from all vertices in its input domain. It ranges from 0 (no proximity prestige) to 1 (highest proximity prestige).

Input degree		Unrestricted input domain size		Proximity prestige	
28	MUGGLETON, S. H.	152	LAMMA, E.	0.082030307	RAEDT, L. D.
21	RAEDT, L. D.	152	RIGUZZI, F.	0.077044151	DZEROSKI, S.
20	DZEROSKI, S.	152	PEREIRA, L. M.	0.068453862	LAVRAC, N.
17	LAVRAC, N.	152	RAMON, J.	0.066777042	MUGGLETON, S. H.
17	BLOCKEEL, H.	152	FLACH, P. A.	0.064946309	ADE, H.
12	FLACH, P. A.	152	LAVRAC, N.	0.06462585	BRUYNOOGHE, M.
12	SRINIVASAN, A.	152	STRUYF, J.	0.063683172	LAER, W. V.
11	GYIMOTHY, T.	152	BLOCKEEL, H.	0.060918631	TODOROVSKI, L.
10	JACOBS, N.	152	DEHASPE, L.	0.057783113	FLACH, P. A.
10	BERGADANO, F.	152	LAER, W. V.	0.054504505	SRINIVASAN, A.
9	WROBEL, S.	152	BRUYNOOGHE, M.	0.054346497	GAMBERGER, D.
9	STEPANKOVA, O.	152	DZEROSKI, S.	0.052812523	SABLON, G.
9	ITOH, H.	152	RAEDT, L. D.	0.051974229	DEHASPE, L.
9	ADE, H.	152	GAMBERGER, D.	0.051837094	BLOCKEEL, H.
8	KING, R. D.	152	LACHICHE, N.	0.048245614	KING, R. D.
8	OHWADA, H.	152	TODOROVSKI, L.	0.048015873	STERNBERG, M. J. E.
8	BRUYNOOGHE, M.	152	KAKAS, A. C.	0.047743034	KAKAS, A. C.
8	BOSTROM, H.	152	JOVANOSKI, V.	0.047283414	LACHICHE, N.
8	KRAMER, S.	152	TURNEY, P.	0.044957113	JOVANOSKI, V.
8	FURUKAWA, K.	152	ADE, H.	0.044957113	TURNEY, P.
8	CSIRIK, J.	152	DIMOPOULOS, Y.	0.043609897	RAMON, J.
7	HORVATH, T.	152	SABLON, G.	0.043226091	STRUYF, J.
7	ESPOSITO, F.	77	KING, R. D.	0.040507749	RIGUZZI, F.
7	SHOUDAI, T.	77	MUGGLETON, S. H.	0.040341393	DIMOPOULOS, Y.
7	DEHASPE, L.	77	SRINIVASAN, A.	0.035082604	LAMMA, E.

Figure 8: Top 25 authors in the ILP domain according to the three structural prestige measures, namely input degree, unrestricted domain size, and proximity prestige

Ranking. We now discuss a technique for extracting discrete ranks from social relations. A recipe for determining the hierarchy, named *acyclic decomposition*, is presented. Once we have determined the nature of our network, we can start discovering the clusters and/or the hierarchy. The first approach we discuss is the so called *acyclic decomposition*. While cyclic sub-networks (i.e. strong components) represent clusters of equals, acyclic sub-networks perfectly reflect the hierarchy. The recipe for determining the hierarchy is as follows:

1. Partition the network into strong components (i.e. clusters of equals, described in Section 4.1).
2. Create a new network in which each vertex represents one cluster.
3. Compute the maximum depth of each vertex to determine the hierarchy.

Figure 9 shows the hierarchy in the ILPnet2 network. Each vertex represents one strong component (cluster of equals), each labeled by a random representative (e.g. #KING, R. D.). If we then "extract" individuals from each of the

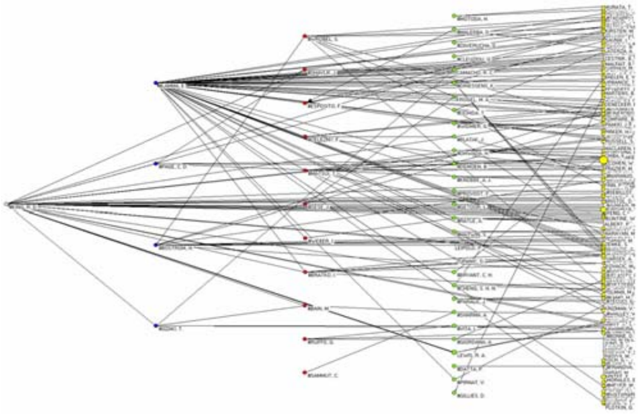


Figure 9: The hierarchy in the ILPnet2 network.

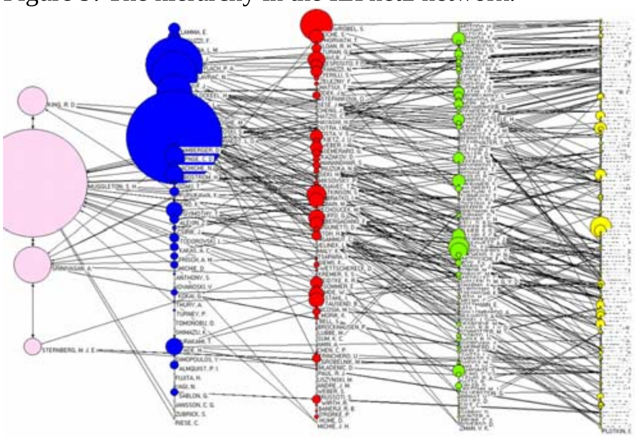


Figure 10: The hierarchy in the ILPnet2 network. The individuals were "extracted" from the strong components.

components, we get the network shown in Figure 10. The size of the vertex denotes the author's productivity (the number of publications). Once the hierarchy has been established, we remove the inter-cluster arcs (i.e. arcs that were interconnecting the strong components), and convert the bi-directed intra-cluster arcs (arcs within a strong component) into edges. After removing all the remaining arcs, we are left with the network shown in Figure 11. With this procedure we have fine-grained each strong component into smaller clusters of people that are interconnected (see an enlarged cluster in Figure 11).

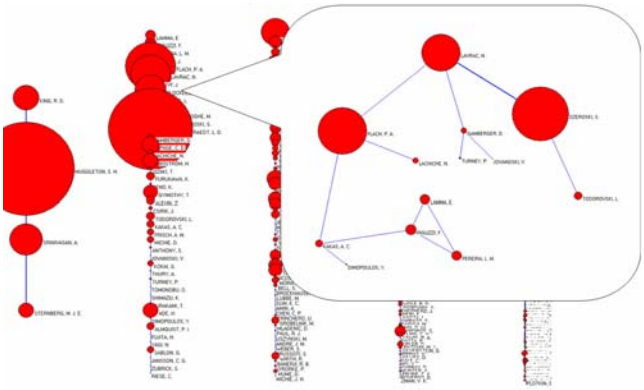


Figure 11: The hierarchy in the ILPnet2 network. The strong components were fine-grained into smaller clusters of bi-directional connected individuals.

5 Conclusions

We have presented techniques for social network analyses and the regularities discovered in the ILPNet2 scientific publications database, using the network analysis software Pajek.. The graphical presentations give us an insight into the relational ties between the ILPNet2 authors.

Acknowledgments
This work was supported by the Slovenian Research Agency and the IST Programme of the EC under TAO (IST-2004-026460-STP).

References

[1] http://www.cs.bris.ac.uk/~ILPnet2/
[2] http://vlado.fmf.uni-lj.si/pub/networks/pajek/
[3] W.Nooy, A. Mrvar, V.Batagelj. Exploratory Social Network Analysis with Pajek.

MACHINE LEARNING FOR RESOLVING RESEARCHER AFFILIATION

Marjan Šterk, Daniel Vladušič, Eva Milošev
XLAB d.o.o.
Teslova 30, 1000 Ljubljana, Slovenija
e-mail: marjan.sterk@xlab.si

Jure Ferlež, Dunja Mladenić, Marko Grobelnik
Jožef Stefan Institute
Jamova 39, 1000 Ljubljana, Slovenia
e-mail: jure.ferlez@ijs.si

ABSTRACT

This paper describes the Institution Finder, an approach to develop a simple web mining procedure to find the internet domain of the institution(s) that a given researcher is affiliated with. The Institution Finder starts several queries on public Web search engines and tries to extract from the hits the institution names and internet domains that are likely to be related to the given researcher. A simple procedure based on machine learning is used to improve ranking of the hits. A researcher can be also rejected by the system if the corresponding domain cannot be found reliably. The performance is quantified by accuracy, i.e. the conditional probability P(correct | not rejected), and by the reject rate. The hits obtained from various queries can be combined in different ways, enabling the trade-off between reasonable accuracy with almost no reject (i.e. of the 363 test examples about 44% are correctly classified) or high accuracy with high reject (for example 55% of the test examples rejected and 75% of the rest correctly classified).

1 INTRODUCTION

Publicly available information on the Web are in general not very reliable and organized only to some extent. Extracting information on researchers and the associated institutions is thus a nontrivial task that can benefit from machine learning methods. We are proposing an approach using machine learning and combining several basic methods for finding corresponding institution(s) given a name of researcher. The goal of the proposed approach as implemented in the Institution Finder is providing a simple web mining procedure to find the internet domain of the institutions that a given researcher is affiliated with. The data sources used in our experimental evaluation of the approach include the Google and Google Scholar search engines [1, 2].

1.1 Problem Formulation

A program P is to be developed such that:
P(initial, surname) = domain list with probabilities,
e.g.,
P("J", "Public") = (ox.ac.uk, 0.9), (ijs.si, 0.08)
for Mr. John Q. Public that is most probably working at the Oxford University. If the correct domain cannot be found reliably, the example should preferably be rejected (unclassified).

1.2 Assumptions

It is assumed that a researcher is well-represented by the papers and other work he/she has published. In our experiments we obtain the data from Google Scholar. The obtained data can be further used to form queries for general web search engines. We decided to use the Google Scholar database even though it is less accurate than some other publicly available publication databases because it has by far the largest coverage and is not limited to any specific area of science.

This paper is organized as follows. First, four basic approaches are described, followed by description of using machine learning to improve the results of the basic approaches. Next we describe the process of combining the four basic approaches and experiments showing the trade-off in performance (between accuracy and reject). Finally, the results are summarized and some additional comments are given.

2 BASIC APPROACHES

Four basic approaches were developed to find candidate domains. Let us introduce them by explaining how they search for the person "*J Public*":

1. *Trivial Google search* asks Google about '*Public*' and takes the domains from URLs of the returned hits as candidates for the institution domains.
2. *E-mail search* asks Google Scholar about '*author:"J Public" Public*', which causes the snippets of returned hits to be centred around occurrences of the word '*Public*'. The snippets are then searched for e-mail addresses and the domains of the e-mails are taken as candidates.
3. *Institution keyword search* asks Google Scholar about '*author:"J Public*" KeyWord', where KeyWord is "*institute*", "*university*" or similar, and searches the snippets for institution names such as "*University of Something*". It then converts the institution names to domains by asking Google about "*University of*

Something” and taking the domains of the returned Google hits as candidates.

4. *Title-word search* finds the words with highest TFIDF score [7] in titles of all papers by "*J Public*" that are found by Scholar, and uses these title words to improve the query used in the trivial Google search.

All candidate domains are assigned *a priori* probabilities based mainly on:

- Google hit rank (except in case of e-mail search),
- total number of e-mails or institutions found in the snippet – a certain e-mail is more likely to be "correct", i.e. to have the same domain as the given person's institution, if less e-mails were found in total,
- TFIDF score of the title word.

Additionally, certain domains were found to appear often among the candidates but were never correct, such as *amazon.com* and any domain containing the word *journal*. These *stop-domains* are discarded in all basic approaches (referred to also as searchers).

3 IMPROVING RANKING BY MACHINE LEARNING

All the four basic approaches often find the correct domain but do not rank the hits correctly, i.e. they assign the highest a priori probability to an incorrect domain. Designing an "*oracle*" to assign each domain a realistic probability of correctness would thus be beneficial.

The problem can be formulated as one of machine learning (ML) and classifying [7]. A set of *attributes* is extracted from each hit, together with the information on the hit correctness. A machine learning algorithm is then run over the hits for the whole learning set to construct a classifier specific to the selected basic approach. During classification of a new person, the attributes are extracted from each hit. Then, the classifier is run over the hits' attributes, returning an *estimate of the probability of correctness* for each hit. This estimate is termed *ML probability* and is multiplied by the a priori probability of each hit to obtain the *a posteriori probability*. The latter also have to be normalized so that their sum for a single person is 1.

Since some of the proposed basic approaches, in particular the institution keyword search, return up to a few thousand hits for some people, using all of them for learning and classifying would cause the correct hits to be under-represented in the learning sets. Only a subset with the highest a priori probabilities is thus used for learning. For classification, on the other hand, all hits are used.

A large set of attributes was defined for each basic approach, e.g. "does family name appear in the domain?", snippet length, number of authors of the paper found by Google Scholar etc. The attributes that can be meaningfully incorporated into the a priori probability, such as the Google hit rank, were not used for ML. Additionally, some feature selection can be performed (in our case eliminating attributes with low ReliefF score [9]).

The classifier implementations were taken from the Weka package, version 3.4.7 [7]. The following classifiers were tested: naive Bayes, C4.5 decision trees, support vector machines [8], and nearest neighbour classifiers. Since the ML probability is merely an additional hint used to rank the hits, the classifier need not be very good. In particular, its classification accuracy is not so important, only the relative ML probabilities of different hits for the same person are important. The classifiers are thus used as-is in the weak intelligence sense, omitting internal cross-validation and with only small hand-made changes to the learners' parameters.

Figure 1 shows the procedure used to test the approach described above using five-fold cross-validation. For each test example E, the learning set contains the 4 folds that do not include E. The selected searcher is run once for each learning example and the domains returned are used to construct a classifier. The searcher is then run for E, the domains returned are classified and the obtained ML probabilities are multiplied by the a priori probabilities.

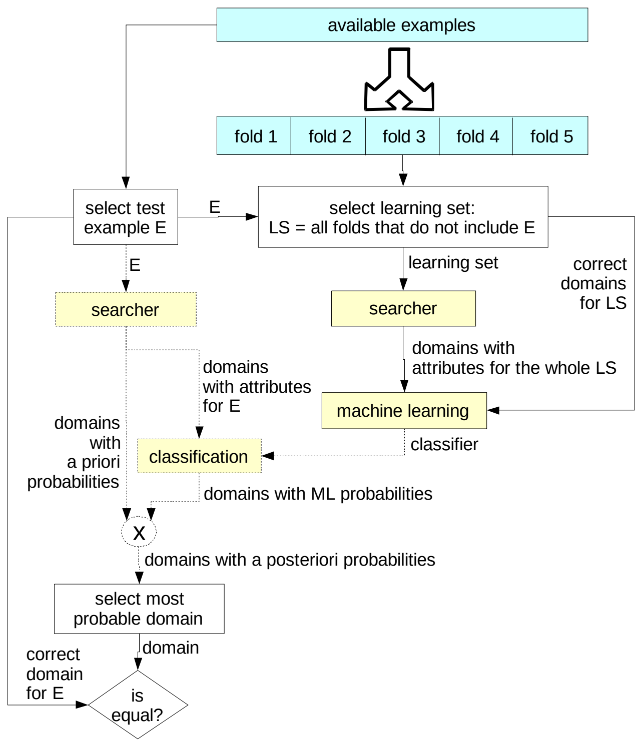


Figure 1: Usage and testing of the ML ranking scheme

Using the final ML-improved searcher (which is obtained by running the machine learning on all 5 folds) involves only the dotted parts of the diagram.

4 COMBINING BASIC APPROACHES

The final step is combining the results of the four basic approaches to searching researcher's institution(s). In general, if the individual models that are combined are complementary then the combination will be more accurate than the individual models.

4.1 Combining Based on Ranks

In our experiments we assume that each individual basic approach returns up to 5 hits (up to 3 for the e-mail search) for a total of up to 18 candidate domains. Each of them has a set $R = \{r_i\}$ of up to 4 ranks (because it was found by up to different 4 searchers), $0 <= r_i <= 4$. The hits can thus be sorted by the number of 0's in R, breaking ties in favour of those with more 1's etc. This is termed *combining by best rank*. Accuracy can be increased by only accepting the hits on which at least c searchers agree, i.e. rejecting those with less than c 0's in R.

4.2 Combining Based on Assigned Probabilities

The basic approaches can also be combined so that all the hits for the same domain returned by different searchers are merged into one. The probabilities can be simply averaged.

5 EXPERIMENTS

The test set consisted of N_{TEST} = 363 examples obtained from researchers in the Pascal Network of Excellence database [3]. Although most of these come from academic institutions, the Institution Finder should work for researchers employed in the industry as well.

We use the following metrics to measure the performance:

- *accuracy* = P(correct | not rejected) = N_{CORRECT} / ($N_{\text{TEST}} - N_{\text{REJECTED}}$),
- *reject* = P(rejected) = N_{REJECTED} / N_{TEST},
- *total accuracy* = P(correct) = N_{CORRECT} / N_{TEST}.

5.1 Results

Table 1 summarizes all experimental results. The uppermost part shows the performance of the trivial Google searcher without and with ML ranking. The total accuracy of the first hit is given, followed by the proportion of test examples for which the correct domain appears within the top two and the top five hits, respectively. For the other three basic searchers, accuracies on non-rejected examples are also given following the slash, as well as the reject rate. We only report the results of the best performing classifier for each basic approach (searcher), namely C4.5 decision tree for the institution keyword searcher and naive Bayes for the other three searchers.

It can be seen that the e-mail searcher achieves high accuracy but also has high reject. The other three find a lot of candidate domains with the correct one often being among the top 5 hits. However, the hits are often ranked inappropriately, which is alleviated by using ML ranking. The benefit from ML ranking is particularly high with institution keyword searcher.

The lower part of Table 1 shows the performance of the combination of all four basic searchers. Combining based on probabilities is a better option than rank-based combining, although the accuracy of the first hit is similar in both cases. ML ranking does not help as much as with a

Searcher		Total accuracy / accuracy on non-rejected examples	
		without ML	with ML rank
trivial Google searcher	In first hit:	0.226	**0.287**
	W/in 2 hits:	0.300	**0.364**
	W/in 5 hits:	0.380	**0.457**
e-mail searcher	In first hit:	0.207 / 0.452	0.209 / 0.458
	W/in 2 hits:	0.223 / 0.488	0.223 / 0.488
	W/in 3 hits:	0.229 / 0.500	0.229 / 0.500
	Reject:	0.543	
institution keyword searcher	In first hit:	0.287 / 0.300	**0.402 / 0.421**
	W/in 2 hits:	0.369 / 0.386	**0.457 / 0.478**
	W/in 5 hits:	0.466 / 0.487	**0.510 / 0.533**
	Reject:	0.044	
titleword searcher	In first hit:	0.284 / 0.289	**0.303 / 0.309**
	W/in 2 hits:	0.363 / 0.371	**0.383 / 0.390**
	W/in 5 hits:	0.430 / 0.438	**0.449 / 0.458**
	Reject:	0.019	
all four, combining based on ranks	In first hit:	0.394	**0.430**
	W/in 2 hits:	0.438	**0.518**
	W/in 5 hits:	0.548	**0.592**
all four, combining based on prob.	In first hit:	0.399	**0.441**
	W/in 2 hits:	0.485	**0.559**
	W/in 5 hits:	0.540	**0.650**

Table 1: Experimental results evaluating four basic approaches, their combination and influence of using machine learning for reordering the hits returned by a search engine.

single basic searcher so the total accuracy is 0.441, versus 0.402 for the best basic searcher (institution keyword).

Supposing that the final assigned probabilities of the hits are correlated to their correctness, trading total accuracy and low or no reject for higher accuracy can be done by simply rejecting any hits with the assigned probability below a certain threshold. This is known as Chow's rule, which has been proven to be the optimal reject rule [10]. Figure 2 shows the achievable accuracy as a function of acceptable reject. For example, discarding hits with probability less than 0.25 causes a reject of 0.548 and decreases the total accuracy to 0.339, but improves the accuracy on non-rejected examples to 0.750. Note that using machine learning for reordering of hits contributes more in case of setting a high reject level. For instance, the reject level of 0.623 results in accuracy of 0.686 if no machine learning is used, while when using machine learning for reordering the hits a similar reject level of 0.628 results in accuracy of 0.815.

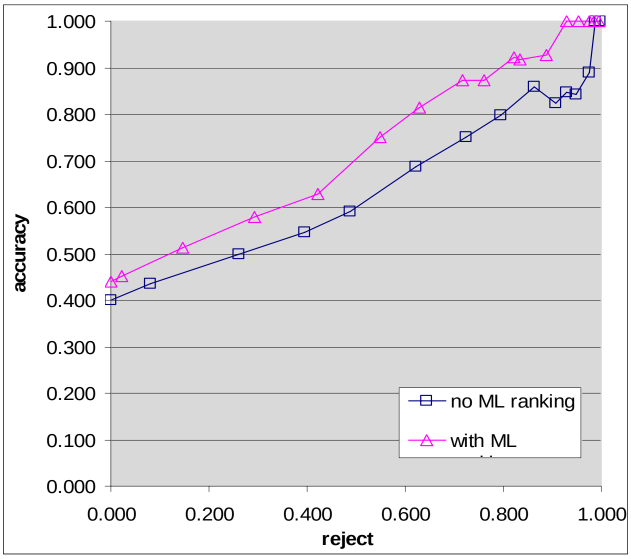


Figure 2: Accuracy-reject trade-off for combination of all four searchers

6 CONCLUSIONS

A web mining application was developed implementing an approach to finding internet domains of institutions that a given researcher is likely affiliated with. Queries on Google and Google Scholar are used as sources of information and candidate domains are extracted from the hits' snippets or URLs in four different ways.

Experimental evaluation of the four basic approaches to searching institutions shows that the domains of institutions found by searching Google Scholar snippets for e-mails are reliable but many of the test examples are rejected because no e-mail is found in the snippet. The other three searchers typically find many domains, including the correct one, but they often rank the domains so that the correct one is far from the top of the list. Each of these three can be improved by using a machine learning scheme to assist in domain ranking.

Finally, we propose that the four searchers are combined into a single Institution Finder. The highest accuracy achieved on the test set was 0.44. Some of the total accuracy can be traded for higher accuracy with higher reject by using Chow's rule, i.e. discarding the hits with the final assigned probabilities below a certain threshold. For example, if a reject of 0.548 is acceptable, the accuracy rises to 0.750.

Acknowledgement

This work was supported by the Slovenian Research Agency and the IST Programme of the EC under SEKT (IST-1-506826-IP), PASCAL (IST-2002-506778) and NeOn (IST-2004-27595-IP).

References

[1] Google Search Engine, www.google.com

[2] Google Scholar, scholar.google.com

[3] PASCAL Project – Pattern Analysis, Statistical Modelling and Computational Learning, www.pascal-network.org

[4] List of Internet top-level domains – Wikipedia, en.wikipedia.org/wiki/List_of_Internet_top-level_domains

[5] S. Brin and L. Page. The Anatomy of a Large-Scale Hypertextual Web Search Engine. *Computer Networks and ISDN Systems*, vol. 30, 1998, pp. 107-117.

[6] Stop word list at meta.wikimedia.org/wiki/Stop_word_list/consolidated_stop_word_list

[7] I. H. Witten and E. Frank. *Data Mining, second edition.* Elsevier Inc, 2005.

[8] N. Cristianini and J. Shawe-Taylor. *An Introduction to Support Vector Machines and other kernel-based learning methods*. Cambridge University Press, 2000.

[9] K. Kira and L. Rendell. A practical approach to feature selection. In *Proceedings of the Ninth International Workshop on Machine Learning.* Morgan Kaufmann, 1992, pp. 249-258.

[10] G. Fumera, F. Roli, G. Giacinto. Multiple Reject Thresholds for Improving Classification Reliability. In *Proceedings of Advances in Pattern Recognition: Joint IAPR International Workshops*, Alicante, 2000.

Zbornik 10. mednarodne multikonference

INFORMACIJSKA DRUŽBA - IS 2007

Proceedings of the 10th International Multiconference

INFORMATION SOCIEY - IS 2007

Sodelovanje, programska oprema in storitve v informacijski družbi

Collaboration, Software and Services in Information Society

Uredil/ Edited by

Marjan Heričko

http://is.ijs.si

9. oktober 2007 / 9th October 2007
Ljubljana, Slovenia

PREDGOVOR

Prehod v informacijsko družbo in družbo znanja spremlja prenova poslovnih procesov ter pripadajočih informacijskih sistemov. Vsi ti sistemi postajajo vse bolj obsežni in zapleteni, zato je eden glavnih izzivov, s katerim se srečujemo, uspešno obvladovanje kompleksnosti programske opreme in poslovnih storitev, ki omogočajo učinkovito sodelovanje med posamezniki, organizacijami in sistemi.

V zborniku konference CSS'2007 so zbrani prispevki, ki naslavljajo in vpeljujejo nove pristope, tehnike in metode za uspešno upravljanje znanja, komunikacijo in kooperativno delo kot tudi za učinkovito programsko in storitveno inženirstvo.

dr. Marjan Heričko
predsednik konference CSS'2007 - Sodelovanje, programska oprema in storitve v informacijski družbi

PREFACE

The transition into an information and knowledge society is being accompanied by a redefinition of business processes and a renewal of information systems. There is an evident growth in the size and complexity of these systems. Therefore the main challenge is how to successfully manage and control the complexity of software and services so as to enable efficient collaboration between individuals, organizations and other systems. The CSS'2007 proceedings bring together papers that address and introduce new techniques, approaches and methods for efficient knowledge management, communication and cooperative work as well as successful software and service engineering.

dr.Marjan Heričko
CSS’2007 – Collaboration, Software and Services in Information Society Conference Chairman

PROGRAMSKI ODBOR / PROGRAMME COMMITTEE

Dr. Marjan Heričko
University of Maribor, Faculty of Electrical Engineering and Computer Science

Dr. Ivan Rozman
University of Maribor, Faculty of Electrical Engineering and Computer Science

Dr. Kimmo Salmenjoki
Seinäjoki University of Applied Sciences

Dr. Adel Taweel
University of Manchester, Department of Computer Science

Dr. Gabriele Gianini
University of Milano, Faculty of Mathematical, Physical and Natural Sciences

Dr. Lorna Uden
Staffordshire University, Faculty of Computing, Engineering and Technology

Dr. Matjaž B. Jurič
University of Maribor, Faculty of Electrical Engineering and Computer Science

Dr. Mateja Podlogar
University of Maribor, Faculty of Organizational Sciences

Dr. Aleš Živkovič
University of Maribor, Faculty of Electrical Engineering and Computer Science

Mag. Urška Kežmah
University of Maribor, Faculty of Law

FACILITATING KNOWLEDGE MANAGEMENT AND E-COLLABORATION WITH BLIKIS

Reinhard Bernsteiner, Peter Mirski
Management, Communication & IT, MCI - Management Center Innsbruck
Universitaetsstrasse 15, 6020 Innsbruck, Austria
{reinhard.bernsteiner, peter.mirski}@mci.edu

Aleš Živkovič
University of Maribor, FERI Maribor
Smetanova 17, 2000 Maribor, Slovenia
ales.zivkovic@uni-mb.si

ABSTRACT

This paper explores the inter-relationship of social software and e-collaboration in the context of knowledge management and contributes how this new type of software-tools can support these tasks in virtual teams.

The terms "Social Software" and "Web 2.0" nowadays are commonly used. The term "Social Software" summarizes a special type of software which is usually internet-based. Social software is characterized by the fact that it can support people to work-out and develop contents together in teams. This way of working facilitates interactions and cooperation among users.
The employment of wikis and weblogs in the context of collaboration and knowledge management with their specific characteristics (strengths and shortcomings) of the**se** tools will be shown in this paper. In order to benefit from the advantages of both tools, the functionalities are merged and integrated to a new tool. Thus weblogs and wikis are gradually (coming together) merging and this combination (weblog and wiki) can be (called) named bliki. The characteristics and possible benefits of this combination will be presented.

1 INTRODUCTION

Due to the ongoing globalization of today's business intra- and inter-organizational knowledge sharing is necessary to obtain a competitive advantage within the market place. Maintaining such an alliance is an arduous and complex task, as relations need to be supported to ensure benefits arise for all parties involved [1].
The emerging discussion on knowledge management during the last years has led to many theories and models in the literature. Many authors have outlined the singular importance of knowledge transfer as a challenge in managing knowledge. The issue becomes especially critical in distributed organizations and virtual teams.
On the other hand there is a rapid development of technologies that enable the creation of communities and resources that allow individuals to virtually come together to learn, collaborate, exchange thoughts and ideas. In this context also the term "Web 2.0" is used, because a new generation of the internet arises [2].
It is the combination of these two sides that offers new possibilities and approaches in the field of e-collaboration and knowledge management. The leveraging of the relevant intellectual assets of an enterprise is not limited to technology but knowledge sharing applications can greatly support knowledge management activities.
Weblogs, wikis, and several other social software technologies have emerged to support knowledge and information sharing with increased capabilities and will play a central role in the new context [3, 4, 5].

2 KNOWLEDGE MANAGEMENT AND E-COLLABORATION

This section describes the framework concerning e-collaboration and knowledge management.

2.1 E-Collaboration

Electronic collaboration (e-collaboration), which is referred to as collaboration through internet and digital technologies among a group of allied parties, by using information and communication technologies to initiate and facilitate the sharing of resources especially across national boundaries or between organizations in order to improve the partners' profitability [6, 7].

2.2 Knowledge Management

Knowledge management has gained an important position in management literature where the implications of knowledge-based work and knowledge-based competitive advantages are outlined. A lot of theories have been developed until now. At the turn of the last century Grant and Sveiby presented the fundamentals of a knowledge based theory of the firm. "Based on certain premises regarding the nature of knowledge and its role within the firm, the [knowledge based] theory explains the rationale for the firm, the delineation of its boundaries, the distribution of decision making authority and the determinants of strategic alliances" [8, p. 451].

While competitive-based or product-based strategies [9] generally (makes) create markets and atttract customers, the starting point of knowledge management initiatives the resource-based approach, tends to place more emphasis on the organization's capability or core competences. Thus the knowledge-based strategy formulation should start with the primary intangible resource – the competence of people.

Sveiby [9 ->as above] states that people can use their competence to create value in two directions: by transferring and converting knowledge externally (e.g. customer relationships, brand awareness, reputation) or internally (e.g. better processes, new products) to the organization they belong to. So knowledge sharing becomes a critical factor for the organizational performance.

2.3 Knowledge Sharing and Collaboration

In the beginning knowledge sharing focused on sharing knowledge related to industrial products or applications, primarily in the field of new product design and development or industrial innovation processes.

Knowledge sharing has been further developed and emphasizes more on non face-to-face interactions between members of different groups in an organization or community that are not always working at the same geographic location [10].

Classical knowledge sharing models suggest that the knowledge transfer and sharing process involves the conversion of tacit knowledge into explicit and vice versa. At the same time, there are processes that help share tacit and explicit knowledge without conversion, despite the fact that for Nonaka and Takeuchi [11] the conversion of knowledge from tacit to explicit and finally tacit is the basis for knowledge creation. The knowledge conversion process involves close interaction between and complete understanding amongst key employees, the so called knowledge group of an organization.

Knowledge sharing means collaboration. "Collaboration is the process of two or more people working together toward a common purpose or goal, where the participants are committed and interdependent and work in a common context, physically co-located and using shared resources" [12].

It can be said, that the need for collaboration in today's business world is greater than ever. An increasingly fierce competitive environment in business coupled with increased complexity of tasks, more need for collaboration in interdisciplinary teams and solutions that must be developed in teams requires solutions to support these processes.

(If we look at) Adressing the tools that knowledge workers are provided with today, it can be seen (we can see) that only a few tools are taking account for the interrelatedness of processes. Document management systems support the location of information. Using information, sharing it, making meaning of it and discussing it is done elsewhere. Cognitive Tools, such as mindmapping software, other visualization tools or personal information management tools are designed for the solitary worker and are not addressing the social context of knowledge creation [13].

Organizations are redesigning their internal structure and their external relationships, creating knowledge networks to facilitate improved communication of data, information, and knowledge, while improving coordination, decision making, and planning. These new intra- and inter-organizational relationships are based on new technologies not available just a few years ago [14].

2.4 Social Software for Knowledge Management and e-Collaboration

Social software comprises a wide range of different types of activities but social software and the changing goals in knowledge management seem to be moving in the same direction. From a technical perspective, it can involve the use of social software technologies and to electronically link allied parties to exchange information and data to achieve a desired task.

Some of the key attributes of knowledge sharing and collaboration in the context of knowledge management are supported by social software tools. Social software tools provides [15].

- support for conversational interaction between individuals or groups ranging from real-time instant messaging to asynchronous collaborative teamwork spaces. This category also includes collaborative commenting on and within blog spaces.
- support for social feedback which allows a group to rate the contributions of others, perhaps implicitly, leading to the creation of digital reputation.
- support for social networks to explicitly create and manage a digital expression of people's personal relationships, and to help them build new relationships

3 SOCIAL SOFTWARE

The term „social software" emerged and came into use in 2002 and is generally attributed to Clay Shirky. Shirky, a writer and teacher on the social implications of internet technology, defines social software simply as "software that supports group interaction" [16].

Users are no longer readers, audiences, users or consumers they have the ability to become active producers of content. User can act in a user and a producer position and they can change the position rapidly.

The roots of social software applications can be found in various technical and social developments that are embraced by the term "Web 2.0". Web 2.0 technologies such as blogs, wikis and RSS feeds or discussion forums have been dubbed “social software” because they are perceived as being especially connected, allowing users to develop Web content collaboratively and open to the public [17].

The internet (web 1.0) until now has one big disadvantage. It is easy to get information, but it is quite complicated and inconvenient to act as an author and take part in the development of contents in the internet. Web 2.0 should enable all internet users to actively take part in the development of the internet. Everyone should be able to contribute easily. The focus of web 2.0 is on the behaviour of the user. It should empower people to communicate and collaborate at the one hand side and contribute and participate on the other.

3.1 Description and Characterization of the selected Social Software Tools

In the following section weblogs and wikis, are described more in detail and the tools are compared.

Weblog

A weblog, a compound of “web“ and “logbook”, usually just called “blog”, is a website that contains new articles or contributions in a primarily chronological order, listing the latest entry on top of the list.

Primarily, a weblog is a discussion-oriented instrument especially emphasizing two functions, RSS-feed and trackback. RSS-feeds, also called RSS-files can be read and processed for further use by other programs. The most common programs are RSS-readers or RSS-Aggregators that check RSS-enabled websites on behalf of the user to read or display any updated contribution that can be found. The user can subscribe to several RSS-feeds. Thus, information of different websites can be retrieved and combined. Preferably, news or other weblogs are subscribed to.

Trackback is a service function that notifies an entry in a weblog if a reference to this contribution has been made in another weblog. By this mechanism a blogger (person who writes contributions in a weblog) is immediately informed of any reactions to his contribution on other weblogs [18].

Wiki

A WikiWikiWeb?, shortly called Wiki, is a hypertext system for storing and processing information. Every single site of this collection of linked web pages can be viewed through a web browser. Furthermore, every site can also be edited by any person. The separation between authors and readers who write their own text, change and delete them is obsolete as also third parties can carry out these functions [19].

Characterization of the Social Software Tools

Weblogs can be defined to be “discussion-oriented“ tools because the discourse and exchange of ideas related to a certain topic is the pre-eminent aim. The substantial strength of weblogs is the simple way of writing contributions, which are represented in chronological order. So the development of ideas and thoughts can be reconstructed easily.

Central problems are the representation of “lexical” knowledge, e.g. representing lexical knowledge – information about companies, products, people, books, etc. and the relations between them. This does not fit well with the mainly narrative-focused approach traditionally encouraged. This limits the usefulness of weblogs as personal knowledge mapping tools [24]. The categorization of posts as well as the retrieving of posts or contributions are causing problems. By using indexing systems or tagging systems these problems can be solved with some effort.

The special strengths of wikis lies in collecting and linking information in a structured way and the ease of changing contents and manage pages within the wiki. The contents in wikis is organized according to the topics. Hyperlinking the differente pages is very easy and full-text indexing is supported,changes made to wiki-pages are logged.

Every piece of information that is stored in a wiki must have a name. Even this piece of information is just temporariliy stored for later processing. This leads to a situation that authors have to think about proper naming and naming conventions. The author must have a good knowledge about the existing structure of the wiki in orde to place the new contribution in the right place. Wikis have no practical facility to deal with short-term information.

Wikis and Weblogs in the Enterprise

Weblogs and wikis are the social software applications which many major companies have started adopting. Approximately 30 % of companies worldwide are already using or planning to use blogs and/or wikis at the moment [20]. Wikis have been implemented in both large and small organizations. Various technology-oriented interest groups are also using wikis [21].

3.2 Bliki

Bliki, the combination of weblog and wiki, are merged and **integrate** the functionality of weblogs and wikis to combine "the spontaneity of the weblogs marrying the structure of wikis” [22, p. 56]. Kantel states that through the additional linking of weblogs, wikis and forums, there is the possibility to develop a personal knowledge collection [23].

The largest advantage lies however in the revision and adoption of contributions, which has certain limitations within weblogs. By the integration several points of entrance into the knowledge space can be offered to the user. Several points of entrance are to be ordered by the integration to the user into the knowledge space.

The advantages of the integration of these two systems is to be achieved by the following characteristics [24]:

- Each contribution in the weblog is linked with a separate page, where the discussion of the entry is resumed. Also the weblog entry can be resumed in the wiki, so that the original entry serves as introduction. Thus develops the linkage of wiki structures and the chronological structure of weblogs

- The weblog is on a special page in the wiki, whereby the whole weblog archives can be regarded there also. So the current actualizations of the contributions in the wiki can be logged.
- Each new wiki page is represented chronologically on the weblog and thereby represents the entries in the weblog. Thus the narrative form of weblogs remains ("narrative glue").

4 CONCLUSION

The benefits of cross-linking and inter-exchanging features of weblogs and wikis could have the potential to introduce blikis as a new and powerful tool for knowledge management and IT-supported collaboration.

In order to evaluate the mentioned advantages more thoroughly, research on the successful usage of blikis will be conducted. Thereby investigations and explorative studies will investigate requirements or shortcomings, which are not yet considered but relevant for the intended purpose of this tool.

References

[1] E. W. L. Cheng, P. E. D. Love, C. Standing, H. Gharavi. Intention to e-collaborate: propagation of research propositions. *Industrial Management & Data Systems, 106*(1), 139–152. 2006.

[2] M. Koch, A. Richter. Social Software - Status Quo und Zukunft No. 2007-01. 2007.

[3] C. Wagner, N. Bolloju. Supporting Knowledge Management in Organizations with Conversational Technologies: Discussion Forums, Weblogs, and Wikis. *Journal of Database Management, 16*(2), 1–8. 2005.

[4] S. Gillmor. Weaving Social Nets for the Enterprise. URL: http://www.eweek.com/article2/0,1895, 1523237,00.asp. 2004.

[5] D. Hedgebeth. Making use of knowledge sharing technologies. *VINE, 37*(1). 2007.

[6] H. Gharavi,P.E.D. Love, E. W.L. Cheng 2004. Information and communication technology in the stockbroking industry: an evolutionary approach to the diffusion of innovation. *Industrial Management & Data Systems, 104*(9). 2004.

[7] A.F. Rutkowski, D.R. Vogel, M. van Genuchten, T.M.A. Bemelmans, M. Favier. E-collaboration: the reality of virtuality, IEEE Transactions on Professional Communication, 2002, Vol. 45 No. 4, pp. 219-230. 2002.

[8] R. M. Grant. The knowledge-based view of the firm: Implications for management practice. *Long Range Planning, 30*(3), 450–454. 1997.

[9] K.-E Sveiby. A knowledge-based theory of the firm to guide in strategy formulation. *Journal of Intellectual Capital, 2*(4), 344–358. 2001.

[10] T.H. Davenport, G.J. Probst. *Knowledge Management Case Book: Siemens Best Practices.* New York, NY, USA: John Wiley & Sons, Inc. 2002.

[11] I. Nonaka, H. Takeuchi. The Knowledge-Creating Company. *Harvard Business Review*, (November-December), 97–130. 1991.

[12] D. Mayrhofer, A. Back. *Workplace E-Collaboration: Theoretical Foundations and Practical Implications:* Learning Center der Universität St. Gallen. 2003.

[13] L. Efimova, L. Discovering the iceberg of knowledge work: A weblog case. In B. Renzl, H. H. Hinterhuber, & K. Matzler (Eds.), *Proceedings of the Fifth European Conference on Organizational Knowledge, Learning, and Capabilities. 2-3 April 2004, Innsbruck/Austria*. Innsbruck. 2004.

[14] M. Warkentin, R. Bapna, V. Sugumaran. E-knowledge networks for inter-organizational collaborative e-business. *Logistics Information Management, 14*(1/2), 149–162. 2001.

[15] M. Owen, L. Grant, S. Sayers, K. Facer. *Social software and learning,* URL: http://www.futurelab.org.uk/download/pdfs/research/opening_education/Social_Software_report.pdf. 2007.

[16] C. Shirky. *Social software and the politics of groups*. Clay Shirky's Writings About the Internet: Economics & Culture, Media & Community, Open Source. URL: http://shirky.com/writings/group_politics.html. 2003

[17] B. Alexander. Web2.0: A New Wave of Innovation for Teaching and Learning? *Educause Review, 41*(2), 32–44. 2006.

[18] T. Hammond, T. Hannay, B. Lund, J. Scott. Social Bookmarking Tools (I) - A General Review. *D-Lib Magazine, 11*(4). 2005.

[19] N. Augar, R. Raitman, W. Zhou. Teaching and learning online with wikis. In R. Atkinson , C. McBeath, D. Jonas-Dwyer, R. Phillips (Eds.), *Beyond the Comfort Zone*, Proceedings of the 21st ASCILITE Conference, Perth, Western Australia, December 5-8 2004. ASCILITE. 2004.

[20] J. Bughin, J. Manyika. *How businesses are using Web 2.0: A McKinsey Global Survey.*2007.

[21] L. Aronsson. Operation of a Large Scale, General Purpose Wiki Website. Experience from susning.nu's first nine months in service. In J. Álvaro Carvalho (Ed.), *Advances in media technology: Vol. 1. Technology interactions. Proceedings of the 6th International ICCCIFIP Conference on Electronic Publishing held in Karlovy VaryCzech Republic 6 - 8 November. 2002*. 1. Aufl (pp. 27–37). Berlin: VWF Verl. für Wiss. und Forschung. 2002.

[22] G. Avram. At the Crossroads of Knowledge Management with Social Software. In Dan Remenyi (Ed.), *6th European Conference on Knowledge Management, September 8-9, 2005, University of Limerick, Ireland* (pp. 49–58). Academic Conferences Limited, Reading, UK. 2005

[23] J. Kantel. *Vom Weblog lernen... Community, Peer-to-Peer und Eigenständigkeit als ein Modell für zukünftige Wissenssammlungen*. Retrieved on 12 March, 2007 from http://static.userland.com/sh4/gems/schockwellenreiter/blogtalktext.pdf. 2003.

[24] C. Langreiter, A. Bolka, A. Snips and Spaces: Managing Microlearning. In T. Hug, M. Lindner, & P. A. Bruck (Eds.), *Microlearning: Emerging Concepts, Practices and Technologies. Proceedings of Microlearning 2005: Learning & Working in New Media Environments*. Innsbruck: University. Press. 2006.

ANALIZA SPLETNIH OKOLIJ ZA KOOPERATIVNO DELO

Gregor Polančič
Fakulteta za elektrotehniko, računalništvo in informatiko
Univerza v Mariboru
Smetanova 17, 2000 Maribor, Slovenija
e-mail: gregor.polancic@uni-mb.si

POVZETEK

Spletne aplikacije postajajo vse bolj zmogljive in čedalje bolj posegajo v domene, ki so tradicionalno pripadale namiznim aplikacijam. S prednostmi, ki jih že v osnovi predstavlja koncept tankega odjemalca in s pojavom »Web 2.0« tehnologij so se začela pojavljati celo spletna pisarniška okolja in spletni operacijski sistemi.
V prispevku so predstavljena spletna okolja, ki so namenjena projektom razvoja programske opreme in preostalih elektronskih izdelkov. Predstavljena so okolja za razvoj specialističnih in vodstvenih izdelkov projekta. Predstavljene so izkušnje uporabe takšnih okolij, ki smo si jih pridobili pri razvoju skupnosti ITPoster.net.

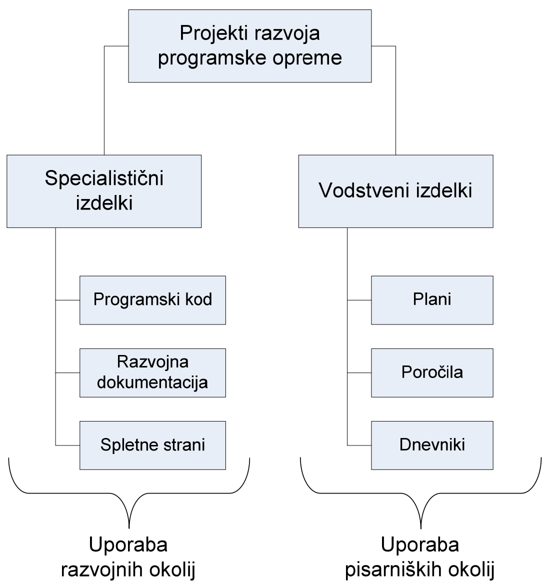
1 UVOD

Spletne aplikacije postajajo vse bolj zmogljive in čedalje bolj posegajo v domene, ki so tradicionalno pripadale namiznim aplikacijam. S prednostmi, ki jih že v osnovi predstavlja koncept spletnega odjemalca (centralizirano hranjenje podatkov, odpadejo lokalne namestitve in vzdrževanje aplikacij) in s pojavom »Web 2.0« tehnologij so se začela pojavljati celo spletna pisarniška okolja in spletni operacijski sistemi[1]. Takšna spletna okolja so osnova številnim virtualnim skupnostim, socialnim mrežam in projektom, ki razvijajo odprto programje.
V nadaljevanju so predstavljena spletna okolja za podporo skupinskemu delu, ki so namenjena razvoju programske opreme in drugih elektronskih izdelkov ter storitev.

2 OKOLJA ZA PODPORO SKUPINSKEMU DELU

Programska oprema in okolja za podporo skupinskemu delu (POPSD) *(collaborative software, groupware)* so uporabniški programi, namenjen skupinam, ki sodelujejo v omrežju za potrebe izvajanja določene delovne naloge. Predstavljajo podpomenko socialne programske opreme *(social software)*, ki vključuje še programsko opremo, ki se uporablja izven delovnih okolij (socialne mreže, spletne igre, »second life«). Glede na vrsto sodelovanja se POPSD deli na komunikacijska (elektronska pošta, takojšnje sporočanje, wiki), konferenčna (spletne klepetalnice, forumi, video konference) in koordinacijska orodja (spletni koledarji, obvladovanje delovnih tokov, spletne preglednice, sistemi za upravljanje znanja). S POPSD se ukvarjajo raziskave na področju računalniško podprtega sodelovanja *(computer supported collaboration)*, ki preučuje tehnologije, ki vplivajo na družbene skupine, organizacije in skupnosti [1,2].

Glede na projektno organizacijo dela po metodologiji PRINCE 2 [3], se lahko POPSD deli tudi na aplikacije, ki so namenjene razvoju vodstvenih izdelkov (plani, poročila in ostala dokumentacija) in aplikacije, ki so namenjene razvoju specialističnih izdelkov (izdelkov, ki predstavljajo končni produkt ali storitev) (Slika 1).



Slika 1: Delitev POPSD glede na projektno organizacijo

POPSD, ki je namenjena izdelavi vodstvenih izdelkov so spletne pisarne *(web office)*. Spletne pisarne predstavljajo derivat namiznih pisarniških okolij (Open Office, MS Office) in so zaradi spletne narave še posebej primerne za skupinsko delo in delo na različnih odjemalcih. Spletne pisarne vključujejo množico spletnih aplikacij, ki omogočajo uporabnikom izdelovati, pregledovati in deliti najrazličnejše vrste informacij [4]. Pregled lastnosti nekaterih namiznih in spletnih pisarniških okolij je prikazan v naslednji tabeli (Tabela 1).

[1] AjaxWindows, http://www.ajaxwindows.com

Tabela 1: Pregled priljubljenih namiznih in spletnih pisarniških okolij

Pisarniško okolje	**Razvoj**	**Prva izdaja**	**Podprti operacijski sistemi**	**Plačljiv**	**Podpora Open Document**	**Licenca**	**Št. vključenih aplikacij**
Microsoft Office	Microsoft	1992	Windows Mac OS X	Da	Ne (Da z dodatki)	Lastniška	11
Open Office	Open Office	2001	Windows Mac OS X Linux, BSD, Unix	Ne	Da	LGPL	9
Google Apps	Google	2006	Web	Ne	Da	Lastniška	5
Share Office	ShareMethods	2007	Web	Da	Da	Lastniška	4
Cmyos	eyeOS	2007	Web	Ne	Ne	GPL	3*

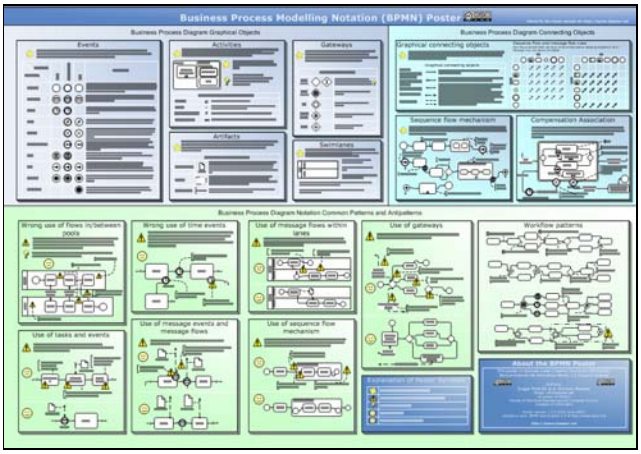
V projektnih okoljih so spletne pisarne namenjene predvsem vodenju projektov oziroma izdelavi vodstvenih izdelkov, medtem ko so za potrebe izdelave specialističnih izdelkov običajno potrebne specialne aplikacije. V primeru razvoja programske opreme so to spletna okolja za podporo razvoju programske opreme. Takšna okolja vsebujejo spletne aplikacije, ki so potrebne pri razvoju in vzdrževanju programske opreme, med katere spadajo: sistem za upravljanje konfiguracije, sistem za objavo napak, sistem za dodeljevanje opravil, sistem za sinhrono in asinhrono komunikacijo med člani projekta, sistem za distribucijo programskega koda in pripadajočih izdelkov. Primeri takšnih okolij so: BerliOS, Tigris.org in Sourceforge.net[2].

3 RAZISKAVA

Uporabnost spletnih kooperativnih okolij smo preverili na osnovi sistematičnega analiziranja izkušenj, ki smo si jih pridobili pri razvoju spletne skupnosti ITPoster.net in pripadajočih izdelkov.

Cilj spletne skupnosti ITPoster.net[3] je poenostaviti uporabo zapletenih IT tehnologij in standardov oziroma le te približati njihovim ciljnim uporabnikom. Skladno z izjavo Marka Ardisa, da »specifikacija, ki je ne moremo zapisati na papir velikosti A4 ne more biti razumljiva« smo si zadali cilj, da le te poskušamo prikazati v obliki postrov, ki so uporabni v papirnati ali elektronski obliki.

Prvi izdelek skupnosti ITPoster.net predstavlja BPMN *(Business Process Modeling Notation)* Poster (Slika 2). BPMN Poster vsebuje specifikacijo elementov BPMN notacije, kakor tudi dobre in slabe primere uporabe te notacije. BPMN Poster uporabljamo kot učni pripomoček na Inštitutu za informatiko in je doživel pozitivne odzive s strani študentov kakor tudi v širši spletni javnosti. Od njegovega pojava marca 2007, si ga je na svoje lokalne računalnike preneslo že preko 4000 uporabnikov.



Slika 2: BPMN Poster

3.1 Predmet raziskave

Predmet naše raziskave sta bili dve spletni kooperativni okolji, ki se uporabljata v okviru skupnosti ITPoster.net - Google Apps[4] in Sourceforge.net[5].

Google Apps je spletna pisarna podjetja Google. Google Apps vključuje naslednje spletne aplikacije: Gmail (e-poštni odjemalec), Google Calendar (spletni koledar), Talk (takojšnje sporočanje), Page Creator (spletno objavljanje) , Google Docs (urejevalnik teksta) in Google Spreadsheets (preglednice). Poleg omenjenih aplikacij smo v našem primeru uporabili še Google AdSense (spletno oglaševanje) in Google Analytics (statistike dostopov spletnih strani), ki pa nista sestavni del pisarne Google Apps. Google Apps smo uporabili za vodenje projekta.

Sourceforge.net je priljubljeno in preizkušeno spletno okolje, namenjeno podpori razvoja odprto-kodnih projektov. Osrednje mesto okolja Sourceforge predstavlja sistem za upravljanje konfiguracije (SUK), ki je lahko CVS *(Concurrent Versions System)* ali SVN *(Subversion)* Poleg SUK zagotavlja Sourceforge še ostale storitve, namenjene

[2] Celoten seznam prosto dostopnih okolij je dostopen na http://en.wikipedia.org/wiki/Comparison_of_free_software_hosting_facilities
[3] http://itposter.net
* Vključene še številne druge, nestandardne aplikacije

[4] https://www.google.com/a/
[5] http://sourceforge.net

razvijalcem programske opreme: sistem za objavo napak, sistem za dodeljevanje opravil, spletni forum, objavo novic, distribucijo programskega koda in pripadajočih izdelkov, statistika dostopa in uporabe, sistem za upravljanje dokumentacije in izdelavo varnostnih kopij [5]. Sourceforge.net smo uporabili za razvoj specialističnih izdelkov (IT postrov, spletna stran projekta).

3.2 Načrtovanje raziskave

Cilj naše raziskave je bil analizirati uporabnost spletnih kooperativnih orodij in izpostaviti poglavitne prednosti in pomanjkljivosti omenjenih okolij glede na »klasičen pristop«. Pri tem je pojem »klasičen pristop« v našem primeru pomenil uporabo namiznih okolij z enakimi ali podobnimi funkcijami kot jih imajo okolja, ki so bila predmet raziskave.

Oba predmeta raziskave smo analizirali glede na karakteristike kakovosti programske opreme, skladne s standardom ISO/IEC 1926: funkcionalnost, zanesljivost, uporabnost, učinkovitost, zmožnost vzdrževanja in prenosljivost [6]. Pri tem smo upoštevali še pod-karakteristike posameznih karakteristik kakovosti.

Rezultate smo podali v opisni obliki, ločeno za okolje Google Apps in Sourceforge.net. Pri vsaki karakteristiki kakovosti smo poskušali izpostaviti poglavitne prednosti in pomanjkljivosti obravnavanega okolja.

3.3 Rezultati

3.3.1 Analiza uporabe Google Apps

Spletna pisarna Google Apps se je izkazala za izjemno primerno okolje za vodenje skupinskega dela in sicer predvsem v začetnih fazah, ko je ob poplavi idej članov projektne skupine potrebno le te hkrati zapisovati in izmenjati.

Kot poglavitno slabost Google Apps bi lahko izpostavili pomanjkanje naprednih funkcij za oblikovanje dokumentov in poročil, ki so zaenkrat prisotne le v sodobnih namiznih pisarniških okoljih.

Povzetek celotne analize Google Apps je prikazan v spodnji tabeli (Tabela 2).

Tabela 2: Analiza okolja »Google Apps«

	Prednosti	Slabosti
Funkcionalnost	- Brezplačna uporaba. - Dosegljive so vse osnovne funkcije, ki jih vsebujejo klasična pisarniška okolja. - Dostop do dokumentov je neodvisen od lokacije. - Dostop do dokumentov je zaščiten. - Podpora revizijam, omogočeno je hkratno delo, delitev in objava dokumentov. - Interoperabilnost z drugimi sistemi in dostopen programski vmesnik.	- Manj naprednih funkcij kot klasična pisarniška okolja. - Tveganje iz vidika varovanja osebnih podatkov.
Zanesljivost	- Visoka zanesljivost delovanja, pogojena predvsem z zanesljivostjo internetne povezave. - Zaradi avtomatskega arhiviranja revizij, izguba podatkov praktično ni možna. - Vključeno je avtomatsko arhiviranje.	- Pri odprtju več hkratnih oken brskalnika lahko pride do preobremenitve in zaprtja brskalnika.
Uporabnost	- Enostavna uporaba, ikone in koncepti skladni z namiznimi pisarniškimi orodji. - Sortiranje po datumih sprememb in koncept značk. - Privlačen in sodoben uporabniški vmesnik.	- Zaradi spletnega vmesnika, težje oblikovanje tabel in vstavljanje slik. - Izreži prilepi sliko ni izvedljivo. - Uporabniški vmesnik ni dosegljiv v slovenskem jeziku. - Izgled lahko pogojuje brskalnik.
Učinkovitost	- Hitrost nalaganja aplikacije je v območju namiznih aplikacij, pri tem je poraba računalniških virov (delovni pomnilnik, procesor) manjša.	
Zmožnost vzdrževanja	- Za uporabnika transparentno dodajanje novih funkcij.	- Uporabnik nima vpliva na spremembe različic aplikacij.
Prenosljivost	- Podpora vseh operacijskih sistemov (odvisno le od brskalnika) - Podpora »open document« formatu in preostalim formatom pogostih namiznih pisarniških okolij. - Lokalne namestitve niso potrebne.	- Glede na namizna okolja je omejeno prilagajanje uporabniškega vmesnika.

3.3.2 Analiza uporabe Sourceforge.net

Spletno okolje Sourceforge.net je prav tako koristilo izdelavi specialističnih izdelkov. Poglavitna prednost je sistem za obvladovanje konfiguracije, ki je pri skupinskem razvoju programske opreme skoraj nujen. Izpostaviti velja še dobro povezljivost sistemov za objavo napak in dodeljevanjem opravil.

Slabost okolja je njegova preobremenjenost, ki se kaže v počasnem odzivanju določenih spletnih aplikacij (spletni forum, Subversion) in v nezanesljivem delovanju. Povzetek celotne analize Sourceforge.net je prikazan v spodnji tabeli (Tabela 3).

Tabela 3: Analiza okolja »Sourceforge.net«

	Prednosti	Slabosti
Funkcionalnost	- Uporaba vseh orodij je brezplačna. - Posamezna orodja so med sabo povezana. - Enotna prijava v vsa okolja.	- Za varnost podatkov je slabše poskrbljeno (okolje je namenjeno odprtem programju).
Zanesljivost	- Zmožnost ponovne vzpostavitve sistema je dobra. - Okolje je zrelo in dobro testirano.	- Okolje včasih zaradi preobremenjenosti ni dostopno.
Uporabnost		- Pogosto in včasih nezaželeno menjavanje uporabniškega vmesnika. - Uporabniški vmesnik motijo oglasi.
Učinkovitost	- Potreba po lokalnih računalniških virih je manjša kot pri namiznih aplikacijah.	- Počasnejši odziv okolja kot pri namiznih rešitvah.
Zmožnost vzdrževanja	- Z vidika uporabnika ni potrebe po vzdrževanju. - Redne nadgradnje okolja.	
Prenosljivost	- Namestitev okolja ni potrebna. - Sistem za upravljanje konfiguracije in spletni prostor se lahko preprosto nadomestita.	- Uporabniškega vmesnika okolja ni mogoče prilagajat. - Prenos podatkov iz okolja ni možna za vse aplikacije.

3.4 Omejitve raziskave

Upoštevali smo naslednje omejitve raziskave: predmet raziskave, metoda raziskave in analiza podatkov. Predmeta raziskave sta bila »Google Apps« in »Sourceforge.net«. Kljub temu, da spadata okolji med najbolj priljubljene v njihovi skupini, ne moremo posplošiti rezultatov na vsa okolja iz pripadajočih skupin, saj nismo preučili nobenih drugih okolij. Raziskava temelji na praktičnih izkušnjah uporabe teh dveh okolij in ni uvedla sistematičnega pristopa, ki je značilen za eksperiment ali anketo. Zato je vprašljiva ponovljivost raziskave. Analiza podatkov je temeljila na kvalitativnih metodah pri katerih nismo mogli preveriti notranje in zunanje veljavnosti rezultatov. Glede na omejitve raziskave moramo rezultate raziskave obravnavati s previdnostjo. Prav tako priporočamo dodatne raziskave v smislu določitve kavzalnega teoretičnega modela in izvedbe laboratorijskega poizkusa ali ankete.

4 ZAKLJUČEK

Neodvisno od omejitev raziskav lahko predpostavljamo, da imajo spletna okolja za podporo skupinskemu delu svetlo prihodnost, predvsem zaradi narave spletnih aplikacij in hitrega napredka na področju spletnih uporabniških vmesnikov. Prednosti spletnih okolij so predvsem v enostavnejši skupinski komunikaciji in delu. Prednosti so tudi v fleksibilnosti delovnega okolja, kjer nismo odvisni od fizične lokacije, konfiguracije strojne in programske opreme. V prihodnosti lahko pričakujemo postopen prehod uporabnikov iz namiznih v spletne pisarne. Prav tako lahko pričakujemo spletna okolja, ki bodo v celoti podprla razvoj programske opreme (v smislu okolij kot so »Eclipse IDE« ali »MS Visual Studio«).

LITERATURA

1. Collaborative software, http://en.wikipedia.org/wiki/Groupware.
2. Computer supported cooperative work, http://en.wikipedia.org/wiki/Computer_supported_cooperative_work.
3. PRojects IN Controlled Environments - PRINCE 2, http://www.prince2.org.uk/home/home.asp.
4. Web Office, http://en.wikipedia.org/wiki/Web_office.
5. Gregor Polančič: Odprta koda pri študiju informatike, zbornik konference ERK 2005.
6. ISO 9126. ISO/IEC TR 9126-Software engineering, product quality, quality model. 2001. International Organization for Standardization.
7. ISLOVAR, slovar informatike, www.islovar.org.

COMMUNICATION WITHOUT SENDER OR RECEIVER? ON VIRTUALIZATION IN THE INFORMATION PROCESS

Dirk Müller, Aaron Ruß, Wolfgang Hesse
FB 12 – Mathematics and Computer Science
Philipps-Universität Marburg(Lahn)
Hans-Meerwein-Str., D-35032 Marburg, Germany
Tel: +49-6421-282-1541; fax: +49-6421-282-25419
e-mail: {dmueller, russa, hesse}@informatik.uni-marburg.de

ABSTRACT

A communication process can be described in terms of a sender transmitting information to a receiver. What happens if one of the two subject roles in this process is virtualized, i.e. substituted by a machine? Is it still appropriate to refer to this as an *information transfer* even if its source or target is missing? Can information originate from an unknown sender or be transmitted to a (completely) unknown receiver?

Before examining these questions and answering them, one has to clarify what is understood by *information*. As it turns out, different interpretations of this term lead to considerably different answers and consequences to the initially raised questions.

We consider these questions particularly important since the ongoing dissemination of so called *information and virtualization technologies* changes the human communication processes fundamentally. These changes are part of the ongoing formation of an *information society* and may eventually lead to the formation of a new *image of man*.

1 INTRODUCTION

Man-machine interaction is a core issue of information technology and is often regarded as a form of communication process. A simple and useful model for communication consists of a sender subject transmitting information to a receiver subject (cf. fig. 1). In case of continued communication, the subject roles may change. If machines – and in particular computer systems – come into play, the question arises what is their precise role or in other words, how do they fit into this model: Can a human *communicate* with a computer? Or do computers merely *assist* communication between humans?

Writing an email, we can usually assume that the computer systems assist us in doing so. But what about receiving an automatically generated email: Is the sender of this message a machine? Is in this case a human communication partner actually substituted by a machine or does it rather act on behalf of a human? When reacting to a dialog prompt of a computer program containing a message or a question, do we really communicate with the computer system or are we merely following the path prescribed by the system's programmer?

What exactly are the consequences if a communication partner in the role of the sender or receiver is replaced, i.e. *virtualized*? In order to answer this question we consider communication as an *information process*. In this regard it is worth noticing that the concept *information* has raised much controversy with no definitive clarification as to its meaning (for discussions see e.g. [1], [3], [6], [8]). Depending on the understanding of the information concept one may come to different answers to the question whether and to which degree the sender or the receiver in a communication process can be virtualized by a technical system.

If machines are not acknowledged as (virtual) communication partners, this has several implications. For instance, an *anthropomorphic* view on machines has to be rejected in this case, instead users of machines have to be advised on their technical limitations in a transparent way. As an example, we consider search engines that accept natural language requests. For experts it is clear that these systems are not able to (completely) process such requests, let alone to comprehend their (full) semantic implications. An "understanding" of such requests by a machine can only be considered metaphorical. In a case like this, the user should be notified on how the request was interpreted and which parts were not "understood" (e.g. ignored).

On the other hand, if machines are accepted as communication partners, this has severe consequences as well. It would, for example, imply to grant them (to a certain degree) authority and responsibility and – at least in the long term – would strongly influence the image of man.

A systematic analysis will point out the terms under which a virtualization is possible. In principle, either communication role (sender or receiver) may be substituted by a machine. A special case is the virtualization of both of

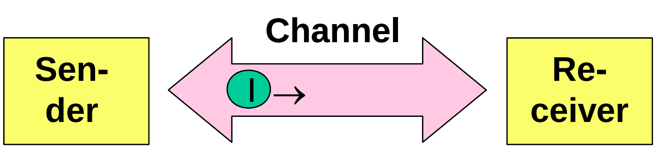


Figure 1: *Sender-receiver model for communication.*

them. Examining each alternative in combination with the different information concepts will show their practicability and reveal some inherent problems.

A further distinction concerns the substitution of communication partners by a technical system (e.g. a robot or an agent) or their complete absence or at least anonymity. Evidently, such substitutions or “anonymizations” influence the essence of what communication means – up to the point where the term "communication" is no longer appropriate or merely metaphorical. Any receiver of “virtual” information – e.g. from the Internet – places his trust in messages from unreliable sources: sent by an unknown third party or generated by inscrutable and possibly proprietary search engines.

On the other side, the sender of messages to “virtual” or unknown receivers usually makes assumptions about the willingness and abilities of the receiver in regard to reception, interpretation and cooperation. Ultimately, communication processes in which both parties are virtualized bear manifold risks, e.g. uncontrollability and (as a result) erroneous as well as blocking behavior, waste of resources etc.

2 DIFFERENT CONCEPTS OF INFORMATION

In fig. 2 we cite three exemplarily selected definitions for ”information” that illustrate the bandwidth of the different possible interpretations for this term.

Examining these definitions shows their different qualities and foci, in particular with respect to the three semiotic dimensions of *syntax*, *semantics* and *pragmatics* (cf. e.g. [4] for a semiotic access to information and information systems). Definition 1 is limited to the syntactical aspect of information (*data*) and in that it follows largely Shannon’s concept of *syntactical information* [10]. This notion also conforms to materialistic and naturalistic approaches on information (see e.g. [12] and discussion in [6]).

At the opposite end of the spectrum, definition 3 describes information by its semantic and pragmatic aspects, that is its meaning and effect on some observer (*originator* or *addressee*) – ignoring any connection to syntactic qualities. This definition implies qualities such as consciousness and intelligence on the observer(s) side. Related conceptions place information in a human-centered, culturalistic context (cf. [4], [5], [6]) and often are reminiscent of the classical educational aspect of information (cf. [3]).

The concept of information from Definition 2 lies in between the two extremes discussed. It integrates most of the naturalistic and some of the culturalistic aspects: Information is an independently existing pattern. In contrast to the purely naturalistic view this pattern needs to be (actually or potentially) useful for some observer. But unlike the culturalistic conception, little is said about creation or (re-)construction of the meaning of information, i.e. there are no concrete restrictions on relevance, sense, meaning etc.

> *Definition 1:* In connection with computing *information* is an aggregate (n-tuple) of binary elements.
>
> *Translated from: W. Händler, Lexikon der Datenverarbeitung, cit. cf. [11]*
>
> *Definition 2:* Information (from lat.: *informare* = forming, giving a form) is a potentially or actually usable (or used) pattern of matter or some energy form that is relevant for some observer within a certain context.
>
> *Translated from: Wikipedia: „Information“(German version), [13]*
>
> *Definition 3:* Information is knowledge on certain facts and/or processes which are part of the perceived or imagined reality. Information consists of communicated and received particles of knowledge. These are derived from (linguistically articulated) knowledge and communicated by means of linguistic tools. On the one hand side they represent (subjective) knowledge of the originator and on the other hand they can actualize or extend the (subjective) knowledge of the addressee.
>
> *Translated from: Barkow et. al. in: Lexikon Informatik und Datenverarbeitung [9]*

Figure 2: *Definitions for the concept of information.*

3 VIRTUALIZATION

So far, the roles of sender and receiver in the presented standard model are played by human *subjects*. Likewise, in the definitions given above observers (sender and receiver) are (explicitly or implicitly) assumed to be human. At least, they are at the source and target position of – possibly complex and multistage – information processes and responsible for giving meaning to the data being transferred.

Virtualization / Inf. concept	Virtualized sender	Virtualized receiver	Virtualized sender and receiver
Definition 1	(Non-human) operator as signal generator	(Non-human) operator as signal receiver	Data interchange between systems
Definition 2	Agents as artificial pattern- and signal generator in inf. systems	Agents in databases, inf. systems, search engines, data warehouse etc.	Agent communication, feedback between (several) inf. systems
Definition 3	Artificial „intelligent“ sender	Artificial „intelligent“ receiver	Communication between autonomous (AI-capable) systems

Figure 3: *Examples for virtualization in the information process.*

However, we have got used to include non-human actors in processes for exchanging, storing and transmitting information. Often, they are awarded human capabilities such as sending, receiving, searching, finding and sorting in a metaphorical way.

Here the question arises which are the consequences if sender or receiver or even both are omitted or replaced, e.g. by anonymous actors, devices, proxies or other non-human sources. In the case of virtualization, sender or receiver are replaced by an artificial instance which plays a functionally equivalent role – with respect to the interpretation of information – of a human sender or a receiver (cf. fig. 3).

The information concept of definition 1 poses no constraints on "virtualizing" sender or receiver by a computer system: In this context, binary data is just information.

This turns out quite differently if we take the culturalistic conception of information in definition 3. Here information is inextricably linked to an entity capable of consciousness and operating in terms of *meaning* and *validity* – concepts which do not occur in Shannon-like conceptions of information. Furthermore, definition 3 (indirectly) suggests that the emergence of information is necessarily coupled with *intelligence*: Information is the result (or process) of *understanding*. Thus virtualization of the sender or receiver needs to come along with some kind of *Artificial Intelligence (AI)* – this requirement holds regardless whether or not AI is possible or has even been realized yet.

Definition 2 demands some *relevance* and *usefulness* of a pattern for an *observer* in order to become information. Key in this conception is the observer: Information is what he or she *conceives* to be a pattern and what is relevant to him or her: Note that there is no objective instance required to decide what is a pattern or not – only the (subjective) perception on part of the observer is important. The constraint of *relevance* for the observer is much weaker than that of *understanding* and leaves it open for all kinds of interpretation.

Thus the semantic dimension – getting the meaning of information [7] – is highly dependent on the kind of *observer*. Take for example a scenario of perceiving differences in temperature: If the observer is a human, the patterns signaling the temperature can be assumed to have a semantic dimension. If we chose a technical temperature sensor this assumption no longer holds, but following definition 2, we are still allowed to call its measurements information, since temperature differences are patterns relevant to the sensor which reacts to them in a defined manner.

Taking this interpretation in its widest sense all processing of data can be termed information: Data are *patterns* for computer systems which deem them *relevant* for their own reactions.

4 ANONYMITY

A question related to virtualization of sender and receiver is concerned with *anonymity*: What can we say about information processes where the sender or receiver are unknown (cf. fig. 4) – be it temporarily or even forever.

An example for an anonymous sender is the Rosetta Stone with its hieroglyphic scripture – that holds at least for the time between its discovery and its decipherment by Champillion in 1822. In this case, the anonymity of the (apparently human) sender could at least partially be uncovered by its decryption – lifting its content from the syntactic (data-) level to the semantic (information-) level which was accomplished due to successful interpretation.

Patterns and structures of animate and inanimate matter are ubiquitous and their interpretation often ambiguous or arguable. Among the biggest mysteries for mankind are questions about the universe, earth, nature and life, their origin, meaning, purpose and end. Patterns found by geologists, archaeologist, biologists etc. are believed to give us answers to these mysteries – “received” by scientists, but never been “sent” by any human source.

Another example of anonymous “information” construed from celestial structures are the star constellations. As we know today, they do not convey any “semantic meaning” in form of animals, heroes or gods since often there are big distances between stars belonging to one and the same constellation. The geocentric perspective takes only the two angular coordinates polar angle and azimuth into account, but not the distance.

A well-known example of an "information process" with unknown receiver is the Pioneer mission from 1972. The plaque placed on board of the Pioneer 10 spacecraft features a message from humankind addressed to potential aliens.

On closer inspection of that example, one might come to the conclusion that the sending of information in its semantic sense to a completely unknown receiver turns out impossible. There are always certain assumptions about the receiver to be made which are prerequisite for a

Anonymization / Inf. concept	Sending without explicit receiver	Reception without explicit sender
Definition 1	Broadcasted radio signal	Received signals by radio telescopes
Definition 2	Postsigns, cultural monuments, e.g. *plaque of Pioneer 10 spacecraft*	Discoveries (archeology), geological outcrops (geology), constellations (astronomy)
Definition 3	NA *(only indirectly possible)*	NA *(only indirectly possible)*

Figure 4: *Examples for anonymous sender and receiver in the information process.*

reconstruction of the information sent. In case of the plaque, these are of physiological and cognitive kind and concern not only the ability to perceive the gravure on the plaque, i.e. the presence of appropriate sensor organs but also a rather profound understanding of mathematical and physical facts and relations.

5 CONCLUSION

Considering (partly) virtualized information and communication processes supports our thesis that man is replaceable by machine only to a very limited degree. If e.g. a superiority of machines to men is conjured by exponents of the strong thesis of AI, one has to inquire whether and to which degree their abilities go beyond pure adaptation and acceleration of technical tasks and services as e.g. combing through and rearranging huge amounts of data.

Without any doubt, conducting such complex information processes can be supported, accelerated and may even be qualitatively improved. But, mostly decisions are to be made as e.g. concerning the relevance or priorities during selection, editing and representation of results of search engines. Most probably, these problems and limitations will not completely be overcome by an upcoming *Semantic Web* [2]. These issues should be highlighted and alluded to the users by clever computer systems instead of hiding them behind dazzling advertisement slogans and nebulous metaphoric talk. Rich interaction facilities have to provide human users the control and transparency they need to make the responsible decisions they require and deserve.

In this context, the question of responsibility recurs from a new perspective. An extensive and – even worse – *irreversible* delegation of responsibility to computer systems conflicts both with the occidental idea of man and that of Enlightenment. Not only that man would voluntarily abdicate his self-proclaimed role as the *pride of creation* but also that he would jeopardize his release from his self-incurred tutelage (in terms of Kant) by ceding responsibility to "superior" machines. Accepting the proclaimed "informational superiority" of machines to men would entail a new image of man no longer compatible with the ideas of humanism.

Those reflections reveal a strong impact of Man-machine interaction, information and communication processes on existing and future self-images of man. Hence, the penetration of virtually all areas of life by computers and "information technology" should raise our sensibility for autonomy and responsibility issues when conceiving and designing new applications, interfaces and systems – and makes a deliberate reflection about possible consequences and implications indispensable.

References

[1] R. ABBOTT: The World as Information. Overload and Personal Design. Intellect Books, 1999

[2] T. BERNERS-LEE, J. HENDLER, O. LASSILA: The Semantic Web. Scientific American, Vol. 284, Issue 5, May 2001, pp. 34-44

[3] R. CAPURRO: The concept of Information. Annual Review of Information Science and Technology. Ed. B. Cronin, Vol. 37, Chapter 8, 2003, pp. 343-411

[4] E. FALKENBERG, W. HESSE, P. LINDGREEN, B.E. NILSSON, J.L.H. OEI, C. ROLLAND, R.K. STAMPER, F.J.M. VAN ASSCHE, A.A. VERRIJN-STUART, K. VOSS: FRISCO - A Framework of Information System Concepts - The FRISCO Report. IFIP WG 8.1 Task Group FRISCO. Web version: http://www.mathematik.uni-marburg.de/~hesse/papers/fri-full.pdf (1998)

[5] P. JANICH: Human nature and neurosciences: a methodical cultural criticism of naturalism in the neurosciences. In: Poiesis & Praxis, Berlin / Heidelberg: Springer, Volume 2, Number 1, November 2003, pp. 29-40

[6] P. JANICH: Was ist Information? Kritik einer Legende. Suhrkamp, Frankfurt/M. 2006

[7] D. NAUTA: The Meaning of Information; Mouton, Den Haag/Paris, 1972

[8] S. OTT: Information - zur Genese und Anwendung eines Begriffs. UVK Verlagsgesellschaft Konstanz, 2004

[9] H.J. SCHNEIDER (Hrsg.): Lexikon Informatik und Datenverarbeitung, Version 4.0, Oldenbourg, 1997

[10] C. E. SHANNON, W. WEAVER: The mathematical theory of communication. Urbana: Univ. of Illinois Press, 1949

[11] H. STOYAN: Information in der Informatik. In: R.KUHLEN, T.SEEGER: Grundlagen der praktischen Information und Dokumentation. Saur Verlag, 2004 (2003)

[12] N. WIENER: „Cybernetics or Control and Communication in the Animal and the Machine", Cambridge: MIT-Press, 1948

[13] *Wikipedia*: „Information", http://de.wikipedia.org/w/index.php?title=Information&oldid=33670304, 2007

INFORMATION IN ECONOMIC HISTORY: AN INTRODUCTION

Jure Stojan
University of Oxford
e-mail: jure.stojan@sant.ox.ac.uk

ABSTRACT

The article reviews the main contributions of the economic history literature towards understanding the role of market information. Pre-modern financial markets were highly inefficient and access to them was closed to most companies. Instead, entrepreneurs relied on personal networks to raise capital. The market evolution was based on improvements in the dissemination and the reliability of information. It occurred even before the major advances in information technology of the nineteenth and twentieth centuries. Early financial centres like Amsterdam and London rose to prominence because of their privileged access to international information flows.

1 INTRODUCTION

Information makes market transactions possible. In markets, information comes in several guises – most importantly, as price. If a product has a high price, it is scarce, or expected to become scarce soon. Scarcity, in turn, arises because demand outstrips or is expected to outstrip supply. But prices do not exist in isolation. Prices are set in agreement. There has to be someone who is willing to sell and someone else who is prepared to buy at that price. They both, in turn, need information to decide which price will do. They also need information where to find each other – not a simple task, as the existence of trade directories attest. Information does not only help markets. Information is a sellable commodity in its own right. Market analysts sell advice on which instruments are mispriced and therefore represent an opportunity for investment. On a less abstract level, information comes in the form of 'information goods' such as books, journals, computer software and videos [1]. In financial markets, information is by no means free. It has to found, collected, processed, analysed – each of these steps requires knowledge and the aid of information technology. This opens up opportunities for trade in information – it creates 'the market for information.'[2]

It may be useful to state what 'markets for information' are not – they are not necessarily 'information markets.' The latter term has lately come to mean 'prediction markets' or 'event futures'. According to a definition, 'these are markets where participants trade in contracts whose payoff depends on unknown future events.'[3] Since the markets are assumed to be efficient, the pricing of these options should accurately reflect the beliefs traders have – their expectations how likely an underlying future event is likely to occur [4]. In 1988, for example, economists in Iowa used an experimental political stock market to predict US presidential elections. The 'market's prediction of President Bush's margin of victory was off by less than one percentage point [5].

Real-life markets, however, have lagged behind their laboratory counterparts. Niall Fergusson shows that the London bond market – the biggest financial market of the early twentieth century – failed to anticipate the Great War of 1914. The bond prices did not reflect the increased risk of war before its outbreak [6]. The crash of 1987 was similarly surprising. During the two months immediately preceding the breakdown, the prices of S&P 500 futures options did not reveal investor worries [7].

These examples suggest that there may be a gap between market models, the laboratory experiments based on them, and the market reality. After several decades of economic research, it is still disputed to what extent markets process information efficiently – that is, 'whether securities prices at any time "fully reflect" all available information,' as Eugene Fama puts it [8]. Financial markets are, however, more efficient than they used to be. The worst information inefficiencies were relieved even before the major advances in information technology of the nineteenth and twentieth centuries, such as the telegraph and electronic computers. The improvements in the processing of information were indeed essential for the creation of financial markets. Without reliable information about a company, who would have bought its debt? It might have already mortgaged it assets. Who would have invested in its shares? The promoters might have been fraudsters. And who would have known the fair price of financial instruments?

2 INFORMATION PROBLEMS IN HISTORY

In the pre-industrial era, information was scarce and so was the investment capital. Trading companies found it difficult to access external financing, partly because they could not transmit information credibly. This was exacerbated by the lack of enforceable standards in financial reporting. Bookkeeping existed but it carried little importance. In England, for example, financial auditing approached professionalism only in the 1870s [9]. As M.M. Postan put it, 'The reservoirs of savings were full enough, but conduits to connect them with the wheels of industry were few and meagre.'[10] Most business was based on personal relationships; partners had to trust one another. In the absence of objective information, merchants could only tell the success of their joint venture by actual cash flows. J.B. Baskin describes the nuisance of reassuring shareholders that was the frequent liquidation of capital. 'Typically, all assets were sold and the proceeds redistributed at the end of each voyage, and the next voyage was financed by soliciting new subscriptions, usually among the same group of investors.'[11]

Access to early credit markets was limited to the State. By issuing bonds, the national governments raised capital for various projects – among them, war featured prominently [12]. The State drew on a continuous, reliable, and more or less predictable stream of revenue – on taxation. It could therefore guarantee repayment with a fixed amount of interest, and investors could readily evaluate the bonds. There was no need for specialised knowledge and dissemination of financial information [13]. A State's credit-worthiness was a function of its institutional commitment and good track record. In Britain, for example, Parliament voted on the budget, while in the French monarchy, public finances were not open to inspection. France even went into partial bankruptcy in 1770. This meant that compared to the British, the French governments had to borrow at higher interest rates [14].

3 INFORMATION SOLUTIONS IN HISTORY

The development of financial markets was slowed by information problems. The first solutions to these problems, however, did not wait until the advent of capitalism. There were two major fields of improvement; in the dissemination of information and in the information reliability (which meant, in the optimal case, its truthfulness).

Reliability could be assured by trustworthy financial intermediaries. In pre-revolutionary Paris, information problems were relieved by notaries. These legal professionals had drafted wills, deeds, as well as other contracts, and were therefore familiar with their clients' financial situation. A notary 'could thus select the good credit risks – borrowers with sound collateral – and match them with other clients who had money to lend,' explain Hoffman *et al* [15]. Since dissatisfied lenders could have switched notaries easily, the latter had an incentive to arrange financial transactions with care.

Information dissemination required social networks as well as technology. Information did travel in the past, even before the advent of the internet, the telephone and the television. It travelled more slowly, though. Trade information spread through trade channels like any other commodity. Information about Indian spices arrived on the same ship as spices proper. Centres of trade were therefore centres of information as well. The 'nature of information as a commodity and as a by-product of the operations of trade network led in the seventeenth century to the evolution in Amsterdam of a central information exchange for all of Europe,' explains Smith [16].

In the seventeenth-century Amsterdam, a range of activities and channels related to information. Data flowed through correspondence of merchants and institutions; it came with businessmen travelling to and from Amsterdam; it was embedded in consular and ambassadorial reports from other trading centres and political capitals; and it flowed through 'special channels' like the one the Vereenigde Oostindische Compagnie (the Dutch East India Company) built to reach its Asian agents [17]. Once information arrived at the information exchange, it was transferred between participants. By 1650, specialised information brokers had emerged [18]. Further functions of the information exchange included the aggregation and dissemination of data. These short-term functions were joined by long-term accumulation and analysis. Since 1692, for example, the Vereenigde Oostindische Compagnie used time-series methods to forecast trends in the pepper market [19].

The late seventeenth century saw the ascendancy of another commercial centre, the City of London [20]. The rise of London was due to arbitrage – London-based bankers profited from exchange-rate differentials between commercial centres overseas, for example between Cadiz and Amsterdam. Such deals required a broad network of commercial contacts that went beyond traditional family relations, religious ties and guild memberships. Bankers needed to find agents abroad, as well to pass funds to them, exchange information with them, and monitor their activities. It was a 'web of credit and information,' as Neal and Quinn put it, and operated jointly by bankers and merchants [21]. Merchants offered a channel of transport and communication, as well as of monitoring. Bankers, in return, offered financial services.

The efficiency in handling information throughout national borders was reflected in the integration of international capital markets. The more efficient the information flows, the more integrated the markets. A good measuring rod existed for market integration – the stock prices of companies listed on several exchanges. The price of a company ought to have reflected the same fundamentals regardless at which exchange its stock was traded. The stock price difference therefore showed how fast the information travelled between commercial centres, and how investors in different locations responded to the same information. In short, they measured how informationally efficient the markets were. Larry Neal shows that by the eighteenth century, Amsterdam and London 'were closely integrated even by early twentieth-century standards.'[22] With the nineteenth-century advances in shipbuilding, information transmission improved further. In 1820, it took at least 23 days for information to travel from New York to London. In 1860, it required 10 days. By 1870, the telegraph had shortened transfer time to 2 days [23].

3 INFORMATION SOLUTIONS IN HISTORY

The development of capital markets relied on improvements in information. Crucial innovations occurred in two areas: in the dissemination of information and in its realiability. Since information was transmitted in writing or by word-of-mouth, the speed of information transfer was increased by general improvements in transportation technology. The reliability of information was improved by the emergence of information professions such as information brokers, notaries, and, since the nineteenth century, accountants. The improved informational efficiency was reflected in greater market integration even before the great discoveries in information technology such the telegraph or the electronic computer. This is not to say, however, that the latter innovations were without importance. On the contrary, they made information transfer quicker, cheaper, more detailed, and above all, independent of paper, parchments, and other material carriers.

References

[1] H.R. Varian, 'Buying, sharing, and renting information goods,' *The Journal of Industrial Economics,* 48/4 (2000), pp 473–88.

[2] R.G. Barker, 'The market for information—evidence from finance directors, analysts and fund managers,' *Accounting and Business Research*, 29/1 (1998), pp 3–20.

[3] J. Wolfers, E. Zitzewitz, 'Prediction Markets ,' *The Journal of Economic Perspectives,* 18/2 (2004), pp 107–126, 108.

[4] C.R. Plott, 'Markets as information gathering tools,' *Southern Economic Journal,* 67/1 (2000), pp 1–15.

[5] R. Forsythe, F. Nelson, G.R. Neumann, J. Wright, 'Anatomy of an Experimental Political Stock Market,' The *American Economic Review*, 82/5, pp 1142–61.

[6] N. Ferguson, 'Political risk and the international bond market between the 1848 revolution and the outbreak of the First World War,' *Economic History Review,* 59/1 (2006), pp 70–112.

[7] D.S. Bates, 'The crash of '87: Was it expected? The evidence from options markets,' *The Journal of Finance,* 46/3 (1991), 1009–44.

[8] E. Fama, 'Efficient capital markets: A review of theory and empirical work,' *The Journal of Finance,* 25/2 (1970), pp 383–417. For the main critique, see S.J. Grossman, J.E. Stiglitz, 'On the impossibility of informationally efficient markets,' *The American Economic Review,* 70/3 (1980), pp 393–408. Also M.-A. Muendler, 'On the possibility of informationally efficient markets,' *Journal of Economic Theory,* 133/1 (2007), pp 467–83.

[9] P. Barnes & R.J. Firman, 'Difficulties in establishing a limited liability company in Great Britain during the 1860s and the role of financial information: a case history,' *Financial History Review,* 8/2 (2001), pp 143–61. M. Anderson, J.R. Edwards & D. Matthews, 'A study of the quoted company audit market in 1886,' *Accounting, Business and Financial History,* 6/3 (1996), pp 363–87.

[10] .M. Postan, 'Recent trends in the accumulation of capital,' *Economic History Review,* 6/1 (1935), pp 1–12, 2.

[11] J.B. Baskin, 'The development of corporate financial markets in Britain and the United States, 1600–1914: Overcoming asymmetric information,' *Business History Review*, 62 (1988), pp 199–237, 202.

[12] N. Ferguson, *The cash nexus: Money and power in the modern world 1700–2000*, (London, 2001).

[13] Baskin, 'The development of corporate financial markets,' 236.

[14] M.D. Bordo & E.N. White, 'A tale of two currencies: British and French finances during the Napoleonic wars,' *Journal of Economic History,* 51/2 (1991), pp. 303–16.

[15] P.T. Hoffman, G. Postel-Vinay, J.-L.Rosenthal, 'Information and economic history: How the credit market in old regime Paris forces us to rethink the transition to capitalism ,' *The American Historical Review*, 104/1 (1999), pp. 69–94, 80.

[16] W.D. Smith, 'The functions of commercial centers in the modernisation of European capitalism: Amsterdam as an information exchange in the seventeenth century, *Journal of Economic History,* 44/4 (1984), pp 985–1005, 987.

[17] Ibid. 990.

[18] Ibid. 996.

[19] Ibid. 1002.

[20] L. Neal & S. Quinn, 'Networks of information, markets, and institutions in the rise of London as a financial centre, 1660–1720,' *Financial History Review*, 8/1 (2001), pp 7–26.

[21] Ibid. 14.

[22] L. Neal, 'Integration of international capital markets: Quantitative evidence from the eighteenth to twentieth centuries,' *Journal of Economic History,* 45/2 (1985), pp 219–26.

[23] Y. Kaukiainen, 'Shrinking the world: Improvements in the speed of information transmission, c. 1820–1870,' *European Review of Economic History,* 5 (2001), pp 1–28, Appendix 2b.

KNOWLEDGE MANAGEMENT FOR CONNECTING BUSINESSES AND EGOVERNMENT

Kornélia Pupáková
Department of Applied Informatics and Process Control
Technical university of Košice
Bozeny Nemcovej 3, 041 00 Košice, Slovakia
e-mail: Kornelia.Pupakova@tuke.sk

Kimmo Salmenjoki, Aki Vainio
Department of Computer Science
University of Vaasa
Box 700
65100 Vaasa
e-mail: akivain@uwasa.fi

ABSTRACT

A major challenge for European governments is solving the paradox of increasing security in relation to international trade and at the same time reducing the administrative overhead produced by commercial and public administration organizations. Governments constantly increase the security and control because of the high percentage of fraud in international trade, which leads to loss of revenues. Furthermore, the threat of terrorism stresses the urgent need for extra control and security requirements. All these requirements increase the administrative load on companies and make it more difficult for them to do business across borders.

On the other hand, European Union aims to promote trade between member states. Due to that fact, it is necessary to reduce the administrative load of all the trading partners. Thus EU governments need to solve the dilemma of the high demand for control and security and at the same time decrease of administrative load burden.

The goal of this paper is to present the major focus and challenges which are addressed within one of the European Integrated Project – ITAIDE (Information Technology for Adoption and Intelligent Design of eGovernment)[1]. The focus will be oriented on a fact that IT has the potential to bring innovation to eBusiness solutions that will enable the connection of businesses and Governmental organizations in relation to cross-border trade. Knowledge management will be used as the enabler for the detection of essential data required by involved stakeholders and government, its gathering and further sharing among such a network of stakeholders.

1 INTRODUCTION

European Governments constantly increase the security and control at the international trade environment due to the high percentage of fraud leading to loss of revenues. All these Governmental requirements increase the administrative load on companies.

At the same time, EU aims to promote trade between member states. That is why; EU governments need to solve the dilemma of their high demands for control and security and at the same time decrease of administrative load burden.

In respect of ICT being widely perceived as a key component of such a solution to the dilemma of the EU governments; a creation of a sufficient and reliable physical, financial and information flows will help to increase the transparency of the essential business processes and a savoir increase both, control and efficiency.

Currently, several technological solutions for cross-border trade are being developed. However, almost each of the EU member states prefers to implement their own specifics in the eGovernment systems and this brings the challenge of how to make these systems interoperable.
Even if problems with integration of technology are solved, technology can bring only some value, if it intends to replace just the paper-based communication without re-organizing current business procedures.

In case of the ITAIDE project, the challenge of eCustoms solutions is that they have to work in an international setting. Such solutions should unite the interests of commercial companies as well as the public institutions, e.g. customs and taxation authorities, companies and supply chain service providers. This means that the development and adoption of IT-enabled eCustoms solutions presents a very complex challenge, which needs to be viewed from all the stakeholders' points of view. Only that way the proposed solution will be addressed to the dilemma of the EU governments for increased security and at the same time reduced administrative burden.

2 MAIN GOALS

ITAIDE project contributes to the vision of European governments by developing overall eGovernment innovative solutions for eCustoms and taxation.

European commission, Taxation and Customs Union has drafted a vision statement and plan for implementation of actions enabling simple and mainly paper-less environment for customs and trade. Two long-term goals were stated in a Multi-Annual Strategic Plan published in November 2003 [2].

The **first** is enabling Authorized Economic Operators (AEO), where businesses may be authorized by a public administration office to provide certain customs and tax related services within and outside the country. For these AEO companies, simplified customs and tax procedures will be applied, which will lead to a significant reduction of the administrative burden and a reduction of costs as well.

The **second goal** is the provisioning of online Single-Window Access Points (SWA) services, where businesses can do all their interactions with public administration offices with one online access point.

3 ACHIEVEMENT SEQUENCES

An essential part of the eGovernment action plan is to create the possibility to provide an on-line access to all administrative procedures. For eCustom purposes, SWA enables traders to have access to an eGovernment information portal with all government information/documentation for import and export transactions.

The enabling of AEO and SWA is a complex process, which will require efforts at EU, as well as at national levels and will include the involvement of legislative bodies and government officials and business companies. ITAIDE does not aim to directly contribute to the development of AEO and SWA. It aims to provide a set of development tools, which will facilitate the process of implementing the AEO and SWA concepts into the practice.

The ITAIDE project aims to develop an innovative approach for the interoperability between existing electronic documents based on standards implementations. The Single Window Access concept enables the elimination of redundant work and redundant data from the involved documents, e.g. it is not necessary to describe a particular piece of information several times in different documents if this information can be used from such documents. This necessitates an innovative **reuse of data** from already existing electronic documents. This possibility of reusing data predetermines the researchers for using the knowledge management approaches enabling data modeling and creation of new electronic standards concepts.

The removal of redundant data from the current classic trade and customs documents will lead to new types of interoperable electronic documents.
For this purpose, the development of a canonical model is of a great importance for the contribution to the creation of new eGovernment solutions. The canonical model enables covering all the data requirements of cross-border trading.

The canonical model bases on existing international standards. The ITAIDE canonical model will be customized to support the European customs and taxation trading requirements and will provide a technical starting point for new interoperable developments of Customs Authorities or traders.

The canonical information provides a comprehensive list of detailed pieces of information (data elements) used in the business domain and related processes. This dictionary will be made available to all involved parties and provides unique names, definitions, data format specifications (e.g. code lists), and supplementary information (such as synonym business terms) on the data elements. The canonical model – especially the message layer – is used for a syntactical and semantic mapping. Pursuant to the specified pieces of information in already existing electronic documents, a further assembly of data elements based on the data mapping principle can be carried out. By data mapping, pieces of information – building blocks - will be collected from several different existing documents and hence prepared to be used, respectively re-used for new purposes evolving from new eGovernment solutions. The building blocks range from simple element aggregations up to the level of message assembly.

4 NEED FOR RE-DESIGN

To be able to get a good understanding of the current inter-organizational processes, a description of the current AS-IS eCustom processes will be provided.
After completing the description of the AS-IS situation, the AS-IS processes will be analyzed, areas of inefficiencies and sources of administrative burden will be identified and redesign scenarios will be generated. For the generation of alternative scenarios, possibilities for trade facilitation efficiency and reduced administrative burden will be sought, among others in introducing new technology, combination of technologies, or applying the piggybacking principle.

The piggybacking principle here means reusing existing systems used currently by other processes for the process under redesign. This is crucial for the enabling of a Single Window Access solution, because at the procedural levels this requires optimal reuse of the data provided by businesses to government institutions. However, this reuse of data across various institutions processing customs, taxation and statistical data typically requires modifications in the procedures at each of these institutions.

5 DIVERSITY OF THE STAKEHOLDERS

The difficulties related to the design and adoption of eBusiness innovations within ITAIDE project are related to the international trade and eCustom innovations. A specific attention is given to the diversity and the scale of the actors involved. It is needed to distinguish between the following major types of actors, who are involved in the development and adoption of eCustoms solutions:

- citizens, who as consumers are expected to benefit indirectly through reduced tax and who at the same time have expectations for certainty of the supply of goods;
- commercial companies and supply chains;
- public administration, e.g. different national customs offices;
- standardization bodies, coordinating the standard development and actively developing international standards for taxation and customs messages;
- ICT companies.

Each of these types of actors has its own interests and characteristics, which makes the network of stakeholders diverse and implies different and even contradicting perceptions and expectations.
While commercial companies are mostly interested in adopting information technology and process redesign pursuing efficiency gains and economic interests, public administration is more interested in the issues related to control and security. Due to the diversity of the stakeholders involved it is a key challenge how to enable the process of achievement acceptable among such a network of actors.

One of the major tasks within ITAIDE in this respect will be to develop a well founded understanding of the relevant stakeholders, their roles, perspectives and incentive. It is expected to use this understanding, develop representations (i.e. models) of relevant parts and perspectives of the network and to engage with relevant players to facilitate a shared understanding of the issues and to initiate processes of negotiations among them.

6 CONCLUSION

The need for a new methodology for redesign of eCustom procedures will be examined from a modeling perspective within the ITAIDE project. This perspective is important to provide a clear view of the current situation and possible redesign scenarios.

However, in a redesign project, the socio-political perspective plays an equally if not even more important role than the modeling perspective. In the context of traditional BPR projects, many of the BPR projects fail and some of the key reasons for failure are the lack of sustained management commitment and leadership, unrealistic scope and expectations, and resistance to change. These issues relate to the social processes that take place in the redesign project and show their tremendous importance.

In eCustoms redesign projects however the challenges related to the social perspective are much harder than those in BPR projects, where only business parties are involved. Furthermore, such a redesign may affect the relationship among the different actors. These changes may be acceptable or even suitable for some actors and on the other side completely unacceptable for the others. This means that it is important to understand the social processes that can lead to alignment of interest and expectations. Furthermore, due to the specifics of the eCustoms context, there are legislative and political elements, which make this collaboration extremely challenging.

The contribution of the network approach is to develop a broad understanding of the roles and linkages of the relevant actors, including discussions about the boundaries of the network. Within ITAIDE, the processes of developing joint solutions are expected, which rely on acceptable compromises.

Knowledge management will play an essential role in the dissemination activities, where the objective is to establish connections in order to achieve visibility of the ITAIDE research results for a large number of organizations, at the governmental and business level and, in particular for SMEs. ITAIDE dissemination campaign is based on the principle of distributed networks. Research results will be first propagated into the individual nodes of the network. These results will be further forwarded in the other layers of the network of each partner. These networks include governmental organizations, SMEs, standardization bodies and the academic community.

Reference

[1] Tan Y-H., Klein S., Rukanova B., Higgins A., Baida Z. – Information Technology for Adoption and Intelligent Design for eGovernment

[2] TAXUD/477/2004 and The Role of eGovernment for Europe’s Future, COM (2003) 567: Policy reports of the European Commission - The Draft eCustoms Vision State and Multi-Annual Strategic Plan

INFORMATION SYSTEM FOR KNOWLEDGE TRANSITION IN SOFTWARE PROCESS MEASUREMENT

Jari Soini
Department of Software Engineering
Tampere University of Technology - Pori
P.O. Box 300, FIN-28101 Pori, Finland
Tel: +358 2 6272890; fax: +358 2 6272727
e-mail: jari.o.soini@tut.fi

ABSTRACT

Being successful in knowledge transition is one of the most essential factors in any organization if one wishes to succeed in business in the future. Especially in knowledge intensive organizations, like software companies, this aspect is emphasized. Existing knowledge must be easily available for all and it must be possible to bring new information easily to the awareness of everyone. Additionally, because of the fast changing business environment in software engineering, there also needs to be a way for evaluating, discussing and, if need be, improving the existing knowledge inside the organization interactively. Generating and developing, and also updating this kind of information system demands collaborative work and open communication about the knowledge system between participants, developers and users. In this paper I present the application we have developed for managing this challenging work. The paper presents the ideology behind the application and also how to utilize it in practice, in this case, by guiding software process measurement and software process improvement. The web-based application was successfully implemented in April 2007. This system is one approach to trying to solve the challenges related to the growing needs for information transfer.

1 INTRODUCTION

In a networking economy, which is typical of today's information society, the ability of organizations and their members to cooperate, interact and share their information and knowledge is a prerequisite for strategic operation [1]. The globalization of markets and the development of the communication technology create both possibilities and pressures on companies to network. Networking is considered to be one of the chief factors of modern business [2, 3, 4]. It seems that networking and collaboration between companies are effective means to enhance profit and growth [3, 5, 6]. An organization's success depends, maybe more than ever, on its ability to create and share knowledge effectively and efficiently [7]. There is a strong belief that the systematic transformation of human capital into value requires structural capital as a multiplier, to realize sustainable earnings potential for the organization [8]. This has forced companies to create a co-operation relationship with other organizations and try to increase its own learning and knowledge by utilizing the knowledge sharing which occurs during this interaction. In this paper I present one example of how to manage and collaborate on this essential but challenging topic. The application described is meant for knowledge transition and also to guide software organizations in the control of software process quality. The aim of this study is to give an empirical example of how knowledge transition can be organized in practice.

The structure of this paper is as follows: Firstly, briefly the background of the study is described in Chapter 2. In Chapter 3, I present the ideology and the structure of the application developed. Next, in Chapter 4, I discuss and evaluate the contribution of the application from the research viewpoint. Finally, the conclusions are presented in Chapter 5.

2 BACKGROUND OF THE STUDY

This study is based on the SoMe research project, which was aimed at developing a common and open measurement system for Finnish software companies to help monitor and measure the quality of their software processes and products. To promote a better understanding of measurement, the Finnish Software Metrics Association (FiSMA) [9] initiated the SoMe (Software Measurement) project in autumn 2005. FiSMA itself is a non-profit making organization created to promote the usage and utilization of software measurement to improve the quality of processes and products. Its members, and also the participants of this study, consist of nearly 40 Finnish software companies, plus several universities and other public organizations. The participants in this study consist of Finnish software companies (members of FiSMA) and two Finnish universities, the Tampere University of Technology (TUT) [10] and the University of Joensuu, (UJ) [11]. The project is funded by Tekes [12] and FiSMA [9] and coordinated and mainly implemented by the participating universities. One of the main targets of the study is to get as much experience-based information in that database as possible. Due to this, the empirical part of the research was based on a series of interviews and questionnaires, created to collect the experiences of the companies about individual metrics and measurement in general. The final outcome of the project was a measurement knowledge base consisting of a large metrics database. The expression of this final outcome was a web-based application for knowledge transition. In the next chapter, the ideology and structure of the application is described regarding the aspects that are relevant to the viewpoint of knowledge transfer and transition. There are more publications in relation to the SoMe project [13, 14] which describe in more detail the process we used of capturing, modifying, evaluating and finally sharing the knowledge via the application we developed.

3 THE INFORMATION TRANSIT TOOL FOR SOFTWARE MEASUREMENT

3.1 Ideology behind the measurement tool

The concrete outcome of the SoMe project was a web-based application, which enables individuals and organizations to utilize measurement for controlling and monitoring their software process. This application, or measurement tool, has been developed by two Finnish universities, TUT and JU, in cooperation with the Finnish software industry in a 20-month research project. The background of the research work was based on the recognized need to improve software quality. The ideology behind the measurement tool is based on the assumption that software quality, in general, is caused by and is dependent on the quality of the software development process. The accepted opinion is that most problems in software quality are based precisely on problems in the software development process [15].

Because of this, our aim has been to develop an information tool which will enable organizations to control and improve their software development process quality. Related to process quality, process assessment models like ISO/IEC 15504 process assessment model (SPICE) [16] and Capability Maturity Model Integrated (CMMI) [17] are available, which allow the evaluation of the quality of the current software development process in the organization. The core idea of assessment-based software process improvement is that software practices should be organized according to a reference model [18]. For process improvement work organizations need a deeper understanding of their own processes and to do this they need measurement data [19]. With this measurement information they can reliably seek and find improvement objects in their processes [20, 21]. This approach was selected as the starting point of the development work and it steered the development work throughout the application implementation. The basic idea for developing this measurement tool is precisely to help organizations utilize measurement knowledge to control their software development process and also to use measurement for supporting their process improvement work as well as being the source of objective information for management in their decision making. The application is primarily meant and designed for those responsible for the quality of software processes or products. The main purpose of the measurement tool is for software companies to obtain information about different metrics and their applicability to measuring different processes at all levels.

3.2 Description of the implemented measurement tool

At the beginning of the development work we set a few main goals for the final outcome. The starting point of the planning was that the application must be easy to use from a user viewpoint. The aim is that the user interface (UI) does not become an obstacle to the use of the system. In this work we consulted the TUT/Advanced Multimedia Center (AMC) department and its researchers who are specialists in software usability research. "Keep it simple" is the key when planning and developing the UI of an application. A clearly and simply defined UI, both structurally and visually, is one of the most important factors when intending to introduce some new technical tools [22]. In this work we also had a lot of co-operation with the participant organizations and the people there assumed to be the end users of the tool. This method is a good approach when developing new applications for a certain target group [23]. Secondly, closely related to the previous point, comes the structure and the use of the search taxonomy of the application. Again from a user viewpoint, but now the hidden agenda is to familiarize users with process assessment models. Based on the ideology presented above, the selected search taxonomy was created based on two well-known software process assessment models: CMMI and SPICE. The aim of this selection was to guide the organizations to familiarize themselves with and utilize these assessment models in their operations. This aspect is very important for the measurement viewpoint. The precondition for utilizing software measurement in software development work is that the software development process used has enough maturity [24, 25]. As Zahran has stated, an immature, which commonly means an unstable, process cannot measure reliably [26].

In the measurement system, the knowledge items (individual metrics) are linked to the process groups inside the assessment models. Every item also includes the information for all the process groups to which it relates, and in practice is linked. This characteristic enables the user to see the dependence between process groups from a metric viewpoint and gives important information when planning measurement activities (e.g. measurement program). These connections are also seen from the process group viewpoint, as the proper metrics depend on the selected process group in the selected assessment model (SPICE or CMMI). This realization method enhances awareness of the relationship between process assessment and process measurement. In addition to this, there is also a "word search" alternative for searching for the proper metric(s). The need for this characteristic appears when evaluating the UIs structure with project participants. This situation embodies the reason why this alternative is needed. There may be organizations who are not familiar enough with these models that they can start using the system based on them. The third starting point was the accessibility of the application. On this question our solution was a web-based application. One main reason for this solution is that we have access to and the possibility of utilizing the existing technical framework developed in a previous project, X-item, with FiSMA. This measurement tool extends the previously developed knowledge framework called "gnosis" [27].

The developed application itself works on a database, which contains information about software measurement literature and standards and also actual metrics and measurement practices used in software organizations. The metrics database consists of individual knowledge items (metrics) of information and the manifestations of these items are termed metric documents. There is a standard form used for presenting each item (metric). All metrics in the database, collected for the participants as well as metrics found in literature or standards, are modified using the same base form. The formula for the title level and the terminology used in all documents is congruent with the others. This solution helps the end user to read, perceive the logic and make a comparison between the knowledge items. There are also interactive activities built inside the system. There are several reasons for doing this. Firstly, as stated above, the nature of the environment in software engineering is rapidly changing [28]. Because of this there might be a need for adding, modifying or even deleting some information related to the existing knowledge item (metric) in the system. Also, when users use the system new experiences may arise and with this characteristic new information can be added and combined with the current item. This characteristic creates a line of communication between individuals and organizations, allowing them to share knowledge and learn from each other. The measurement tool also includes a library. A "glossary" is made to help the user if the terms or concepts related to measurement and metrics are not so familiar. The terms and concepts used are mostly based on terms and their definitions in software standards [29, 30, 31, 32]. With this selection we want to guide the organization to harmonized use of the terms related to software measurement.

4 DISCUSSION

From a software engineering point of view, the most valuable contribution in this paper relates to the ideology included the developed tool. The application guide advises the user on how to use measurement as an instrument for software process improvement. With the tool the user has the opportunity to see the connection and the dependence between software metrics and the software process groups. Becoming aware of these correlations is very important when planning, implementing or controlling the software processes or its improvement. From the viewpoint of information transition, the main contribution relates to the application itself. For both aspects, the method created as well as the way of using, the tool gives a unique way of thinking for capturing, evaluating and sharing information. This interactive tool gives an example of how issues related to information can be collected and one approach to solving its transition.

If a brief look is taken from the evaluation viewpoint, there are still a few issues to be addressed in this study. Firstly, this application is implemented only to serve to the issues related to the software measurement; the other subjects are left exposed. Secondly, the experienced knowledge of the metrics inside the database is only collected from a limited set of software companies, mostly small and medium size organizations. This fact must be taken into account when considering the given experiences for using the metrics. Related to the evaluation of the tool, the heavy emphasis on the software process assessment model which has been selected can be a factor of uncertainty for use. This approach could be unfamiliar to some of the users. This factor will be attempted to obviate with the help of the word search characteristic.

5 CONCLUSION

This paper includes a method for knowledge transition as well as for improving software quality, with the help of software application. The study is based on the already executed SoMe research project where one of they key aims was to examine how to realize the knowledge transition process between an individual and an organization in practice. The final outcome of the project resulted in a web-based measurement tool for this purpose. The measurement tool guides the users to select the relevant and proper metric(s) using the process assessment model to control development process behavior and via that offer the required information to recognize those objects which can be improved in software process. The paper describes this application, the ideology behind it and also the structure of it, in order to carry out knowledge transition, in this case, related to the software measurement. This study gives one empirical example on how to act when trying to find ways to manage and solve challenges related to the knowledge transition issues. From a software measurement viewpoint, one relevant topic for future research could be to examine how the capability or maturity level of the organization may affect the utilization of the measurement tool and how, and if, the required measurement information varies depending on the different levels. From a knowledge transition viewpoint, and also to validate the method developed and the tool itself, it could be interesting to implement for some other research subject in software engineering

References

[1] M. Iivonen, M. L. Huotari; *Trust in knowledge management and systems in organizations*. Idea Group Publishing. London. 2004.

[2] H. Hinterhuber, B. M. Levin. Strategic networks – The organization of the future, Long Range Planning. Vol. 27. pp. 43-53. 1994.

[3] C. Snow, R. Miles, H. Coleman. Managing 21st century network organizations. Organizational Dynamics. Vol. 20. No. 3. pp. 5-20. 1992.

[4] J. C. Jarillo, H. Stevenson. Co-operative strategies – The payoff and the pitfalls. Long Range Planning. Vol. 24. pp. 64-70. 1991.

[5] J. S. Whipple, J. J.Gentry. A network comparison of alliance motives and achievements. Journal of business and industrial marketing. Vol. 15. No. 5. pp. 301-322. 2000.

[6] I. Kulmala, A. Vahteristo, E. Uusi-Rauva. Ohjelmistoyritysten verkostoituminen – tutkimus suomalaisten ohjelmistoyritysten toimintatavoista ja tavoitteista. *Research raport* 3/2002. Tampere University of Technology. Tampere. Finland. 55 p. 2002.

[7] T. H. Davenport, L. Prusak.. *Working knowledge: How organizations manage what they know*. Boston. MA: Harvard Business School Press. 1998.

[8] L. Edvinsson, B. Kitts, T. Beding. The next generation of IC measurement: The digital IC landscape. Journal of Intellectual Capital. Vol. 1, No. 3. pp. 263-272. 2000.

[9] FISMA, Finnish Software Measurement Association. Retrieved 7/15/07 World Wide Web, http://www.fisma.fi/eng/index.htm]

[10] TUT, Tampere University of Technology, Retrieved 8/12/07 World Wide Web, http://www.tut.fi/public

[11] UJ, University of Joensuu, Retrieved 5/9/07 World WidWeb,http://www.joensuu.fi/englishindex.html

[12] Tekes, Finnish Funding Agency for Technology and Innovation, Retrieved 8/13/07 World Wide Web, http://www.tekes.fi/eng/

[13] J. Soini, T. Varkoi, V. Tenhunen, M. Tukiainen. Empirical case study of software metrics using the SPICE framework. *Proc. SPICE'07*. Seoul. Korea. 2007.

[14] J. Soini, V. Tenhunen, T. Mäkinen. Managing and Processing Knowledge Transfer between Software Organizations: A Case Study. *Proc. PICMET'07*. Portland. USA. 2007.

[15] T. Conti. *Building Total Quality: A quide for management*. New York. Chapman & Hall. 1993.

[16] ISO/IEC 15504-5:2006 Information Technology - Process Assessment - Part 5: An exemplar Process Assessment Model. 2006.

[17] CMMI for Systems Engineering/Software Engineering. Version 1.02 CMU/SEI-2000-TR-029. Carnegie Mellon University. SEI 2000.

[18] W. S. Humphrey. *Managing the Software Process*. In: SEI Series in Software Engineering. Massachusetts. Addison-Wesley Publishing Company. 1989.

[19] E. Rodenbach, F. van Latum, R. van Solingen. SPI – A Guarantee for Success? – A Reality Story from Industry. *Proc. Profes 2000*, Eds. F. Bomarius & M. Oivo. Oulu. Finland. 2000.

[20] L. Briand, C. Differding, D. Rombach. Practical Guidelines for Measurement Based Process Improvement. Software process Improvement and Practice Journal. Vol. 2. No. 4. pp. 253-280, 1997.

[21] T. Dybå. An Instrument for Measuring the Key Factors of Success in Software Process Improvement. Empirical Software Engineering. Vol. 5. No. 4. pp. 357-390. 2000.

[22] S. Badker. *Through the Interface. A Human Activity Approach to UserInterface Design*. New Jersey. Lawrence Erlbaum Associates. Inc. 1991.

[23] M. Huysman, D. de Wit. *Knowledge sharing in practice*. Kluwer Academic Publishers. 2002.

[24] J. Baumert, M. McWhinney. Software measures and the Capability Maturity Model. Software Engineering Institute, *Technical Report*, CMU/SEI-92-TR-25, ESC-TR-92-0. 1992.

[25] S. L. Pfleeger. *Software Engineering: Theory and Practice*. Prentice Hall. USA. 1998.

[26] S. Zahran. *Software Process Improvement: Practical Guidelines for Business Sucess*. Addison-Wesley Longman Ltd. Essex. UK. 1998.

[27] M. Haavikko, M. Johansson, T. Mäkinen, R. Nevalainen, I. Saastamoinen, M. Tukiainen, T. Varkoi. Gnosis – An approach for SPI knowledge management. *Proc. SPICE'04*. Lisbon. Spain. 2004.

[28] R. Petty, J. Guthrie. Intellectual Capital literature review – measurement reporting and management. Journal of Intellectual Capital. Vol. 1. No. 2. pp. 155-176. 2000.

[29] ISO 9000-3 (1997). Guidelines for the application of ISO 9001:1994 to the development, supply, installation and maintenance of computer software. Internal Organization for Srandardization. 1997.

[30] ISO/IEC 9126-3, 2003. Software engineering – Product quality – Part 2: External metrics. Technical report.

[31] ISO/IEC 9126-3, 2003. Software engineering – Product quality – Part 2: Inernal metrics. Technical report.

[32] IEEE Std 1061-1998. IEEE Standard for Software Quality and Metrics Methodology. IEEE-SA Standard Board. 1998.

EVALUATING THE CORRELATION BETWEEN CODE QUALITY, SOFTWARE SIZE AND EFFORT

Aleš Živkovič[1], Marjan Heričko[1], Zoltán Porkoláb[2]
[1] University of Maribor, Faculty of Electrical Engineering and Computer Science, Smetanova 17, SI-2000 Maribor, Slovenia
[2] Eötvös Loránd University, Faculty of Informatics, Pázmány Péter sétány 1/C , H - 1117 Budapest, Hungary
E-mail: {ales.zivkovic, marjan.hericko}@uni-mb.si, gsd@elte.hu

ABSTRACT

The software size is the fundamental metric for project planning. Based on the size estimate, effort and duration are calculated. However, for the same software size, the actual effort could be significantly different. The question is wheather the increase in effort is due to the low productivity of the development team or higher product quality. In the research presented in the paper, the focus is on the correlation between the quality and productivity. This paper presents the basic idea and describes the tool that was developed to collect product metrics based on the .NET common intermediate language. The metrics are used to calculate the quality index. The index is then used to weight the performance value.

1 INTRODUCTION

Software size is an elementary measure often used to calculate project effort, costs, productivity and duration. In practice, the actual effort measured during the project development time could be significantly different although the estimated project size is the same. The effort is influenced by several factors like complexity of the solution, development team size, development platform, etc. In this research the focus is on the quality that could as well influence the project total effort. The quality is defined as the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs. [ISO 8402: 1986, 3.1]. In terms of measures, it is a collection of metrics that cover categories like functional correctness, supportability and maintainability, efficency, portability, usability and dependability. The number of metrics used to determine product quality is not well defined and it could range from just a few to hundred and more. In contrast there is the idea of a single number that express quality - the quality index (QI). The quality index is based on the 20/80 rule. According to some findings, 20 % of the variables can capture 80 % of the intrinsic quality. The second principle behind the quality index is conssistency and repeatability. If we perform the same procedure over and over again it will provide us with the insight to the product quality regardless of its accuracy. However, the standard deviation of the accuracy should be low. In this research the code quality is measured in order to justify the deviations in project effort. Besides the productivity, also code quality should be evaluated when comparing the performance of the development teams. The general functional relation between the productivity and software size is:

$$P = \frac{E}{S}$$

where E is actual effort spend developing some functionality and S is the total size of the functionality in question. For software size estimation, different methods are used [6, 10], all of which have their roots in the Function Point Analysis (FPA) method. Albrecht [1, 4] introduced this method in 1979. Since then, it has become the most important method for software size estimation. The method introduced a specific way of representing a software system and distinguished between data functions and transactional functions. The method was intended for all domains, although in practice, its accuracy is different within different domains. From a practical standpoint, it can be concluded that the FPA method application is more difficult with object-oriented projects. The elements and constructs of the FPA method are not directly applicable to object-oriented concepts also used within the .NET framework. Therefore, a mapping of object-oriented concepts into FPA elements is needed. The mapping is not defined within the FPA method itself and is consequently not uniform. Different authors have proposed different mapping functions [2, 3, 9, 12], mostly in the form of additional rules. Information is gathered from different diagrams (e.g. Use Case diagrams, class diagrams, sequence diagrams) which are considered separately. More detailed research has shown that the weight factors of the standard FPA method have to be calibrated for use in object-oriented projects [2, 3, 12]. Consequently, several FPA-like methods were developed that map object concepts into metrics similar to function points. Sneed proposed Object Points and Minkiewicz developed Predictive Object Points. The results are therefore incomparable to those calculated within the original FPA method. Additional

adjustment factors are needed that have to be proven statistically.
This paper is divided into four sections. In the next section, the FPA method is briefly presented. The product metrics are introduced in section three. Section four presents the tool that was developed to collect the metric data. The last section summarizes the findings and discusses the potential direction for future work.

2 FUNCTION POINT ANALYSIS METHOD

The FPA method is declared as technologically independent and can be used on artifacts from the late analysis phase. The use of the method in early stages is also possible [5, 11] with the use of historical data and statistics. In this paper, the topic of early estimates is not discussed. In practice, the use of the FPA method proved to be more difficult with object-oriented projects. The reason for that is the gap between object-oriented concepts and the FPA abstraction of the software system. The FPA method is based on its own concepts describing a software system. The abstraction of the software system is gained by the standard separation in two parts: one part considers the data's influence and another part takes into account the functionality of the system. Data functions (DF) are further divided into internal and external logical files (ILF and EIF) assigning different weights to each data function type. The transactional functions (TF) describe functionality through three abstract types, namely: external inputs (EI), external outputs (EO) and external inquiries (EQ). To be able to determine the contribution of the FPA element (ILF, EIF, EI, EO or EQ) to the final estimated size value, the complexity is assigned to each element. The complexity is determined by the number of simple data elements named Data Element Type (DET) or structured elements named Record Element Types (RET). To get actual values in Function Points (FP), the tables defined in the method are used. The FPA abstraction concept is easily applied to structured analysis and design artifacts. The mapping of entities, attributes and processes to FPA elements is straightforward. With object-oriented design mapping is not that obvious. Therefore, several researchers [2, 3, 9, 12] proposed additional rules on how to use the FPA method with object-oriented concepts.

3 PRODUCT METRICS

In the software engineering community the term metric has been used in many distinct ways. For the purpose of this research, metrics is defined as a function, whose value is derived from a product, process or resource. It is important to distinguish between objective and subjective metrics. An objective metric is a function whose inputs are software data (elements) and whose output is a single numerical value. Subjective metrics, on the other hand, attempt to track less quantifiable data and usually depend on the subjective judgment. When speaking about quality metrics the obtained metric value indicates the degree to which software possesses a given quality attribute. Therefore quality metrics are an indirect measure of software quality. We need validated metrics, metrics whose values have been proven to be statistically associated with corresponding software attributes. For object-oriented software the following metrics are often used:

- Weighted Methods per Class (WMC) - the sum of the complexities of the methods of a class (if all method's static complexities are considered to be unity, the number of methods)
- Depth of Inheritance Tree (DIT) - depth of inheritance of the class
- Number Of Children (NOC) - the number of immediate sub-classes subordinated to a class in the class hierarchy
- Response For a Class (RFC) - the sum of the number of its methods and the total of all other methods that they directly invoke
- Coupling Between Objects (CBO) - the number of non-inheritance related couples with other classes (class is coupled with another if its methods use the attributes of the other class)
- Lack of Cohesion in Methods (LCOM) - the number of disjoint sets produced from the intersection of the sets of attributes that are used by the methods reduced by the number of method pairs acting on at least one shared attribute
- Method Hiding Factor (MHF) - sum of the invisibilities of all methods defined in all classes / total number of methods
- Attribute Hiding Factor (AHF) - sum of the invisibilities of all attributes defined in all classes / total number of attributes
- Method Inheritance Factor (MIF) - sum of inherited methods / total number of available methods
- Attribute Inheritance Factor (AIF) - sum of inherited attributes / total number of available attributes
- Polymorphism Factor (POF) - actual number of possible different polymorphic situation / maximum number of possible distinct polymorphic situation
- Coupling Factor (COF) - actual number of couplings not imputable to inheritance / maximum possible number of couplings

4 TOOL FOR COLLECTING DATA

In order to collect and analyses data, the tool in the Microsoft .NET framework 2.0 was developed (see Figure 2). The input is arbitrary executable format for the Microsoft platform.

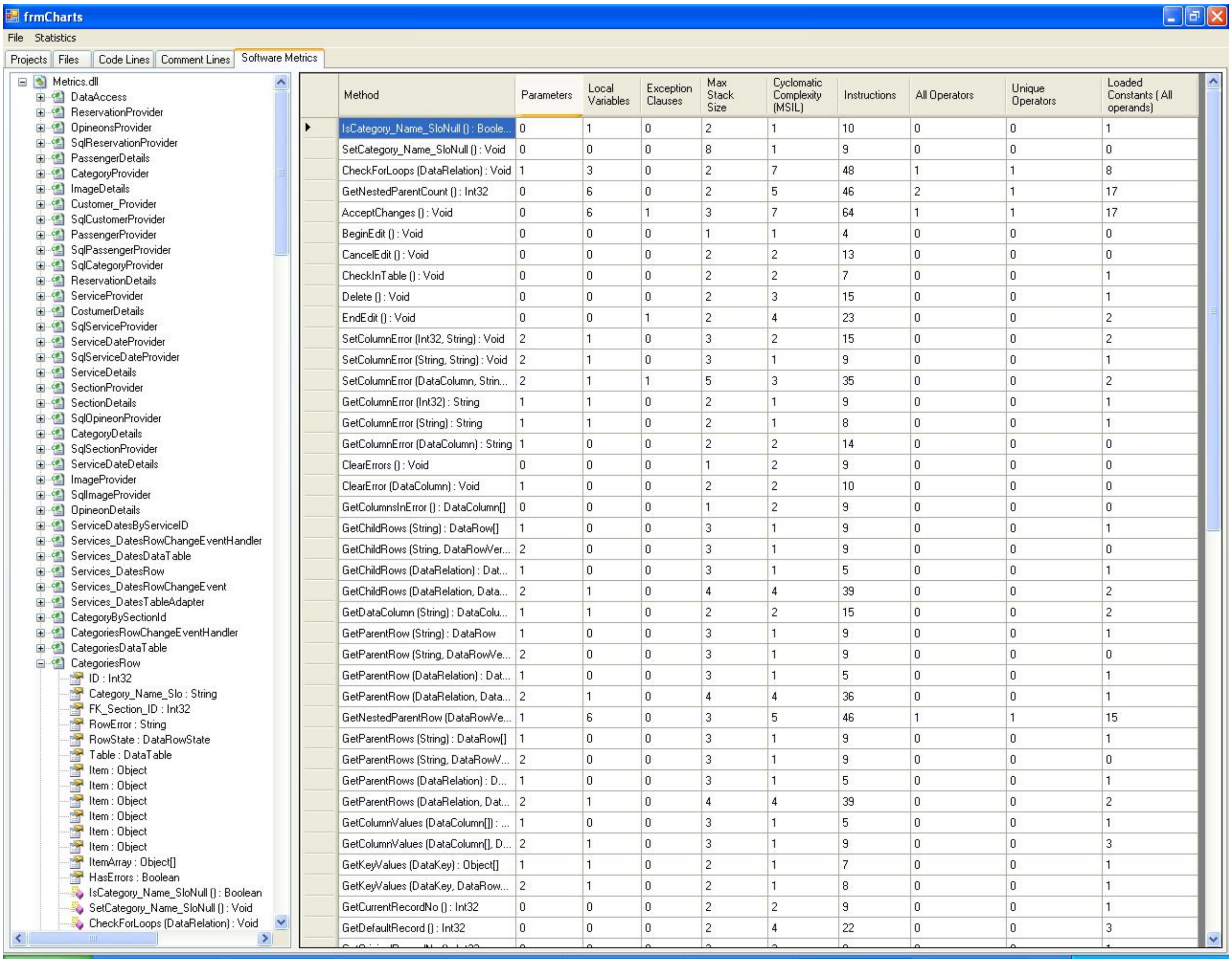


Figure 2: *The Tool for Collecting Product Metrics*

Table 1: The Metric Data Collected by the Tool

Class Level	Method Level
number of methods	number of parameters
number of properties	number of local variables
number of constructors	number of exception blocks
number of nested classes	max stack size
number of data fields	cyclomatic code complexity
number of events	number of instructions
number of attributes	number of all operators in the method
the number of all instructions	number of distinct operators
max cyclomatic complexity of all methods within the class	number of operands
interface (true/false)	
abstract (true/false)	

The parser that is a part of the tool performs analysis directly on the common intermediate language code as defined in the .NET framework (see Figure 1). In addition to the metrics presented in section three, the tool collects the data presented in Table 1The results are exportable to the XML or text format.

Based on the collected data and the quality metrics presented in section two, the correlation between the project size, effort and code quality was investigated. The metrics proposed for the comparison of productivity and quality are listed in the previous section. The empirical validation of the proposed metrics will enable the construction of the most efficient metrics subset. The results should give different perspective on the individual's or team's performance. The project manager should then be able to distinguish between the low productivity with good quality and low productivity with bad quality as the latter will impact one or more of the following: product maintainability, required effort for testing and product performance results.

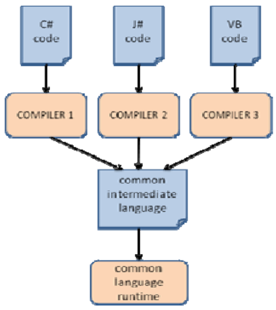


Figure 1: *The .NET Intermediate Language*

5 THE PROPOSED APPROACH

Figure 3 shows the proposed approach for evaluating the development team performance. In the analysis phase the project size and effort are calculated based on the UML models and projects characteristics. In the implementation phase the code analysis is performed and acctual effort data collected. Based on the code analysis that takes into consideration all four parameters (softwere size, estimated project effort, acctual project effort and code quality), the team's performace could be calculated as:

$$PER = \frac{E}{S} * QI = P * QI$$

where PER is team's performance, P is productivity, E is acctual effort, S is software size and QI is quality index. The QI is defined as:

$$QI = \frac{\sum_{i=1}^{n} PMQR_i}{n}$$

where PMQR is product metric quality rating. Product metrics that were considered in this research are described in section two. Quality rating is described for each metrics seperately and could have values between 0 and 10. QI is composed of n product metrics. The number of metrics and its type should be defined accordint to the project and environment characteristics.

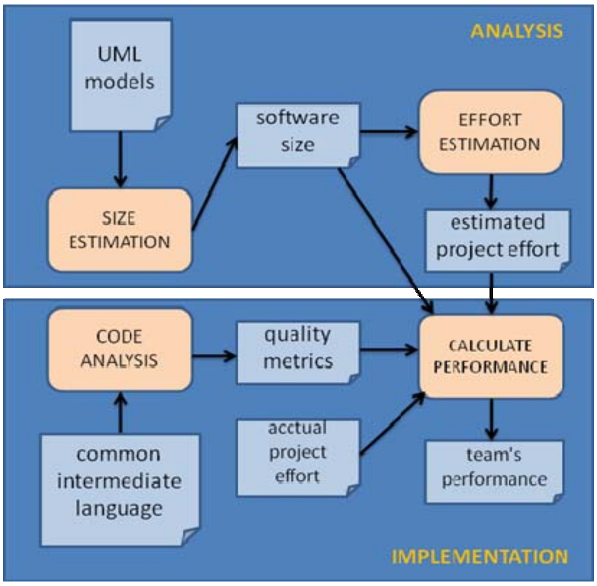


Figure 3: The Scematic View on the Proposed Approach

6 CONCLUSION

The quality of code could influence the amount of development effort and consequently increase or lower the development productivity rating. However, the productivity should not be the only metrics upon which the developer performance is evaluated. In this paper the idea of combing the software size and effort estimated with product quality is presented. The tool developed in .NET framework collects metrics data directly on the .NET common intermediate language. The collected data is used to calculate selected object-oriented metric. The preliminary analysis on several .NET projects showed that the correlation between the size, effort and code quality exists. The selected set of metrics should be empirically evaluated and tested upon different sets of metrics in order to prove the correctness selection. The defined metric set should then be used when evaluating development productivity or predicting project effort based on the estimated software size.

References

[1] Albrecht,A., 1979. Measuring Application Development Productivity, IBM Applications Development Symposium, pp. 83-92.

[2] Antoniol,G., Lokan,C., Caldiera,G., and Fiutem,R., 1999. A Function Point-Like Measure for Object-Oriented Software, Empirical Software Engineering, 4 (1999), pp. 263-287

[3] Antoniol,G., Fiutem,R., and Lokan,C., 2003. Object-oriented function points: An empirical validation, Empirical Software Engineering, 8 (2003), pp. 225-254

[4] IFPUG, 2004. Function Point Counting Practices Manual, Release 4.2, International Function Point Users Group, Princeton Junction, USA, January 2004

[5] ISBSG, 2001. Practical Project Estimation, A toolkit for estimating software development effort and duration. International Software Benchmarking Standards Group

[6] Jeffery,D.R., Low,G.C., and Barnes,M., 1993. A Comparison of Function Point Counting Techniques, IEEE Transactions on Software Engineering, 19 (1993), pp. 529-532

[7] Lokan,C., 1999. An empirical study of the correlations between function point elements, Proceedings of METRICS '99: Sixth International Symposium on Software Metrics, pp. 200-206

[8] Lokan,C.J., 2000. An empirical analysis of function point adjustment factors. Information and Software Technology, 9 (2000), pp. 649-659

[9] Uemura,T., Kusumoto,S., and Inoue,K., 2001. Function-point analysis using design specifications based on the Unified Modelling Language. Journal of Software Maintenance and Evolution-Research and Practice, 13 (2001), pp. 223-243

[10] Živkovič,A., Heričko,M., and Kralj,T., 2003. Empirical assessment of methods for software size estimation. Informatica (Ljubljana), 4 (2003), pp. 425-432

[11] Živkovič,A., Heričko,M., Brumen B., Beloglavec S., Rozman I., 2005a. The Impact of Details in the Class Diagram on Software Size Estimation, Informatica (Lithuania), 16 (2), 2005

[12] Živkovič, A., Rozman, I., Heričko, M., 2005b. Automated Software Size Estimation based on Function Points using UML Models, Information & Software Technology, Volume 47, Issue 13, October 2005, 881 - 890

Acknowledgement

This work was realised as a part of the Slovenian-Hungarian bilateral research project BI-HU/06-07-01 Application of OO Metrics to estimate .NET project software size.

COMPARATIVE STUDY OF ID-BASED AUTHENTICATED KEY AGREEMENT PROTOCOLS FROM PAIRINGS

Marko Hölbl, Tatjana Welzer Družovec*, Hannu Jaakkola***
*Faculty of electrical engineering and computer science
University of Maribor
Smetanova ulica 16, 2000 Maribor, Slovenia
e-mail: marko.holbl@uni-mb.si
** Tampere University of Technology, Pori
Pohjoisranta 11 A, 28100 Pori, Finland

ABSTRACT

Authenticated key agreement protocols from pairing enable two or more entities establish a shared secret key. The key is subsequently used to achieve a cryptographic goal, like confidentiality or integrity. The paper deals with comparison of the majority of ID-based key agreement protocols employing pairings from the efficiency and security point of view. The intent of the comparison is to get an overview of the current research state and to clarify which protocol is the most efficient and most secure.

1 INTRODUCTION

Key establishment is a process with help of which two or more entities establish a shared secret key. The key is subsequently used to achieve confidentiality or integrity. A common division of key establishment protocols can be as follows: key transport protocols where one entity generates the key and transfers in to the other entity and key agreement protocols in which both entities contribute data to establish a shared secret key. In the paper we focus on key agreement protocols for the asymmetric (public-key) two-entity setting.

Suppose two honest entities A and B establish a key agreement protocol. We say that a key agreement protocol provides implicit key authentication if entity A is assured that not other entity besides entity B can learn the value of a particular secret key. A protocol which provides implicit key authentication for both entities A and B is called an authenticated key agreement protocol (AK).

In 1984, Shamir introduced the concept of identity-based cryptosystem [18], which has the property that a user's public key is an easily calculated function of his identity (e.g. email address, phone numbers, office locations, etc.), while a user's private key can be calculated for him by a trusted party, referred to key generation centre (KGC). We focus on a subgroup of AK protocols which use pairing operations. Based on the Weil or Tate paring, Smart[22], Chen-Kudla [5], Scott [17], Shim [19] and McCullagh-Barreto [14] and others [3], [16], [27], [29], [7], [25], [13] designed identity based authenticated key agreement protocols. Some of the protocols were found to have security weaknesses [4], [7], [13], [20], [23], [26], [28]. Still it remains to be an open problem to design efficient secure identity based and authenticated key agreement protocols.

The paper deals with comparison regarding security and efficiency of ID-based authenticated key agreement protocols from pairings. The rest of the paper is organized as follows: In chapter 2 preliminaries are given including bilinear maps, security properties and efficiency properties. Chapter 3 very briefly discusses the protocols which are later compared in chapter 4. The comparison in chapter 4 is conducted in regard to efficiency, security and known attacks. A brief conclusion is given in chapter 5.

2 PRELIMINARIES

2.1 Bilinear maps

In this section, we describe in a more general format the basic definition and properties of the pairing: more details can be found in Joux [12] and Boneh-Franklin [1]. Let G_1 and G_2 denote two groups of prime order q. G_1, with an additive notation, denotes a subgroup of the group of points on an elliptic curve. G_2, with a multiplicative notation, denotes a subgroup of the multiplicative group of a finite field. A pairing is a computable bilinear map between these two groups. Two pairings have been studied for cryptographic use, namely the Weil pairing [15], [21] and a modified version [1], [24] and the Tate pairing [9], [10], [11]. For our purpose, let $\hat{e}$ denote a general bilinear map $\hat{e}: G_1 \times G_1 \rightarrow G_2$; which satisfies the following three properties:

1. *Bilinear:* If $P, Q \in G_1$ and $a, b \in Z_q^*$, then $\hat{e}(aP, bQ) = \hat{e}(P, Q)^{ab}$.
2. *Non-degenerate:* There exist non-trivial points $P, Q \in G_1$ both of order q such that $\hat{e}(P, Q) \neq 1$.
3. *Computable:* If $P, Q \in G_1$, $\hat{e}(P, Q) \in G_2$ is efficiently computable (in polynomial time).

We say that G_1 is a bilinear group if the group action in G_1 can be computed and there exists a group G_2 and an efficiently computable bilinear map $\hat{e}: G_1 \times G_1 \rightarrow G_2$ as above. Concrete examples of bilinear groups are given in [3], [12].

2.2 Security properties

For a sound key agreement protocol, we need to define particular properties, which are described in detail in [1]. We assume A and B are two honest entities. It is desirable for authenticated key agreement protocols to possess the following security attributes [5]:

- *Known-Key Secrecy:* In each round of key agreement protocol, A and B should generate a unique secret key. Each key generated in one protocol round is independent and should not be exposed if other secret keys are compromised, i.e. the compromise of one session key should not compromise other session keys.
- *Forward Secrecy:* If long-term private keys of one or more of the entities are compromised, the secrecy of previously established session keys should not be affected. We say that a system has *partial forward secrecy* if the compromise some but not all of the entities long-term keys can be corrupted without compromising previously established session keys, and we say that a system has *perfect forward secrecy* if the long-term keys of all the entities involved may be corrupted without compromising any session key previously established by these entities.
- *Key-Compromise Impersonation:* Assume that A and B are two principals. Suppose A's secret key is disclosed. Obviously, an adversary who knows this secret key can impersonate A to other entities (e.g. B). However, it is desired that this disclosure does not allow the adversary to impersonate other entities (e.g. B) to A.
- *Unknown Key-Share:* After the protocol, A ends up believing he shares a key with B, and B mistakenly believes that the key is instead shared with an adversary. Therefore, a sound authenticated key agreement protocol should prevent the unknown key-share situation.
- *Key Control:* The key should be determined jointly by both A and B. Neither A nor B can control the key alone.

In some case, in the ID-Based system, we need Perfect Forward Security - Non-Escrow: Even the KGC is compromised, the previously established session keys are not compromised.

2.3 Efficiency properties

Desirable efficiency properties of authenticated key agreement (AK) protocols include:

- minimal number of passes (the number of messages exchanged in run of the protocol)
- low computational overhead
- low communicational overhead (data transmitted)

3 CURRENT PROTOCOLS

In our comparison the following protocols will be included:

- Smart's protocol [22]
- Chen-Kudla's protocol [5]
- Scott's protocol [17]
- Shim's protocol [19]
- Ryu-Yoon-Yoo's protocol [16]
- McCullagh-Barreto's protocol [14]
- Xie's Protocol's protocol [27]
- Boyd-Mao-Peterson's protocol [3]
- Yuan-Li's protocol [29]
- Choie-Jeong-Lee's protocol I [7]
- Choie-Jeong-Lee's protocol II [7]
- Wang's protocol [25]
- Li-Yuan-Li's protocol I [13]
- Li-Yuan-Li's protocol II [13]

A detailed description of every protocol would exceed the boundaries of the paper. Therefore the reader is advised to look-up the appropriate reference.

Nevertheless, we give the structure that is common to all protocols. An ID-based authenticated key agreement protocol is commonly specified by three algorithms: *Setup, Extract, and Key Agreement*. Some of them are based on Weil, some on the Tate pairing. The system setup and extract phases are common to many of the discussed protocols. The two phases set-up the environment and the needed parameters for the later key agreement. Most protocols differ in the key agreement phase in which the key is derived that is later used for securing the transmitted data. Based on the analysis of the structure of the protocol, published attacks and authors claims about security properties a comparison is conducted in the sequel chapter.

4 COMPARISON

In this section we perform a comparison of efficiency and security of the reviewed protocols which serves as a basis for later attacks and the development of a new ID-based protocol from pairing.

4.1 Efficiency

An important factor when assessing a protocol is its efficiency. ID-based AK protocol using pairings share different performance properties and can be measured by counting operations required per protocol run. Different operations require different computation effort. More expensive operations include: pairing operations (PairOp), exponentiation in G_2 (Exp), scalar multiplications in G_1 (ScMul) and multiplications in G_2 (Mul). Other computations operations, which are less expensive include: point additions in G_1 (Add) and map-to-point hash operation (Hash).

Table 1: *Computation effort per user*

Protocol	***PairOp***	***Mul***	***Exp***	***Add***	***Hash***

Smart	2	2	0	0	1
Chen-Kudla	1	2	0	1	1
Scott	1	2	1	1	0
Shim	1	2	0	2	1
Ryu-Yoon-Yoo	1	2	0	0	1
McCullagh-Barreto	1	1	1	0	0
Xie's Protocol	2	2	1	1	0
Boyd-Mao-Peterson	1	2	0	0	2
Yuan-Li	1	3	0	2	1
Choie-Jeong-Lee I	2	4	0	0	1
Choie-Jeong-Lee II	2	4	0	0	2
Wang	1	3	0	0	3
Li-Yuan-Li I	1	3	2	0	0
Li-Yuan-Li II	1	3	2	1	0

PairOp - pairing operations
ScMul - scalar multiplications in G_1
Mul - elliptic curve multiplication
Exp - exponentiation in G_2
Add - point additions in G_1
Hash - map-to-point hash operation

As can be seen from table 1 the protocols have different efficiency characteristics. The most efficient is Ryu-Yoon-Yoo's protocol, Boyd-Mao-Peterson's protocol and McCullagh-Barreto's protocol. The least efficient protocols are: Choie-Jeong-Lee's protocol and Xie's Protocol. The rest are intermediate regarding efficiency. As can be observed newer protocols do not necessarily offer better performance (e.g. Xie's Protocol)

4.2 Security

Security properties are the most important ones when dealing with key agreement protocols. We sum up the security properties in table 2. We do not list the property of key control, because all the schemes discussed in this paper hold this property at the same level. Later we give published attacks or weaknesses for each protocol. Despite the fact that a protocol fulfils particular security properties it can not be used, if a weakness or attack was published.

Table 2: *Security properties*

Protocol	***KKS***	***PeFS***	***PaFS***	***KCI***	***UKS***
Smart	+	-	+	+	+
Chen-Kudla	+	+	+	+	+
Scott	+*	+	+	-	+*
Shim	+	+	+	+	+
Ryu-Yoon-Yoo	+	+	+	-	+
McCullagh-Barreto	+*	+	+	-	+*
Xie's Protocol	+	+	+	+	+
Boyd-Mao-Peterson	+	+	+	-	+
Yuan-Li	+	+	+	+	+
Choie-Jeong-Lee I	+	+	+	+	+
Choie-Jeong-Lee II	+	+	+	+	+
Wang	+	+	+	+	+
Li-Yuan-Li I	+*	+*	+*	+*	+*
Li-Yuan-Li II	+*	+*	+*	+*	+*

KKS - Known-Key Secrecy PeFS - Perfect Forward Secrecy
PaFS - partial forward secrecy KCI - Key-Compromise Impersonation
UKS - Unknown Key-Share KC - Key Control
* - there is no an acceptable proof

Most protocols conform to the above security properties (see table 2). Exceptions are: Ryu-Yoon-Yoo's protocol, Smart's protocol and McCullagh-Barreto's protocol. None the less, many authors do not offer proofs for the claimed security properties.

4.2.1 Known attacks

Some of the reviewed protocols have been shown to have serious security flaws, which were exploited for attacks. For some of the presented protocols no attacks have been published so far: Scott's protocol, Boyd-Mao-Peterson's protocol, Yuan-Li's protocol, Choie-Jeong-Lee's protocols, Wang's protocol and Li-Yuan-Li's protocols. An attack was presented on Shim's protocol. Two attacks were published for Smart's and McCullagh-Barreto's protocol. The worst case regarding published attacks applied to protocol of Ryu-Yoon-Yoo and Xie's Protocol. Some of the protocols were security patches of existing protocols and nevertheless they were shown to be flawed (i.e. Ryu-Yoon-Yoo's protocol).

Table 3: *Known attacks*

Protocol	***Attacks***
Smart	- Shim's key-compromise impersonation attack [20] - Cheng et et al.'s attack [6]
Chen-Kudla	- Cheng et al.'s attack [6]
Scott	/
Shim	- Sun-Hsieh's man-in-the-middle attack [23]
Ryu-Yoon-Yoo	- Wang et al.'s key-compromise impersonation attack [26] - Yuan-Li's reveal attack [29] - Yuan-Li's key compromise impersonation attack [29]
McCullagh-Barreto	- Xie's key compromise impersonation attack [28] - Choo's attack [8]

Xie's Protocol	- Li-Yuan-Li's man-in-middle attack [13] - Li-Yuan-Li's key compromise impersonation attack [13] - Shim's key compromise impersonation attack [20]
Boyd-Mao-Peterson	/
Yuan-Li	/
Choie-Jeong-Lee I	/
Choie-Jeong-Lee II	/
Wang	/
Li-Yuan-Li I	/
Li-Yuan-Li II	/

When a protocol suffers from attacks, it can not be used anymore nevertheless it conforms to the above presented security properties.

5 CONCLUSION

We presented an up-to-date comparison of the majority of authenticated key agreement protocol from pairing. The comparison was from the efficiency and security point of view. It can be observed that Boyd-Mao-Peterson's protocol is the most efficient and at the same time secure from the security properties point of view and the attack's point of view (no attack are known for the protocol). Nevertheless, much more analysis and research has to be conducted in developing new protocols and analysis the existing ones.

References

[1] Blake-Wilson, S., Johnson, D., Menezes, A.: Key agreement protocols and their security analysis (Extended abstract). Cryptography and Coding, Proceedings 1355 (1997) 30-45

[2] Boneh, D., Franklin, M.: Identity-based encryption from the Weil pairing. Siam Journal on Computing 32 (2003) 586-615

[3] Boyd, C., Mao, W.B., Paterson, K.G.: Key agreement using statically keyed authenticators. Applied Cryptography and Network Security, Proceedings 3089 (2004) 248-262

[4] Cheng, Z., Chen, L.: On security proof of McCullagh Barretos key agreement protocol and its variants. International Journal of Security and Networks 2 (2007) 251-259

[5] Chen, L., Kudla, C.: Identity Based Authenticated Key Agreement Protocols from Pairings. Cryptology ePrint Archive, Vol. 2002/184 (2002)

[6] Cheng, Z., Nistazakis, M., Comley, R., Vasiu, L.: On The Indistinguishability-Based Security Model of Key Agreement Protocols-Simple Cases. Cryptology ePrint Archive, Vol. 2005/129 (2005)

[7] Choie, Y.J., Jeong, E., Lee, E.: Efficient identity-based authenticated key agreement protocol from pairings. Applied Mathematics and Computation 162 (2005) 179-188

[8] Choo, K.K.R.: Revisit Of McCullagh-Barreto Two-Party ID-Based Authenticated Key Agreement Protocols. International Journal of Network Security 1 (2005) 154- 160

[9] Frey, G., Mller, M. and Rock, H., The Tate pairing and the discrete logarithm applied to elliptic curve cryptosystems. In IEEE Transactions on Information Theory, 45(5):1717-1719, 1999.

[10] Galbraith, S., Supersingular curves in cryptography. In Advances in Cryptology - Asiacrypt 01, LNCS 2248, pages 495-513, Springer-Verlag, 2001.

[11] Galbraith, S.D., Harrison, K. and Soldera, D. Implementing the Tate Pairing. In ANTS 2002, pages 324-337, 2002.

[12] Joux, A.: A one round protocol for tripartite Diffie-Hellman. Algorithmic Number Theory 1838 (2000) 385-393

[13] Li, S., Yuan, Q., Li, J.: Towards Security Two-part Authenticated Key Agreement Protocols. Cryptology ePrint Archive, Vol. 2005/300 (2005)

[14] McCullagh, N., Barreto, P.S.L.M.: A new two-party identity-based authenticated key agreement. Topics in Cryptology - Ct-Rsa 2005, Proceedings, Vol. 3376 (2005) 262-274

[15] Menezes, A., Okamoto T. and Vanstone, S., Reducing elliptic curve logarithms to logarithms in a finite field. In IEEE Transactions on Information Theory 39, pp.1639- 1646, 1993.

[16] Ryu, E.K., Yoon, E.J., Yoo, K.Y.: An efficient ID-Based authenticated key agreement protocol from pairings. Networking 2004 3042 (2004) 1458-1463

[17] Scott, M.: Authenticated ID-based Key Exchange and remote log-in with simple token and PIN number. Cryptology ePrint Archive, Vol. 2002/164 (2002)

[18] Shamir, A.: Identity-Based Cryptosystems and Signature Schemes. Advances in Cryptology: Proceedings of CRYPTO 84 (1985) 47

[19] Shim, K.: Efficient ID-based authenticated key agreement protocol based on Weil pairing. Electronics Letters 39 (2003) 653-654

[20] Shim, K.A.: Cryptanalysis of Two ID-based Authenticated Key Agreement Protocols from Pairings. Cryptology ePrint Archive, Vol. 2005/357 (2005)

[21] Silverman, J.H., Advanced topics in the arithmetic of elliptic curves, Graduate Texts in Math., vol. 151, Springer-Verlag, Berlin and New York, 1994.

[22] Smart, N.P.: Identity-based authenticated key agreement protocol based on Weil pairing. Electronics Letters 38 (2002) 630-632

[23] Sun, H.M., Hsieh, B.T.: Security Analysis of Shim's Authenticated Key Agreement Protocols from Pairings. Cryptology ePrint Archive, Vol. 2003/113 (2003)

[24] Verheul, E., Evidence that XTR is more secure than supersingular elliptic curve systems. In Advances in Cryptology - EUROCRYPT 2001, LNCS 2045, pages 195-210, Springer-Verlag, 2001.

[25] Wang, Y.: Efficient Identity-Based and Authenticated Key Agreement Protocol. Cryptology ePrint Archive, Vol. 2005/108 (2005)

[26] Wang, S.B., Cao, Z.F., Bao, H.Y.: Security of an efficient ID-based authenticated key agreement protocol from pairings. Parallel and Distributed Processing and Applications - Ispa 2005 Workshops 3759 (2005) 342-349

[27] Xie, G.: An ID-Based Key Agreement Scheme from pairing. Cryptology ePrint Archive, Vol. 2005/093 (2005)

[28] Xie, G.: Cryptanalysis of Noel McCullagh and Paulo S. L. M. Barreto's two-party identity-based key agreement. Cryptology ePrint Archive, Vol. 2004/308 (2004)

[29] Yuan, Q., Li, S.: A New Efficient ID-Based Authenticated Key Agreement Protocol. Cryptology ePrint Archive, Vol. 2005/309 (2005)

TEMPORAL CONSTRAINTS GENERATION FOR CLINICAL ALGORITHMS

*Aida Kamišalić****, David Riaño**, Tatjana Welzer**
*University of Maribor, Faculty of Electrical Engineering and Computer Science, Maribor, Slovenia
**Rovira i Virgili University, Department of Computer Engineering and Mathematics, Tarragona, Spain
{aida.kamisalic, david.riano}@urv.cat, {aida.kamisalic, welzer}@uni-mb.si

ABSTRACT

We present an overview of approaches for temporal constraints generation from hospital databases. Temporal constraints are introduced to define time dimension of clinical algorithms (CAs), which make explicit the knowledge needed to assist physicians in order to make appropriate decisions. There are different formalisms for CAs representation. We have decided to use SDA* formalism which corresponds to our requests considering time representation. There are two methods presented for generation of temporal constraints, one using statistical model and other using quantiles.

1 INTRODUCTION

Clinical Practice Guidelines (CPGs) are published as statements that gather all knowledge necessary to assist physicians making appropriate healthcare decisions. They can be considered as a set of plans for management of patients with a particular disease. Clinical algorithms (CAs) obtained from CPGs use the healthcare knowledge to assist patients suffering from one or several diseases. They are introduced to make the procedural knowledge (indications on what to do) explicit and formal. There are different formalisms which can be used for CAs representation, such as Asbru [1], PROforma [6], EON [7], SDA* [4], etc. Asbru, for example, is oriented to the description of healthcare activities as processes. It is not used for representation of the treatment as explicit procedure. Asbru and EON are very complete formalisms which are difficult to manage by untrained physicians, while PROforma is limited in the representation of time. SDA* is more simple and intuitive formalism, which meets our requirements for time representation. In *Figure 1* there is a SDA* formalism representing a clinical algorithm for hypertension [5].

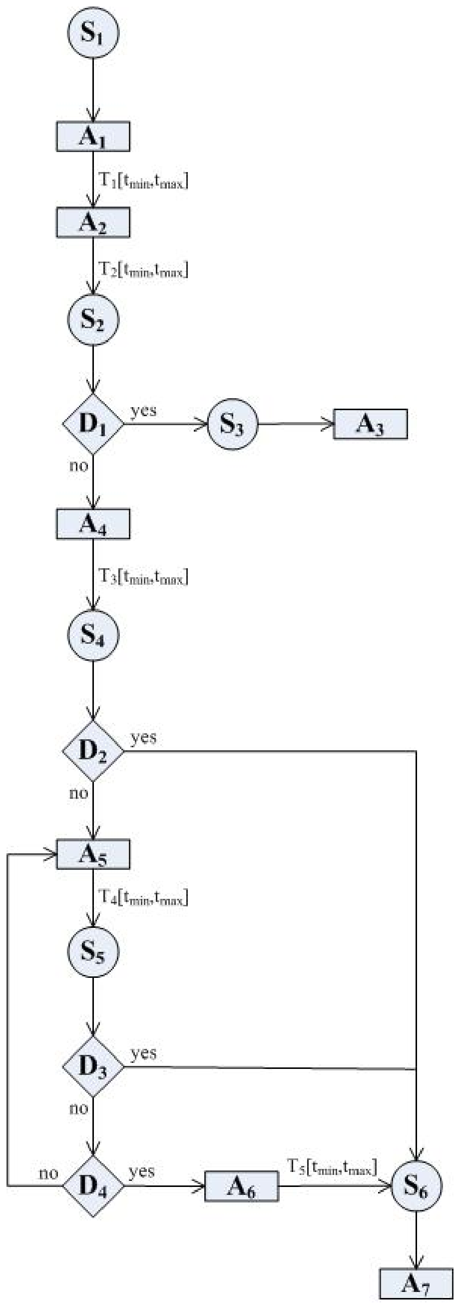
Very often CAs are timeless, which means that there is no explicit time labelling. To define time dimension of CAs it is necessary to obtain temporal knowledge from physicians or by other mechanism. Physicians often have difficulties defining general temporal constraints for some diseases and there is no other mechanism which would help us to explicitly obtain temporal knowledge for CAs. As data saved in hospital databases are time dependent, they can be used to obtain temporal constraints for CAs. Our proposal is to generate temporal constraints considering patients' data of a particular disease for timeless CAs represented as SDA* diagrams.

The rest of the paper is devided into four main sections. Section 2 provide definition of temporal constraints. SDA* formalism is described in the section 3. Section 4 is dedicated to explanation of approaches for generation of temporal constraints. Conclusions are gathered in the section 5.

2 TEMPORAL CONSTRAINTS DEFINITION

We have defined two types of temporality: micro-temporality and macro-temporality. The concept of micro-temporality is defined as constraint [s_t, e_t, f_t] on the start time, end time and frequency of occurrence for some term [1]. Terms that represent the signs and symptoms of a particular patient at the moment of making observation are called state terms. Decision terms are building decision criteria which leads the treatment to a specific direction considering patient's current signs and symptoms. While action terms represent activities which should be taken as a result of an earlier made decision. So the concept of micro-temporality can be assigned to all three types of terms (state, decision and action terms). For example, the term 'prehypertension' can be considered as a state term, where [1w, 1d, 8h] constraint means that 'prehypertension' was part of the patient condition since one week ago (1w), till one day ago (1d), and it was observed every eight hours (8h). In the case of action term, micro-temporality means that the action must start after time s_t, that should last till e_t, and that the application of the action has a frequency of f_t (for example, take beta-blocker agent for three weeks every eight hours [-, 3w, 8h]).

The other type of temporality that we have defined is named macro-temporality. Macro-temporality is defined as a constraint [t_{min}, t_{max}] on the time required to cross a particular edge of a CA, where t_{min} indicates lower and t_{max} upper bound [1]. Macro-temporality denotes time constraints which have to be fulfilled before the treatment of the patient proceeds. For example, [2d, 5d] assigned to the edge between two actions, would mean that after applying first action there should be waited minimum of 2 days and maximum of 5 days before proceeding with next action. In this paper, we will focus only on macro-temporality generation.



S_1: BP ≥ 140/90 or ≥ 130/80 in patients with diabetes, chronic kidney disease, hearth failure or CAD

S_2: Initial assessment completed

S_3: Secondary cause suspected

S_4: Initial treatment applied

S_5: Secondary treatment applied

S_6: Hypertension controlled

D_1: Secondary cause suspected?

D_2: BP at goal?

D_3: BP at goal?

A_1: Confirm elevated blood pressure

A_2: Evaluate accurately stage and complete risk assessment

A_3: Order additional work-up, consider referral

A_4: Order lifestyle modification and/or drug therapy (initially: thiazide-type diuretic; secondary: beta-blocker, angiotensin-converting enzyme inhibitor, angiotensin receptor blocker, calcium antagonist)

A_5: Change treatment → increase initial agent, add another agent from a different class, substitute new agent

A_6: Order hypertension consultation

A_7: Order hypertension continuing care

Figure 1: Clinical algorithm for Hypertension in SDA representation*

3 SDA* FORMALISM

SDA* stands for state-decision-action notation and it is used for representation of CAs as SDA* diagrams, where each diagram contains state, decision and action nodes (see *Figure 1*). Each state node contains the set of terms which represent the signs and symptoms of a particular patient at the moment of making observation. At the diagram it is indicated as a circle, which brings patient health condition.

Decision node provides decision criteria to derive the treatment in one or other direction considering the patient's current state condition. It is represented with rhombus point of branching that allows alternative clinical treatments. Action node represents the activities which should be taken as a result of an earlier made decision. It is described as square, which gives recommendation about medical orders considering medication and clinical procedures [1]. Connector between nodes is another important construct in the SDA* diagrams. Connector C_{ij} is defined as a connector between node i and node j. There exist nine different connectors; whose starting node is a state (C_{SS}, C_{SD}, C_{SA}), a decision (C_{DS}, C_{DD}, C_{DA}) or an action (C_{AS}, C_{AD}, C_{AA}).

Considering mentioned SDA* structure we assign earlier defined temporal constraints to the SDA* constructs. Micro-temporality is assigned to the terms of state, decision and/or action nodes. Macro-temporality is related to the connectors between nodes in SDA* diagrams (see T_1, T_2 in *Figure 1*). Macro-temporality constraints affect some of the above connectors, such as C_{SS}, C_{AS}, C_{AD} and C_{AA} [1]. The rest of the connectors are defined as the constraint [0, 0], which means that there is no delay (there is made instantaneous transition between nodes). For C_{SS} connectors, macro-temporality is obtained from the times between consecutive encounters in which the patient has not received any treatment as a consequence of the first encounter. Encounter is defined as a meeting between a health care professional and a patient in order to assess the patient's condition and to determine the best medical course of action [1]. For C_{AS} connectors, macro-temporality is calculated from the times between consecutive encounters in which, during the first encounter the physician has ordered the actions A, and in the second encounter the patient has evolved to state S. In the case of C_{AD} and C_{AA} connectors, macro-temporality is a combination of the times between consecutive encounters in which a treatment was proposed during the first encounter and the state of the patient in the second encounter is implicit. Lack of medical interest leads us to the implicit states [1].

4 GENERATION OF TEMPORAL CONSTRAINTS

As above mentioned the paper is dedicated to make an overview of the approaches for macro-temporality generation. The primary goal is to generate macro-temporalities from a provided set of temporal data and to introduce them to CA. Input data represent the evolution of patients through a medical treatment as sequences of state transitions. CAs are timeless structures representing healthcare treatments as SDA* diagrams.

4.1 Data Model

The health evolution of a patient can be seen as the sequence of state transitions of the patient through different encounters. The sequences of state transitions of all the patients affected by a particular disease define a data model that describes the input data. There are defined three different data levels in hospital databases [2]. The description of the treatment of a particular patient is defined at level 0, when only the states the patient passes through and the times passing between consecutive states are provided. Level 1 data describe individual treatments of concrete patients as sequences of states (level 0) with the healthcare actions performed between each pair of consecutive states and the time that each change of state takes. Level 2 data extends level 1 data with decisions representing the reasons that justify the actions.

4.2 Macro-temporality Generation

Considering different data levels introduced in the previous subsection, there are also defined different procedures for generation of macro-temporalities. In some cases the input data can follow some of the known distributions, such as normal distribution, while in others not. For generation of macro-temporalities in both cases we have defined two different approaches considering distribution of input data. In the case of known distribution we can use known statistical methods to generate macro-temporality. In this case we obtain more adjusted macro-temporality interval and we can reach a higher confidence in the obtained interval. In the case where the distribution function of the data is unknown, for generation of macro-temporality we use quantiles, which gives us first approximation about the interval with less confidence. Both approaches will be described in the next subsections.

In the case of level 0 data, for each pair of consecutive states S_i, S_j, it is applied process of macro-temporality constraint generation from all the t_{ij} times of all the sequences available. Each time a patient takes to evolve directly from S_i to S_j is taken in the calculation of macro-temporality interval, whether using one of the known statistical models or using quantiles. In the case of level 1 data, first there is applied process of actions classification, where all the actions of the sort A_{ij} are used to obtain a group of action classes in which each action class contains A_{ij} actions that are mutually similar and dissimilar to the actions in other actions classes. The tij times related to evolutions in which the actions applied belong to a concrete action class are used to calculate a macro-temporality constraint. Finaly for level 2 data, there is applied not only the process of actions classification (as in the case of level 1 data) but also the process of decisions classification (the same procedure as in the case of actions classification for level 0 data). The next step consists of calculating the time t_{ij} between states from all of the times t_{ij} of all the classified transitions from S_i to S_j taken from all the sequences available [2].

4.2.1 Statistical Model

We can consider that for each pair of consecutive states S_i, S_j and time between them t_{ij}, the sample of t_{ij} times of all the transitions from S_i to S_j taken from patient sequences approach one of the known distributions. Here we will present the statistical model for the sample approaching a t-student distribution. In this case, $\bar{t}_{ij}$ represents the mean of all t_{ij} values in the sample of patients evolving from S_i to S_j. $S_{t_{ij}}$ is the standard deviation of that same sample. *Equation 1* is used to calculate the macro-temporality, where t_n is the z-value of t-student distribution.

$$t = \bar{t}_{ij} \pm t_n \cdot S_{t_{ij}} \qquad (1)$$

4.2.2 Quantiles

Quantiles of q-quantiles are the data values that divide an ordered list of data into q essentially equal-sized data subsets. They are data which values mark the boundaries between consecutive subsets. For example, we can calculate percentiles, which are 100-quantiles. The 1st percentile cuts off the lowest 1% of data and the 99th percentile cuts off the highest 1% of data. Considering the confidence we aim to reach for the generated interval we can decide which lowest and highest percentiles we will cut off. For example, if we decide to keep 90% of confidence in generated interval, we would cut off till 5th and from 95th percentile. In this case, macro-temporality interval would consist of t_{min} as a value of 5th percentile and t_{max} as a value of 95th percentile [8].

5 CONCLUSION

Clinical algorithms (CAs) obtained from Clinical Practice Guidelines (CPGs) can be used for making procedural predictions considering healthcare procedures. As CAs did not contain temporal constraints we were not able to make temporal predictions about healthcare procedures. In the paper we have provided an overview of the approaches for generation of temporal constrains. In the case of known distribution function of input data, we use corresponding statistical model, while in the case of unknown we use quantiles. SDA* formalism was used for representation of CAs with time restrictions. As CAs now include temporal constraints we are able not only to give indications on what to do, but also indications on what are the time restrictions.

Acknowledgements

This work was realised as a part of K4CARE project (IST-2004-026968) and HYGIA project (TIN-2006-15453-c04).

References

[1] A. Kamišalić, D. Riaño, F. Real, T. Welzer: "Temporal Constraints Approximation from Data about Medical Procedures", CBMS2007, Maribor, Slovenia.

[2] A. Kamišalić, D. Riaño, T. Welzer: "Generating Macro-Temporality in Timed Transition Diagrams", AIME2007 workshop 'From Knowledge to Global Care', Amsterdam, Netherlands.

[3] A. Seyfang, S. Miksch, M. Marcos, "Combining Diagnosis and Treatment using Asbru", International Journal of Medical Informatics, December 2002, 68 (1-3): 49-57.

[4] D. Riaño, "The SDA Model v1.0: a Set Theory Approach", URV, Tech. report, DEIM-RT-07-001, Feb 2007.

[5] "Health Care Guideline: Hypertension Diagnosis and Treatment", Institute for Clinical Systems Improvement, October 2006, http://www.icsi.org/hypertension_4/hypertension_diagnosis_and_treatment_4.html, last visited 30.8.2007.

[6] J. Fox, N. Johns, A. Rahmanzadeh, "Disseminating Medical Knowledge-The PROforma Approach", Artificial Intelligence in Medicine 1998, 14(1-2): 157-182.

[7] M.A. Musen, S.W. Tu, A.K. Das, Y. Shahar, "EON: A component-based approach to automation of protocol-directed therapy", Journal of the American Medical Information Association 1996, 3(6): 367-388.

[8] Wolfram Research: "Statistics – Descriptive Statistics", Mathematica 5.2. Documentation, www.wolfram.com, last visited 25.8.2007.

MODELIRANJE KOMPENZACIJ POSLOVNO NARAVNANIH STORITEV

Kristjan Košič, Marjan Heričko
Laboratorij za informacijske sisteme,
Inštitut za informatiko,
Fakulteta za elektrotehniko, računalništvo in informatiko
e-pošta: kristjan.kosic@uni-mb.si,marjan.hericko@uni-mb.si

POVZETEK

Prisotnost modelno usmerjenega pristopa za razvoj storitev je v uporabi že kar nekaj časa, toda premalo pozornosti je posvečeno modeliranju kompenzacij spletnih storitev in s tem tudi transakcijskih lastnosti. Narava heterogenosti, avtonomnosti in dolgo-živečih storitev onemogoča uporabo klasičnega transakcijskega modela ACID. Kompenzacija storitev in posledično tudi odvisnosti le-teh postajajo vse pomembnejše pri kompleksnejših storitveno naravnanih sistemih. V članku predstavimo kompenzacije storitvenih sistemov, pristope in standarde, ki so na voljo za modeliranje le-teh. Prav tako predlagamo uporabo novega stereotipa, ki poenostavlja modeliranje kompenzacij storitev na modelu poslovnih primerov uporabe.

1 KOMPENZACIJE STORITEV

Storitve in storitveno naravnana arhitektura so pojmi, ki jih zadnje čase veliko srečujemo. Agilnost, ponovna uporaba, šibka sklopljenost, kompozicija so pridobitve storitveno naravnanih sistemov. Kompozicija storitev je ena izmed takšnih pridobitev, ki združuje atomarne in sestavljene storitve v nove, kompleksnejše ter uporabnejše storitve. Z uporabo kompozicije storitev pa se stvari začnejo zapletati. Namreč, če že govorimo o sodelovanju med storitvami, potem moramo imeti na voljo tudi mehanizme, ki zagotavljajo transakcijsko obnašanje[1].

Pomemben del poslovnih procesov predstavljajo transakcije. Poznamo več transakcijskih modelov, eden izmen bolj znanih je t.i. model ACID (Atomicity, Consistency, Isolation, Durability). Transakcije ACID so učinkovite v sistemih, kjer se skupina operacij izvede kot samostojna delovna enota (atomarno) in rezultati izvajana niso vidni izven te skupine. Tradicionalni sistemi, ki zahtevajo večkratne atomarne transakcije uporabljajo protokol 2PC (two phase commit)[3]. Protokol 2PC zahteva transakcijsko obnašanje od vseh udeležencev kot tudi koordinatorja, ki transakcijo nadzira. Takšne zahteve seveda niso skladne z lastnostmi storitveno naravnanih sistemov. Torej heterogenost, avtonomnost, šibka sklopljenost, ponovna uporaba in storitve brez stanja onemogočajo uporabo klasičnega transakcijskega modela ACID. Splošno je znano, da ACID transakcije ne zagotavljajo transakcijskega obnašanja storitvenim sistemom, saj so v večini primerov namenjenje kratkim operacijam nad podatkovnimi bazami in ne odvisnim, trajajočim transakcijam.

Zaradi tega so bili predlagani dodatni transakcijski modeli[1]. Večina teh modelov predlaga razširitev orkestracije storitev s kompenzacijami, ki uporabljajo storitvene kompozicijske storitve[3]. Kompenzacija storitev je sestavljena iz nabora aktivnosti (storitev), ki zna povrniti prvotno stanje oz. zagotoviti povrnitev nastale škode. Kompenzacija storitev ne zagotavlja karakteristik ACID, čeprav v večini primerov zadošča. Deluje v transakcijskih kot tudi v navadnih okoljih. Kompenzacijsko zasnovan pristop obravnava vsako posamezno storitev kot eno majhno ACID transakcijo, ki v logičnem smislu razveljavi nastale operacije z vidika spletne storitve[5]. V osnovi ločimo dve vrsti kompenzacij, in sicer:

- <u>Popolne kompenzacije:</u>
  Povratna logika zna razveljaviti vse operacije prvotne storitve. Torej popolna razveljavitev. Primer bi bil popolno brisanje rezervacije.
- <u>Nepopolne kompenzacije:</u>
  Na voljo imamo alternativno rešitev, ki ne razveljavi aktivnosti prvotne, ampak jo obide po alternativni poti. Kot primer lahko navedemo preklic rezervacije namesto popolnega brisanja.

V nadaljevanju bomo spoznali vrste odvisnosti med kompenzacijami, obdelali poslovni vidik kompenzacij in nazadnje podali predlog za vpeljavo novega stereotipa nad poslovnimi primeri uporabe.

2 KOMPENZACIJE Z VIDIKA POSLOVNEGA MODELA

Sedaj, ko smo spoznali kaj kompenzacije so in katere tipe kompenzacij poznamo, si lahko ogledamo še poslovni vidik storitvenih kompenzacij. Z vidika ponudnika storitev identificiramo dve večji kategoriji [5]:

<u>Kompenzacija kot nova poslovna transakcija:</u>

V tem primeru kompenzacija ne predstavlja nobene posebne logike z vidika ponudnika storitev. Opravilo kompenzacije se obnaša kot nova poslovna transakcija, torej storitev nima potrebe po dodatni implementaciji kompenzacijske storitve in tako ostaja dokaj preprosta. Primer takšne kategorije bi bila borza. Če kupimo delnice, jih lahko kasneje prodamo ter s tem kompenziramo. Seveda to ni popoln model in služi le kot primer. Ponudnik storitev je v tem primeu brez stanja (stateless).

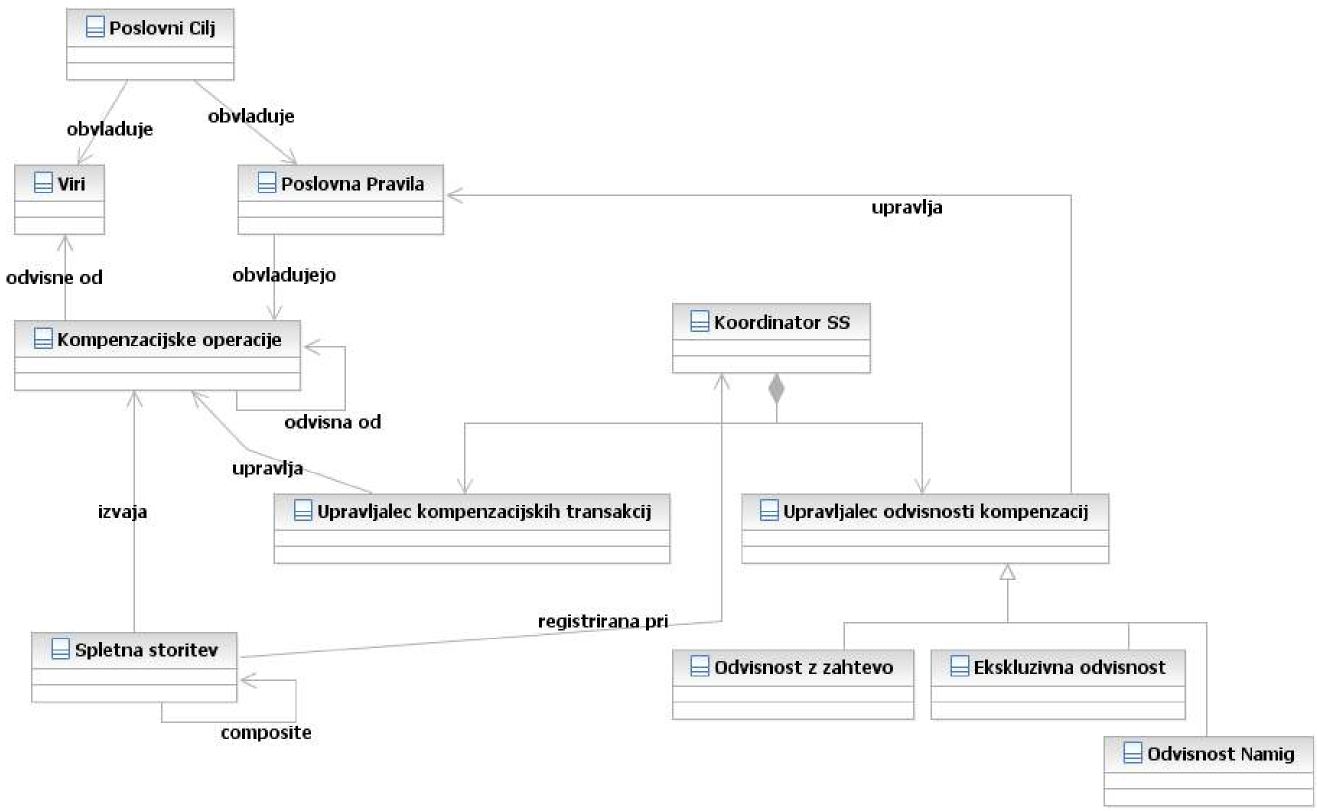
Kompenzacija kot druga faza poslovne transakcije:
Tukaj kompenzacija eksplicitno predstavlja drugo fazo iste poslovne transakcije z vpeljavo dodatne logike in kodiranja za zagotavljanje stanja poslovne transakcije. Kot tipičen primer lahko navedemo sistem za rezervacije letalskih kart. Ta pristop je tudi znan kot *Try-Cancel/Confirm* pristop (TCC)[5]. *Try* predstavlja normalno poslovno logiko, torej rezervacija sedeža na letalu. *Cancel* predstavlja morebiten preklic rezervacije z uporabo kompenzacijskega mehanizma. Če ni preklica, potem *Confirm* potrdi trditev, ki je navedena kot Try. Confirm se v tem primeru obnaša kot majhna ACID transakcija. Ponudnik storitev mora zagotavljati ohranjanje stanja (statefull).

3 KOMPENZACIJSKA ODVISNOST S POSLOVNIMI PRAVILI

Poslovna pravila postavljajo ključne kriterije za sodelovanje med storitvami. Seveda so dobro podprta z industrijskimi standardi kot sta BPEL4WS[6] in WS-Transactions[7]. Odvisnost med storitvami z uporabo poslovnih pravil ločimo v tri sklope[1]:
Odvisnost od zahtev je najpogostejša med poslovnimi pravili. Kompenzacijske aktivnosti bodo implementirane samo v primeru izpolnitve zahtev definiranih v poslovnih pravilih.
Ekskluzivna odvisnost ilustrira poseben primer odvisnosti, kadar kompenzacijska aktivnost ne bo izvajana.
Odvisnost tipa namig je realizirana s strani poslovnega pravila in omogoča morebitno vključevanje dodatnih kompenzacijskih aktivnosti.

Kompenzacijska aktivnost je predstavljena z dodajanjem poslovnih pravil kompenzacijski operaciji. Tako kot druge kompenzacijske aktivnosti deluje na semantičnem nivoju. Njene funkcionalnosti sestavljajo:

- opis poslovnih pogodb med storitvami v poslovnem svetu,
- vzdrževanje konsistentnosti kompenzacij,
- pomagati razvijalcem ob spremembah poslovnih pravil in s tem tudi kompenzacijskih aktivnosti.



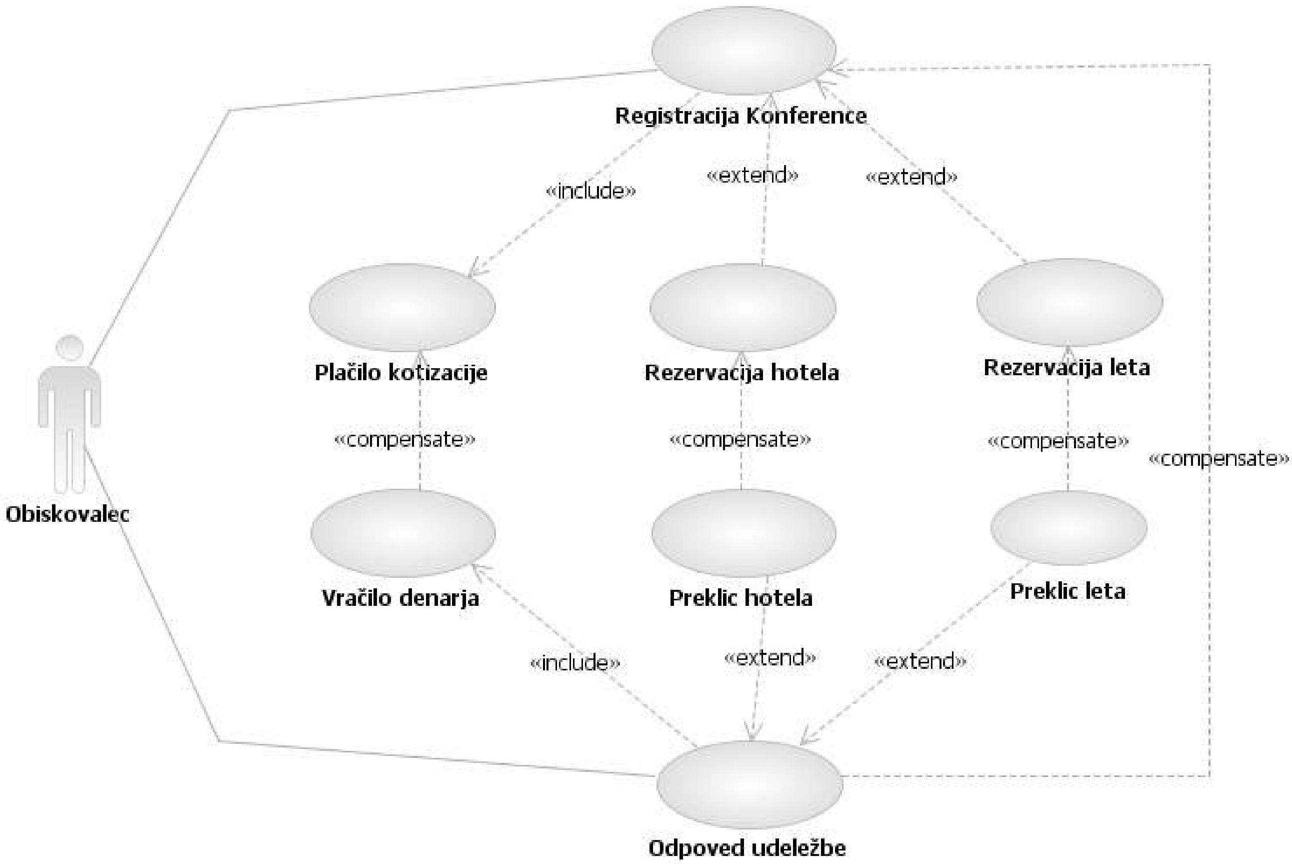
Slika 1 Razširjeno konceptualno ogrodje za kompenzacijo spletnih storitev[1]

Slika 1 prikazuje razširjeno ogrodje za kompenzacijo spletnih storitev. Na sliki je vidna vpeljava upravljalca odvisnosti med storitvani, ki se potem deli na prej omenjene vrste odvisnosti. Prav tako je glavno gonilo za kompenzacije poslovni cilj, ki je sestavljen iz poslovih pravil in virov. Ti pa potem naprej določajo storitvene pogodbe in s tem tudi scenarije za kompenzacijske aktivnosti, opravila in/ali storitve.

4 UPORABA STEREOTIPA <<compensate>>

Kot smo že omenili so kompenzacije ključnega pomena za zagotavljanje transakcijskega obnašanja storitveno naravnanih sistemov. S poslovnega vidika kompenzacije podajajo mehanizme za povračilo »škode« ali povrnitev morebitnih napak. Slika 1 prikazuje razširitev modela za kompenzacije storitev, toda še vedno manjka mehanizem za modeliranje kompenzacij v poslovnem svetu. Kako bi najenostavneje prikazali katera funkcionalnost (primer uporabe) rešuje problem kompenzacij že na konceptualnem modelu. S tem bi razrešili kar nekaj težav, s katerimi se srečujemo ob implementaciji. V nadaljevanju bomo prikazali vpeljavo stereotipa <<compensate>>, ki nakazuje, katere storitve so kompenzacijske narave in kako jih implementiramo. Slika 2 prikazuje primer uporabe stereotipa <<compensate>>.

Namen vpeljave je poenostavitev modeliranja poslovnih primerov uporabe. S pomočjo novo vpeljanega stereotipa je že takoj na konceptualnem nivoju viden namen in cilj poslovnih storitev.



Slika 2 Primer uporabe predlaganega stereotipa <<compensate>>

Na sliki 2 je prikazan primer registracije na konferenci. Registracija na konferenci je razširjena s tremi primeri uporabe (plačilo kotizacije, rezervacija hotela in leta). Odpoved udeležbe je grajena podobno kot sama registracija. Vpeljali smo primere uporabe za preklic posameznih delov in/ali preklic celotne rezervacije. Na sliki je tudi prikazana uporaba različnih tipov kompenzacij. Povezava <<compensate>> med krovnima primeroma uporabe, to sta Registracija konference in Odpoved udeležbe prikazuje uporabo enostavnega modela transakcij (brez stanja), ker rezervacija še ni bila potrjena, ampak je v čakajočem stanju potrditve, potem jo lahko enostavno izničimo brez dodatne implementacijske kode (t.j. prej omenjena kategorija-kompenzacija kot nova poslovna transakcija).

Povezava <<compensate>> med primeri uporabe na nižjem nivoju (primer povezava med Rezervacija leta-Preklic leta) pa predstavljajo transakcije tipa TCC. Tukaj moramo biti pozorni na ohranjanje stanja, ki ga zagotovimo s pristopom TCC(Try-Cancel/Confirm).

Stereotip <<compensate>> vpeljuje dodaten pristop k modeliranju kompenzacijskih aktivnosti. Vpeljava stereotipa pa ni na voljo samo za konceptualno razumevanje poslovnih pogodb in kompenzacijskih storitev. Z uporabo modelno usmerjenega pristopa gremo še korak dlje. Na osnovi stereotipa sedaj lahko generiramo primerne dele kode, ki bodo vnaprej znali implementirati kompenzacijske vmesnike. Edino, kar potrebujemo, je primerno orodje, ki zna preslikavo model-koda prilagoditi in uporabiti na novo definirane stereotipe.

Kot nadgradnjo sterotipa bi lahko uporabili lastnost *vrsta_kompenzacije*. Lastnost bi se izkazala še za posebej koristno na nivoju generiranja implementacijske kode. Poleg preslikave pa si pomagamo še z jezikom OCL (object constraint language), ki bi ga povezali z lastnostmi povezave *compensate* in tako še natančneje opredelili postopke generiranja kode.

Seveda pa ima predlog vpeljave stereotipa tudi nekatere pomankljivosti. Pojavlja se problem modeliranja varnosti in pravic sodelovanja med storitvami. Ampak to so težave, ki se ponavadi razrešijo s pogodbo SLA(service level agreement), po drugi strani pa nas na konceptualnem nivoju ne zanimajo vse podrobnosti.

4 ZAKLJUČEK

Kompenzacije so značilnost vseh večjih storitvenih modelov, saj brez kompozicije storitev in transakcijskega obnašanja ne moremo ustrezno modelirati in implementirati realnih poslovnih procesov in pravil. V prispevku smo spoznali kaj so kompenzacije (poslovnih) storitev in kakšen je njihov namen. Našteli smo vrste kompenzacij in razloge za vpeljavo le-teh. V nadaljevanju smo predlagali vpeljavo novega modelirnega elementa, t.j. stereotip <<compensate>>, ki poenostavlja modeliranje kompenzacij v (poslovnih) diagramih primerov uporabe.

V prihodnosti bomo naleteli na več modelirnih tehnik, ki bodo poskušale povzeti poslovno logiko v svojih modelih, medtem ko bodo industrijski standardi kot so BPEL4WS[6] in WS-Transactions[7] poskrbeli za implementacijo modela. Transakcijski nivo za storitve še ni popoln. Obstaja še kar nekaj izzivov, ki jih je potrebno nasloviti, da bomo standardizirali tudi ta nivo. Prav tako pričakujemo spremembe in dopolnitve v modelirnih metodologijah in standardih. Ko bodo zadeve standardizirane, bo izpeljava transakcij in njihovih lastnosti mogoča iz diagramov načrtovanja. Z izpeljavo transakcij pa tudi enostavneje načrtovanje kompenzacij in kompenzacijskih storitev.

Literatura

[1] Lili Lin, Fanffang Liu, Department of Computing and Information Technology, Fudan University. *Compensation with Dependency in Web Services composition*. China. 2005

[2] Benjamin A. Schmit, Schahram Dustdar, Vienna University of Technology. *Model Driven Development of Web Sevice Transactions*

[3] Dragos Manulescu, Boris Lublinsky. *Service Compensation, http://orchestrationpatterns.com , 2006*

[4] D. Fensel, C. Bussler, Vrije Universitat Amsterdam, Oracle Corporation. *The Web Service Modeling Framework – WSMF*

[5] Guy Pardon, Atomikos. *Business Transactions, Compensation and Try-Cancel/Confirm(TCC) approach to Web Services*

[6] Specifikacije: BPEL4WS. http://www.ibm.com/developerworks/library/specification/ws-bpel/

[7] Specifikacije: WS-Transactions. http://www.ibm.com/developerworks/webservices/library/specification/ws-tx/?S_TACT=105AGX04&S_CMP=LP

POSLOVNA PRAVILA V STORITVENO USMERJENI ARHITEKTURI

Aleš Frece, Matjaž B. Jurič
Univerza v Mariboru
Fakulteta za elektrotehniko, računalništvo in informatiko
Smetanova ulica 17, 2000 Maribor, Slovenija
e-pošta: ales.frece@uni-mb.si, matjaz.juric@uni-mb.si

POVZETEK

Poslovanje podjetij še nikoli v zgodovini ni bilo toliko podvrženo spremembam, kot smo temu priča na zelo konkurenčnem trgu dandanes. Informacijska podpora mora čim tesneje slediti poslovanju, saj to odloča o tem, ali podjetje lahko ostane konkurenčno.

Zgodovina je poskrbela, da ni enostavno povezati obstoječih sistemov v eno celoto, ki bi zagotavljala tako želeno poslovno koherentnost kot nujno prilagodljivost. Koherentnost v teoriji zagotavlja uporaba sistemov za upravljanje poslovnih pravil (business rules management system, BRMS), a jih je v praksi običajno nemogoče vpeljati na ravni celega podjetja zaradi odsotnosti poenotene informacijske platforme. Slednjo zagotavlja storitveno usmerjena arhitektura (service oriented architecture, SOA) ne glede na obstoječe stanje v podjetju. Je mogoče da BRMS in SOA združita moči?

1 UVOD

Zahteve za spreminjanje IT podpore nastajajo zaradi zunanjih ali notranjih vzrokov – od spremembe zakonodaje, preko prilagajanja trgu, pa vse do vključevanja sistemov prevzetih podjetij. Vse te zahteve moramo čim hitreje upoštevati in ustrezno prilagoditi IT podporo poslovanju. Tako SOA kot BRMS ciljajo na hitro prilagajanje poslovnih procesov. Pristop SOA ponuja v ta namen koncept storitev. Storitve so zaključene funkcionalne enote, ki pokrivajo dobro določeno področje poslovne funkcionalnosti, uporabljati pa jih je mogoče znotraj celotnega podjetja in tudi širše. Po drugi strani poslovna pravila ponujajo koncept enkapsulacije poslovnega znanja, ločenega od tehničnega okolja. Takšen ločen razvoj omogoča zelo hitro prilagajanje poslovnih pravil in enovit pogled na poslovno logiko podjetja. Pristopa SOA in BRMS sta si podobna v smislu, da oba vodijo funkcionalne zahteve celotnega podjetja, a imata vsak svoje zadolžitve. Prvi ponuja mehanizme za interakcijo znotraj celotnega nabora aplikacij podjetja, slednji pa izvaja enkapsulacijo poslovne logike znotraj storitev ali pa ponuja odločitvene storitve, ki temeljijo izključno na poslovnih pravilih.

2 OZADJE POSLOVNIH PRAVIL IN STORITVENO USMERJENE ARHITEKTURE

Industrija močno podpira SOA in ponuja orodja za njeno vpeljavo. Poglejmo, kaj SOA sploh je in zakaj je tako popularna. BRMS so, če nanje gledamo kot na evolucijsko stopnjo ekspertnih sistemov, prisotni že skoraj od same pojavitve programske opreme. Poglejmo še, kako to, da se je koncept poslovnih pravil obdržal na trgu tako dolgo.

2.1 Storitveno usmerjena arhitektura

Izrazu *storitveno usmerjena arhitektura* (ang. Service-Oriented Architecture ali krajše SOA) pripisujemo veliko različnih pomenov. Večini pogledov pa je skupno to, da SOA pojmujejo kot arhitekturni stil, ki podpira storitveno usmerjenost. *Storitveno usmerjenost* definirajo kot način razmišljanja v konceptu storitev, na storitvah temelječem razvoju in rezultatih, ki jih tak razvoj prinaša. *Storitev* je logična predstavitev ponovljive poslovne aktivnosti, ki ima predpisan izid (npr. »preveri komitentovo stanje«, »pridobi vremenske podatke« itd.). Storitev je samostojna, lahko je sestavljena iz drugih storitev, a je v vsakem primeru za odjemalca vidna kot črna škatla.

Ostali koncepti, ki se skrivajo za to ali ono razlago, so prisotni že dobro desetletje, a zasluge za njihovo popularnost, ki smo ji priča danes, moramo pripisati *spletnim storitvam*. SOA se ravno zaradi njih razlikuje od vseh ostalih porazdeljenih tehnologij – večina ponudnikov IT rešitev ponuja lastne platforme oz. rešitve, ki omogočajo implementacijo SOA ravno na temelju spletnih storitev. SOA s podpirajočo armado standardov prinaša lažjo ponovno uporabo rešitev in gradnjo novih rešitev na temelju obstoječih. Dovoljuje tudi evolucijske spremembe v implementaciji aplikacij, ki ne vplivajo na odjemalce. Ti so lahko druge aplikacije ali poslovni procesi, ki s povezovanjem storitev ponesejo obstoječo infrastrukturo še nivo više.

2.2 Poslovna pravila

Danes sta pred podjetjem in njegovim IT oddelkom predvsem dva izziva: spremembe in kompleksnost. Odgovor nanju je prav tako dvodelen: poslovna pravila in umetna inteligenca. Podjetja se zanašajo na stotine poslovnih pravil, ki so zakopana globoko v na desetinah kosov programske opreme v podjetju. Za sprejemanje

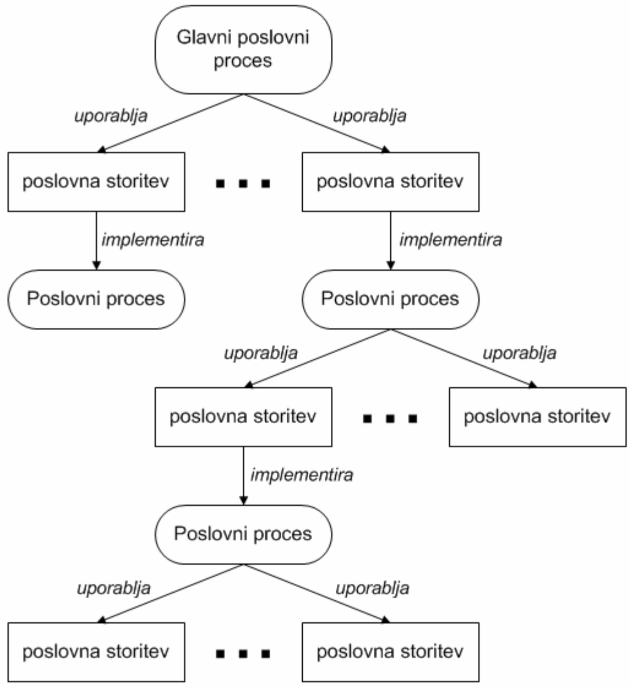
pravih odločitev je nujno, da so ta pravila pravilno povezana med seboj in tako tvorijo uporabno verigo odločitev. Da bi dosegli to, moramo pravilno zasnovati programsko opremo in poslovna pravila v njej, šele nato jih lahko ustrezno povežemo med sabo. Problem se pojavi, ker večina podjetij še vedno v tradicionalnem pristopu h kodiranju s tradicionalnimi programskimi jeziki poslovna pravila zacementira globoko v programsko opremo. To seveda pomeni, da je za spremembo poslovnih pravil potrebno spreminjati prav jedro programske opreme. To za sabo potegne aktivnosti skoraj celotnega življenjskega cikla te opreme: od spreminjanja, preko prevajanja, testiranja in razhroščevanja, pa vse do nameščanja novih različic.
V [1] definirajo poslovno pravilo z vidika informacijskih sistemov (IS). Ta definicija pravi, da so *poslovna pravila* dejstva, ki so zabeležena v obliki podatkov in omejitev sprememb njihovih vrednosti. To pomeni, da določajo, kakšni podatki se smejo in kakšni ne smejo zapisati v IS. Tako poslovna pravila izražajo osnovne omejitve ob ustvarjanju, spreminjanju in odstranjevanju podatkov v IS. Z vidika IS je npr. poslovno pravilo »Zapisa o kupljenem blagu ni mogoče vnesti, če finančno stanje stranke ni dovolj visoko.« v poslovnemu vidiku opazno kot »Strankam s prenizkim finančnim stanjem ne prodamo želenega blaga.«. Razlika je majhna, a kljub temu opazna. Ožja definicija je v uporabi zaradi lažjega razumevanja in modeliranja pravil kot omejitve podatkov ter ker iz obravnave izloči vsa mehka pravila (npr. odločitve na podlagi človeške presoje).

2.3 Izvori ideje o uporabi poslovnih pravil v SOA

Pri podpori vpeljave SOA sta enako poudarjena integracija obstoječih rešitev in razvoj novih. Ker se za vzdrževanje obstoječih sistemov vedno porabi več sredstev, se zaradi tega razvija *SOA infrastruktura*, kar teži v smeri upravljanja, spreminjanja, razširjanja in izboljševanja teh obstoječih sistemov. [2] pravi, da so v času razvoja SOA ponudniki mehanizmov sklepanja (ang. inference rules engines) začeli svoje produkte označevati kot sisteme za upravljanje poslovnih pravil, s čimer so si odprli velik trg. Vendar se je, logično, kmalu izkazalo, da obe rešitvi naslavljata isti trg in da imata več komplementarnih lastnosti. Posledica je seveda jasna: ponudniki SOA rešitev so posvojili poslovna pravila in jih vključili v svoje produkte, ponudniki rešitev na osnovi poslovnih pravil pa so se usmerili v prilagajanje svojih rešitev upravljanju s procesi. Lažje delo imajo seveda ponudniki SOA rešitev, zato je tudi na tem področju več rezultatov.

3 KOMPLEMENTARNE LASTNOSTI SOA IN BRMS

SOA naslavlja predvsem problem nenehnega spreminjanja poslovnih zahtev, s tem da zagotavlja odzivno IT arhitekturo, ki se je zmožna hitro prilagajati vedno novim zahtevam. To se običajno doseže z ločevanjem delov implementacije, ki se pogosto spreminjajo, od tistih, ki se zelo redko. Tipična pristopa k temu sta dekompozicija in enkapsulacija. V smislu *dekompozicije SOA* (glej sliko 1) teži k oblikovanju storitev, ki predstavljajo stabilni del implementacije, in poslovnim procesom – delu, ki se intenzivno spreminja. V praksi se je pokazalo, da se storitve res ne spreminjajo pogosto, njihove kompozicije pa se poleg nastajanja novih, konstantno spreminjajo [3]. Vendar takšna dekompozicija ne naslavlja direktno vprašanja poslovnih pravil, še ene pogosto spreminjajoče se komponente IT podpore. Zaradi spremenljive narave poslovnih pravil se je široko sprejela praksa njihove



Slika 1: *Hierarhična dekompozicija poslovnih procesov.*

implementacije v prav tako spremenljivih poslovnih procesih. Popularnost takšnega pristopa sta razširila dva velika ponudnika SOA rešitev, IBM in BEA Systems, ko je prvi razvil, drugi pa podprl, model Business Process Definition Metamodel [4]. Ta model namreč združuje poslovna pravila in procese v enem samem modelu, kar je povzročilo napačen vtis, da gre za tekmujoči tehnologiji. Poglejmo si nekaj pomembnih področij, na katerih tehnologiji ne tekmujeta, ampak se dopolnjujeta:

- *sinhronost* (ang. *synchronicity*) – obravnava poslovnih pravil je vedno sinhrona in BRMS so zgrajeni, da v čim krajšem času izvedejo vsako pravilo; po drugi strani so poslovni procesi po naravi asinhroni, saj tečejo dolgo časa; odlika BRMS je zato podpora dolgo izvajajočim se procesom, kjer se aktivnosti izvajajo dalj časa, zato tudi zagotavljajo mehanizme za asinhrono proženje, korelacijo vhodno-izhodnih sporočil, kompenzacije ipd.,
- *hranjenje stanja* (ang. *statefulness*) – BRMS ne hranijo nikakršnega stanja; ko se sproži poslovno pravilo, BRMS prebere njegove vhode iz vhodnih parametrov in iz baze znanja, jih ovrednoti in spremeni bazo znanja in/ali razširi izhode preko izhodnih parametrov; poslovni procesi so zgrajeni posebej z namenom, da hranijo stanje vsake instance procesa posebej, izločajo to stanje v zunanje shrambe za daljši čas po končanju neke aktivnosti; stanje tam počaka na izvedbo nove

aktivnosti, ko se zopet prenese v sistem za izvajanje poslovnih procesov,

- *determinizem* (ang. *determinism*) – BRMS proži pravila, katerih pogoji se ovrednotijo simultano, vendar njihovega dejanskega zaporedja ni mogoče določiti vnaprej; BRMS torej delujejo nedeterministično, poslovni procesi pa so v večini deterministični; kjer to ni samo po sebi umevno, se dodajajo vanje razne aktivnosti preverjanja,
- *zrnatost* (ang. *granularity*) – poslovna pravila je mogoče uporabiti na nivoju celotnega podjetja, a se običajno smatrajo kot komponente, saj tako zagotavljajo fino zrnatost in večjo fleksibilnost njihovega vzdrževanja; po drugi strani so poslovni procesi bolj grobo zrnati, saj pokrivajo nek vidik poslovanja od začetka do konca.

Različne implementacije poslovnih komponent, ki predstavljajo liste drevesa (glej sliko 1), so lahko ovojnice funkcionalnosti obstoječih aplikacij, nove implementacije v splošnonamenskih programskih jezikih, implementacije na temelju poslovnih pravil ali v obliki orkestracij [5].

4 POSLOVNA PRAVILA KOT DEL POSLOVNIH PROCESOV

Večina sodobnih strojev za izvajanje poslovnih procesov nam ponuja možnost izvajanja preprostih pravil z njihovo vgradnjo v BPEL (način 1, temelječ na kodi). Za takšno implementacijo enostavnih pravil se sicer lahko odločimo, a spreminjanje pravil v takem primeru od nas zahteva celovito testiranje spremenjenega procesa in njegovo ponovno nameščanje. Kompleksnejša pravila moramo v vsakem primeru izvleči iz procesa in jih prestaviti v BRMS s pomočjo storitev, zakaj ne bi enako storili tudi z enostavnejšimi?
Še en tipični scenarij je ta, ki smo ga že nakazali: poslovni proces se ne spreminja dosti, ampak pravila, ki nadzorujejo prehode med aktivnostmi in so relativno enostavna, pa se precej pogosto. Izločitev teh pravil iz procesa v BRMS in dostop do njih v obliki storitev nam precej olajša vzdrževanje procesa. Lahko namreč do neke mere spreminjamo njegovo obnašanje brez posegov v sam proces in brez njegovega ponovnega nameščanja. Na opisan način (način 3, storitveno usmerjen), kjer BRMS skrbi za poslovna pravila, ki jih stroj za izvrševanje procesov uporablja kot storitve in na njihovi osnovi orkestrira ostale storitve, deluje večina implementacija SOA. Klic storitve lahko sistem veliko stane (npr. klic preko omrežja), zato nekatere implementacije združujejo stroja za izvrševanje procesov in poslovnih pravil (način 2, modelno zasnovan). Takšne so npr. rešitve Microsoft Biztalk, IBM WebSphere, PegaSystem BPM Suite idr. [5]

4.1 Primerjava načinov sodelovanja BRMS in SOA

Rešitve (1) podpirajo direktno implementacijo poslovnih pravil v poslovnih procesih. Najbolje se obnesejo pri procesih, kjer se poslovna pravila uporabljajo le znotraj konteksta procesa in ne potrebujejo zunanjih informacij (npr. realnočasovnih podatkov iz BAM, Business Activity Monitoring). Običajno nam ne omogočajo prenosa pravil v/iz obstoječih BRMS, zato moramo v primeru želenega uvoza poslovno logiko razviti iz nič ali razviti algoritem za uvoz oz. izvoz pravil. Rešitve za upravljanje s poslovnimi procesi, ki temeljijo na odprtih standardih, kot je npr. BPEL, nam omogočajo vse tri načine uporabe pravil. V primeru (2) ali (3) pri teh rešitvah je izbira BRMS prepuščena nam. Lahko torej uporabljamo obstoječi BRMS, če pa potrebujemo kakšna zunanja dejstva, nam v primeru (3) ni potrebno skrbeti za sinhronizacijo metapodatkov med pravili v različnih BRMS. Kdaj torej izbrati kateri pristop?

V [6] priporočajo naslednje:

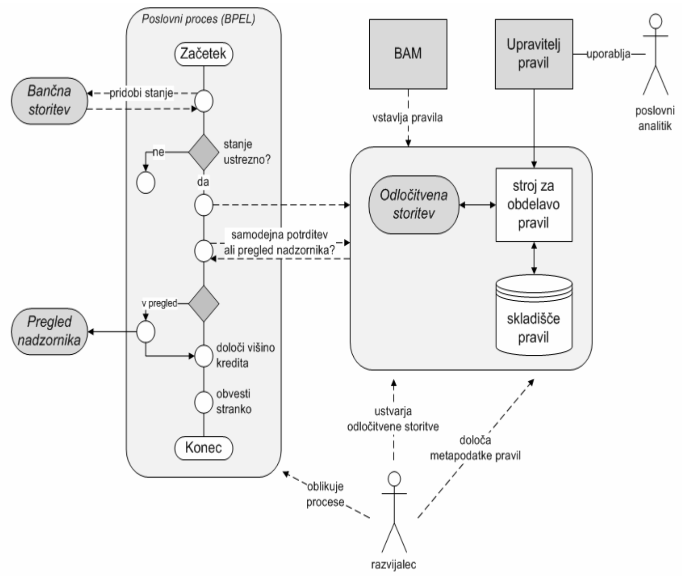
- (1) za enostavna pravila, katerih spreminjanje po namestitvi procesa ni verjetno, npr. preverjanje omejitev; če so v zajemanje pravil vpleteni poslovni uporabniki, obstaja zelo velika verjetnost, da se bodo taka pravila spreminjala, in je boljši pristop
- (2), t.j. za pravila, ki se bodo pogosto spreminjala; ta pravila je potrebno ločiti od procesne logike, s čimer se omogoči tudi ločen razvoj poslovne logike (razvijalci procesov) in poslovnih pravil (poslovni analitiki); dokler pravila ne zahtevajo zunanjih dejstev, je (2) primeren, sicer je potrebno razmisliti o
- (3), ki se najbolje obnese v primeru, ko je dejstva potrebno zajeti iz več procesov ali aplikacij oz. želimo uporabiti obstoječi zunanji BRMS; (3) zahteva nekaj več truda za implementacijo, a se odkupi z večjo fleksibilnostjo in možnostjo propagiranja pravil preko celotne podpore poslovanju.

(1) in (2) sta dokaj enostavna načina za vpeljavo poslovnih pravil v poslovne procese, zato raje podrobneje analizirajmo (3).

4.2 Odločitvene storitve in vpeljava poslovnih pravil v poslovne procese

(3) k vpeljavi poslovnih pravil v poslovne procese uporablja koncept odločitvenih storitev (ang. decision service) [6]. Gre za mehanizem objave poslovnih pravil v obliki ponovno uporabljivih storitev. Da ta pristop (glej sliko 2) začne delovati, je potrebno definirati poslovna pravila in jih izpostaviti kot (spletne) storitve. Še prej je potrebno definirati dejstva v predpisani obliki (v primeru spletnih storitev so to XML sheme), šele nato se lahko lotimo gradnje pravil, običajno z ustreznim orodjem, ki je del BRMS. Seveda taka orodja podpirajo enostavnejša pravila, zato bo za kakšno kompleksno pravilo še vedno potreben ročen poseg v kodo zapisa pravila. Na tej točki se lahko odločimo, katera pravila bodo lahko spreminjali poslovni analitiki. Naslednji korak je izpeljava odločitvenih storitev iz pravil. Te storitve ovijejo pravila in omogočijo poslovnim procesom, da vstavljajo dejstva v BRMS, bodisi v paketu, bodisi inkrementalno, kjer z zaključkom vstavljanja proces naznani BRMS, da naj začne s sklepanjem. Nalaganje dejstev, ki smo jih definirali na začetku, lahko poteka direktno iz procesov. Pridobivanje se lahko izvaja tudi periodično iz npr. podatkovne baze, BAM

ipd. BRMS deluje kot običajno skladišče pravil, katerih vsebina je izpostavljena preko odločitvenih storitev.



Slika 2: *Arhitektura storitveno usmerjenega pristopa k vpeljavi poslovnih pravil v poslovne procese.*

Razvijalec torej definira metapodatke pravil, ustvari odločitvene storitve in poslovni proces, ki jih uporablja. Poslovni analitik na podlagi teh metapodatkov definira pravila. Ko je proces nameščen in definirana vsa pravila, začnejo proces, BAM in druge aplikacije vstavljati dejstva v BRMS in izvrševati pravila preko odločitvenih storitev. Poglejmo si natančneje, kako so implementirane odločitvene storitve.

4.3 Arhitektura storitev na osnovi poslovnih pravil

Arhitekturo storitev na osnovi poslovnih pravil opisano v nadaljevanju predlaga [7]. Arhitektura ni edina, gotovo pa predstavlja dober vzgled. Poslovno odločitvena logika je v tej arhitekturi zbrana v skladišču pravil. Preko razvojnega okolja za pravila se pravila lahko grupirajo v nabore pravil, t.j. funkcijske bloke za opravljanje določene naloge. Odvisno od stroja za obdelavo pravil, ki je vključen v BRMS, je včasih mogoče nabore pravil združevati v proceduralen tok pravil (ang rule flow) in tako določiti zaporedje, ki doseže neko želeno poslovno odločitev. Različne podmnožice tokov in naborov pravil ter posameznih pravil se aktivirajo znotraj posameznih storitev pravil (ang. rule service), ki so namenjene vodenju poslovnih procesov. Storitve pravil lahko kombiniramo in jih tako napravimo izvršljive znotraj storitev za upravljanje odločitev (ang. decision management service), ki na zahteve odjemalcev le-tem pošiljajo ustrezne odločitve. Za svoje delovanje sprejemajo vhode odjemalcev, ostale podatke pa črpajo preko zunanjih storitev.
Hierarhija od posameznih poslovnih pravil do storitev pravil zagotavlja kar najvišjo možno raven fleksibilnosti ter ponovne uporabe odločitvene logike. Storitve lahko namreč potrebujejo nekaj obstoječih, skupnih pravil, nekaj pa je takih, ki so in bodo gotovo lastna le njim. Tako se v ponovno uporabo ne ponuja pravil, ki jih ni mogoče ponovno uporabiti, kar pospeši razvoj in zmanjšuje stroške. V teoriji to pomeni, da je tudi lažje spreminjati aplikacije na najnižjem nivoju (poslovna pravila), a je za to potrebno zagotoviti samozadostne storitve. Če zagotovimo takšne storitve, je njihovo jedro enostavno spreminjati, saj to početje nikakor ne vpliva na vmesnik storitve in posredno na njene interakcije z ostalimi storitvami.

5 SKLEP

Z integracijo poslovnih pravil v SOA prednosti pravil dopolnijo in razširijo prednosti SOA, še posebej v procesih, kjer je potrebno poslovno odločanje. V SOA infrastrukturi brez poslovnih pravil bi takšno odločanje morali implementirati v proceduralnem programskem jeziku, kar ob spremembah za sabo potegne popravljanje kode, prevajanje in nameščanje v produkcijsko okolje, brez da bi to vplivalo na ostale storitve. Če v isti situaciji uporabimo poslovna pravila, ki implementirajo storitev zadolženo za poslovno odločanje, rešitev postane bolj agilna. Uveljavljanje sprememb v poslovnih pravilih namreč ne zahteva nikakršnega posega v izvorno kodo, kar odstrani tudi potrebo po prevajanju in nameščanju, spremembo pravil pa lahko uveljavimo kar med izvajanjem samim. Poleg agilnosti, ki jo lahko še dodatno povečamo z dovoljenjem poslovnim uporabnikom, da spreminjajo poslovna pravila, pridobimo tudi na hitrosti uveljavljanja sprememb poslovne logike. Poslovni analitiki s poslovnimi pravili pridobijo večjo transparentnost, saj lahko na enostaven način pregledujejo pravila, če ustrezno implementirajo politiko podjetja.

Viri

[1] Business Rule Group, *Defining Business Rules – What Are They Really?*, 2000, http://www.businessrulesgroup.org/first_paper/BRG-whatisBR_3ed.pdf
[2] B. Lowenthal, *Rules Evolution in Service-Oriented Architecture*, april 2006, http://www.ftponline.com/ea/magazine/spring2006/features/blowenthal/default_pf.aspx
[3] B. Lublinsky, *Defining SOA as an Architectural Style*, januar 2007, http://www-128.ibm.com/developerworks/architecture/library/ar-soastyle/
[4] IBM, *Business Process Definition Metamodel*, januar 2004, http://www.omg.org/docs/bei/04-01-02.pdf
[5] B. Lublinsky in D. L. Tien, *Implementation of business rules and business processes in SOA*, marec 2007, http://www.infoq.com/articles/business-rules-processes.
[6] M. Afshar in B. Nainani, *Building Flexible Business Processes Using BPEL and Rules*, SOA World Magazine, december 2005, http://webservices.sys-con.com/read/155649.htm
[7] J. Taylor, *Achieving Decision Consistency Across The SOA-based Enterprise*, oktober 2005, http://www.fairisaac.com/NR/rdonlyres/830231C4-33BF-476C-95C0-B49A326B75EF/0/AchievingDecisionConsistencywp.pdf

ESSENTIAL KNOWLEDGE FOR MULTIPARADIGM PROGRAMMING

Zoltán Porkoláb, Viktória Zsók
Department of Programming Languages and Compilers
Faculty of Informatics, Eötvös Loránd University
Pázmány Péter sétány 1/C, 1117 Budapest, Hungary
Tel: +36-1-3812319; fax: +36-1-3812185
e-mail: gsd@elte.hu, zsv@inf.elte.hu

ABSTRACT

Multiparadigm programming is an emerging practice in computer technology. Co-existence of object-oriented, generic and functional techniques can better handle variability of projects.

The present paper gives an overview of teaching multiparadigm programming approach through typical language concepts, tools in higher education. Students learning multiparadigm-oriented subjects would gain considerable expertise, which is highly needed by the industrial side in large-scale application development.

1 INTRODUCTION

In the software development process *abstractions* play a central role. An abstraction focuses on the essence of a problem and excludes the special details [6]. Abstractions depend on many factors: user requirements, technical environment, and the key design decisions. In software technology a *paradigm* represents the directives in creating abstractions. The paradigm is the principle by which a problem can be comprehended and decomposed into manageable components [5]. There are several questions regarding abstractions and components. What types of categories can be established when the components are identified? What types of entities can be created and how? What should be created: procedures or cooperating objects? Where are the boundaries between modules? What types of rules should be applied in composing abstractions? In practice a paradigm directs us in identifying the elements in which a problem will be decomposed and projected. The paradigm sets up the rules and properties, but also offers tools for developing applications.

Software development is fundamentally a human activity. Today it is largely supported by automated tools, but still considerably influenced by personal experiences, traditions, conventions and customs. These behavioural patterns have huge impact upon the software development process by determining the way programmers form abstractions. Many of these human factors are formed by higher education. The first programming language, abstraction methods, and practiced paradigms are imprinted in computer science students. Techniques and practices acquired in an early period tend to return later, even if the current problem would require a different approach. These impediments may hinder the programmers from producing outputs in the expected time frame and quality.

One possible solution is to prepare students to identify the nature of the problem to be solved and consciously choose the best-fitting tools and techniques. It is especially important to teach how different kinds of problems could be targeted using appropriate paradigms. Since complex problems usually have a multi-dimensional nature, in most cases they require multiparadigm approach researches.

2 PROGRAMMING PARADIGMS

The very first goal in computer science was the automation of computations. Computations which could not be executed by human resources were calculated automatically by a machine, therefore this effort was called *automatic programming*. Although at the beginning the hardware was unreliable and the software technology tools were rudimentary, the problems were still manageable at the expense of the paradigm subordinated to the hardware restrictions. The typical programming language was FORTRAN, which gained huge popularity despite its well known weaknesses, since the language provided high compilation efficiency: on average 10 machine code statements were generated from 9 FORTRAN commands, which was of major importance.

Since the hardware became cheaper and more reliable, the software architecture gained more importance in applicability, maintenance and innovation. Earlier language constructs (like the infamous backward GO TO) were soon considered harmful [8]. *Structured programming* [7] prescribed sequences, branches, loops, procedures and emphasised the description of the adequate algorithm. In the second wave of imperative languages the attention was focused on data abstraction. Languages, like Pascal and their successors have sophisticated data abstraction constructs like enumeration, and features like strong typing, generics, tasks, exception handling, packages.

Object-orientation is evolved from block-structured languages. The Simula language introduced the first steps towards object-oriented programming and let a new paradigm appear. The object-oriented paradigm is based on identifying adequate data structures and methods upon them using the encapsulation principle. The languages supporting object-oriented programming contain special language constructs. Classes describe the objects with the same data structures and methods. Inheritance offers the possibility of building a hierarchy between similar classes, thus expressing the relationship between them.

The main feature of the object-oriented paradigm is the strong unity between data structures and methods inside a class, and the loose liaisons with other classes. The repeated features of similar classes (with similar data structures, behaviours and importance) can be grouped into a base class by generalisation. It is also possible to create new classes by specialisation. This can be achieved by extending the data structure and changing the behaviour of the base class by adding new methods. The obtained class hierarchy enables the definition of every important element of the program exactly one time facilitating further developments and code maintenance. Object-oriented programming is supported by strongly typed languages. These languages explore the polymorphic possibilities of dynamic linking during the run-time. The security of a construction is checked during compile-time. Class hierarchy is also a good design choice to express *subtype relationships*.

3 MULTIPARADIGM PROGRAMMING

The object-oriented programming methodology is an extensively researched area, and at the same time it is the most widely used paradigm in the industry. In the early stage of the paradigm there were high expectations that the code written using the object-oriented paradigm would be shorter, clearer and more maintainable. Although these great expectations where not baseless, and object-orientation proved to be effective in many cases, we experienced a number of its deficiencies. Problems with crosscutting concerns, and multidimensional separation of concerns [2] arise at design stage. Shortage of symmetric extensibility of class hierarchies − as described in the infamous expression problem [3, 17] blocks the development of effective extensible class libraries. Undeniably the object-oriented implementation techniques still cause efficiency problems.

As one can observe, in the past there was a paradigm turnout in about every 20 years. The turnout occurred every time when the size and the complexity of typical high-end applications exceeded the manageable extent of the older paradigm. Currently there are again many signs of a new paradigm turnout. The *aspect-oriented programming* [13] is already used in the industry to answer for the problems of crosscutting concerns and dangling code. The appearance of *generic programming* [1] to solve the expression problem is concretised in professional programs by the use of the C++ Standard Template Library.

Functional programming had a great history since LISP language, now we can experience a new renaissance. The ML language is an impure functional language, since it contains imperative elements (e.g. let statements). The ML dialects have introduced several language elements from the object-oriented programming paradigm. The Objective CaML dialect is based on the notion of objects, classes, class hierarchy, inheritance. JoCaML is an extension of the Object CaML for distributed, concurrent and mobile programming [9].

It is important to stress that a new paradigm does not completely replace the old one, but rather forms a new code organisation method above the old one. When object-orientation became popular, we did not disavow structured programming at all, we just introduced classes and inheritance hierarchy as a new way to organise the source code. Methods are still implemented according to the structural paradigm.

4 TEACHING PROGRAMMING PARADIGMS

Since the work of Dahl, Dijkstra, and Hoare, structured programming was the taught paradigm for undergraduate students. Naturally, the first programming language to be taught was a choice of Pascal, Modula (or Modula2), and C. Object-orientation introduced, sometimes optionally, for graduate students with the help of languages, like Simula67, and Smalltalk, was built on the experiences students received previously via structural languages. That approach let the students learn structural programming and gradually acquire object-oriented principles.

Nowadays the focus is trended towards introducing object-oriented programming as the first paradigm. This is partly a result of the pressure coming from industry, wanting *production ready* programmers as soon as possible. The present first language is therefore either C# or Java (sometimes C++), which enables students to learn objects early, but having the danger to give the misleading suggestion that object-orientation is the only paradigm on stage.

Our approach is different. From the very beginning of the curricula we try to provide the students with the experiences of naturally coexisting programming paradigms. Our choice for the first programming language is C++, a multiparadigm language with well-separated procedural, object-oriented and generic features. Early codes are written in structured way. Writing a `hello world` program does not require the introduction of *output stream objects*, etc... Later, objects are introduced naturally, when more complex programs require their own data structures. Students can also accumulate generic programming knowledge by extensive use of the Standard Template Library.

Functional programming is another challenge to the first language to be taught. Since modern functional programming style is very close to the mathematical way of thinking, it is quite often proposed as the first paradigm for students. We do not follow this direction, however, some functional style solution is used in early C++ examples. Recursion is practiced from the beginning, and higher order functions are introduced in connection with Standard Template Library function objects.

As mentioned earlier, the new paradigms can easily coexist with the older ones. We will illustrate this by the properties of the constructive interaction of several pairs of paradigms. Aspect oriented programming has the same basic structure as the object oriented one. The aspects decrease the code repetition inside classes and improve the modularity of a program. The paradigm is more efficient in following the positive and negative changes. Generic programming also gathers principles from the object-oriented style. It has several common basic constructs like abstract datatypes, classes, functors. Functional programming also presents similarities with object-oriented programming. It provides abstract datatypes, classes, encapsulation, subtyping, basic structures. The generic paradigm also coexists with functional programming. The Standard Template Library provides functions, which are similar to the higher order functions of the functional programming style or to the functions parameterised by strategies. There are other common concepts in the two paradigms like generic data structures and functions, or parametrical polymorphism.

Higher education should accentuate the theoretical and practical teaching of the already widespread new paradigms and their supporting language tools and programming environments too. Students can deepen their knowledge-base by acquiring new programming paradigms and styles like generative programming, functional programming, aspect-oriented programming, logic programming. As a result they will be able to combine all these paradigms in a creative way and they will be able to use new tools and new technologies in their future work. It is very important to mention that a new paradigm never sets the previously gained programming experiences aside. Structural programming has overtaken the notions of the earlier imperative languages. The object-oriented paradigm does not cancel structural programming in the implementation of methods. The alternation of paradigms incorporates all the already existing tools, methods, experiences in a higher structural unity.

A typical example can be seen in generic programming. The generic algorithms are separated from the data structure contrary to the object-oriented principles. At the same time some data structures are implemented as template classes with well-defined public interfaces and private implementations. However even some algorithms appear as classes (functors). The aspect-oriented paradigm uses in the same way the notion of aspects, since aspects are very closely related to classes. Generative programming and object-oriented programming can safely work together using *mixin* [16] technique.

```
template <typename T1, typename T2>
class Mixin : public T1, public T2 {…};
```

A mixin type inherits from their own template parameter, thereforeit can export the public interface of the parameter type. This the construct extremely useful when components must be assembled automatically [2, 20].

There are a number of examples linking the generative and the functional paradigm. The `boost::bind` library [12] implements full functional programming environment in the compilation time of C++ programs. It supports arbitrary function objects, functions, function pointers, and member function pointers, and is able to bind any argument to a specific value or route input arguments into arbitrary positions.

Functional programming is a paradigm that treats computations as evaluation of mathematical functions, so it is very appropriate to the mathematical ways of thinking. First-year students enter the university with a large mathematical knowledge, for this reason functional programming is appropriate for the first programming paradigm to be presented in the university curricula. The theoretical background of functional languages can form the thematic of more courses, which can be of lambda calculus, compiler construction, etc. Theoretical knowledge is indispensable for further researches or further compiler developments.

Special courses integrate the teaching of functional programming with commercial languages (e.g. Common LISP). Others combine the teaching of functional program design with modern object-oriented languages like C++, Java, Pizza. Some courses introduce the functional style in pedagogical programming environments, where this paradigm is used for implementation of programs with pedagogical relevance.

More advanced topics can form the subject of special courses, even a complete subject curricula can be formed out of these. Here we enumerate several advanced topics with their main issues. Special advanced compiler construction courses present the extensions and libraries of the modern functional languages like Haskell or Clean, where tracing, debugging, heap profiling are studied. Issues like combinator libraries, parsing libraries and grammar analysis are even more advanced concepts. Other types of special courses are formed at the boundaries of different informatics subjects (for example type-safe database handling in Haskell DB). Games and animations are developed as functional reactive animations in the framework of several computer science practical courses. There are several theoremproving tools developed in functional programming languages which form the subject of logic-oriented courses.

Patterns and skeletons are seen in monadic or in ObjectIO special programming courses, where arrows, meta programming (Template Haskell), advanced type classes (with multi-parameter, functional dependencies), abstract data structures are also studied. Higher order functional programming based on skeletons and evaluation strategies can solve high complexity problems and also distributed computations in GRID systems. Nevertheless, it is quite prevailing to use complementary paradigms in developing programs for multiparadigm based systems in distributed environments [11].

5 RELATED WORK

Research of multiparadigm programming has a long history. In 1986 IEEE published a special issue on multiparadigm programming [10]. The [19] paper discusses a compositional approach to multiparadigm programming. Since "most of the experienced programmers are confined to their favorite language's one paradigm", the author propagates multiparadigm approach using composition of a collection of single-paradigm programs. An opposite opinion can be found in [18]. The paper describes that "most programming languages courses have students use several distinct languages to gain experience with different language paradigms and implementation issues". This practice gives some real experience in a number of languages, but the time spent on learning new languages and environments necessarily reduces the capabilities to learn the new paradigm itself. Therefore the author argue for using a single multiparadigm programming language, called GED. GED supports the imperative, functional, logic, and object-oriented paradigm. Experiences with GED are described in [15]. The G language, the predecessor of GED is reviewed in [14]. One of the most referred multiparadigm programming language is the LEDA language [4], a general purpose language, which was designed both as a research tool and as a teaching environment. The language is based on imperative and object-oriented features, like assignment, class definition and single inheritance with polymorphism. For functional programming LEDA implements functions as first-class values including their dynamic creation capturing actual environment. Logic programming is supported via relations. Multiparadigm software design and its implementation in the C++ programming language are deeply investigated by James Coplien [6]. One of his most important conclusions is that different kind of domain problems should be targeted using different programming paradigms. The domain analysis, especially identifying positive and negative variability, helps to select the most appropriate paradigm.

6 CONCLUSION

The evolution of paradigms involves the evolution of teaching methodologies, tools, programming languages and environments. The academic and the industrial research provide the future challenges for the higher education of programmers. The new paradigms can coexist quite easily with the old ones producing many new valuable properties. The multiparadigm environments and tools give the opportunity to use more programming styles inside one application and to experience the multi-faceted property of one programming construct or feature.

The higher education of computer science has great responsibilities in preparing the programmer students when responds to the challenges provided by the industrial side. This involves the teaching of all those new technologies, paradigms, languages, tools which are not yet widely used in industry, but they have already proved their applicability. However, the new technologies, paradigms are not against the currently widely used ones. The new issues reflect the boundaries of the older ones and they enable a deeper understanding and applicability of them. Teachers continually adjust their lectures to the new technology requirements. The efforts for developing new topics according to the state-of-the-art will be exploited by the students in their future work.

References

[1] Austern, M.H. (1999). *Generic Programming and the STL*, Addison-Wesley.

[2] Bergmans, L., and Aksit, M. (2001). Composing Crosscutting Concerns Using Composition Filters. *Communications of the ACM*, **44** (10), pp. 51-57.

[3] Bruce, K.B. (2003). Some challenging typing issues in object-oriented languages, In: Bono, V., and Bugliesi, M. (eds.), *Electronic Notes in Theor. Comp. Sci.*, **82**, Elsevier.

[4] Budd, T.A., Justice, T.P., Pandey, R.K. (1995). General-purpose multiparadigm programming languages: an enabling technology for constructing complex systems, ICECCS'95, pp. 334-337.

[5] Cardelli, L., Wegner, P. (1985). On Understanding Types, Data Abstraction, and Polymorphism. *ACM Computing Surveys*, **17** (4), pp. 471-522.

[6] Coplien, J.O. (1998). *Multi-Paradigm Design for C++*, Addison-Wesley.

[7] Dahl, O.-J., Dijkstra, E. W., Hoare, C. A. R. (1972). Structured Programming, Academic Press.

[8] Dijkstra, E.W. (1968). Go To Statement Considered Harmful. *ACM*, **11** (2), pp. 147-148.

[9] Fournet, C., Le Fessant, F., Maranget, L., Schmitt, A. (2001). The JoCaml language beta release, Documentation and user's manual, INRIA.

[10] Hailpern, B. (ed.) (1986). Special issue on Multiparadigm Languages and Environments, *IEEE Software*, **3** (1), pp. 6-77.

[11] Horváth Z., Zsók V., Serrarens, P., Plasmeijer, R. (2003). Parallel Elementwise Processing in Concurrent Clean, *Mathematical and Computer Modelling*, **38**, Elsevier, pp. 865-875.

[12] Karlsson, B. (2005). *Beyond the C++ Standard Library: An Introduction to Boost*, Addison Wesley Professional.

[13] Kiczales, G., Lamping, J., Mendhekar, A., Maeda, C., Lopes, C. V., Loingtier, J-M., Irwin, J. (1997). Aspect-Oriented Programming, ECOOP, Finland, Springer-Verlag, LNCS 1241, pp. 220-242.

[14] Placer, J. (1991). The Multiparadigm Language G, *Computer Languages*, **16** (3-4), pp. 235-258.

[15] Placer, J. (1993). The Promise of Multiparadigm Languages as Pedagogical Tools, *Proceedings of the ACM conference on Comp. Sci.*, pp. 81-86.

[16] Smaragdakis, Y., Batory, D.S. (2000). Mixin-Based Programming in C++, In: Proceedings of Net.Object Days, pp. 464-478.

[17] Wadler, P. (1998). The expression problem, Posted on the Java Genericity mailing list

[18] Westbrook, D. S. (1999). A Multiparadigm Language Approach to Teaching Principles of Programming Languages, *29th ASEE/IEEE Frontiers in Education Conference*, 11b3-14.

[19] Zave, P. (1989). A Compositional Approach to Multiparadigm Programming, *IEEE Software*, **VI** (5), pp. 15-25.

[20] Zólyomi I., Porkoláb Z. (2003). An extension to the subtype relationship in C++ implemented with template metaprogramming, *Proceedings of GPCE 2003*, Springer-Verlag, LNCS 2830, pp. 209-227.

RAZVOJ APLIKACIJ NA OSNOVI PROGRAMSKIH TOVARN

Jernej Novak, Boštjan Kežmah
Univerza v Mariboru
Fakulteta za elektrotehniko, računalništvo in informatiko
e-pošta: {jernej.novak1, bostjan.kezmah}@uni-mb.si
URL: http://www.cot.si

POVZETEK

Programska tovarna je pristop k razvoju informacijskih rešitev, ki imajo skupne značilnosti, funkcionalnosti ter arhitekturno zasnovo. V prispevku so opisane pridobitve in značilnosti razvoja na osnovi programskih tovarn. Analizirane so vloge posameznih komponent programske tovarne in sicer na primeru vsebine programske tovarne za razvoj spletnih aplikacij.

1 UVOD

Zahteve po novi programski opremi se bodo v naslednjem desetletju še povečevale. Gnale jo bodo potrebe globalne ekonomije, kot je povečevanje vloge informacijskih storitev in rešitev v vsakdanjem življenju, novi tipi aplikacij kot so poslovne integracije in poslovne rešitve, in nove tehnologije kot so spletne storitve, mobilne naprave in pametni odjemalci. Brez povečanja produktivnosti pri razvoju programske opreme bomo do konca desetletja zelo zaostajali za potrebami, ki jih bo narekoval trg. Nekaj bo potrebno spremeniti v načinu razvoja aplikacij, da bomo lahko zadovoljili ogromno povečanje potreb. Verjetno ne gre pričakovati povečanja števila razvijalcev. Zato je potrebno spremeniti metode in prakse razvoja programske opreme in tako naredili razvijalce veliko bolj produktivne.

Če ne bo večjih izboljšav v programskih jezikih, platformah in razvojnih procesih, ne bo mogoče zadostiti naraščajočim potrebam naročnikov po kakovostni programski opremi. Da bomo lahko dosegli potreben nivo produktivnosti in kakovosti, se bomo morali odmakniti od današnjih vzorcev za gradnjo programske opreme. Namesto gradnje programske opreme z uporabo tretje generacije programskih jezikov bomo morali preiti h gradnji aplikacij iz prilagodljivih in nastavljivih programskih komponent z uporabo domensko specifičnih orodij ter čim bolj avtomatizirati proces razvoja.

2 PROGRAMSKE TOVARNE

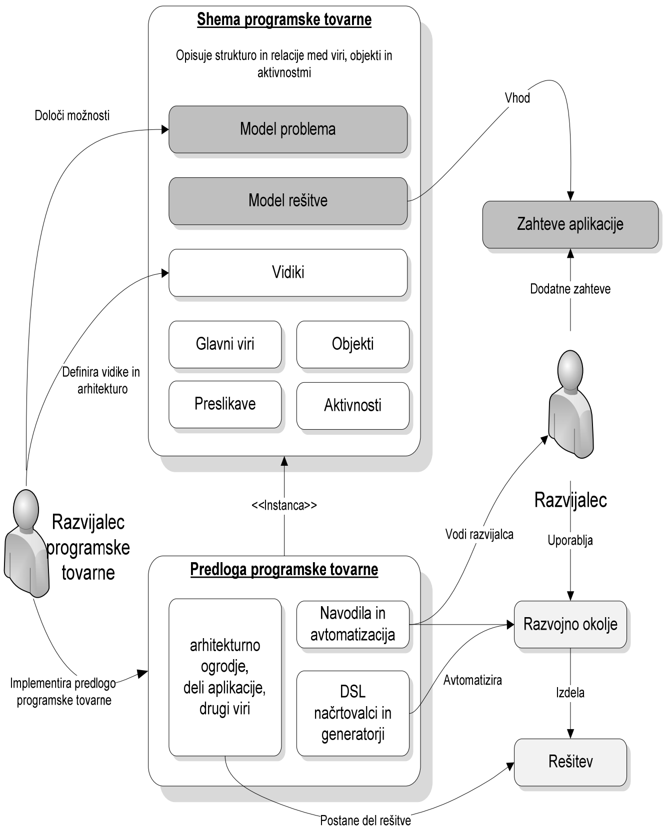
Programska tovarna je strukturna zbirka povezanih programskih pripomočkov. Ko programsko tovarno namestimo v razvojno okolje, pomaga arhitektom in razvijalcem predvidljivo in učinkovito ustvariti zelo kakovostne instance aplikacij določenega tipa [1].

Obstaja še več različnih definicij programske tovarne, npr.:
Programska tovarna je programska produktna linija, ki jo sestavljajo razširljiva orodja, procesi in vsebine z uporabo predlog programske tovarne, ki temeljijo na shemi programske tovarne. Pomagajo pri avtomatizaciji razvoja in vzdrževanju različnih izdelkov programske opreme s prilagajanjem, združevanjem in nastavljanjem komponent ogrodja [2].
Programska tovarna je vzorec za pristop k razvoju programskih sistemov, kjer si primerke teh sistemov delijo zmožnosti, funkcionalnosti in arhitekturo v smislu razvoja podobnih, komaj različnih aplikacij [3].
Programska tovarna je definirana kot organizacija programske strukture, ki omogoča, da so programski projekti zgrajeni v diskretnih delovnih središčih. Delovna središča predstavljajo programske dejavnosti, kot so arhitekturna zasnova, integracija, testi, vzdrževanje, idr. Programske tovarne imajo jasno določen postopek izdelave produktov in procese upravljanja[4].

Osrednja elementa programske tovarne sta shema programske tovarne in predloga programske tovarne. Programska tovarna temelji na shemi programske tovarne. Predloga programske tovarne je primerek določene sheme in določa razširljiva orodja, procese in vsebine za izgradnjo produkcijskih pripomočkov za končni produkt. Koncept programske tovarne je prikazan na sliki 1. Ta diagram bomo uporabili, da bomo na kratko opisali dele programske tovarne, ter predstavili, kako zgraditi programsko tovarno in kako jo uporabiti pri gradnji novih informacijskih rešitev z uporabo programskih tovarn.

2.1 Shema programske tovarne

Shema programske tovarne je model, ki ga interpretirajo ljudje in orodja, tako da opisujejo delovne produkte, v shemi definirane postopke, da izdelajo delovne produkte in uporabljajo vire za uprizoritev delovnih diagramov, za določeno družino programskih produktov v določeni domeni.

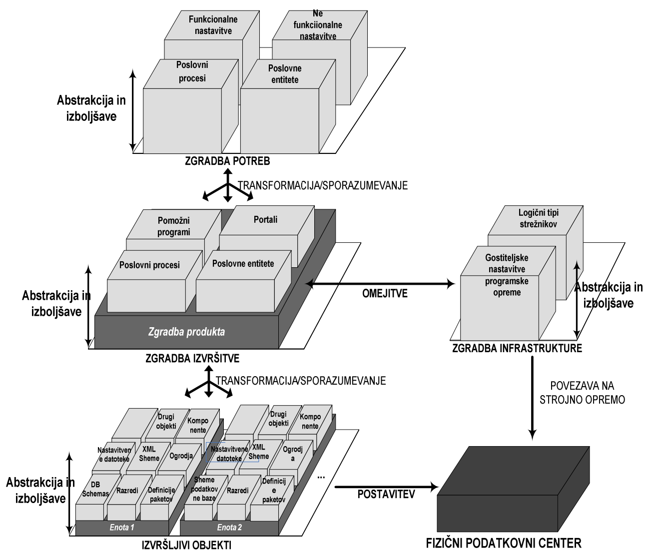


Slika 1: *Koncept programske tovarne*

Shema programske tovarne je organizirana okoli vidikov, ki opisujejo sistem iz svoje perspektive, kot so obnašanje, struktura logike in implementacije, združevanje komponent ali fizična distribucija med omrežji. Vsak vidik opisuje določen pogled na sistem in način opisa problemov. Da zgradimo sistem, moramo kombinirati vse vidike. Vidiki vsebujejo opis virov, koristnih za določen vidik, to pomeni orodja, komponente, knjižnice, vzorce ali celo dokumente, ki so potrebni za implementacijo. Sheme programske tovarne definirajo tudi relacije med vidiki. Na primer, logični pogled, predstavljen z objektnim modelom, je tesno povezan s fizičnim pogledom na shemo podatkovne baze. Nazadnje shema programske tovarne definira tudi aktivnosti, ki so potrebne za izdelavo objektov, definiranih z vidiki in za sestavo produkta.

2.2 Sheme programske tovarne kot diagram

Shema programske tovarne je pravzaprav usmerjen diagram, katerega vozlišča so vidiki in katerega robovi so izračunljive relacije med vidiki. Ta struktura dovoljuje vozliščem, predstavo, da so povezana. Najbolj pomembno je, da dovoli shemi odražanje programske arhitekture. Na primer shema za skupino poslovnih aplikacij ima lahko več skupin vidikov, po enega za vsak podsistem. Kot primere lahko navedemo upravljanje s strankami, upravljanje s seznami, upravljanje z naročili ali izpolnjevanje naročil. Vidiki v vsaki skupini so lahko nato nadalje združeni v podnize, ki odražajo slojno arhitekturo podsistema, kot je prikazano na sliki 2.



Slika 2: *Shema programske tovarne*

Diagram sheme programskih tovarn smo poimenovali tako, ker opisuje objekte, ki jih moramo razviti, da ustvarijo programski produkt. Tako kot XML shema opiše elemente in atribute, ki jih moramo ustvariti, da oblikujemo s shemo skladen dokument, tako shema podatkovne baze opisuje vrstice, ki jih moramo ustvariti, da napolnijo bazo. Arhitekturno opisni standard ADS (Architectural Description Standard) je shema programske opreme za opisovanje elementov skupine programskih produktov. Kljub tej podobnosti najdemo kar nekaj pomembnejših razlik med shemo programske opreme in ADS[7].

Shemo programske tovarne lahko razumemo kot recept za gradnjo skupine programskih produktov. Vidiki definirajo sestavine in orodja za pripravo le teh. Razvojno ogrodje je lahko izdelano z definiranjem mikro procesov, potrebnih za razvoj vsakega člena povezanih objektov in z definiranjem omejitev glede na predpogoje, ki jim moramo zadostiti, preden je objekt narejen. Popogoji, ki morajo zadoščati po izdelavi in nespremenljivosti, se morajo zadržati, ko se objekti stabilizirajo.

2.3 Predloga programske tovarne

Predlogo programske tovarne lahko smatramo kot primerek sheme programske tovarne, podobno, kot je model instanca metamodela. Predloga je praktično zbirka vseh virov, definiranih z vidiki sheme programske tovarne.
Če imamo shemo programske tovarne, potem lahko opišemo vire, uporabljene pri gradnji skupine členov, v nasprotnem primeru to ni mogoče. Da pravzaprav zgradimo elemente skupine produktov, moramo implementirati shemo programske tovarne, s katero definiramo domensko specfične jezike, vzorce, ogrodja in orodja. To novo implementacijo združimo in jo ponudimo razvijalcem

produktov. Skupaj ti objekti predstavljajo predlogo programske tovarne. Predloga programske tovarne vsebuje programsko kodo in metapodatke, ki jih lahko naložimo v razširjena orodja, kot je integrirano razvojno okolje. S tem avtomatiziramo razvoj in vzdrževanje skupine produktov. Predloga programske tovarne se imenuje zato, ker določa orodja za izdelavo določenega tipa programske opreme. Podobno kot predloga dokumenta v Microsoft Word-u ali Excel-u, določa specifičen tip dokumenta. Kakor je določena shema programske tovarne, tako mora biti določena tudi predloga programske tovarne, da lahko zgradimo specifično skupino produktov. Medtem, ko definiranje sheme prilagaja opis programske tovarne, definiranje predloge prilagaja orodja in druge dele razvojnega orodja, uporabljene za gradnjo skupine produktov.

3. PROGRAMSKE TOVARNE V OGRODJU .NET

Programska tovarna je strukturirana zbirka povezanih elementov programske opreme, npr. dokumentacije, modelov, izvorne kode, ki rešujejo specifičen problem ali množico problemov. Ko programsko tovarno namestimo v razvojno okolje, pomaga arhitektom in razvijalcem predvidljivo in učinkovito ustvarjati kakovostne aplikacije[5]. Vsaka programska tovarna je narejena tako, da pomaga pri gradnji aplikacij, ki si delijo oziroma imajo skupno arhitekturo in objekte. Primeri takšnih aplikacij so recimo aplikacije za mobilne odjemalce, pametni odjemalci in transakcijske spletne storitve.

Programska tovarna sestoji iz različnih programskih orodij in virov. Slednji vsebujejo izvorno kodo, ki jo lahko večkrat uporabimo, dokumentacijo in referenčne implementacije. Programska orodja vključujejo čarovnike, generatorje izvorne kode in vizualne načrtovalce. Ponavadi programske tovarne vsebujejo predloge in druga orodja, ki pomagajo razvojnim ekipam k hitri vzpostavitvi prve implementacije ogrodja nove aplikacije. Razvijalcem pa nudijo smernice in avtomatizacijo razvojnih aktivnosti skozi celoten razvoj aplikacije.

Ključna lastnost programske tovarne je, da si arhitekti in razvijalci lahko programsko tovarno dopolnijo in prilagodijo, da ustreza zahtevam in posebnostim projektne skupine ali organizacije. Običajno arhitekt izvrši prilagoditev tovarne, jo ponovno združi in distribuira projektnim ekipam.

Microsoftova ekipa je razvila štiri programske tovarne in sicer so na voljo[6]:

- programska tovarna za pametne odjemalce,
- programska tovarna za spletne storitve,
- programska tovarna za mobilne naprave,
- programska tovarna za spletne aplikacije.

Drugih komercialnih programskih tovarn še nismo zasledili. Vendar lahko predvidevamo, da bodo v prihodnosti tudi druga podjetja začela ponujati programske tovarne za določena področja. Tako bomo z osnovnimi programskimi tovarnami sestavili večje programske tovarne. Izdelek programske tovarne bo še večja programska tovarna. Tudi enostavno programsko tovarno bo mogoče nadgraditi in prilagoditi, da bo ustrezala ožjemu področju. Vendar bo na vse to treba počakati, da se še bolje definira in uveljavi metodologija programskih tovarn.

3.1 Programska tovarna za spletne aplikacije

Arhitekti in razvijalci lahko uporabljajo programsko tovarno za spletne aplikacije, da izkoristijo prednosti preizkušenih praks in vzorcev pri gradnji spletne aplikacije. Te prakse in vzorci so bili dognani med razvojem velike množice spletnih aplikacij in njenih komponent. Te aplikacije so imele eno ali več skupnih lastnosti:

- zapleten potek strani (“page flow”) in delovni tok,
- razvijalo jih je več sodelujočih ekip,
- sestavljene aplikacije so preko poenotenega uporabniškega vmesnika prikazovale informacije, pridobljene iz različnih virov,
- podpirale so enostavno namestitev več neodvisno razvitih modulov ali komponent.

Programska tovarna vsebuje zbirko ponovno uporabljivih komponent in knjižnic, predlog za okolje Visual Studio 2005, čarovnikov, razširitev, nasvetov, avtomatiziranih testov, razširjeno dokumentacijo, vzorce in referenčne implementacije. Programska tovarna uporablja produkte podjetja Microsoft kot so: ASP.NET, ASP.NET AJAX, Windows Workflow Foundation in Enterprise Library-Januar 2006.

3.1.1 Vsebina programske tovarne

Programska tovarna za spletne aplikacije je sestavljena tako, da omogoča razvoj porazdeljenih spletnih aplikacij. Sestavljena je iz naslednjih elementov:

Deli aplikacij in knjižnic. V programski tovarni so vključeni del za porazdeljene spletne aplikacije in del za diagram poteka stanj. Vključeno ima tudi Enterprise Library za varnost, upravljanje z izjemami, beleženje in dostop do podatkov.

Del za porazdeljene spletne aplikacije (Composite Web Application Block)

Velik del spletnih aplikacij je sestavljenih iz različnih sistemov, ki jih zgradijo sodelujoče razvojne ekipe. Programska tovarna za spletne aplikacije pomaga arhitektom in razvijalcem razvoj porazdeljenih spletnih aplikacij. Sestavljeno spletno aplikacijo sestavljajo diskretni, neodvisni, komaj funkcionalni deli. Ti deli so združeni v spletni aplikaciji.

Del za porazdeljene spletne aplikacije pomaga arhitektom in razvijalcem doseči naslednje cilje[1]:

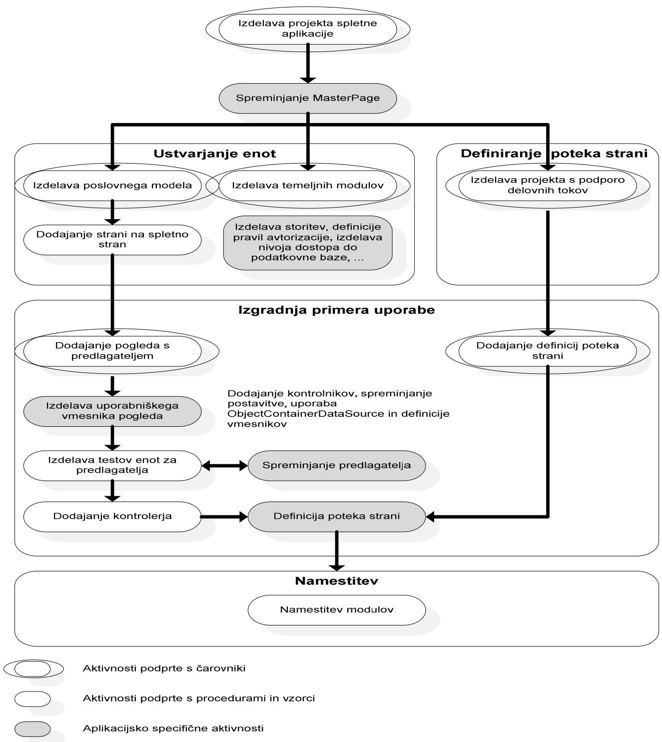
- kompleksno spletno aplikacijo razgradi v neodvisne dele, ki jih lahko zgradijo, sestavijo in namestijo neodvisne ekipe,
- zmanjša odvisnost med ekipami, kar omogoča specializacijo ekip za področja, npr. za načrtovanje uporabniškega vmesnika in za implementacijo poslovne logike,
- povečati kakovost aplikacij z abstrakcijo pogostih storitev, ki so dosegljive neodvisnim ekipam,

• postopna instalacija novih zmožnosti in s tem minimizacija nedosegljivosti strežnika,
• povečati pokritost izvorne kode z avtomatiziranimi testi.

Orodja za načrtovanje. Programska tovarna vključuje orodja za načrtovanje poteka strani. Orodja za načrtovanje pomagajo načrtovalcem in razvijalcem, da modelirajo aplikacije na višjem nivoju abstrakcije. Orodja za načrtovanje lahko generirajo izvorno kodo, ki je skladna z arhitekturno osnovo.

Referenčna implementacija. Programska tovarna vsebuje Global Bank referenčno implementacijo. Ta implementacija je dokončana aplikacija, po kateri se lahko zgledujemo.

Arhitekturna navodila in vzorci. Programska tovarna vsebuje arhitekturna navodila in vzorce, ki pomagajo razložiti odločitve in utemeljijo uporabo programske tovarne pri načrtovanju aplikacije.



Slika 3: *Potek razvoja z uporabo programske tovarne za spletne aplikacije*

Začetni primeri. Programska tovarna vsebuje začetne primere, ki korak po korak opisujejo kako implementirati priporočeno prakso v določeni domeni. Začetni primeri so kratki, lahko razumljivi primeri ključnih aktivnosti programske tovarne. Začetni primeri so idealni za začetno razumevanje aktivnosti programske tovarne in za enostavno učenje novih tehnik s pregledovanjem izvorne kode. Programska tovarna za spletne aplikacije vključuje naslednje začetne primere:
• pogled – prikazovalec (z aplikacijskim nadzornikom) prikazuje ključne komponente pri implementaciji vzorca pogled – prikazovalec in vzorca aplikacijski nadzornik,
• ObjectContainerDataSource prikazuje scenarije uporabe te kontrole,
• modularnost prikazuje ključne modularne koncepte v sestavljeni spletni aplikaciji,
• potek strani prikazuje osnovno uporabo delovanja oz. navigiranja med stranmi v sestavljeni spletni aplikaciji.

4. SKLEP

Programsko tovarno uporabimo, če se programska tovarna ujema s potrebami našega scenarija. Tako dosežemo, da je razvoj aplikacij hitrejši, lažji, bolj predvidljiv in s tem seveda tudi cenejši. Aplikacije ni potrebno graditi iz nič, ampak implementiramo samo aplikacijsko specifične dele. Za ostalo poskrbi programska tovarna.

Programska tovarna zagotovo ni primerna za vse razvojne ekipe, kajti razvoj specifične programske tovarne lahko zahteva veliko časa in sredstev. Seveda obstaja možnost, da vzamemo že implementirano programsko tovarno in del projekta, ki nam ustreza, razvijemo s pomočjo programske tovarne, preostanek pa izven. Velik del programske tovarne temelji tudi na ponovni uporabi izvorne kode, kar lahko povzroči veliko preglavic, če je ne implementiramo in uporabljamo pravilno.

Ali se bo uporaba programskih tovarn uveljavila pri razvoju programske opreme, ne moremo vedeti. Lahko pa sklepamo glede na to, kako se je razvijala panoga programske opreme in kako so se razvijale druge panoge. Ključnega pomena je, da združimo znanje izkušenih razvijalcev, da ga lahko drugi uporabijo.

Literatura

[1] Web Client Guidance Community, Web Client Software Factory June - 2007, Microsoft Corporation, 2007
[2] Jack Greenfield, Keith Short, Software Factories: Assembling Applications with Patterns, Models, Frameworks, and Tools, John Wiley & Sons, 2004
[3] Gunther Lenz, Christoph Wienands, Practical Software Factories in .NET, Apress, 2006
[4] Software factory, http://en.wikipedia.org/wiki/Software_factory, obiskano: julij 2007
[5] Web Client Guidance Community, Web Client Software Factory June - 2007, Microsoft Corporation, 2007
[6] Software factory, http://en.wikipedia.org/wiki/Software_factory, obiskano: julij 2007
[7] Multi-paradigm design. In Proceedings of the GCSE '99, J. Coplien

MODELNO USMERJEN RAZVOJ PROGRAMSKE OPREME - DOMENSKO SPECIFIČEN PRISTOP

Tomaž Lukman
Odsek za sisteme in vodenje
Institut "Jožef Stefan"
Jamova 39, 1000 Ljubljana, Slovenija
e-mail: tomaz.lukman@ijs.si

POVZETEK

Članek obravnava novejši pristop v programskem inženirstvu, imenovan modelno usmerjen razvoj programske opreme (*Model Driven Software Development - MDSD*). Njegovi temeljni značilnosti sta uporaba modelov kot primarnih entitet za razvoj in bližina domeni uporabe (s pomočjo domensko specifičnih jezikov in generatorjev kode). V obravnavi se najprej ozremo v širše okolje, ki obdaja ta pristop, in ga primerjamo s sorodnimi pristopi razvoja programske opreme.

V osrednjem delu članka spoznamo splošen proces modelno usmerjenega razvoja in njegove temeljne sestavne dele. Ker je končni cilj takega procesa (delna) avtomatizacija razvoja programske opreme, ne moremo mimo programskih orodij, ki so sredstva za doseg le-tega. Natančneje pišemo o visokonivojski arhitekturi takega programskega orodja, opisujemo njegove sestavne dele in obravnavamo načine, ki so na voljo za njegovo implementacijo.

1 UVOD

Modeli so vseprisotni v naših življenjih, "brez njih ne bi bili sposobni reducirati neizmerne poplave informacij na stopnjo, ki smo jo sposobni obvladati" [8]. Moč modelov je osnovana na ideji abstrakcije, ki omogoča obravnavanje samo tistih informacij, ki so bistvene za določen nivo razčlenitve. Podrobne odločitve pa odložimo v čim bolj pozne faze razčlenjevanja.

S pomočjo modelov lahko dvignemo abstrakcijo našega dela. Tako se, na primer pri modeliranju načrta aplikacije, razvijalcu ni potrebno že na začetku ubadati s tehnološkimi in implementacijskimi podrobnostmi, ampak se lahko osredotoči na pomembnejše koncepte razvijajoče se aplikacije (na primer na arhitekturo aplikacije). V modelih lahko najprej specificiramo KAJ naj aplikacija dela, medtem ko KAKO to dela prepustimo programerjem ali celo kompleksnim avtomatiziranim preslikavam, ki to odločitev opravijo kasneje [12].

V programskem inženirstvu modele uporabljamo že od vsega začetka te mlade discipline, zato se poraja vprašanje, kakšna je razlika med klasičnim razvojem programske opreme (ki občasno uporablja modele) in modelno usmerjenim razvojem programske opreme?

Dejanska razlika je v premiku paradigme od "dokumentno osredotočenega" k "modelno osredotočenemu" razvoju [5]. To pomeni, da vse informacije povezne z razvojem programske opreme ne hranimo v množici implicitno povezanih dokumentov, ampak zgolj na enem mestu, znotraj enega integriranega in povezanega artefakta – modela. Običajno imamo za vsako fazo življenjskega cikla svoj model, ki je dobro definiran, kar omogoča avtomatizacijo transformacij med temi modeli.

2 KONTEKST MODELNO USMERJENEGA RAZVOJA (PROGRAMSKE OPREME)

Dejstvo je, da "modelno osredotočen" razvoj v industriji še ni širše prakticiran. Zakaj torej razvijalci ne skočijo v deročo reko "modelno osredotočenega" programskega inženirstva?

Glavni razlog je vsekakor ta, da do te reke ne morejo tako zlahka prodreti, saj se jim na pot postavlja ogromen gozd izrazov, kratic in dvoumnosti. Ta terminološka grozljivka odvrne mnogo razvijalcev, da bi se sploh poskušali potopili v svet modelov. Lahko trdimo, da na tem področju vlada zmeda, saj v literaturi ne obstaja poenotena in natančno definirana terminologija, ki bi razvijalcem omogočala neboleče uvajanje v razvojne procese temelječe na modelih. Tukaj bomo poskušali razjasniti glavne pristope in tehnologije s tega področja, ki smo jih zasledili pri pregledu literature.

Kot nadpomenka za vse pristope, ki uporabljajo modele kot primarne entitete razvoja, se v literaturi pojavlja izraz **modelno usmerjeno inženirstvo** (*Model Driven Engineering* - ***MDE***). MDE je ena izmed redkih kratic, povezanih z modeli, ki ni licencirana s strani standardizacijske skupine OMG (*Object Management Group*), zato jo v literaturi uporabljajo kot nadpomenko za vse modelne pristope, tudi tiste, ki niso skladni s standardi omenjene skupine. V mnogih publikacijah MDE predstavljajo kot odprto in integrirano področje, znotraj katerega se pojavljajo posebne realizacije razvojnih procesov, povezanih z modeli. Negativni učinek tega, da se oznaka MDE ni pojavila pod okriljem katere organizacije, je pomanjkanje natančnejše definicije MDE. Vsi modeli znotraj MDE bi sicer naj bili dobro definirani [7], žal pa v literaturi ne obstaja niti en dobro definiran model MDE [2], kar predstavlja protislovje s filozofijo tega področja. V sklopu MDE je že nekaj časa možno zaslediti dve polarizaciji, ki zagovarjata različna pristopa k modeliranju; ena zagovarja splošno namenski, druga pa domensko usmerjen pristop.

Splošno namensko modeliranje (*General/Generic Purpose Modeling* - ***GPM***) se uporablja kot nadpomenka za označevanje razvojnih procesov, ki zagovarjajo modeliranje s sistematično uporabo (grafičnih ali tekstovnih) **splošno namenskih jezikov** (*General/Generic Purpose Language* - ***GPL***). To so jeziki, ki se uporabljajo pri modeliranju programske opreme za (zelo) različne problemske domene. Izogniti se je potrebno nevarnosti, da bi taki jeziki bili preobsežni, zato morajo zanemariti nekatere specifične abstrakcije posameznih domen in delovati na nivoju skupnih abstrakcij za vse domene. Zgodi se, da tako prej abstrahirajo rešitveni prostor (tehnični način implementacije), kot pa problemski prostor (značilnosti posla, ki ga informatizirajo). To pa pomeni velik semantičen razkorak med opredelitvami zahtev in modeliranjem. Primer takega jezika je UML (*Unified Modeling Language*), ki je najbolj prominenten predstavnik takih jezikov.

Domensko specifično modeliranje (*Domain Specific Modeling - DSM*) je nadpomenka, ki označuje razvojne procese, ki pri modeliranju zagovarjajo sistematično uporabo (grafičnih ali tekstovnih) **domensko specifičnih jezikov** (*Domain Specific Language* - ***DSL***). To so jeziki, ki formalizirajo strukturo aplikacij, obnašanje in zahteve znotraj določenih domen (na primer v aeronavtiki) [11]. Domensko specifični jeziki so opisani s pomočjo metamodelov, ki definirajo relacije med koncepti znotraj domene in natančno definirajo ključne pomene in omejitve teh konceptov [11]. Ti jeziki povečajo namenskost razvoja (*intentionality*) in omogočajo, da razvoj programske opreme opravljajo tudi domenski eksperti.

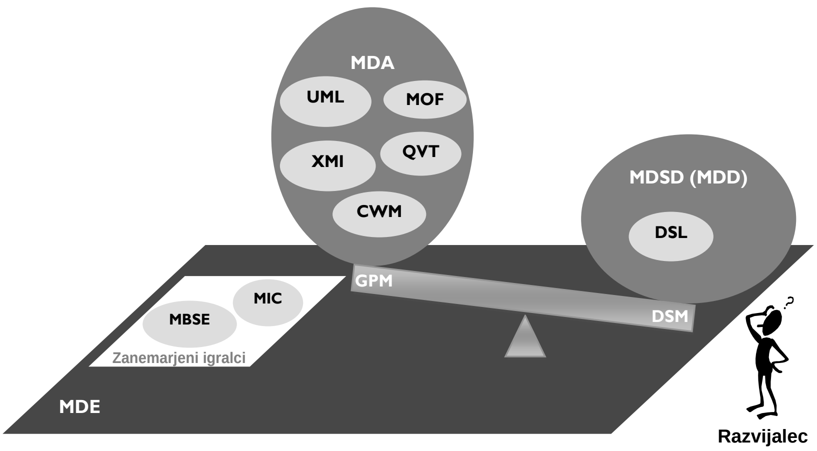
Ob omenjenih nadpomenkah so se pojavili konkretni razvojni procesi, ki dejansko predstavljajo instance MDE in se med seboj razlikujejo v nekaterih ključnih značilnostih.

Najbolj znan izmed vseh "modelno osredotočenih" pristopov je vsekakor **MDA** (*Model Driven Architecture*), ki predstavlja instanco MDE, implementirano v obliki niza standardiziranih tehnologij, definiranih s strani OMG [7]. Te so: UML, MOF (*Meta Object Facility*), QVT (*Queries/Views/Transformations*), XMI (*XML Metadata Interchange*) in CWM (*Common Warehouse Metamodel*). Tudi sam MDA je standardiziran in je definiran kot "iniciativa za pristop k sistemski specifikaciji in interoperabilnost (*interoperability*), na podlagi uporabe formalnih modelov" [10]. Potek procesa razvoja s pomočjo MDA je tak, da najprej izdelamo platformsko neodvisen model - PIM (*Platform-Independent Model*). Tega nato s pomočjo avtomatiziranih transformacij pretvorimo v platformsko specifične modele - PSM (*Platform-Specific Model*), iz katerih se v končni fazi generira izvorna kode za omenjene platforme (npr. za Javo in za MS .NET). Ker MDA večinoma uporablja splošno namensko notacijo UML, ga bomo tukaj uvrstili v tabor DSM.

Drugi konkretni pristop k "modelno osredotočenemu" razvoju se imenuje **modelno usmerjen razvoj (programske opreme)** in je dejansko glavna tema tega članka. Žal se največ nejasnosti v literaturi pojavlja prav v zvezi s tem izrazom in njegovo kratico. V številnih virih s modelno usmerjenega področja je zasledimo kratico **MDD** (*Model Driven Development*), ki pa jo uporabljajo za opis enega izmed dveh različnih principov. Prvi pomen kratico predstavlja kot sopomenko za MDE. Do tega je prišlo, ker je tudi ta kratica licencirana s strani standradizacijske organizacije OMG, ki jo uporablja v takem smislu. Drug pomen MDD, ki je v literaturi bolj pogost, pa opisuje konkretno instanco MDE, ki temelji na uporabi DSL, transformacij in generiranja programskih artefaktov. Kar pomeni, da MDD v takem pomenu prištevamo v tabor DSM. Da bi se izognili nesporazumom, so nekateri avtorji uvedli alternativno kratico za modelno usmerjen razvoj - **MDSD** (*Model Driven Software Development*). Ker kratica MDSD enolično opisuje modelno usmerjen razvoj v takem kontekstu, kot je obravnavan s tem članskom, bo odslej uporabljena tudi v tem delu.

Obstajajo še drugi pristopi, ki so manjkrat uporabljeni v literaturi (npr. *Model Integrated Computing – MIC*) ali pa predstavljajo starejše pristope s podobnimi idejami (npr. *Model Based Software Engineering - MBSE*) in jih tukaj ne bomo obravnavali.

S ciljem, da bi bralcu pojasnili vpeljane pojme oziroma njihove kratice in postavljene relacije med njimi, smo se odločili, da izdelamo grafični prikaz področja "modelno



Slika 1: *Igrišče "modelno osredotočenega" programskega inženirstva s svojimi glavnimi igralci. Predstavljena je polarizacija področja, s pristopi GPM na eni strani in pristopiDSM na drugi strani. Prikazano je tudi naše prepričanje, da "zmaguje" DSM.*

osredotočenega" programskega inženirstva, ki je predstavljen na sliki 1.

Za definicijo natančnejših relacije med vsemi pojmi znotraj tega področja, bi bilo smotrno izvesti intenzivnejšo raziskavo. Rezultat le-te bi lahko bil članek, ki osvešča potencialne uporabnike "modelno osredotočenih" procesov in tehnologij.

3 MDA (SPLOŠNI NAMENSKI PRISTOP) vs. MDSD (DOMENSKO SPECIFIČEN PRISTOP)

Katerega izmed obstoječih "modelno osredotočenih" pristopov naj razvijalec uporablja pri svojem delu, če sploh?

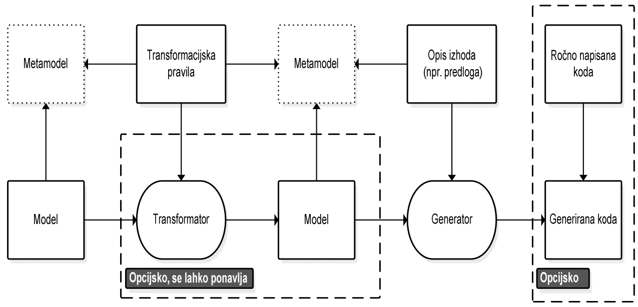
MDA kot iniciativa OMG obsega več tisoč strani dokumentacije in prav ta obsežnost je ena večjih ovir, ki so preprečile njen uspeh. V [5] zasledimo, da MDA, namesto da bi zakril kompleksnost razvoja programske opreme, le-to premakne od programiranja k modeliranju, razlog zato moramo iskati predvsem v uporabi splošno namenske notacije UML. UML ima 13 diagramskih tipov in 3 prilagoditvene mehanizme, ta kompleksnost pa povzroča razvijalcem nemalo preglavic. Eden izmed glavnih ciljev, ki jih želijo doseči novi pristopi k razvoju programske opreme, je povečanje produktivnosti in tako posredno zmanjšanje stroškov razvoja programske opreme. Žal pa MDA na tem področju ni zelo uspešen, saj je v študijah sponzoriranih s strani OMG pokazal zgolj 35% povečavo produktivnosti, kar pa težko opravičuje stroške povezane z njegovo uvedbo (na primer za izobraževanje, nakup orodij in spremembo razvojnega procesa). Glavni razlog za majhno povečanje produktivnosti je dejstvo, ki ga je priznal sam OMG, "da generiranje celotne kode iz UML ne bo mogoče" [6]. Za izvajanje MDA obstaja potreba po specializiranih znanjih in orodjih. Še ena kritika je usmerjena na slabo definiranost nekaterih standardov, ki jih uporablja MDA (na primer QTV).

MDSD obljublja bistveno povečanje produktivnosti pri razvoju. To omogoča DSL z definiranjem simbolov, ki so povezani s pojmi iz naše poslovne domene (problemski prostor). Na kocu avtomatsko generiramo celotno kodo neposredno iz domensko specifičnih modelov, kar naj bi pospešilo hitrost razvoja od 5 do 10 krat [6]. MDSD omogoča dejansko skrivanje kompleksnosti današnjih programskih jezikov in platform (npr. tako kot ti programski jeziki skrivajo kompleksnost zbirnika), saj zaradi domenske specifičnosti zagotavlja modeliranje na zelo visokem nivoju abstrakcije [13]. Pri modeliranju zadošča majhno število diagramskih tipov, saj ni potrebno pokriti veliko število domen tako kot pri GPM. Avtomatizirane preslikav omogočajo povečanje kvalitete programske opreme, saj ni prisotnih napak, ki jih vnesemo pri ročnem kodiranju.

4 MODELNO USMERJEN RAZVOJ (MDSD)

4.2 Proces modelno usmerjenega razvoja

Proces modelno usmerjenega razvoja lahko na splošno opišemo kot zaporedje korakov, ki je sestavljeno iz modelov in transformacij med njimi (glej sliko 2).



Slika 2: *Posplošeni proces modelno usmerjenega razvoja (programske opreme)*

Modeli so običajno ustvarjeni s pomočjo domensko specifičnih jezikov, ki jih definirajo njihovi metamodeli. Model iz enega nivoja pretvorimo v model drugega nivoja s transformacijami. Transformacije po [1] lahko klasificiramo na:

- transformacije "**model v model**" (*model-to-model*) in
- transformacije "**model v kodo**" (*model-to-code*).

Proces modelno usmerjenega razvoja je lahko najmanj dvonivojski, kar pomeni, da je sestavljen zgolj iz izvornega modela v izbranem DSL, iz ciljnega programskega jezika in iz "model v kodo" transformacije med njima. Dvonivojski MDSD proces je najpogosteje uporabljen in hkrati najenostavnejši, saj vsebuje zgolj eno "model v kodo" transformacijo. Taka transformacija je implementirana v obliki generatorja, ki lahko uporablja enega izmed sledečih načinov generiranja:

- generiranje na **principu obiskovalca** (*Visitor based*),
- generiranje na **principu predlog** (*Template based*).

Bistvo generiranja kode po principu obiskovalca je mehanizem, ki potuje po notranji predstavitvi modela in piše kodo v tekstovni tok (*text stream*) [1]. To je najenostavnejši način generiranja.

Bistvo drugega pristopa h generiranju so predloge, v katerih je zakodirana transformacija iz izvornega modela v ciljni programski jezik. Pri generiranju kode, so predloge običajno sestavljene iz teksta ciljnega programskega jezika ter iz delčkov metakode, ki dostopajo do informacij v izvornem modelu. Prednost predlog je v tem, da jih lahko enostavno tvorimo iz primerov izvorne kode ciljnega programskega jezika in da enkapsulirajo sintakso tega programskega jezika [1].

Kadar izvajamo proces modelno usmerjenega razvoja, ki ima tri ali več nivojev, moramo izvesti tudi "model v model" transformacije, za izvedbo katerih so se uveljavili sledeči načini [1]:

- **pristop z direktno manipulacijo,**
- **relacijski pristop,**
- **pristop s transformacijami grafov,**

- **strukturno usmerjen pristop,**
- **hibridni pristop.**

Opise teh pristopov lahko najdemo v [1].

Avtomatizacija transformacij med modeli različnih faz življenjskega cikla sicer ni nujna, je pa končni cilj modelno usmerjenega razvoja [13]. Taka avtomatizacija je možna zgolj s programskimi orodji, ki vsebujejo transformacijski stroj (*transformation engine*) in generator programskih artefaktov v obliki tekstovnih datotek.

4.3 Splošna arhitektura orodij za tovrsten razvoj

Da bi dosegli tako povečanje produktivnosti, kot ga obljublja modelno usmerjen razvoj, nujno rabimo programsko orodje, ki podpira avtomatizacijo takega procesa. Na podlagi pregleda literature in analize obstoječih MDSD orodij, smo identificirali domensko specifično arhitekturo takih orodij in jo prikazali na sliki 3.

Za uporabnika je vsekakor najpomembnejši del **grafični urejevalnik modelov**. Ta mora omogočati uporabniško prijazno in enostavno modeliranje v domensko specifičnih jezikih. Izpolnitev tega cilja pa zahteva napor in čas, zaradi česar je v [9, 13] možno zaslediti poročila, da je to za razvoj najzahtevnejši del takega orodja.

Osrednji del programskega orodja je **notranja predstavitev modelov**, ki mora omogočati hranjenje modelov v taki obliki, da jih lahko programsko obdelujemo [13] (na primer pridobivanje informacij o elementih modela in manipulacijo modela). Medtem ko je grafična predstavitev, ki jo omogoča grafični urejevalnik modelov, namenjena ljudem, ki smo po naravi vizualna bitja, pa taka oblika ni primerna za računalniško obdelavo.

Za generiranja programskih artefaktov je pristojen **generatorski del** programskega orodja. Ta kot vhod dobi opis izhoda (ponavadi v obliki predloge) in notranjo predstavitev trenutnega modela, po katerem se sprehaja (*traverse*) in pridobiva podatke, ki so zahtevani v opisu izhoda. Nato pa na podlagi obeh vhodov generira izhodno tekstovno datoteko.

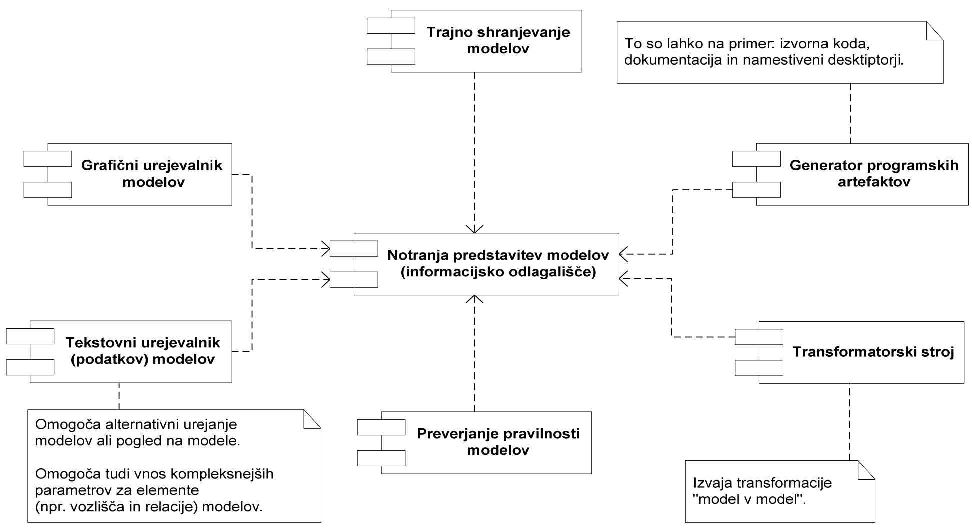
Če smo se odločili, da bo naše orodje podpiralo tri ali več nivojski modelno usmerjen razvoj, potem mora orodje vsebovati **transformacijski stroj**. Ta izvaja transformacije "model v model", ki jih opišemo s transformacijskimi pravili. Transformacijska pravila in notranja predstavitev izvornega modela sta vhoda v transformatorski stroj, ki na njuni podlagi izdela notranjo predstavitev ciljnega modela.

Programsko orodje mora omogočati še **trajno shranjevanje modelov** (priklic in shranjevanje) in **preverjanje semantične pravilnosti modelov**. Opcijsko pa lahko nudi tudi **tekstovni urejevalnik modelov**.

4.4 Načini realizacije takih orodij

Sedaj, ko smo spoznali bistvene elemente MDSD orodij, si oglejmo načine za razvoj takega orodja. Uberemo lahko eno izmed naslednjih možnosti [13]:

1. Uporabimo **obstoječa UML orodja** in modele razširimo s profilom, to je z množico stereotipov (*stereotypes*), označenih vrednosti (*tagged values*) in omejitev (*constrains*).
   - **Prednosti**: enostavnost implementacije; (zgleda kot) standard; bolj ali manj sprejemljiv izvozni format XMI; na voljo so funkcije orodja (npr. iskanje).
   - **Slabosti**: grafična funkcionalnost je zelo omejena; skoraj nemogoče je realizirati DSL, ki ni podoben diagramom v UML standardu; ni se mogoče popolnoma znebiti UML semantike; še vedno je potrebno uporabljati zelo kompleksna obstoječa UML orodja; generiranje kode je omejeno z zmožnostmi uporabljenega orodja.
2. Prilagoditev **generičnih risalnih orodij** (recimo Microsoft Visio). To storimo tako, da povežemo dejanski model, ki ga gradimo (podatke), z risbo (grafiko).
   - **Prednosti**: zahteva običajno majhen trud, vložen v implementacijo (odvisno od orodja); zmogljiva



Slika 3: *Domensko specifična arhitektura programskih orodij za modelno usmerjen razvoj (programske opreme).*

grafična funkcionalnost; ni podedovanih funkcionalnosti, ki bi bile vsiljene s strani orodja.
   - **Slabosti**: običajno orodje ne ve nič o metamodelu; vprašljive možnosti za implementacijo generatorja kode; ni standardov.
3. Uporabimo orodja za gradnjo MDSD orodij, tako imenovana **MetaCASE orodja** (recimo MetaEdit+ ali Microsoft DSL Tools).
   - Prednosti: hitra implementacija; zmogljiva grafična funkcionalnost; relativno enostavna gradnja urejevalnika in generatorja.
   - Slabosti: cena nekaterih orodij; nezrelost drugih orodij; kompleksnejše DSL je težko implementirati.
4. Razvijemo **lastno MDSD orodje "iz nič"** (*from scratch*)
   - Prednosti: običajno zelo zmogljiva grafična funkcionalnost; ni privzetih lastnosti, ki bi bile vsiljene s strani orodja – popolna prilagodljivost; možna je samo veljavna konkretna sintaksa; orodja so lahko zelo enostavna (ne tako kot UML orodja).
   - Slabosti: cena in zahtevnost razvoja, ni standardov.

Pri odločitvi, katero izmed možnosti izbrati za naš projekt, moramo vedeti, kake cilje imamo. Če izberemo prvo možnost, imamo opravka z UML ter omejitvami, ki jih vsiljuje. Pri drugi možnosti je največji problem zelo težavno implementiranje generiranja kode. Tako sta za izbiro najprimernješi zadnji dve možnosti. Tretjo možnost priporočamo vsem, ki nimajo kompleksnega DSL, saj MetaCASE orodja omogočajo najhitrejšo in najenostavnejšo gradnjo MDSD orodij. Če je izbran DSL prekompleksen in ga ni mogoče zgraditi s pomočjo teh orodij preostane zgolj gradnja lastnega orodja "iz nič".

6 SKLEP

Spoznali smo modelno usmerjen razvoj (programske opreme), ki združuje principa domensko specifičnih jezikov (DSL) in generatorjev kode, uvedena v sklopu domenskega inženirstva, in ju dopolnjuje z idejo o modelih kot primarnih entitetah razvoja. Kljub trenutnim otroškim boleznim MDSD smo spoznali velik potencial take metode razvoja programske opreme. Indikator, da MDSD ni le muha enodnevnica, dokazuje vedno večja ponudba orodij MetaCASE na trgu, ki omogočajo dokaj enostaven in hiter razvoj MDSD orodij za poljubne domene uporabe, domensko specifične jezike in ciljne programske jezike.

Da bi ugotovili, katere obljube MDSD so v praksi uresničljive, izvajamo na Odseku za sisteme in vodenje projekt, znotraj katerega razvijamo MDSD orodje. Cilj orodja je (delna) avtomatizacija izdelave programske opreme za vodenje industrijskih procesov, izvedljive na programirljivih logičnih krmilnikih (PLK). Natančneje mora omogočati dvonivojski MDSD proces, kjer se iz modelov, izdelanih v notaciji ProcGraph, generira programska koda, zapisana v funkcijskem blokovnem diagramu. ProcGraph je "visokonivojska, domensko specifična specifikacijska notacija, ki temelji na treh tipih diagramov, ki opisujejo modelirani sistem z uporabo domensko usmerjene hierarhične strukture, sestavljene iz medsebojno odvisnih entitet postopkovnega vodenja in iz diagramov prehajanja stanj" [4]. "Zaradi večanja kompleksnosti PLK se pojavlja povečana potreba po sistematičnem pristopu k razvoju take programske opreme." [3]. Tak sistematičen pristop pa nam omogoča ravno MDSD, ki dvigne abstrakcijo razvoja in avtomatizira razvojno fazo kodiranja.

Sicer obstaja potencialna ovira za uspeh MDSD, to je pomanjkanje standardizacije, ki je dobesedno ni. Tako lahko pride do pojava divergence, kar ovira prehodnost razvijalcev med različnimi organizacijami, torej bi se ti morali vedno znova učiti nove DSL. Čakamo torej, da se v kaotični svet MDSD, kjer ni standardov ne za specifikacije DSL, ne za orodja in niti za skupne abstrakcije v posameznih domenah (na primer v aeronavtiki), uvede red.

Če se bo, potem vidimo zelo svetlo prihodnost za MDSD, ki bi dejansko lahko revolucioniral način, kako gradimo programsko opremo. Takrat (nekaterim) razvijalcem ne bo več potrebno pisati programske kode, ker bo le-ta v celoti generirana iz modelov.

Literatura

[1] K. Czarnecki, S. Helsen, Classification of Model Transformation Approaches, *OOPSLA 2003 Workshop on Generative Techniques in the Context of Model-Driven Architectures*, 2003.

[2] J. M. Favre, Towards a Basic Theory to Model Model Driven Engineering, *Workshop on Software Model Engineering (WISME),* Lisboa, Portugal, 2004.

[3] G. Godena, Conceptual model for process control software specification, *Microprocessors and microsystems*, 20, (1997), 10, str. 617-630.

[4] G. Godena, ProcGraph: a procedure-oriented graphical notation for process-control software specification, *Control Engineering Practice*, 12, (2004), 1, str. 99-111

[5] B. Hailpern, P. Tarr, Model-driven development: The good, the bad, and the ugly, *IBM Systems Journal*, 45, (2007), 3, str. 451-461.

[6] S. Kelly, Comparison of Eclipse EMF/GEF and MetaEdit+ for DSM, *In 19th Annual ACM Conference on Object-Oriented Programming, Systems, Languages, and Applications, Workshop on Best Practices for Model Driven Software Development*, 2004.

[7] P. Klint, R. Lämmel, C. Verhoven, Toward an engineering discipline for grammarware, *ACM Transactions on Software Engineering Methodology*, 14, (2005), 3, str. 331-380.

[8] J. Ludewig, Models in software engineering – an introduction, *Software and Systems Modeling*, 2, (2003), 1, str. 5-14.

[9] T. Lukman, Modelno usmerjen razvoj sistemov vodenja industrijskih procesov, diplomsko delo, Fakulteta za elektrotehniko, računalništvo in informatiko, Maribor, 2007.

[10] J. D. Poole, Model-Driven Architecture: Vision, Standards And Emerging Technologies, *Workshop on Metamodeling and Adaptive Object Models*, 2001.

[11] D. C. Schmidt, Model-driven Engineering, *IEEE Computer*, 39, (2006), 2, str. 25-31.

[12] Y. Smaragdakis, D. Batory, Application generators, *Software Engineering volume of the Encyclopedia of Electrical and Electronics Engineering*, John Wiley and Sons, 2000.

[13] T. Stahl, M. Völter, Model-Driven Software Development: *Technology, Engineering, Management*, John Wiley & Sons, 2006.

Zbornik 10. mednarodne multikonference

INFORMACIJSKA DRUŽBA - IS 2007

Proceedings of the 10th International Multiconference

INFORMATION SOCIEY - IS 2007

Kognitivne znanosti

Cognitive Sciences

Uredili / Edited by

Urban Kordeš, Matjaž Gams, Olga Markič

http://is.ijs.si

9. oktober 2007 / 9th October 2007
Ljubljana, Slovenia

PREDGOVOR

Pristopi in modeli pri raziskovanju zavesti/duševnih procesov

Letos že štirinajstič nadaljujemo tradicijo vsakoletnih srečanj kognitivnih znanstvenikov v okviru Slovenskega društva za kognitivne znanosti in že desetič pod okriljem multikonference »Informacijska družba«. Leto 2007 ni najbogatejše s konferenčnimi prispevki, kar pa ne pomeni, da se na področju kognitivne znanosti nič ne dogaja. Nasprotno! V istem mesecu kot bo naša konferenca se bosta zgodili še dva povezana dogodka: nevroznanstvena konferenca pod okriljem Sinapse in konferenca o meritvah energetskih polj v uredništvu Igorja Kononenka. Še bolj pomembno pa je, da je konec avgusta izšla knjižica *Kognitivna znanost v Ljubljani – možnosti za študij in raziskovalno delo*, ki poskuša narisati zemljevid stanja raziskovalnega dela na tem področju. Knjižica je mišljena kot prvi korak k snovanju študija kognitivne znanosti na Ljubljanski univerzi in verjetno predstavlja vrh dosedanjih prizadevanj za povezovanje pod dežnikom kognitivnih znanosti.

Knjižica *Kognitivna znanost v Ljubljani – možnosti za študij in raziskovalno delo* (ki jo je sofinancrial Evropski socialni sklad in jo bodo zastonj dobili vsi udeleženci konference) vsebuje predstavitev kognitivne znanosti, predvsem pa je zamišljena kot vodnik vsem, ki jih zanima študij ali raziskovalno delo na tem področju in kot pomoč raziskovalcem, ki bi si želeli združiti svoje delo s predstavniki drugih raziskovalnih področij. Risanja zemljevida kognitivne znanosti v Ljubljani smo se lotili tako, da smo izbrali predstavnike konstitutivnih disciplin naj zberejo relevantne skupine in projekte, napišejo predstavitev področja in oris raziskav v Ljubljani ter uredijo prispevke na svojem področju. Uredniki posameznih področij so: doc. dr. Olga Markič (filozofija), izr. prof. dr. Zvezdan Pirtošek (nevroznanost), doc. dr. Janez Mlakar (psihologija), akademik prof. dr. Ivan Bratko (umetna inteligenca), doc. dr. Tatjana Marvin (lingvistika), izr. prof. dr. Gregor Tomc (družbeni vidiki kognicije), prof. dr. Igor Jerman (biološko-fizikalni vidiki kognicije). Uredniki so po svoji presoji izbrali način obveščanja skupin in uvrščanja prispevkov. Struktura tekstov dobro odseva kompleksno in raznoliko strukturo kognitivne znanosti.

Enako velja za strukturo člankov, ki bodo predstavljeni na letošnji konferenci. Pokrivajo širok spekter področij od filozofije, preko znanosti o sistemih do lingvistike, umetne inteligence do biologije in medicine. Kot taki odsevajo stanje na področju kognitivnih znanosti, kjer se problemov vsaka disciplina loteva po svoje (mnogokrat izjemno uspešno), malo pa je primerov uspešnega združevanja rezultatov v celovit, interdisciplinarne modele kognitivnih pojavov. Lahko bi rekli, da se kognitivna znanost kot enovita disciplina sooča z metodološkime težkim problemom: kako povezati naravoslovje (ki preučuje nevrofiziološke procese) in humanistične vede (ki preučujejo doživljajske vsebine), ki je ekvivalent klasičnemu kognitivnemu »težkemu problemu« (torej problemu ločitve telesnega in duševnega).

Na kognitivni konferenci vzpodbujamo interdisciplinarno debato med znanstveniki, ki se tako ali drugače ukvarjajo z raziskovanjem zavesti. Pričujoči teksti vsebujejo poročila o raziskavah, pa tudi razmišljanja o predpostavkah, na katerih temeljijo posamezne raziskave (ki so znotraj posameznega raziskovalnega polja včasih tako samoumevne, da se jih sploh ne zavedamo).

Urban Kordeš
Matjaž Gams
Olga Markič

KOT Z OČESOM IN VIDNIM POLJEM (5.633)

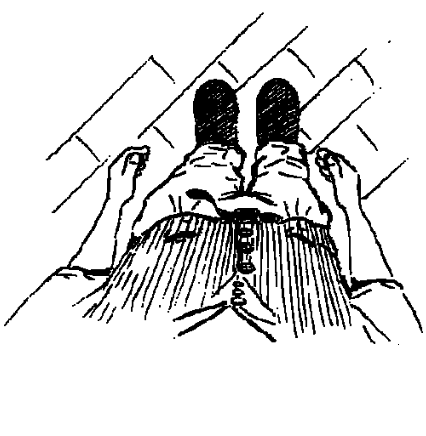
Damjan Bojadžiev

Odsek za Tehnologije Znanja, Institut Jožef Stefan
Jamova 39, 1000 Ljubljana
http://nl.ijs.si/~damjan/me.html
E-mail: damjan.bojadziev@ijs.si, Fax: (+386 1) 477-3315

POVZETEK

Referat, namesto običajnega Gödlovanja (Bojadžiev 2006), komentira popularno mesto v Wittgensteinovem "Traktatu", ki zgošča nekaj tradicionalnih tem optične metafizike subjekta.

Filozofska in siceršnja refleksija o subjektu (jazu, zavesti, …) pogosto uporablja optične modele ali metafore, npr. v tradicionalnem dojemanju subjekta kot notranjega očesa (oculus mentis: Eckhart, Locke, Fichte, Brentano, …) V tem se predvidoma odraža prevladujoči optični način doživljanja sebe kot točke oz. izhodišča pogleda ali perspektive na svet. Pri tem je zanimivo, da gre vedno za implicitno kiklopski model, ki gladko zanemarja dejstvo, da imamo, tako kot vsa druga bitja, z izjemo mitoloških kreatur, dve očesi. Kiklopski model se nekako spontano vzpostavi in se obnaša, kot da ne bi bilo pomembno, koliko oči pravzaprav imamo (notranje oko je takorekoč že po (sicer manjkajoči) definiciji eno), zakaj jih imamo ravno toliko, in zakaj je to število tudi sicer prevladujoče, tudi v fosilnem zapisu. Ta redukcija števila oči sicer ustreza dejstvu, da, čisto fenomenološko gledano, vendar le na prvi pogled, oči pravzaprav nimamo tj. nimamo niti enega očesa, kot tudi glave ne (Harding).



S tem se spregled oz. prostodušna ali morda velikodušna postavitev v oklepaj dejanskega števila oči mogoče nekoliko ublaži ("what's an eye or two between metaphysicians"), vseeno pa kaže domnevati, da je s tem šla v izgubo bistvena lastnost oči (ne "očesa", kot bi rekla tradicionalna formulacija), kar postavlja pod vprašaj pojasnjevalno moč analogije subjekta in očesa. Pri tem se lahko kvečjemu tolažimo z dejstvom, da dokler ne vemo dosti bolj natančno, kaj se dogaja v delu videnja, ki poteka izza oči, v možganih, količina obskurnosti pri obeh členih primerjave ostaja približno enaka.

Eksplicitno obliko pritajene premise, da gre pri subjektu-kot-očesu za kiklopski model, je najti v Wittgensteinovem "Traktatu" (1922/1976), v nekoliko nenavadni trditvi, da

Očesa dejansko ne vidiš, in v vidnem polju ni mogoče po ničemer sklepati, da ga neko oko vidi (teza5.633)

Das Auge siehst du wirklich nicht, und nichts am Gesichtsfeld lässt darauf schliessen, dass es von einem Auge gesehen wird

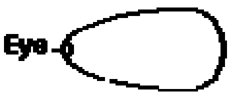
Tu je seveda res, da očesa ne vidimo, saj ne vidimo niti roba vidnega polja, kaj šele njegovo izhodišče – oko pač leži v mrtvem kotu lastnega zrenja. Bolj natančno rečeno, očesi (dvojina) ležita v mrtvem kotu njunega zrenja, ker ju pač nimamo na pecljih, in neodvisne eno od drugega. Seveda je tudi res, da nič v vidnem polju ne dopušča sklepa, da to vidno polje gleda oko (dass es von einem Auge gesehen wird), toda le zato, ker vidno polje ne gleda eno oko, temveč ga gledata dve (es wird ja nicht von einem Auge gesehen, sondern von denen zwei). Trditev, da nič v vidnem polju ne dopušča sklepa, da ga gleda oko, pa je precej površna; natančnejši pogled pokaže, da marsikaj v vidnem polju lahko ne le dopušča, temveč tudi narekuje sklep, da ga vidi oko oz. očesi. To so lahko določene metrične lastnosti vidnega polja in fenomeni na njegovem robu (npr. prozorna senca nosu; Gibson), po drugi strani pa je to osnovna značilnost notranjosti vidnega polja, da je namreč njegov centralni del, ki je presek vidnih polj obeh oči, trodimenzionalen (pri očeh gre tako za prostor oz. videnje prostora, zaradi gibanja telesa v njem). Iz same trditve, da nič v vidnem polju ne dopušča sklepa, da ga gleda oko, pa je mogoče sklepati npr. da Wittgenstein ni nosil očal in ni imel pretirano dolgih obrvi ali težav s prostorsko navigacijo.

Na tem mestu “Traktata” se para-optika subjekta:

Kje v svetu lahko opazimo metafizični [misleči, predstavljajoči si] subjekt? Praviš, da je s tem povsem tako, kot z očesom in vidnim poljem.

$$\frac{\text{Subjekt}}{\text{Welt}} = \frac{\text{Auge}}{\text{Gesichtsfeld}}$$

povezuje s še eno klasično metafizično temo, namreč s pozicijo solipsizma. Pri tem je zanimivo ravno to, da se para-optika subjekta povezuje s solipsizmom, ne pa z njegovo negacijo (anti-solipsizmom: obstaja le svet, subjekta pa ni). Iz trditve, da »ni mislečega, predstavljajočega si subjekt« (5.631) bi namreč ravno to sledilo, toda Witgenstein se raje prikloni intenci (čeprav ne formulaciji) solipsizma, in nadaljuje v smeri nekoliko nejasne metaforike meja: subjekt je meja sveta, jezik subjekta (ki ga razume le subjekt sam) pa tudi. Ob tem bi se dalo pripomniti, kot bi lahko to storil pozni Wittgenstein, če bi se mu zdelo vredno, da v svetu, ki ne bi bil poln subjektov, ne bi bilo niti subjekta, ki bi lahko razglabljal o svoji poziciji v njem ali na njegovi meji, v kakršnem koli jeziku.



Literatura

Bojadžiev, D., Meje formalizacije v logični semantiki, Doktorska disertacija, Filozofska fakulteta, Univerza v Ljubljan 1992; povzetek, kazalo in sklep na http://nl.ijs.si/~damjan/phd.html

Bojadžiev, D. Reflections on Reflection – Assumptions and Analogies, Proc. Int. Multi-conference “Information Society – Cognitive Science”, Ljubljana 2006

Gibson, J., The perception of the Visual World, Riverside Press 1950

Harding, D., On having no head, v Hofstadter in Dennett 81, pp. 23-30

Hofstadter, D., Dennett, D. (ur.), The Mind's I, Penguin 1981

Wittgenstein, L., Logično-filozofski traktat (Logisch-Philosophische Abhandlung, 1922), Mladinska Knjiga, 1976

AN FMRI STUDY OF VERBAL WORKING MEMORY PROCESSING IN FLUENT AND NON-FLUENT BILINGUALS

Naja Ferjan
Department of Neuroscience
Brown University, Providence, Rhode Island 02912, USA
Email: Naja_Ferjan@hotmail.com

Matjaž Gams
Odsek za inteligentne sisteme
Institut Jožef Stefan, Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 477 3644; matjaz.gams@ijs.si

Abstract

The neurolinguistic and psycholinguistic research has not yet conclusively established whether the neural substrates underlying one's first and second language (L1 and L2) are anatomically segregated in the brain. There is extensive evidence supporting distinct as well as common cerebral representations of L1 and L2. Relatively few studies have approached the problem of information processing in L1 and L2 from the perspective of verbal working memory (WM). By using functional magnetic resonance imaging, this study aims to determine whether there is a functional dissociation of WM associated with L1 and L2. We determine the volume of activation in each region of interest (ROI), and then calculate the proportion of overlapping activations of L1 and L2. We first investigate the impact of language proficiency on the pattern of activation in the neural correlates of WM. We analyze hypotheses that the same neural network is used for WM processing in L1 and L2 even if the subjects are more proficient in one language than in the other, and that there is a greater volume of activation within each ROI in the subjects' less proficient language. This study also considers a possible effect of L2 acquisition age on the activations associated with WM processing. We claim that the same neural networks are used for WM processing in L1 and L2 even if L2 is acquired after the so called critical period.

1 INTRODUCTION

Although there are a number of neurolinguistic studies that have investigated how two different languages are represented in a bilingual brain, the question of distinct or common neural networks for L1 and L2 processing remains to be solved. The issue of L1 and L2 representation is complex because of a high number of variables that can influence the neural organization of the two languages. Some neuroimaging studies provide evidence for the role of age of L2 acquisition in determining the pattern of brain activation associated with language processing. Linguists generally agree that in the case of L2 acquisition, there is a gradual decline related to age in the ease with which people learn a second language, so that young children have an advantage over adults (Johnson at all. 1989). Moreover, the critical period hypothesis claims that in adulthood, the language faculty is no longer available in the same way as in early childhood. L2 acquisition is still possible after puberty, but late L2 learners have to resort to other cognitive capacities (Bhatia et all. 2004) or to translation via L1. Considering this theory, it is therefore possible that the implications of L2 acquisition age would be reflected in differential activations in the language sensitive areas. It has also been established that any differences in L1 and L2 proficiency can result in differential spatial representation of the two languages in the brain. In (Chee et al, 2001) it has been shown that in a semantic judgment task, L2 proficiency modulates the distribution and the magnitude of BOLD signal. Specifically, the change in BOLD signal was smaller and more spatially confined in a participant's more proficient language.

The neural networks underlying L1 and L2 processing have been widely studied and discussed in the literature. Nevertheless, relatively few studies have approached the problem of information processing in L1 and L2 from the perspective of verbal working memory (WM). A brain system of verbal WM provides temporary storage and manipulation of a limited amount of linguistic information (Baddeley 1992). Bilinguals can perform cognitive functions in two languages, but it has not yet been established whether information processing in the two languages employs a common cognitive-neural system of working memory. By using functional magnetic resonance imaging (fMRI) one can identify the neural correlates involved in working memory of native and second languages and determine whether there is a functional dissociation of WM associated with L1 and L2. Although some behavioral studies have shown that WM processing in L1 and L2 use the same cognitive mechanisms (Cheung et al. 2000), this does not necessarily mean that WM of the two languages employs a common cognitive-neural network. The results of brain imaging studies of neural correlates of WM in L1 and L2 have so far been inconsistent as seen by comparing (Kim et al. 2002) and (Xue et al. 2004).

By using functional magnetic resonance imaging, this study aims to determine whether there is a functional dissociation of WM associated with L1 and L2. As proposed by Xue et al., we determine the volume of activation in each region of interest, and then calculate the proportion of overlapping activations of L1 and L2 within each region of interest. Considering that language proficiency has been suggested as one of the most critical factors determining spatial representation of the two languages in the brain (Chee et al. 2001), our goal is to investigate whether any differences in processing of L1 and L2 in non-fluent bilinguals extend to a functional dissociation of verbal WM associated with L1 and L2. In order to further examine the impact of language proficiency on the pattern of activation in the neural correlates of WM, this study compares the brain activations associated with a WM task in the native and second language of fluent and non-fluent adult learners of French.

In addition, the study considers a possible effect of L2 acquisition age on the activations associated with WM processing. As already mentioned, the critical period hypothesis suggests that the implications of L2 acquisition age can be reflected in differential activations in the language sensitive areas. It is therefore possible the age of L2 acquisition also affects the activations in the neural correlates of verbal WM. In order to investigate this question, we compare brain activations associated with WM processing in L1 and L2 of fluent adult learners of French with the activations of fluent bilinguals who have acquired English and French simultaneously.

2 METHODS

Participants

Thirty-six healthy, right handed adult native speakers of English of comparable age were recruited from the Brown University community for the study. The number of males and females was equal, exclusion criteria included any past or present history of neurological, general medical, or psychiatric illness. After a complete description of the study the subjects were given written informed consent. All experiments were performed with the relevant laws and institutional guidelines. The subjects were grouped according to their age of acquisition of French (before of after the age of 6), and proficiency level in French assessed by a standardized test and a story reading task. The subjects were divided into three groups:

- Early learners, high proficiency (EH group, 12 participants)
- Late learners, high proficiency (LH group, 12 participants)
- Late learners, low proficiency (LL group, 12 participants)

While the difference in L2 proficiency between EH and LH as determined by the standardized test and by the reading task was not significant, the difference in proficiency level between LH and LL group was significant on both measures of L2 proficiency. All subjects have lived exclusively in the United States. Participants in the LL and LH group have started learning French after the age of 12. The LL and LH subjects were all students in the French Department at Brown University, which assured that they had an approximately equal level of exposure to L2 at the time of our study. The subjects in the EH group have acquired French at home simultaneously with English, and have been using it on a daily basis to communicate with their family members.

Cognitive Task

WM task was a sequential order task with a typical 2-back condition in which the subjects were required to continuously monitor a sequence of stimuli and to make judgments on semantic relations between the word currently presented and the word that had been presented two words earlier in the sequence. The task required the subjects to keep in mind both the identity and the order of the presented objects and to continuously update the information in their working memory. The task therefore entailed temporary storage and manipulation of information. The control task involved naming and judging: subjects had to silently name each of the presented words in the sequence and judge whether the word was circled or not.

One hundred English and one hundred French words of approximately equal length were selected for the study. In order to minimize the effects of familiarity with the words, none of the words presented in English had the same meaning as the words presented in French. All the words were high frequency nouns with concrete meanings. The number of syllables in each word, as well as the use frequency of words was carefully matched. The stimuli in each language were divided into two groups for the semantic and the control task. Before the brain scans, subjects were trained and were thus familiar with the experimental procedure.

The two scanning sessions, one for English and one for French, involved 10 blocks each: five semantic blocks for the experimental task and five for the control task. Each block consisted of 10 items and lasted 30 seconds. A cue of 5 seconds was presented before each block to instruct the subjects about the task for that block. Stimuli were presented through a mirror attached to the head-coil, materials were presented in black color on a white background. Each word was presented for one second, followed by an interstimulus interval of two seconds. Positive response was indicated by pressing the key with the right index finger, and negative response was indicating by pressing the key with the left index finger.

3 IMAGE ACQUISITION AND DATA ANALYSIS

Images were acquired on a 1.5-T scanner with standard head coil at the MRI Research Center at Brown University. Gradient-echo planar T2*-weighted images depicting blood oxygenation level dependent (BOLD) contrast were acquired from 20 contiguous axial slices to cover the whole brain: TE=40ms, TR=2000ms, flip angle=70˚, voxel size 3 x 3 x 3 mm, slice thickness 7mm. BOLD images were smoothed, normalized, corrected for motion artefacts and co-registered to the anatomical scans. The threshold for significant activation was $P<0.05$ (multiple comparison corrected). Finally, group averaged effects were computed. Clusters with more than 10 voxels activated above threshold were considered as significant for group results.

4 ROI SELECTION

To compare the amount of activation in a given area across experimental conditions, a number of ROIs were selected based on previous studies employing a related task (Xue et al. 2004; Kim et al. 2002; Fiez et al. 1996; Paulesu et al. 1993; Clark et al. 2000). The following areas associated with reliable activation in verbal WM tasks and their right hemisphere homologues were selected as ROIs: the pars opecularis ROI consisted of the posterior portion of the inferior frontal gyrus (BA44). The left precentral sulcus ROI included the superior portion of the precentral gyrus (BA6). BA 45/47 was the pars triangularis ROI in the anterior portion of the ventrolateral prefrontal cortex. The parietal ROIs included the inferior parietal lobule (BA40), the superior parietal lobule (BA7) and supramarginal gyrus (BA39). The dorsolateral prefrontal ROIs corresponded to BA9 and BA46.

To compare the activations associated with different experimental conditions, we computed the number of significantly activated voxels in each ROI for each condition. To evaluate the effects of language, we calculated for each participant number of activated voxels within each ROI for the French WM task, the English WM task and the commonly activated voxels in the two tasks. The proportion of voxels activated in each language was compared to the averaged total number of activated voxels in French and English.

5 DISCUSSION

By comparing the percent overlap of activations, and the volumes of activation associated with WM processing in L1 and L2 between the subject groups, one can investigate the effects of language proficiency and L2 acquisition age on the use of neural networks associated with WM. The existence of overlapping activations for WM processing in L1 and L2 would suggest that WM processing in the native and second language is facilitated by the use of a common neural network. Any differences in the volumes of activation associated with each of the two languages would suggest that processing of one of the two languages required more cognitive resources than processing of the other.

By comparing the degree of overlap and the volumes of activation associated with WM processing in L1 and L2 between the EH and LH groups, our study tries to determine how critical period affects WM processing on a semantic task. If we extend the claims of the critical period hypothesis to the neural correlates of verbal WM, we can predict that early L2 learners should show a high percentage of overlapping activations associated with WM processing in L1 and L2. Late L2 learners, on the other hand should show a significantly lower percentage of overlapping regions.

By relating the critical period hypothesis to our study, we can predict the following: if the age of acquisition of L2 affects the neuronal organization of working memory, the overlap in the EH group should be significantly higher than in the LH group. In addition, WM processing of L2 in the LH group may require a greater volume of activation than WM processing of L1 (because additional cognitive resources may be needed). If, however, the EH and the LH groups show a comparable degree of overlap, and a comparable volume of activations, we can conclude that the age of L2 acquisition does not affect the neuronal organization of WM correlates used in this task.

In case we find a comparable degree of overlap, and comparable volumes of activation between the LH and the EH groups, we can claim that there is not a general critical period for the neural organization of working memory. However, it is still possible that the effects of L2 acquisition age on the neural correlates of WM would be observed in a different task (for example, a phonological WM task). In other words, it is possible that a critical period for WM processing, if it exists, is task specific. Task specific dissociations of L1 and L2 processing have previously been reported in studies that directly compared semantic and syntactic processing between early and late bilinguals. Specifically, the study (Wartenburger et al. 2003) suggests that the age of L2 acquisition affects the pattern of brain activity associated with grammatical processing, but not the pattern associated with semantic processing. It is questionable, however, whether such functional subdivisions of linguistic processing exist within the working memory system. Task specific effects of the critical period have not yet been shown in a WM task.

In addition to studying the effects of L2 acquisition age on the activations associated with WM processing, this study also examines how language proficiency modulates cortical representations of WM in the two languages. We compare the degree of overlapping activations and the volumes of activation associated with WM processing in L1 and L2 between the LH and LL groups in each ROI. If L2 proficiency affects the neuronal organization of WM so that WM in L2 in non-proficient bilinguals is mediated by a separate neural network, one would expect that the degree of overlap in the LL group will be significantly lower than the degree of overlap in the LH group. On the other hand, if WM processing in L1 and L2 use a common network in non-fluent and fluent bilinguals, the degree of overlap should be comparable between the two groups.

We expect to see a comparable degree of overlap in the LL and LH groups which would provide evidence to support the claim that the same neural network is used for WM processing in L1 and L2 even if the subjects are more proficient in one language than in the other. However, we may observe differences between the two groups in the volumes of activation within each ROI. Specifically, we expect to observe a significantly higher number of active voxels within each of the ROIs in the LL group than in the LH group. This would suggest that while LL and LH subjects may be using a common neural network for WM processing in L1 and L2, the LL subjects have to recruit additional cortical resources to compensate for a lower L2 proficiency.

This study therefore suggests a common neural network for WM processing in L1 and L2. However, it is possible that further functional subdivisions exist within the verbal working memory system such that a working memory task focusing on a different aspect of language (for example a phonological WM task) would find functional dissociations of neural networks associated with processing of L1 and L2. Furthermore, it is possible that our task will yield different results if we choose to study different languages, for example Japanese and English.

Literature

Baddeley, A., Working Memory. Science 255, 556-559 (1992).

Bhatia, T., Ritchie, W., The Handbook of Bilingualism (chapter 4). Blackwell Publishing, 2004.

Chee, M., Hon, N., Lee, H., Soon, C. Relative language proficiency modulates bold signal change when bilinguals perform semantic judgements. NeuroImage 13, 1155-1163 (2001).

Cheung, H., Kemper, S., Leung, E., A phonological account for the cross-language variation in working memory processing. Psychol. Rec. 50, 373-386 (2000).

Clark, C.R. et al., Updating working memory for words: a PET activation study. Hum. Brain. Map. 9, 42-54 (2000).

Fiez, J.A. et al. A positron emission tomography study of the short-term maintenance of verbal information. Journal of Neuroscience 16 808-822 (1996).

Johnson, J., Newport, E., Critical period effects in second language learning: the influence of maturational state on the acquisition of English as a second language. Cognitive Psychology 21, 60-99 (1989).

Kim, J.J., Kim, M.S., Lee, K.M., Lee, D.S., Lee, M.S., Kwon, J.S. Distinct cortical areas associated with native and second languages: PET investigation. NeuroImage 15, 879-891 (2002).

Xue, G., Dong, Q., Jin Z., Chen, C. Mapping of verbal working memory in non-fluent Chinese-English bilinguals with functional MRI. Neuroimage 22, 1-10 (2004).

Paulesu, E., Frith, C.D., Frackowiak, R.S.J., The neural correlates of the verbal component of working memory. Nature 362, 342-345 (1993).

Wartenburger, I., Heekeren, H., Abutalebi, J., Cappa, S., Villringer, A., Perani, D., Early setting of gramatical processing in the bilingual brain. Neuron 37, 159-170 (2003).

GAZE RELATED DISCHARGE MODULATION IN THE HUMAN CEREBRAL CORTEX DURING A FINGER TAPPING TASK

Naja Ferjan
Department of Neuroscience
Brown University, Providence, Rhode Island 02912, USA
Email: Naja_Ferjan@hotmail.com

Matjaž Gams
Odsek za inteligentne sisteme
Institut Jožef Stefan, Jamova 39, 1000 Ljubljana, Slovenia
Tel: +386 1 477 3644; matjaz.gams@ijs.si

Abstract

Hand displacement to a visible target requires that the target position and the position of the hand are first recognized. An external target is coded in an eye centered reference frame, while a hand movement command should be coded in a hand centered reference frame. The performance of a visually guided, goal-directed hand movement thus requires a sensory-motor transformation from perception of an external target location into a movement command. It has been established that, in humans, frontal, parietal and visual areas use a gaze centered frame of reference to code visual information. However, it is possible that some brain areas might use a hand centered reference frame when planning movements. We have previously shown that in a finger tapping task, gaze centered frame of reference is used to code visual information and plan movements. In this study, however, we show that when the subject's right hand was switched to the left side of the body during the task, no areas with gaze effect on finger movement were found. We suggest that a different, non-gaze cantered reference frame is being used. Further studies are needed to establish the nature of this reference frame.

1 INTRODUCTION

In humans, performing visually guided hand movements relies on transforming the sensory signals about hand and target position in a suitable reference frame. A common reference frame facilitates communication between different areas that are involved in coordinating the response movements.

It has previously been suggested that a significant proportion of parietal neurons transform the sensory signals that are used to guide movement into a common reference frame, which is an eye centered representation that is modulated by eye-, head- or limb position signals. These sensory motor transformations likely occur along the visual-to-motor stream traversing the occipital, parietal and frontal corticles. Previous neural recording studies in monkeys have shown that some brain regions code movements in a gaze-centered reference frame (Anderson and Mountcastle, 1983), likely mediated by the formation of gaze gain fields. Functional MRI studies in humans have suggested a similar organization. Specifically, they have indicated that gaze orientation modulates processing in early visual areas (DeSouza et al., 2002) and finger related activation in parietal and frontal areas (Baker et al., 1999). We have also previously observed that finger movement-related activation is related to vertical and horizontal gaze deviations (Bedard et al., unpublished data).

The process of visually guided goal directed hand movement in humans involves sensory-motor transformations from perception of an external target location, coded in an eye centered reference frame, into a movement command coding a hand centered reference frame. Hand displacement to a visible target therefore calls for a computation involving recognition of target and hand position and then forming an appropriate motor command. As suggested by previous functional MRI studies, visual, parietal and frontal areas use a gaze centered frame of reference to code visual information (De Souza et al., 2002) and plan movements (De Souza et al., 2000). Some experiments on monkeys have suggested, however, that some brain areas might employ a hand related reference frame instead of an eye related reference frame when planning movement. For example, it was suggested that in the dorsal premotor cortex of monkeys performing a delayed arm-reaching task, the strength of gaze related modulation of brain activity was weaker than the strength of arm related modulation of brain activity (Kalaska et al., 2001), which raised a question whether intended movement direction is represented is the premotor area of monkeys in hand rather than in gaze related coordinates.

With that in mind, we investigated the effect of changing the hand position (from right to left side or vice versa) on the activation of the brain areas coding finger movements. If only the gaze reference frame is used, we can expect that for a particular gaze position, there should be no significant difference in the activation of brain areas coding finger movements when the hand position changes from one side to the other. If, however, a hand reference frame is used instead of the eye reference frame, changing the hand position from one side to the other should have an effect on the finger movement-related activation in the brain.

2 METHODS

Participants

Twelve healthy adults (mean age 24 years; 7 female, 5 male, all right handed) recruited from the Brown University community participated in the experiment. All participants provided written informed consent according to established Institution Review Board guidelines for human participation in experimental procedures at Brown University and Memorial Hospital of Rhode Island.

Task and apparatus

Participants performed a repetitive finger tapping task, using their right thumb while statically directing gaze to one of three possible target locations (right, center or left). After receiving task instructions, participants entered the MRI system. They were positioned in the standard supine body position with the right arm either lying fully extended and pronated beside their right side, or lying extended across their trunk to the left side. The experiment consisted of 6 runs of MRI scanning. Three runs were performed with the hand on the right side, and three runs with the hand on the left side. Half of the participants started the experiment with their hand on the right side and switched the hand position to the left after 3 runs, and half of the participants started with the hand on the left side and switched the hand position to the right side after 3 runs. An MRI compatible push-button device was held in the participant's right hand. The device sensed the tapping with the thumb, the occurrence of which was registered and stored in a Macintosh G3 Powerbook. Participants wore a set of LCD-based goggles for delivery of visual stimuli and eye movement monitoring via an embedded infrared camera (Resonance Technology, Inc.; 800×600 pixels resolution; Viewpoint software Arrington Research, Scottsdale, AZ).

For each run, the three eye positions (right, center, left) were presented randomly. For each eye position, there were ten cues to tap, thus 10 trials. The target was visible for any target location. It consisted of a black annula over a white background. The cue to tap was the center of the annula turning black over a period of 1 second. Participants were instructed to tap three times at the onset of cue, as fast as they could. The cues to tap occurred with varying trial-onset asynchronies (between 3.86 sec and 7.72 sec) presented randomly in order to facilitate the subsequent event related functional MRI data analysis procedures and allowing for a combined block- and event-related design.

3 MRI PROCEDURES

We used a 1.5 T Symphony MRI Magnetom MR system equipped with Quantum gradients (Siemens Medical Solutions, Erlangen, Germany) to acquire anatomical and functional MR images.

MRI:

After shimming the standing magnetic field to account for inhomogeneities introduced by the participant, we acquired a high-resolution three-dimensional anatomical image consisting of 160 1 mm parasagittal slices (magnetization prepared rapid acquisition gradient echo sequence, MPRAGE; repetition time (TR) = 1900 msec, echo time (TE) = 4.15 msec, inversion time = 20 msec, 1 mm isotropic voxels, 256 field of view).

After anatomical imaging we acquired T2*-weighted gradient echo images using the blood oxygenation level (BOLD) mechanism. We used a 192 mm field of view with a 64×64 sampling matrix. Forty-eight slices were acquired covering the whole brain. The MRI system acquired the slices in an ascending interleaved manner. Images were acquired during 95 volumes in each of the six runs. The imaging sequence used a TE of 38 msec, a TR of 3.86 sec, and a 3mm sice thickness for 3mm isotropic voxels.

4 MRI SIGNAL PROCESSING AND STATISTICAL ANALYSIS

We used a voxel-by-voxel based statistical procedure to identify significant activation using AFNI (Analysis of Functional Neuroimages; Medica College of Wisconsin; National Institute of Health: http://afni.nimh.nih.gov/afni , Cox, 1996; Cox and Hyde, 1997). The first two volumes in each run were discarded from further consideration due to T1 saturation effect. The anatomical and functional datasets were co-registered and normalized to the MNI template. The BOLD dataset for each participant was motion corrected using six motion parameters (x, y and z translations and roll, pitch and yaw rotations), the linear trends were removed. We performed spatial smoothing to a 6×6×6 mm Gaussian Kernel.

To estimate the BOLD response for each participant, we used a deconvolution procedure applied to the trial events. Reference functions included the three motion correction parameters and the time at which the target turned black for each of the three targets. We then normalized the estimated coefficients for each target into percentage change signal by dividing the coefficients by the mean signal of the entire experiment.

We used a linear regression model to determine which brain areas show gaze influences of finger related activation. We set the regressors to determine voxels showing increased activation as gaze deviated horizontally.

We used the following set of regressors (1 2 3), corresponding to the left, center and right. Positive activation refers to the voxels showing a significant fit to a specific model, and significant inverse relationships to the regressor patterns become referred to as negative activation.

5 EYE POSITION ANALYSIS

The analysis of the eye position provided a means to control that the subjects gaze was actually directed where we predicted it to be. We confirmed that the subjects' gaze was actually directed to the target when the cue was presented. For each run, there were three possible target positions (right, center, left) presented randomly. The eye position analysis shows that during the 1 second onset of the cue to tap, the subjects' eyes were directed either to the left, to the right or to the center, depending on where the target appeared. Knowing that the subjects' gaze was directed to either one of the specific 3 points along the horizontal line, we can attribute the changes in the finger-movement related areas of the brain to horizontal gaze deviations.

6 RESULTS AND DISCUSSION

The analysis of the data for all gaze locations across subjects revealed that finger tapping yielded robust activation in brain areas commonly involved in motor behavior. Consistent with our previous observations (Bedard et al, unpublished data), in the three runs where the subjects' hand was on the right side we found gaze-related modulation of finger movements in motor- (left superior frontal gyrus, superior parietal lobule) and in non-motor related areas in the occipital lobe, in striate and extrastriate regions and in the nearby temporal structures. The gaze effects in visual, parietal and frontal areas have compatibility with results indicating that these areas use a gaze-centered frame of reference to code visual information and plan movements. The part of the task in which the subjects had their hand of the right side of their body when the cues to tap were presented therefore replicated the results of our previous experiment (figure 1).

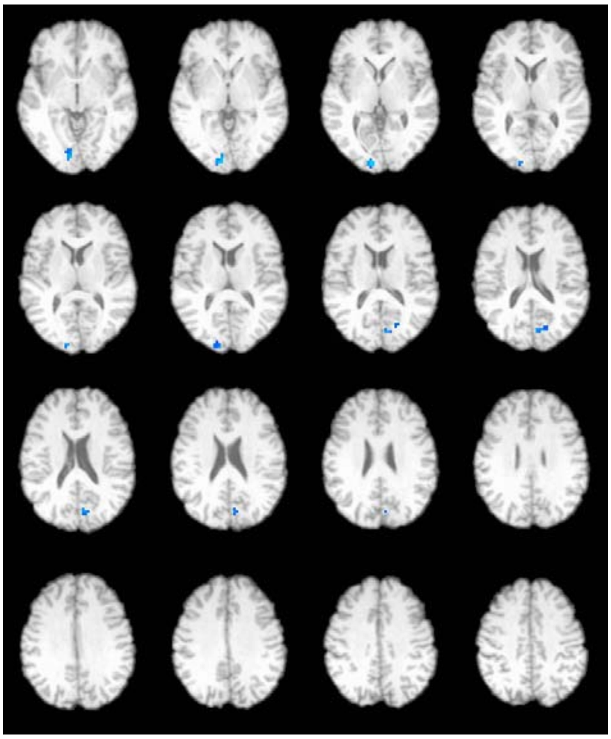


Figure 1: areas with increase in activation as gaze deviates to the right side and hand is on the right.

In the trials where the subjects' right hand was switched to the left side of their body when the cues to tap were presented, however, we did not find areas with gaze effect on finger movement (figure 2).

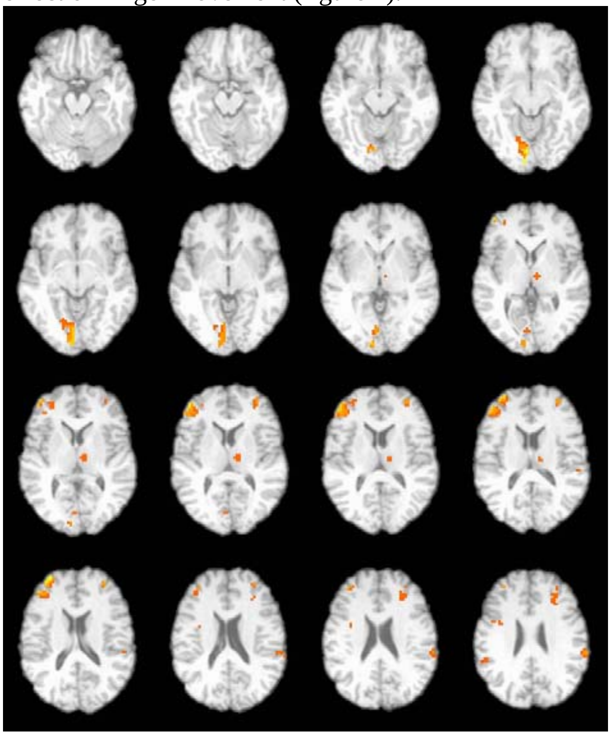


Figure 2: Areas with increase in activation as gaze deviates to the right and hand is on the left.

These results do not seem to be compatible with results indicating the use of a gaze centered frame of reference for coding movements and planning action. If only a gaze frame of reference was used, we would expect that for a particular gaze position, say left, there would be no significant difference in the activation of brain areas coding finger movements when the hand position changes from one side of the body to the other. In this experiment, we showed that the activation patterns of the finger-movement related brain areas differ when the hand position is changed from one side to the other, suggesting a use of another reference frame, which could be hand centered or head centered.

Previous experiments on monkeys have suggested that M1 and SMA may code movements in hand rather than in gaze-centered reference frame (Cisek and Kalaska 2001). It seems likely that the task in this experiment required a hand-centered frame of reference as well, but further studies will be needed to confirm that.

Literature

-Andersen RA, Mountcastle VB (1983) The influence of the angle of gaze upon the excitability of the light-sensitive neurons of the posterior parietal cortex. J Neurosci 3: 532-548.

-Baker JT, Donoghue JP, Sanes JN (1999) Gaze direction modulates finger movement activation patterns in human cerebral cortex. J Neurosci 19: 10044-10052.

-Bedard P, Thangavel A, Sanes JN (2005) Human brain representations of gaze-related gain fields during voluntary finger movements. Unpublished.

-Buneo CA. Jarvis MR, Batista AP, Andersen RA (2002) Direct visuomotor transformations for reaching. Nature 416: 632-636.

-Cisek P, Kalaska JF (2002) Modest gaze related discharge modulation in monkey dorsal premotor cortex during a reaching task performed with free fixation. J Neurophysiol 88: 1064-1072.

-DeSouza JF, Dikelow SP, Vilis T (2002) Eye position signals modulate early dorsal and ventral visual areas. Cereb Cortex 12: 991-997.

BLINDED BY SCIENCE - The hidden meanings of placebo effect

Barbara Hrovatin, dr.med.
Tel: +386 31 31 89 35
e-mail: barbara@fidimed.si

ABSTRACT

The article examines the historical evolution of placebo effect and cultural characteristics that led to its neglected clinical significance. Despite the recent interest in the mechanisms of placebo effect, the term itself still eludes definitions, continuing the legacy of controversies and general aureola of unscientific subjectivity. However we decide to define it, placebo effect reveals important questions about the meaning of human experience in illness and healing and keeps challenging our views of reality and "truth".

It's always useful to start with defining the object of reflection, the one special topic, you're about to dedicate yourself to for awhile. That simple task is strangely difficult in the case of placebo – a term so commonly used in the last 50 years of scientific medicine. There are indeed many definitions of placebo and placebo effect, and even more attitudes attached to it. Placebos are controversial – able to be simultaneously the most tested intervention in randomised controlled trials (RCT) and yet the least understood and notoriously elusive to definition (Vallance, 2006). People "believe" in placebo effect, or they entirely dismiss it, medicine uses it in a scientific endeavour of obtaining psychosocially uncontaminated, objective data, but at the same time placebo effect seems to point to important, non-specific components of human healing. Why so many controversies? What do they tell us about placebo, about medicine, about us?

Let's try to discover some clues by looking at historical development of this intriguing phenomena and it's intimate connections with culture, value systems and meaning.

1 WHAT`S IN A NAME

Placebo in Latin means, "I shall please". First used in the 14th century as the beginning of the vespers for the dead by hired mourners at funerals, the word placebo already carried the connotation of depreciation and substitution (de Craen, 1999) and moral ambiguity (Harrington, 2006). In it's first documented medical use the word placebo is described as "a commonplace method or medicine" (1785, New Medical Dictionary), and by 1811 it is defined as "an epithet given to any medicine adapted more to please than to benefit the patient" (revised Quincy Lexicon – Medicum) (Thompson, 2000). The "merely pleasing" meaning of placebo continued well into the first half of the 20th century. The use of placebos (bread pills, subcutaneous water …) was widespread in medicine before World War II and most ethical codes endorsed "necessary deception". Placebos were considered as having no impact on pathophysiology, only bringing comfort to patients (more probably so, if they were unintelligent, neurotic, subordinate or suggestible (Vallance, 2006).

It's interesting, that placebo controls were first used to test unconventional therapies (that is, to expose it as quackery) over 150 years ago (sham devices for the mesmerism/magnetism controversies; placebo pills to mask active treatment during the homeopathic controversies). These decoy treatments were used to show, how the perception of efficacy of alternative ("irregular") therapies had to do with *appearance* of an intervention (and not with any specific content) – perception that was due to "imagination", "suggestion" or "natural history of the disease". (Kaptchuk et al, 2003).

So, in it's first era, placebos were tools to expose fraud or uselessness of unorthodox treatment on one hand, while on the other they were widely used in medicine as little offerings that "stood in for" truly effective medication (mostly to patients, that could not be helped in a more "true" way or for those, that doctors believed didn't have anything "really" wrong with them, but wouldn't stop complaining (Harrington, 2006). And so the notion of **placebo effect as "medical humbug"** was born – a definition that describes placebo effect as "*a short term and illusory impression of improved health that some patients experience when they take an inert substance that looks like real medicine (dummy or sugar pill)*" (Harrington, 2006) and is still used today in bioethical discussions about the use of placebo and for explanations, that orthodox medical authorities provide for the growing appeal of alternative (unconventional) therapies.

2 PLACEBO IN RCT

Placebo methodology was accepted by conventional medicine for testing it's own therapies only after the World War II, stimulated by the rapid introduction of powerful pharmacological drugs. A significant shift in the concept of understanding what is legitimate or efficacious occurred – concept that still, though maybe with little awareness, strongly determines the frames of biomedical research and therapies (and with it – the attitudes towards placebo). The previous importance of clinical outcomes (changes in patient baseline conditions), that were evaluated by medical doctors – experts, through their experiences and judgement, now turned to seeing efficacious therapy as a treatment, that produces benefits greater than the effects of a placebo intervention in a randomised, placebo controlled trial. Legitimate therapy came to mean the existence of a demonstrable specific (cause-and-effect) relationship between active intervention and a predetermined measurable outcome (Kaptchuk et al, 2003).

The double-blind RCT seeks to confer the ideal of scientific exactitude onto clinical experimentation in an effort to attain the objectivity of the laboratory model (Kaptchuk, 2001). A placebo-controlled RCT is considered to be medicine's most reliable and objective scientific method for representing things as they really are (the truth). Knowledge is attained by rigorous application of methodological safeguards, especially randomisation and blinding, to strip it clean of the unpredictable human bias (foibles of the mind) - selection bias is precluded by randomising patients to groups and by concealing the allocation; observation bias by blinding doctors and patients; reporting bias by blinding outcome assessors and statisticians (Walach, 2001).

The beginning of the era of scientific - evidence based medicine revisited the suggestive powers of placebo, but this time condemning it as a source of bias in the testing conditions – a bias, that could not only affect patients, but also doctors and researchers. Henry Beecher's seminal paper "The powerful placebo" from 1955 demonstrated effect of inert pills in an average one third of patients in placebo group (the size effect still erroneously generalized as the average placebo effect in clinical trials), but placebo remained seen as clinically irrelevant - a "biological lie" and a consequence of the intrusion of the mind into physiology, that could, if uncontrolled for, undermine the efforts of scientists to detect specific effect of "real" new drugs. The era of RCT as the golden standard of biomedical research left the notion of placebo effect even more confused – it was an important part of powerful new methodology of finding scientific truth, but it was still a sham effect, something non-specific that has no clinical relevance, but nevertheless possesses powerful physiology, able to obscure the effectiveness of new therapies.

These developments formed the meaning of **placebo effect as a "scientific confound".** Used predominantly in the world of pharmacology, placebo effect is described as *"the non-specific effects of treatment that, in clinical trials, must be controlled in order for researchers to assess the specific effects of new interventions, especially drugs"* (Harrington, 2006).

3 PLACEBO AND THE ERA OF NEUROSCIENCE

The history of this, most recent, development of our views of placebo effect started well outside the medical establishment. The path for the recognition of placebo effect as a clinically (therapeutically) relevant phenomena, was paved first by faith healing movement (19th century). The power of positive thinking movement followed in the 20th century (NV Peale, Dale Carnegie) – claiming that harnessing the powers, that are lying within everyone, bring not only health but also wealth, success and happiness. With the confidence in medicine shaken (it was seen as technocratic, impersonal and patronizing), the 70ies brought the concept of holistic medicine (that offers patients therapeutic partnership and empowerment) and, in 1976, the cultural phenomenon of Norman Cousin's self–healing story. Paper called "Anatomy of an illness (as perceived by the patient)" was published in the high impact New England Journal of Medicine, describing the healing of ankylosing spondylitis (a progressive and disabling rheumatic disease of the spine and joints) with laughter, vitamin C and positive attitude. Cousins, a prominent editor of Saturday Review, took a step further – although admitting, that all he did could be a demonstration of placebo effect, he proposed, that faith healings and "miracle cures" are worth looking into as they "all say something about the ability of the patient, properly motivated or stimulated, to participate actively in extraordinary reversals of disease and disabilities" (Cousins, 1976, from Harrington, 2006). He received thousands of praising letters from physicians, but the shift in attitudes towards placebo was made possible through simultaneous process of rising neurosciences in the late 70s. The discovery of endorphins (brains own opiates) led to the first report of blocking placebo analgesia with opiate receptor antagonist (naloxon), suggesting, that the relief of pain by placebos is mediated through distinct biochemical substances in the brain (endorphins) (1978). The second scientific discovery, important for understanding placebo effect, came about with the surprising finding, that saccharin water can induce immunosuppression in rats, that were previously treated with cyclophosphamide (a powerful immune-suppressor) and saccharin water simultaneously (these test were the birth for the new field of psychoneuroimmunology).

The surge of public interest for "the powers of the mind" and the important discoveries of emerging neuroscience enabled a new, intriguing concept of **placebo effect as a mind-body intervention** - *a powerful mind-body phenomena with a specific "real" biology all its own, one that medicine should study and exploit* (Harrington, 2006).

Proven by "hard science", placebo effect became, for the first time, a legitimate subject of scientific inquiry – a trend continuing today, mostly with efforts to uncover exact biochemical mechanisms underlying the effect. But, as before, not without dramatic turning-points.

The concept of placebo effect is powerfully connected to larger values and agendas of philosophical, social, political and ethical nature (Harrington, 2006). This "embodiment" of different value systems and conceptual frameworks might be the reason that the attitudes towards placebo effect evoke so many emotional responses and flip-flops in public and professional convictions.

As the saying goes for beauty, the truth, too, might lie in the eyes of the beholder.

4 POERFUL OR POWERLESS?

The public fascination with placebo effect was stirred again with a series of flashing articles, that started with a New York Times cover story titled: “Astonishing medical fact: Placebos work! So why not use them as medicine?” (Talbot, 2000). The article stated many surprisingly successful “sham” treatments, including surgery. By the end of the next year, the story was completely reversed. The reason being a meta-analysis of 114 RCT, that compared placebo with no treatment group and found “little evidence in general that placebos had powerful clinical effects” (Hrobjartsson and Goetzche, 2001). The article was published in high impact New England Journal of Medicine (NEJM) under the title “Is placebo powerless?” and had considerable impact in changing placebo perception from an inherent component of therapy to a phenomenon that doesn’t exist at all (Greene et al, 2001). The editorial in the same journal was even clearer on the subject – “The powerful placebo and the wizard of Oz” invited us to grow up, to put away our childish ideas and admit, that the powerful placebo is a myth, without any basis in reality. Much like the Wizard of Oz, placebo effect was powerful only because others believed so – until “they found that the curtain hid a very ordinary man” (NEJM, 2001). The impact of these articles has been amplified by extensive media coverage, this time celebrating the debunking of a “myth”.

But the story continued.

Kirsch et al shocked with conclusions that 80 % of antidepressant drug effect could be attributable to placebo and suggested the need for alternate methodology of research to be developed (Kirsch et al, 2002), PET scan studies elegantly (and literary) showed us that placebo effect actually modifies brain’s neurotransmissions not only in placebo analgesia (opioid system) but also in Parkinson’s disease (dopamine system) (Benedetti et al, 2005).

5 HIDDEN TREASURES OF PLACEBO

Willingness to look closer inside placebo effect, instead of only trying to most efficiently control for it or, at best, define it’s (biochemical) mechanisms of action, reveals important questions and illuminates the forgotten human part of medicine – a part that was deliberately excluded (we intentionally blinded ourselves to it) in hope for the most efficient treatment. Maybe it’s time to admit that human healing cannot exist without the intangible human substance – the meaning of human experience, that is constantly developing in interactions with surroundings, and be willing to be surprised, and awed, and of service not just by our science, technologies and skills, but by our basic humanness as well.

Placebo effect, with all its mysteries and controversies included, keeps inviting us to reconsider questions of human recovery reaction as a built in potential, which can be modified for good or bad by human interaction; legitimacy of our declarative overemphasis on physical, specific, quantifiable and controllable; the limits of disease orientation and the legacy of an old divide, that makes the human subjective experience inherently unreliable as a source of knowledge.

Looking at it benevolently (and why wouldn’t we?) and intentionally trying to find clues for human healing, placebo response reveals important questions to be asked for the medicine of the future. Not only from the methodological point of biomedical research, but much deeper – it asks who is the person with the disease, who is the doctor and how they interact to strengthen or weaken the process of healing and what is healing after all (and who decides).

Deepak Chopra, MD, probably one of the most famous “mind-body” pioneers, answered a question as to why he thinks he has more spontaneous recoveries in his clinic as compared to average medical practice, with “because we’re looking for them” (The healing mind, 1996).

And so we might want to ask ourselves, what are our intentions in medicine – what are we looking for, what are we hoping (daring) to find?

Maybe the greatest treasure of placebo lies in its constant challenging our (safe) views of reality and “truth”.

Acknowledgment

This article is an abridged version of an essay assignment for the subject of “The production of medical knowledge” at postgraduate studies of Medical Anthropology (Univerza v Novi Gorici; Interkulturni študij; mentors Dr Allan Young, McGill Univerity, Canada, and Dr Borut Telban, SAZU, Slovenija).

References:

[1] Benedetti F, Mayberg HS, Wager TD, Stohler CS, Zubieta JK, (2005). *Neurobiological Mechanisms of the Placebo Effect.* The Journal of Neuroscience, 25(45):10390-402.

[2] Chopra D, (1996). *The Healing mind.* Infinite Possibilities Products, LLC (video).

[3] De Craen AJM, Kaptchuk TJ, Tijssen JGP, Kleijnen J, (1999). *Placebos and placebo effects in medicine: historical overview.* Journal of the Royal Society of medicine, 92:511-15.

[4] Greene PJ, Wayne PM, Kerr CE, Weiger WA, Jacobson E, Goldman P, Kaptchuk TJ, (2001). *The powerful placebo: Doubting the doubters*. Advances in Mind-Body medicine, 17:298-307.

[5] Harrington A, (2006).*The many meanings of placebo effect: Where they come from, why they matter*. Biosocieties, 1:181-93.

[6] Hrobjartson A, & Goetzsche PC, (2001). *Is the placebo powerless? An analysis of clinical trials comparing placebo with no treatment.* New England Journal of Medicine, 344:1594-602.

[7] Kaptchuk TJ, (2001). *The double-blind, randomised, placebo-controlled trial: Gold standard or golden calf?*. Journal of Clinical Epidemiology, 54:541-49.

[8] Kaptchuk TJ, Berman B, Mausell RB, (2003). The placebo and complementary and alternative medicine: Historical, scientific, and methodological considerations, in Office of Cancer Complementary and Alternative Medicine (ed): Expert panels in Cancer CAM Research: Developing the State of the Science in Research Methodologies. DHHS publication, 03-5427.

[9] Kirsch I, Moore TJ, Scoboria A & Nicholls SS, (2002). *The Emperor's new Drugs: An Analysis of Antidepressant Medication Data Submitted to the U.S. Food and Drug Administration.* Prevention & Treatment, 5, Article 23.

New England Journal of Medicine (2001). Editorial: *The powerful placebo and the Wizard of Oz.* New England Journal of Medicine, 344:1630-2.

[10] Talbot M, (2000). *The placebo prescription.* New York Times Magazine, 9 January.

[11] Thompson WG, (2000). *Placebos: A Review of the Placebo response.* The Americain Journal of Gastroenterology, 95(7):1637-43.

[12] Vallance AK, (2006). *Something out of nothing: the placebo effect.* Advances in Psychiatric Treatment, 12:287-96.

[13] Wallach H, (2001). *The Efficacy paradox in Randomized Controlled Trials of CAM and Elsewhere: Beware of the Placebo Trap.* The Journal of Alternative and Complementary Medicine, 7:213-18.

6 VPRAŠANJ KOGNITIVNE ZNANOSTI

Urban Kordeš
Pedagoška Fakulteta Univerze v Ljubljani
Kardeljeva ploščad 16, 1000 Ljubljana, Slovenia
Tel: +386 1 589 2200
e-mail: urban.kordes@guest.arnes.si

POVZETEK

V pričujočem članku bom predstavil rezultate mini "raziskave", ki je nastala ob pripravi pregleda možnosti za študij in raziskovalno delo na področju kognitivne znanosti v Ljubljani. Naštejem nekaj osnovnih vprašanj kognitivne znanosti kot samostojne discipline in ugotovim, da je osnovni problem kognitivne znanosti kot enotne discipline je metodološki problem (kot resna znanstvena disciplina se določeno področje vzpostavi takrat, ko si najde ustrezno, veljavno in zanesljivo metodologijo) in epistemološki problem.

Informacijska metafora oziroma ideja, da so kognitivni pojavi procesiranje informacij je zaslužna za pojavo kognitivne znanosti kot povezane, krovne discipline. Prav ta ideja bila skupna točka razumevanja kognicije različnih disciplin (od psihologije do umetne inteligence). V zadnjih pa letih so upadli upi, da računalnik (oziroma Turingov stroj) zadošča za celostno modeliranje spoznavnih procesov. Pokazalo se je, da razumnost računalnikov ne raste proporcionalno z njihovo zmogljivostjo (oziroma da sploh ne raste), kar je omajalo splošno vero v to, da ponuja Turingov stroj zadovoljiv model delovanja spoznavnih procesov, čustev, še najmanj pa zavesti. Znanstveniki in filozofi so se začeli ozirati po alternativnih razlagah, po drugačnih (večinoma bolj sinergetskih) metaforah in tudi po novih epistemoloških temeljih. Informacijska oziroma računalniška metafora delovanja kognicije je, kot rečeno, v zadnjih letih izgubila povezovalno moč, ki jo je nekdaj imela.

Z dvomi v prvotno intuicijo o tem, kako razložiti kognitivne pojave, pa se ni zmanjšal interes za njihovo raziskovanje. Ravno nasprotno. Raziskave na tem področju so vse bolj razširjene in popularne. Velika "zasluga" t.i. informacijske metafore je torej usmeritev pozornosti na pred tem zapostavljeno področje kognicije. Tudi če se izkaže, da so bili upi iz sedemdesetih in osemdesetih let prejšnjega stoletja previsoki, je v znanstveni skupnosti že prevladal konsenz, da je to področje vredno raziskovalne pozornosti. Seveda pa se postavlja vprašanje: zakaj sploh potrebujemo kategorijo "kognitivna znanost"? Kaj novega nam ta kategorija prinaša? Mar niso dovolj posamezne discipline, ki se na sebi lasten način ukvarjajo s kognicijo povezanimi pojavi? Kot rečeno, doživljajo nekatere od teh disciplin (v zadnjem času predvsem nevroznanost) skokovit samostojen napredek. Spet druge (npr. psihologija) pa imajo raziskovanje kognitivnih pojavov med svojimi osnovnimi nalogami in so se z njim začele ukvarjati že mnogo pred pojavom kognitivne znanosti.

Vprašanje o smislu obstoja kognitivne znanosti je seveda bolj retorično. Navsezadnje je področje kognicije in zavesti najbolj intimno povezano z našim bivanjem in si zato prav gotovo zasluži svojo raziskovalno disciplino, ki bi ga raziskovala kot celoto. Jasno je, da nobena partikularna disciplina ne more dati polnega odgovora, niti ne more zadovoljivo pojasniti fenomenov, kot so npr. spomin, mišljenje, čustva itd. Zatorej so zgornja vprašanja bolj pozivi, ki kažejo, kam je treba usmeriti energijo: v iskanje možnosti združevanja ali/in novih načinov skupnega raziskovalnega dela. Vprašanje o smislu obstoja kognitivne znanosti kot samostojne discipline je torej predvsem metodološko vprašanje. Na tem področju se soočamo z naslednjimi dilemami:

- Je mogoče z združitvijo izsledkov posameznih disciplin o istem fenomenu priti do boljšega poznavanja?
- Je skupek spoznanj različnih disciplin kaj več od preprostega spiska posameznih dosežkov?
- Oziroma: Je sinergetsko združevanje spoznanj, v katerega bi bile vključene relevantne discipline, sploh možno? (Kako naj na primer sodelujeta nevroznanost in sociologija?)

Intuicija pravi, da je interdisciplinarno delo možno in smiselno. V praksi pa so takšni projekti redki in še tistih nekaj se mnogokrat izkaže kot larpurlartistično prizadevanje brez pravega (znanstvenega) učinka. Problemi, povezani z interdisciplinarnim sodelovanjem pod dežnikom kognitivnih znanosti, so v resnici ogromni… oziroma "težki" v Chalmersovem smislu.

Z Olgo Markič sva v sklopu analize stanja na področju možnosti študija in raziskovanja kognitivne znanosti v Ljubljani zaprosila predstavnike posameznih raziskovalnih skupin za odgovore na nekaj preprostih vprašanj:

- Kaj je po vašem mnenju osnovni cilj/namen kognitivne znanosti (kot interdisciplinarnega projekta)?
- Kakšna je vloga vaše discipline pri tem projektu?

· Kako si predstavljate prihodnost/razvoj a) kognitivne znanosti in b) vaše discipline?
· Kaj bi bil dokončen dosežek/skrajni domet kognitivne znanosti?).

Najin namen je bil ustvariti nekakšen zemljevid stanja in pričakovanj na tem raziskovalnem področju pri nas. Predpostavljam pa, da bi podobno stanje dobili tudi v mednarodnem merilu. Glede na to, da je odgovore na zastavljena vprašanja posredovala le približno polovica avtorjev (okrog 15) in tako raziskovalne smeri niso enakomerno zastopane, na tem mestu ne bom predstavil konkretnih rezultatov in primerjav. Že kratek pregled odgovorov pa kaže neznanske razlike med pripadniki različnih raziskovalnih disciplin in jasno ilustrira težave interdisciplinarnega sodelovanja.

Lahko povzamem, da se vsi raziskovalci strinjamo o osnovnem namenu kognitivne znanosti: bolje razumeti kognitivne pojave. Od tu naprej pa se bistveno razlikujemo. Naj navedem nekaj bistvenih razlik, ki odražajo osnovna vprašanja kognitivne znanosti kot samostojne discipline.

1. Vprašanje, kaj sodi med kognitivne pojave. So to le pojavi, ki jih v to kategorijo uvršča klasična psihologija (učenje, odločanje, pomnjenje, mišljenje itd.)? Spadajo sem tudi čustva (zelo "trendovsko" področje kognitivne znanosti v anglo-saksonskem svetu)? Kaj pa zavest? Pojem zavest je bil še nedavno tega neznanstven in so se ga vsi resni znanstveni diskurzi izogibali, v zadnjem času pa postaja raziskovanje zavesti osrednji del kognitivne znanosti.

2. Na točko 1 se nanaša drugi vir razlik: Vprašanje o končnem cilju. Večina avtorjev se strinja, da takšnega cilja ni – da je raziskovanje neskončen proces in da sprotni rezultati narekujejo nadaljnjo smer. Mnogim avtorjem se zdijo trenutni raziskovalni problemi dovolj težki (in jasno zastavljeni), da bi se ukvarjali z "velikimi" vprašanji. Odgovori tistih, ki so cilj vseeno konkretizirali, pa zajemajo vse, od univerzalnega modela kognicije in pojasnitve povezave med fizičnim in duševnim, do praktičnih napotkov za zdravljenje patologij kognitivnega aparata. V splošnem lahko ugotoviva, da si predstavniki klinične prakse ne zastavljajo "velikih" vprašanj – zanima jih, kako bi lahko izboljšali obstoječe prakse zdravljenja in diagnostike in takšne odgovore pričakujejo tudi od kognitivne znanosti.

3. Ko govorimo o "razumevanju" kognitivnih pojavov – kaj pravzaprav mislimo s tem? "Pojasniti" je očitno zelo širok pojem. Na žalost naša vprašanja niso bila dovolj precizno zastavljena, da bi od avtorjev dobili natančnejše pojasnitve tega pojma. Tudi tega vprašanja večina avtorjev ne vidi kot dovolj aktualnega, da bi se mu posvečali. Kljub temu pa nekateri opozarjajo na različne možnosti razumevanja oziroma na različne vrste znanja, ki ga lahko pridobimo o kognitivnih fenomenih. Vprašanje pojasnitve oziroma razumevanja se nanaša na centralni problem, ki pesti moderno kognitivno znanost: Je možno pojave, kot so kognicija, zavest, razum pojasniti algoritmično oziroma z vzročno-posledičnimi modeli? Problem pri raziskovanju kognicije je, da skoraj vsako raziskovanje bistveno spreminja raziskovani pojav. To pomeni, da je zelo težko zagotoviti neudeleženost raziskovalca pri raziskovanem procesu in da so povsem ponovljivi poskusi skoraj nemogoči. Obe našteti lastnosti (neudeleženost raziskovalca in ponovljivost eksperimentov) pa tvorita temelje sodobne (naravoslovne) metodologije in sta nujni za tvorbo relevantne znanstvene teorije. Večina "resnih" znanstvenih raziskav kognitivnih fenomenov poskuša ustvariti čim boljše približke objektivnih in ponovljivih eksperimentov, ne moremo pa se popolnoma izogniti vprašanju, kaj če s tem izgubljamo bistveno lastnost kognicije, o kateri nas prepričuje njeno neposredno izkustvo: njeno enkratnost in neponovljivost?

4. Je obravnava kognitivnih pojavov na enak način kot ostalih naravnih pojavov res najbolj (edina) primerna? Mar ni znanje, ki ga resnično potrebujemo, znanje "od znotraj" oziroma znanje "kako"? Tudi če predpostavljamo, da je kognitivne fenomene (na čelu z zavestjo in zavedanjem) možno pojasniti z logičnimi modeli, se postavlja vprašanje: nam takšni modeli lahko koristijo pri razumevanju samih sebe – svojega izkustvenega sveta? Če ne, kako bi lahko (znanstveno) raziskovali svoje doživljanje?

5. Pri raziskovanju kognicije je zelo pomembna tudi etična komponenta. Sem sodijo vprašanja, ki si jih zastavljajo (ali pa bi si jih morali zastavljati) predvsem predstavniki klinične prakse. Kaj je patološko in kaj normalno? – Resno vprašanje v psihoterapiji in klinični psihologiji. Kje so meje človekove zasebnosti? – Sodobne metode kažejo potenciale, da lahko posegajo v najintimnejše doživljanje sebe in sveta. In še mnoga druga, ki presegajo namen pričujočega teksta in znanje avtorjev.

6. Na koncu liste problemov pri raziskovanju v kognitivni znanosti dodajam še povsem praktično težavo, na katero naleti prav vsaka interdisciplinarna raziskovalna skupina – problem nepoznavanja ostalih sodelujočih disciplin in njihovega strokovnega jezika. Še enkrat je treba poudariti, da pravo interdisciplinarno raziskovalno delo ni le preprost seštevek raziskav na posameznih področjih, ampak da je zanj potrebna prilagojena metodologija. Ko govoriva o interdisciplinarnem združevanju, ne misliva na sodelovanje sorodnih ved (npr. biologija in kemija) – takšno združevanje še ne pripelje do resnih teoretskih težav, saj si vede v veliki meri delijo znanstveni jezik in raziskovalne metode. Problemi, ki jih prinaša raziskovanje kognicije, ne morejo biti rešeni znotraj ozkega okvira zgolj naravoslovnih (niti zgolj družboslovnih ali humanističnih) ved, zaradi tega je ena od glavnih ovir pri celostnem raziskovanju, pomanjkanje povezovalnih strategij, ki bi omogočale srečevanje celotnega spektra znanstvenih disciplin.

Zanimivo je, da se s to ugotovitvijo vračamo k osnovni ideji kibernetskega gibanja, ki se je začelo v petdesetih letih prejšnjega stoletja in ki ga mnogi vidijo kot neke vrste valilnico kognitivne znanosti. Margaret Mead, ena od ustanoviteljic tega gibanja, je nekoč izjavila: "Še posebej želim poudariti pomembnost množice transdisciplinarnih idej, ki […] jim pravimo 'kibernetika' – gre za obliko transdisciplinarnega razmišljanja, ki je omogočila predstavnikom mnogih disciplin medsebojno komunikacijo v jeziku, ki je bil vsem razumljiv.” V začetnem obdobju kibernetike (in kognitivne znanosti) se je informacijska metafora kazala kot tisto vezno tkivo, ki lahko omogoči skupno delo različnih disciplin. Zdaj, ko se je ta metafora izkazala za nezadostno, čaka kognitivno znanost izziv razvoja pristopov za skupinsko interdisciplinarno delo.

Literatura

[1] G. H. Mead, *Um, Sebstvo, Družba*, Krtina, Ljubljana, 1997, navaja ga von Foerster, »Ethics and second order cybernetics«.

[2] H. von Foerster, »Ethics and second order cybernetics«, v: *Stanford Humanities Review*, Stanford, let. 4, št. 2, 1995.

FILOZOFIJA NEVROZNANOSTI IN NEVROFILOZOFIJA: KRATKA PREDSTAVITEV

Olga Markič
Filozofska fakulteta, Univerza v Ljubljani
Aškerčeva 2, 1000 Ljubljana, Slovenia
e-mail: olga.markic@guest.arnes.si

POVZETEK

V članku predstavim dva načina povezave filozofije in nevroznanosti: filozofija nevroznanosti in nevrofilozofija. Prva je del filozofije znanosti in se ukvarja s temeljnimi teoretskimi vprašanji nevroznanosti. Druga, nevrofilozofija, pa se ukvarja z vprašanji, kjer se raziskovanja v nevroznanosti prekrivajo s filozofijo in neposredno prispevajo k razumevanju pojavov in reševanju vprašanj, ki so bila prej domena filozofije.

1 UVOD

Devetdeseta leta prejšnjega stoletja so bila desetletje raziskovanja možganov in tudi v začetku 21. stoletja je nevroznanost eno najbolj živahnih in zanimivih znanstvenih področij. Raziskovanje možganov je v zadnjem času izredno napredovalo in znanstveniki govorijo o pojavih, na primer, branje misli, ki so bili še do nedavnega čista znanstveno fantastična spekulacija ali pa so sodili v domeno sumljivih parapsiholoških zmožnosti. Danes pa o branju misli govorijo na prestižnih znanstvenih konferencah nevroznanstvenikov. Seveda ne gre za neposredno dostopanje do misli, raziskovalci skušajo »brati misli« tako, da »berejo možgane«. O tej izredno odmevni, pa tudi kontroverzni temi so na primer razpravljali na kolokviju, ki je potekal maja 2007 v Berlinu in je nosil pomenljiv naslov »Raziskovanje uma: Kaj naši možgani razkrivajo o naših mislih«. John-Dylan Haynes, profesor na Humboldtovi Univerzi v Berlinu, je »branje misli« uvedel takole: »Vsako misel lahko povežemo s karakterističnim vzorcem v možganih. S tem, da računalnik naučimo, da prepozna te vzorce, postane mogoče brati misli osebe iz vzorcev njenih možganskih aktivnosti. Na ta način možganska aktivnost osebe lahko izda njene misli, čustva, lahko nam poda ključ do odgovora, ali laže, ali celo napove, kaj bo oseba storila. Ta nedavni napredek v znanosti o možganih je omogočil popolnoma nove vpoglede v miselne procese. Zdaj lahko raziskujemo, kako so misli shranjene v možganih, kako namere izvirajo in nezavednega in vplivajo na naše vedenje. Toda ta odkritja niso zanimiva le za vključene znanstvene discipline. Imajo pomembne posledice za naše razumevanje narave človeka. Prav tako so v temelju pomembnih uporabnih naprav. Na primer, s pomočjo »vmesnika med možgani in računalnikom« lahko paralizirani bolniki nadzorujejo tehnične naprave samo s pomočjo »moči svojih misli«. (Dostopno na http://www.daimler-benz-stiftung.de/home/events/berlin/en/start.html)

Zamislimo si torej znanstvenika za zaslonom računalnika, na katerem spremlja delovanje mojih možganov in se vprašajmo – ali lahko ugotovi, ali seštevam ali množim števili, ki so mi jih povedali malo pred tem; ali mislim na Rogerja Federerja ali na mizo v sobi; ali občutim zadovoljstvo ob dobro opravljeni nalogi ali zavist, ker jo je sodelavec opravil bolje; ali govorim resnico, ali lažem; ali mislim oziroma čutim, da mi je nekaj všeč, dejansko (»v resnici«) pa gre za samoprevaro in tiste stvari sploh ne maram? Verjetno hitro opazimo, da gre za precej različna vprašanja, na katera ne moremo dati enotnega odgovora. Raziskave, ki so jih opravili že omenjeni Haynes s sodelavci (za prvo vprašanje) in Christof Koch (California Institute of Technology) s sodelavci (za drugo) kažejo, da je v nadzorovanih okoliščinah na prvi dve vprašanji mogoče dati previden pritrdilen odgovor. V zadnjem času lahko veliko beremo tudi o tem, kako je mogoče s slikovnimi metodami (predvsem funkcionalno magnetno resonanco fRMI) izdelati detektor laži. A zdi se, da problemi, povezani s temi vprašanji, niso odvisni le od stopnje trenutne raziskovalne tehnologije in znanja o delovanju možganov, ampak zahtevajo tudi filozofski razmislek. Preučevanja duševnih procesov je tako kompleksna naloga, da se je znanstveniki lotevajo na različnih ravneh in z različnimi metodologijami in orodji. Ob tem se pojavijo metodološka vprašanja (ali in do katerih mej so izbrane metode in orodja ustrezna), kot tudi vprašanja o metafizičnih in epistemoloških predpostavkah ter etične dileme.

Tako filozofija kot nevroznanost sta del širšega interdisciplinarnega področja kognitivne znanosti in se povezujeta tudi z drugimi sodelujočimi disciplinami (npr. računalništvo, psihologija). Predvsem kognitivna in računska nevroznanost se dandanes ukvarjata z naravo zavesti, dejanja, vedenja in normativnosti, temami, ki tradicionalno sodijo v humanistiko. Empirična odkritja o strukturi in funkciji možganov vplivajo na naturalistične teorije, ki gredo preko zgolj abstraktnih filozofskih razmišljanj. Prav zato poleg običajnega pristopa filozofije znanosti, ki se ukvarja s teoretskimi osnovami posameznih znanosti, v našem primeru filozofija nevroznanosti, govorimo tudi o »nevrofilozofiji«. Izraz je prva uporabila ameriška filozofinja Patricia Churchland, ki je tako naslovila svojo knjigo iz leta 1986. V njej, še bolj pa v naslednji, *Brain-Wise: Studies in Neurophilosophy* (2002) je pokazala, kako raziskovanja v nevroznanosti vplivajo na reševanje tradicionalnih filozofskih vprašanj.

2 FILOZOFIJA NEVROZNANOSTI

Tako kot je bila pred desetletji fizika tista disciplina, s katero so se filozofi znanosti največ ukvarjali in jo jemali kot paradigmatski primer za raziskovanje temeljnih teoretskih pojmov znanosti, kot sta na primer razlaga in redukcija, je v današnjem času posebne pozornosti deležna nevroznanost. Poglejmo nekaj najpomembnejših tem filozofije nevroznanosti. (glej http://artsci.wustl.edu/%7Eneuro/index.html)

- *Razlaga*: Kaj so pojavi, ki naj jih nevroznanost razlaga? Kakšne so ustrezne nevroznanstvene razlage – ali se razlikujejo od razlag v fiziki, kemiji, biologiji? Ali naj delovanje možganov razlagamo s pomočjo teorije dinamičnih sistemov ali je boljši pristop iskanje lokalizacije funkcij in opis nevronskega mehanizma?

- *Ravni*: Kaj pomeni, da so teorije v nevroznanosti na različnih ravneh organizacije in da mehanizmi nižjih ravni implementirajo ali realizirajo pojave na višji ravni? Ali realizacija z mehanizmi nižjih ravni ogroža obstoj ali vzročno učinkovitost pojavov na višji ravni? Ali obstaja odlikovana raven (molekularna, raven nevronskih mrež)?

- *Redukcija ali emergenca*: Kako naj bi potekala redukcija mentalnega pojava na nevrofiziološko ali molekularno raven? Ali gre za enako pojmovanje redukcije kot v primeru, ko govorimo o streli kot električni razelektritvi? Ali je redukcija povezana z mehanicistično razlago? Ali so pojavi na višji ravni realizirani na več načinov? Kakšne so implikacije večnačinovne realizacije za različne oblike redukcije?

- *Mehanizmi, vzroki in zakoni*: Do kakšne mere lahko možgane razumemo mehanistično? Kaj so najboljše strategije za spoznavanje vzročne strukture nevronskega sistema? Ali obstajajo zakoni nevroznanosti? Ali določanje nevronskih korelatov psiholoških funkcij pripomore k razlagi in kaj več od korelacije še potrebujemo?

- *Lokalizacija funkcij*: Kaj pomeni, da je dana funkcija lokalizirana v določenem predelu, predvsem glede na to, da se možgani razlikujejo glede na različne posameznike in se spreminjajo z razvojem? Ali je funkcije najbolje razumeti kot prilagoditve na okolje, ali pa gre le za zmožnosti v sistemu?

- *Računanje in simulacija*: Kako nas simulacije lahko naučijo nekaj novega o možganih in njihovi funkciji? Kakšna je razlika med simulacijo in razlago? V kakšni meri morajo biti uporabne simulacije biološko verodostojne?

- *Eksperimentalne tehnike in modeli*: Kakšne so slabe in dobre strani posameznih eksperimentalnih tehnik (npr. slikovne metode)? Kdaj so upravičena sklepanja na podlagi posameznih primerov in kdaj lahko pridobimo zanesljive podatke s povprečenjem med različnimi osebami?

- *Teoretična nevroznanost*: Ali so možgani računalnik – ali je to zgolj metafora? Ali možgani procesirajo informacije ali predstavljajo značilnosti sveta? Do katere mere mora biti razlaga mentalnih pojavov umeščena v organizem in v njegovo naravno in družbeno okolje? Kakšna je struktura nevroznanstvene teorije in kako le ta vodi znanstveno prakso, npr. načrtovanje poskusov?

2 NEVROFILOZOFIJA

Raziskovanja v nevroznanosti, na primer, procesiranje informacij v možganih, nevrofiziološke motnje kot posledice poškodb možganov, sanje, sinestezija ali bolečine, vodijo do vprašanja, v kakšnem odnosu so mentalni pojavi do možganskih procesov (in s tem do temeljnega filozofske problema duh–telo). Vprašanja o mentalnih pojavih so že v osnovi interdisciplinarna, saj imamo do mentalnih pojavov tudi specifičen neznanstven dostop, t.j. subjektivno izkušnjo. V tem je bistvena razlika med kognitivnimi znanostmi in ostalimi znanstvenimi disciplinami. Z uporabo novih metod lahko nevroznanost prispeva novo znanje o starih pojmih in raziskuje tudi posebne, neobičajne različice, ki poljudni psihologiji niso bile dostopne. Refleksija in poskus umestitve takih novih odkritij v tradicionalne okvire je že nevrofilozofiranje, četudi se tega morda ne zavedamo. Lep primer je raziskovanje bolečine, kjer so nevroznanstveniki odkrili dva sindroma, ki kažeta, da je mogoča *bolečina brez bolečnosti* in *bolečnost brez bolečine*. N. Grahek (2001) je na osnovi teh nevroznanstvenih raziskav ugotavljal pravilnosti in napake metafizičnih, semantičnih in epistemoloških intuicij, ki ležijo v temeljih subjektivističnega in objektivističnega pristopa v filozofiji duha.
Raziskovanje v nevrofilozofiji poteka iz dveh nasprotnih smeri: ali začenja na empirični strani in nato trči na

filozofska vprašanja, ali pa začne s filozofskimi vprašanji in potem potrebuje empirične ugotovitve za njihovo razreševanje. Kot pravi Henrik Walter, ki je zdravnik, nevroznanstvenik in filozof v eni osebi, je nevrofilozofijo najbolje razumeti kot most med subjektivno izkušnjo, filozofskim teoretiziranjem in empiričnim raziskovanjem. Tako sistematično pojasnjuje pojme, ki jih uporabljajo različne discipline, pretresa empirične podatke in se poslužuje splošne argumentacije, resno jemlje prispevke iz filozofske tradicije in pušča odprt prostor tudi za spekulacijo, preverja sklepe in notranjo konsistentnost teorij in skuša določiti meje verjetnim empiričnim stavkom. Nevrofilozofija v širšem smislu vključuje tudi psihologijo in računalništvo, vendar ji gre predvsem za pojasnjevanje neposredne zveze med disciplinama, ki sta vsebovani v imenu. (Walter, 2001, str. 125).

Nevrofilozofijo bi lahko nadalje razdelili na splošno in specializirano. Splošna se ukvarja z nevroznanstveno navdahnjenimi rešitvami problema duh-telo. Tako na primer J. Bickle (1998) predlaga reformulacijo tradicionalnega problem tako, da namesto filozofskih razprav o različicah dualizma in monizma iščemo odgovor v možnostih interteoretične redukcije za različne mentalne pojave. Na ta način je mogoče, da bo empirična znanost pokazala, da nimajo vsi mentalni pojavi enakega statusa, saj bo redukcija zavzemala cel spekter, od pojavov, za katere je redukcija možna, do takih, kjer to morda ni mogoče. Bickle kot primer za redukcijo navaja spomin, subjektivni občutki (qualia) pa so mentalni pojavi, ki se zdijo najdlje od možnosti redukcije.

Specializirana nevrofilozofija pa se ukvarja z reševanjem specifičnih problemov v filozofiji duha, epistemologiji in etiki. Kot primer lahko ob že omenjeni razpravi o bolečini navedemo problem svobodne volje, kjer so nevroznanstvene in psihološke raziskave spodbudile nova razmišljanja o tem, ali je svobodna volja zgolj iluzija (Libet, Wegner). V epistemologiji radikalni konstruktivizem in evolucijska psihologija raziskujeta, kako je človekovo vedenje sploh mogoče. Nevroetiki postavljajo praktična etična vprašanja, ki jih sprožajo nove metode raziskovanja možganov in uporaba nevrotehnologije, kot so na primer vprašanja o dopustnosti poseganja v zasebnost, ki so povezana z novimi slikovnimi metodami, in o nevarnosti zlorabe kemijskih snovi, ki vplivajo na delovanje možganov. Po drugi strani izsledki nevroznanosti prispevajo k novim razlagam o tem, kaj smo, kako se odločamo in vedemo, kar sproža vprašanja povezana z moralno odgovornostjo in razmišljanja o družbenih normah, zakonih in religioznih prepričanjih. (Farah, 2004)

Taka zastavitev nevrofilozofije bi se lahko zdela vprašljiva, saj specialna nevrofilozofija izhaja iz določene predpostavke o odnosu med mentalnimi pojavi in možgani, čeprav je ravno to predmet raziskovanja splošne nevrofilozofije. Strinjam se, da je naturalistična filozofija do neke mere vedno krožna, a po drugi strani je res tudi, da tako filozofija kot empirične znanosti vedno izhajajo iz določenih predpostavk. V kolikor dobimo na osnovi določene predpostavke boljše razlage mentalnih pojavov in napovedi vedenja, potem to lahko štejemo kot podkrepitev te predpostavke.

3 ZAKLJUČEK

Ali bodo raziskovanja v nevroznanosti dala zadovoljive odgovore na vprašanja o človekovih kognitivnih procesih, duševnosti in zavesti, bo pokazal čas. Sklenemo pa lahko z mislijo nemškega filozofa dr. Thomasa Metzingerja: »Nevroznanost in kognitivne znanosti bodo v naslednjih desetletjih povzročile večje spremembe za našo samopodobo in samorazumevanje kot katerokoli odkritje do sedaj.«

Literatura

Bickle, J. (1998), Psychoneural reduction: the new wave, MIT Press.

Churchland, P.S. (1986). *Neurophilosophy*, MIT Press.

Churchland, P.S. (2002). *Brain-Wise: Studies in Neurophilosophy*, MIT Press.

Farah, M. (2005), »Neuroethics: the practical and the philosophical«, *Trends in cognitive Sciences, Vol. 9 No. 1.*, p. 34-40.

Grahek, N. (2001), *Feeling Pain and Being in Pain*, Hanse Studies, Hanse Institute for Advance Study, Volume 1, Biblioteks- und Informationssystem der Universität Oldenburg.

Walter, H. (2001). *Neurophilosophy of Free Will: From Libertarian Illusions to a Concept of Natural Autonomy*, MIT Press.

Wegner, D. (2002), *The Illusion of Conscious Will*, MIT Press.

CELOVITOST V ZNANSTVENEM RAZISKOVANJU

Dr. Matjaž MULEJ[1]*, Dr. Štefan KAJZER*[1]*, Dr. Vojko POTOČAN*[1]*, Dr. Zdenka Ženko*[1]*, Dr. Bojan Rosi*[2]
Univerza v Mariboru, Ekonomsko-poslovna fakulteta, Maribor[1]
Univerza v Mariboru, Fakulteta za logistiko, Celje in Krško[2]
E-naslovi: [mulej; stefan.kajzer; vojko.potocan; zdenka.zenko; bojan.rosi]@uni-mb.si

Povzetek

Celovitost je za znanstvenost raziskovanja nujna, da preprečuje spreglede, a jo zaradi nujne ozke specializacije pojmujemo zelo različno, od omejitve na posamičen vidik do popolne. Predlagamo uporabo zakona zadostne in potrebne celovitosti in lastnost raziskovalcev, da so hkrati specialisti in sposobni za medstrokovno ustvarjalno sodelovanje. Metod je dosti, a za njih tu ni prostora.

Ključne besede: celovitost, dialektični sistem, medstrokovnost, specializacija

Izbrani problem in vidik obravnavanja

Kot vemo, se je znanost razvijala od nekdaj, a zlasti v zadnjih nekaj stoletjih, ko je človek dojel, da bi živel bolje, če bi razumel skrito bistvo narave okrog sebe in v sebi. Zato se je usmeril predvsem v spoznavanje, torej v odgovor na vprašanje ‚kaj in zakaj', medtem ko je vprašanje ‚kako' prepustil praksi in šele kasneje v obliki znanosti o tehnologiji postavil tudi vprašanje ‚kako in zakaj'. Pokazala se je potreba, da bi se dovolj in vse bolj poglobili, kar je vse bolj krepilo ozko specializacijo. Dejstvo, da sta se razvili dve veliki skupini znanstvenih disciplin – naravoslovne (z doktoratom scienciae, kar enači znanost in naravoslovje) in družboslovne (z doktoratom philosophiae, kar se nanaša na manj merljiva spoznanja, bolj odvisna od človekovega premisleka) – nas tukaj zanima manj kot nas vprašanje o celovitosti, ki ga postavlja naraščanje nujne ozke specializacije.

Vpliv raziskovalcev na celovitost v znanstvenem raziskovanju

Ozka specializacija ima dve osnovni bistveni posledici:

- Veliko poglobitev v neki delček stvarnosti znotraj nekega izbranega vidika, iz česar izvirajo dragocena spoznanja o podrobnostih glede tistega delčka stvarnosti.
- Nemoč videti zunaj danega izbranega vidika, iz česa izvira spregledovanje lastnosti, ki v resnici obstajajo, a jih z izbranega vidika ne zmoremo videti.

Spregledovanje bi morda za znanstveno raziskovanje ne bilo tako bistveno, če ne bi znanost služila kot podlaga za obvladovanje prakse, vključno s političnimi in strateškimi odločitvami. Posledica so lahko in pogosto v praksi so enostranske namesto celovite odločitve. Imajo lahko hude posledice, od karambolov in napak pri poskusih zdravljenja do svetovnih vojn.

Takoj po koncu trojne svetovne krize – dveh svetovnih vojn in svetovne gospodarske krize med njima v letih 1914-1945 – je nastala zoper enostranskost dvojna nove teorija, ki se je postopno bolj ali manj zlila v eno: kibernetika in teorija sistemov. Obe sta nastali iz medstrokovnega sodelovanja in pri znanstvenem ukvarjanju s temami, za katere posamična stroka ni mogla dati rešitev sama (Hammond, 2003). Sprožili sta (znova) vprašanje o celovitosti. Uporabili sta pojem sistem, ki naj predstavlja celoto. Če bi se ustavili tukaj ali nadaljevali v zgolj formalno matematični smeri obravnave pojma sistem, bi se pokazalo, da se s kibernetiko in teorijo sistemov ni zgodil tolikšen preobrat v znanosti, kot se v resnici je (Umpleby, 2005). Pokazalo se je namreč, da objektivne znanosti ni, ker je vsako spoznanje odvisno od odločitve raziskovalca, kateri vidik izbere, katere robne pogoje ali meje raziskovanje zato opredeli, kateri del celotnega spleta lastnosti zato postavi v ospredje pozornosti ali pa pusti vnemar. (Prikaz 1).

Teorija sistemov – svetovni nazor in metodologija celovitosti

Prispevki na znanstvenih srečanjih, vključno s tistimi o teoriji sistemov in kibernetiki, puščajo zaradi človeške specializacije ob stran namen Bertalanffyja, avtorja splošne teorije sistemov, ki je uvedel sodobni pojem sistem (Bertalanffy, 1979, s. VII in dalje): teorija sistemov ni ena izmed mnogih ozko specializiranih znanstvenih disciplin, ampak svetovni nazor celovitosti in metodologija, ki ga podpira.

Kaj pa je to – celovitost? Vsaka znanost se ukvarja z delčkom lastnosti, četudi uporablja za opis svoje tematika pojem sistem. Če bi posamične delne lastnosti bile enake lastnostim celote obravnavanega pojava, bi natrij in klorid, ki sta vsak zase zelo strupena, ne zmogla sestavljati jedilne soli. Torej gre pri celovitosti predvsem za sinergijo, kar pomeni, da na osnovi soodvisnosti med deli nastane njihov medsebojni vpliv; tako v procesu emergence nastajajo nove lastnosti zaradi medsebojnega vpliva delov, proces pa se konča s sinergijo ali prevlado novih lastnosti nove celote.

Toda takó povzeto pojmovanje celovitosti je le prvi korak, ki nas pripelje do spoznanja v prikazu 2: celovitost je splet, ki ga tvori realistično upoštevanje lastnosti celote, delov in njihovih medsebojnih odnosov, zlasti soodvisnosti.

Preidimo na drugi korak. Prej smo opozorili na dejstvo, da vsako raziskovanje poteka znotraj nekega izbranega vidika in neke izbrane specializacije. Celovitost iz prikaza 2 se da doseči, vsaj načelno, tudi znotraj posamičnega vidika. Toda to ne bi bila prava celovitost, če upoštevamo opredelitev celovitosti v besednjaku, ki pove, da celovitost pomeni, da zajamemo čisto vse lastnosti. Ne gre za čisto vse spoznane, izbrane, glede na izbrani vidik zajete lastnosti, ampak za čisto vse, ki obstajajo. Take celovitosti človek seveda ne zmore niti sam niti v majhni skupini kot sodelujočem timu, ampak zmore skladnost z zakonom potrebne in zadostne celovitosti (Mulej, Kajzer, 1998), kar omogoča uporaba dialektičnega sistema (Mulej, 2000 in prej, od 1974) – prikaz 3.

Skratka: vsak raziskovalec, avtor, mislec, govornik prevzame odgovornost za svojo stopnjo celovitosti in njene posledice – poglobljenost na eni strani in spreglede na drugi strani. Kajti ni možen enoličen in dokončen odgovor, katera stopnja celovitosti ustreza zakonu potrebne in zadostne celovitosti. Rosi in soavtorji (2006) so uspeli za primer zamrzovanja cest doseči zadostno in potrebno celovitost podlag za sklepe in ukrepe s samo dvema spremenljivkama. V praksi menedžmenta je primerno število nekje vmes (Rosi, Mulej, 2006; Potočan, Mulej, Kajzer, 2005; Ženko, Mulej, Marn, 2004; Ženko, 1999).

Toda ozka specializacija, ki se ne povezuje s sposobnostjo za medstrokovno sodelovanje, le redko omogoča potrebno in zadostno celovitost, saj je nujno zelo redukcionistična in enostranska. Zato je nujno postopati v raziskovanju večfazno (Mulej idr., 2000) – prikaz 4.

Sklep: zadostno in potrebno celovitost zmorejo medstrokovno sodelovalni specialisti

Ozkim specialistom, ki nimajo sposobnosti in volje za medstrokovno sodelovanje, sistemsko razmišljanje ni blizu, ampak jim žal bolj ustreza tradicionalno (Mulej idr. 2003) – prikaz 5. V praksi je potrebna obojna lastnost: ozka specializacija in sodelovanje z drugačnimi specialisti, ki obravnavajo enake pojave, a z drugih vidikov, da bi dosegli sinergijo vseh potrebnih in zadostnih specializacij.

Prikaz 1: Razmejitev kibernetike 0., 1., 2. in 3. reda kot pristopa v znanstvenem raziskovanju

Narava je celota in celovita. Človek ne zmore celovitosti, ko opazuje, razmišlja, sklepa,odloča in vpliva, a jo potrebuje, da preživi/uspe. Nenehno zmaguje v človekovi borbi z naravo in drugimi ljudmi celovitejši.			
Človek in ostala narava – oba sta zapletena: komplicirana (po sestavinah) in kompleksna (po povezavah sestavin v nove lastnosti). Trud obvladati to zapletenost je dal človeško prakso in znanost, vključno s kibernetiko več vrst.			
Praksa, kot pač je	Celota in celovitost prakse	Celota in celovitost spoznanj o praksi	Celota in celovitost odločitev in posledic
Življenje brez razmisleka	Opazovanje danih lastnosti prakse	Vplivanje na prakso	Odločanje na osnovi opazovanja za vpliv
BREZ TEORIJE	ONTOLOGIJA	EPISTEMOLOGIJA	PRAGMATIKA
Praksa	Pozitivizem in materializem	Relativizem / konstrukti-vizem / idealizem	Prakseologija
Sprejemanje danih dejstev kot usode – površinsko	Spoznavanje danih dejstev – naravnih lastnosti – analiza, poglabljanje v ozadja	Spoznavanje danih dejstev, a tistih, ki jih je opazovalec izbral v središče svoje pozornosti	Podlaga za vplivanje na osnovi opazovanja – tveganje, ker ni možna celovitost spoznanj
Dana vidna dejstva	»Večne resnice«	Mnenja, ocena	Odločitve
Nabiranje izkušenj, ki veljajo za logiko, ker se ponavljajo	Posploševanje spoznanj, ki se ponavljajo - analiza	Zato opazovanje opazovalcev in procesov opazovanja	Ni niti opazovanja niti vplivanja brez odločitev – analiza in sinteza
Izkustvene zakonitosti	Dokazane zakonitosti	Dvom o zakonitostih, zav-računje z novimi dokazi	Odločitve morajo biti strokovne in racionalne
Ni znanosti, so le izkušnje – bolj odziv na »kaj« in »kako« kot na »zakaj«	Oblikovanje znanosti in vse več ved, klasifikacija po specializacijah – odziv na »kaj«, »kako« in »zakaj« znotraj njih v obliki modelov o izbranem delu stvarnosti	Upoštevanje vidikov, na katere omejuje človeka specializacija. Revolucija v znanosti – zakonitosti so le relativne, veljajo le pod izbranimi pogoji, ne večno / splošno.	Posamična stroka je le izjemoma podlaga za zadostno in potrebno celovitost namesto za navidezno, ki vodi v neprijetna in nevarna presenečenja
Zavračanje tujega in drugih novosti, ker se ne ujemajo z izkušnjami	Opazovanje, spoznavanje in povezovanje spoznanj v skladu z modeli, brez omembe omejitev na izbrane vidike	Upoštevanje vpliva izbora robnih pogojev (= meja opazovanja in vidikov obravnavanja)	Racionalnost pomeni neupoštevanje vrednot in drugih čustev pri odločanju, a ni možna zaradi človeške narave

Enostransko spoznavanje – površinsko in brez poglabljanja v skrito bistvo (»nadnaravne sile«)	Enostransko spoznavanje kljub analizi, saj modeli puščajo neizbrane dele lastnosti ob strani – navidezna spoznanja, zato neprijetna in nevarna presenečenja pod vplivom prezrtih delov lastnosti	Bistven je človek, njegov splet »znanje, vednost in vrednote ter druga čustva« - znanost in praksa vplivanja sta odvisna od njega – presenečenja velja pričakovati	Odločiti z upoštevanjem okoliščin, ki je odvisno od izbora spleta vidikov, kaj upoštevati in česa ne – nujna medstrokovnost, zato medstrokovno ustvarjalno sodelovanje za več / dovolj celovitosti
Celovitost ni pred očmi, morda pa je prilagoditev naravi	Celovitev je omejena na izbrano specializacijo – vedo – morda nevede	Celovitost je odvisna od izbora spleta vidikov, morda medstrokovna	Celovitost odločitev – odvisna od sposobnosti in volje odločilnih, da sodelujejo z drugače mislečimi
KIBERNETIKA 0. REDA	KIBERNETIKA 1. REDA	KIBERNETIKA 2. REDA	KIBERNETIKA 3. REDA
»Je, kot pač je«. Logika starih izkušenj. Vključno z izkušnjami glede vplivanja in odločanja, ne le opazovanja.	»Zakonitosti so objektivne, a znotraj posamičnih ved« - tradicionalnih znanosti; podrobnosti so v ospredju, povezave in sinergije spregledane. Omejitev na zapletenost tipa kompliciranost, kompleksnost le znotraj posamične vede.	»Zakonitosti so relativne, odvisne od človeka in njegovega izbora« - poleg podrobnosti so morda v ospredju tudi povezave in sinergije, a ne nujno. Ni nujna, a je verjetna omejitev na zapletenost tipa kompliciranost, kompleksnost le znotraj posamične vede.	»Človek odloča o svojem razumevanju in uporabi spoznanj, vključno z zakonitostmi« - uporaba znanosti v praksi. Ni nujna, a je verjetna omejitev na zapletenost tipa kompliciranost, kompleksnost le znotraj posamične vede, če ni timskega odločanja.
Naravna celovitost ljudi, ki opazujejo, razmišljajo, odločajo in vplivajo, pri tem pa so sposobni in voljni sodelovati s tistimi, ki mislijo drugače; zato so uspešnejši od drugih, ki so enostranski. Odseva jo npr. yin-yang, starogrška dialektika, sodobna dia-lektika.	Opisne vede, ki z analizo znotraj specializacije in na njo omejeno celovitostjo nudijo dragocena, a delna spoznanja, ki jih ne povezujejo s spoznanji iz drugih ved.	Opisne vede, ki se ne ukvarjajo z naravo, ampak s človeškim vplivanjem, a zlasti z vidika metod le-tega in na njih omejeno celovitostjo. Nudijo dragocena, a delna spoznanja, ki jih izjemoma povezujejo s spoznanji iz drugih ved.	Opisne vede, ki se ne ukvarjajo z naravo, ampak s človeškim odločanjem kot vmesno fazo med opazovanjem in vplivanjem. Celovitost je omejena na zgolj to temo. Nudijo dragocena, a delna spoznanja, ki jih izjemoma povezujejo s spoznanji iz drugih ved.
NI ODSEVA V TEORIJI SISTEMOV, KER GRE ZGOLJ ZA PRAKSO.	ODSEVA V OPISNIH TEORIJAH SISTEMOV, OMEJENIH NA VIDIK POSAMIČNE TRADICIONALNE VEDE, IN V MATEMATIČNI TEORIJI SISTEMOV.	ODSEVA V TEORIJAH SISTEMOV, KI SE OSREDOTOČAJO NA VPLIVANJE LJUDI.	ODSEVA V TEORIJAH SISTEMOV, KI SE OSREDOTOČAJO NA ODLOČANJE LJUDI.
Gre zgolj za prakso brez teorije.	Ne upošteva opredelitve L. v. Bertalanffyja, da je ustvaril teorijo sistemov zoper pretirano specializacijo in zato kot svetovni nazor celovitosti, podprt z metodami.	Če obravnava vplivanje ljudi na medstrokovni način, upošteva omenjeno opredelitev L. v. Bertalanffyja.	Če obravnava vplivanje ljudi na medstrokovni način, upošteva omenjeno opredelitev L. v. Bertalanffyja.
Naravni redukcionizem, često nevaren	Znanstveni redukcionizem nujen in često nevaren	Znanstveni redukcionizem verjeten in često nevaren	Praktični redukcionizem verjeten in često nevaren
V razmerah globalne in inovativne družbe je za preživetje človeštva in poslovno uspešnost posamičnih organizacij nujno celovito opazovanje, dojemanje, razmišljanje, odločanje in delovanje. Gre za tako, ki ne uporablja teorije sistemov zgolj za bolj ali manj poglobljen opis sestavin in odnosov znotraj obravnavanih			

pojavov z nekega posamičnega izbranega vidika, ampak uporablja medstrokovno ustvarjalno sodelovanje.
Tudi če sprejememo najbolj posplošeno in iz celote Bertalanffyijevega zapisa iztrgano opredelitev pojma sistem, da je to neka celota, sestavljena iz sestavin in povezav med njimi, zaradi katerih ima svojstvene lastnosti, ki niso enake lastnostim njenih delov vsakega zase, ostaja še vedno odprto praktično vprašanje: »Kateri del lastnosti obravnavanega pojava obravnavamo, kajti čisto vseh ne zmoremo?« Če bi jih zmogli, ne bi nastalo v zadnjih stoletjih in zlasti zadnjih desetletjih tako veliko poklicev / specializacij. Vsak/a od njih je dragocen/a, noben/a ni samo zase dovolj, da bi dosegli celovitost spoznanja, odločanja in vplivanja, tako da bi preprečili nepredvidljive in pogosto neprijetne posledice enostranosti.

Prikaz 2: Celovitost kot splet štirih bistvenih lastnosti raziskovanja

- Sistemnost = upoštevanje lastnosti celote, ki jih njeni deli vsak posebej nimajo; kompleksnost; sinergija - Sistematičnost = upoštevanje lastnosti vsakega od delov, ki jih iz njih sestavljena celota sama nima; kompliciranost; razlike med deli kot samostojnimi manjšimi celotami - Dialektičnost = upoštevanje soodvisnosti delov kot lastnosti, zaradi katere se pojavijo njihovi medsebojni vplivi, ki vodijo v nastanek lastnosti celote; emergenca - Materialističnost = upoštevanje stvarnosti v največji možni meri; realističnost raziskovanja in sklepanja

Prikaz 3: Zadostna in potrebna celovitost – med navidezno in popolno

← -- →		
Navidezna celovitost (znotraj posamičnega vidika)	Zadostna in potrebna celovitost (dialektični sistem bistvenih vidikov)	Popolna = resnična celovitost (splet vseh vidikov in vseh lastnosti)

Prikaz 4: Večfazno prepletanje specialističnega in medstrokovnega raziskovanja

Medstrokovna opredelitev subjektivnih in objektivnih izhodišč, dialektičnega sistema vidikov, zaznanih potreb in možnosti, prednostnih potreb in njim ustreznih možnosti ter iz tega izvedenih operativnih ciljev ter za njihovo doseganje potrebnega dialektičnega sistema nalog → specialistično ukvarjanje s posamičnimi nalogami in za njihovo izvedbo potrebnimi dialektičnimi sistemi procesov in postopkov znotraj njih → občasno vsklajevanje dela specialistov na medstrokovni način → specialistično delo → medstrokovno vsklajevanje itd. vse do izidov, ki dovolj zadovoljivo ustrezajo ciljem → nove medstrokovne opredelitve začetnih faz

Prikaz 5: Shematsko skrajnostna primerjava sistemskega in tradicionalnega stila razmišljanja

Št.	**Sistemski / celovit način razmišljanja**	**Nesistemski / stari način razmišljanja**
1	Soodvisnost, odnosi, povezanost, odprtost, dialektični sistem vidikov	Neodvisnost, odvisnost, nepovezanost, zaprtost, en sam vidik
2	Zapletenost tipa kompleksnost (in tipa kompliciranost)	Enostavnost, ali zapletenost tipa kompliciranost sama
3	Atraktorji (privlačne, vplivne sile)	Izoliranost brez privlačnih,vplivnih sil
4	Emergenca, nastajanje novih lastnosti celote, kakršnih deli sami nimajo	Ne nastajajo nove lastnosti celote, lastnosti delov so nespremenjene, edine
5	Sinergija, sistem, sinteza, nova celota z novimi lastnostmi	Nobenih novih lastnosti, ki bi bile posledice odnosov med deli v neki celoti
6	Celota, celovitost, velika slika, vključno s podrobnostmi, lastnostmi delov in povezav ter njihovimi posledicami	Deli in delne lastnosti kot edine, analiza brez sinteze
7	Omreženje, medsebojni vplivi osrednja tema razmišljanja	Medsebojni vplivi izven pozornosti in razmišljanja

Omenjeni viri:

Bertalanffy, L. v. (1979): *General Systems Theory.* New York. Braziller

Hammond, D. (2003): *The Science of Synthesis: Exploring the Social Implications of general Systems Theory.* Boulder, CO. University Press of Colorado

Rosi, B., Kramberger, T., Lisec, Lipičnik, M. (2006): Short Term Road Ice Forecast – a Case study. *Proceedings of IDIMT- 2006*, 13-15 September, 2006, held in Budweise, Czech Republic. The Prague University of Economics (Czech Republic) and The University of Linz (Austria).

Mulej, M., Kajzer, S. (1998): Ethics of Interdependence and the Law of Requisite Holism. . V: Rebernik, M., Mulej, M., ed. (1998): *The 4th STIQE Conference on Linking Systems Thinking, Innovation, Quality, Entrepreneurship, and Environment*. University of Maribor, Faculty of Economics and Business, Institute for Entrepreneurship and Small Business Management, and SDSR – Slovenian Society for Systems Research, Maribor, pp. 129-140

Mulej, M. et al (2000): *Dialektična in druge mehkosistemske teorije*, Univerza v Mariboru, Ekonomsko-poslovna fakulteta, Maribor.

Potocan, V., Mulej, K., and Kajzer, S. (2005). Business Cybernetics. *Kybernetes*, 34(9/10), 1496-1516.

Rosi, B., Mulej, M. (2006). The dialectical network thinking – a new systems theory concerned with management. *Kybernetes*, 35, 7-8

Umpleby, S. (2005): Some Influences on the Cybernetics Movement in the United States. V: Mulej, M., et al, eds (2005): *Proceedings of The WOSC 13th International Congress of Cybernetics and Systems, 6-10 July, 2005, and The 6th International Conference of Sociocybernetics, Theme: Sociocybernetics and Innovation*, 5-10 July, 2005, held in Maribor, Slovenia. WOSC, and ISA, RC 51 on Sociocybernetics, in cooperation with SDSR, and University of Maribor, Faculty of Economics and Business, Institute for Entrepreneurship and Small Business Management. Na CD

Ženko, Z. (1999): *Comparative Analysis of Management in Japan, USA, and Europe.* Dr. dis. Maribor. Univerza v Mariboru, Ekonomsko-poslovna fakulteta

Ženko, Z., Mulej, M., Marn, J. (2004): Innovation before entry into the EU; the case of Slovenia. *Postcommunist Economies*, 16, 2, June, s. 169-189

KVANTNA TEORIJA POLJA, MOŽGANI, ZAVEST

Metod Škarja
Inštitut Bion
Stegne 21, SI-1000 Ljubljana
e-mail: metod.skarja@bion.si

Povzetek

Kvantna teorija polja omogoča nov, bolj fundamentalen pogled na organizacijo žive snovi in s tem tudi možganov. Za razliko od generiranja prostorskega in časovnega reda preko statističnih mehanizmov, značilnih za večino drugih modelov, je red, ki izhaja iz kvantne teorije polja, emergenten red dinamične narave na osnovi kvantnih interakcij. Zanj so značilni kolektivni nihajni načini s pripadajočimi kvanti. Le-ti se pojavijo kot posledica spontanega zloma simetrije v sistemu in so nosilci urejenosti dolgega dosega. Princip, ki velja za neživo materijo, velja splošno tudi za živo materijo in možgane, le da so procesi v slednjih dveh primerih veliko bolj kompleksni. Razlika med neživo, ostalo živo materijo in možgani je v naraščajoči stopnji odzivnosti na vse stimuluse, tako glede razločljivosti kot senzitivnosti.

Uvod

Razlaga procesov v živi materiji in možganih se je začela po dveh vzporednih linijah. Najprej je znan fizik na področju kondenzirane materije Herbert Fröhlich postal pozoren na izredne dielektrične lastnosti celičnih membran. Pri potencialni razliki preko membrane ca 100mV in njeni debelini okoli 10^{-6}cm ta razlika namreč pomeni zelo močno električno polje reda velikosti 10^5V/cm. Tako polje v običajnih materialih povzroči preboj. Glede na samo sestavo membran ga je to navedlo na idejo, da bi lahko bili v živi materiji koherentno vzbujeni določeni longitudinalni električni nihajni načini (Fröhlich 1968), stabilizirani z deformacijami, ki bi bile posledica nelinearnih efektov. K takemu sklepanju je napeljeval tudi opaženi red dolgega dosega v teh sistemih, ki ne izhaja iz molekularne dinamike kratkega dosega, je relativno stabilen, a hkrati daleč stran od termičnega ravnotežja. V omenjenem članku je pokazal, kako se v zelo splošnih pogojih energija, ki se dovaja neselektivno množici nihajnih načinov, nad določenim pragom kanalizira v en sam nihajni način, ki na ta način postane močno vzbujen. Proces zelo spominja na znano bozonsko kondenzacijo (Fröhlich 1975, Austin in Wu 1978; znan primer bozonske kondenzacije je npr. prehod v supertekoče stanje helija). Tako vzbujeni nihajni način lahko privede do selektivnih interakcij dolgega dosega med različnimi makromolekulami (Fröhlich 1972).

Približno v istem času je teoretični razvoj v okviru kvantne teorije polja (KTP) pokazal, da so za pojav urejenosti pri npr. superprevodnost, supertekočnosti, feromagnetizmu ipd odgovorne korelacije dolgega dosega, ki se dinamično generirajo zaradi spontanega zloma simetrije. To privede do novega stabilnega urejenega osnovnega stanja (Anderson 1984, Umezawa, Matsumoto in Tachiki 1982). Vsebinsko to opiše Goldstonov teorem, ki pravi, da se pri zlomu (zmanjšanju) simetrije sistema v njem pojavijo brezmasni bozonski delci oz. nihajni načini, ki so v bistvu dinamični odziv sistema na ta zlom (Itzykson in Zuber 1980). Ti delci vzpostavljajo red dolgega dosega v sistemu (kot znan primer navedimo, da so v primeru kristala to fononi; le-ti se pojavijo kot posledica zloma zvezne translacijske simetrije). Navzven se to vidi kot makroskopska urejenost, ki pa temelji na notranji kvantni dinamiki (dejansko lahko govorimo o netrivialnih makroskopskih kvantnih sistemih). Za vsak tak sistem je značilen od nič različen parameter urejenosti (odvisno od sistema je to lahko magnetizacija, polarizacija itd). Da so to v resnici makroskopski kvantni sistemi, utemeljimo s tem, da ne obstaja noben klasičen model, niti na osnovi nelinearne dinamike (ki sicer pogosto generira zelo bogato in kompleksno dinamiko), ki bi lahko reproduciral ta proces. Poleg tega v klasičnih sistemih urejena stanja ne morejo imeti iste energije kot neurejena; prehod k urejenosti namreč zahteva vložek energije. Pomembna lastnost tega procesa je tudi to, da ne obstaja le eno, ampak neskončno mnogo osnovnih stanj, ki imajo vsi enako energijo, razlikujejo pa se po vrednosti parametra urejenosti. Ker so nosilci urejenosti bozoni, se jih lahko namreč poljubno mnogo kondenzira v ta osnovna stanja. V idealnem primeru neskončnega sistema so ti delci brezmasni, v praksi pa navadno imajo določeno maso, zato se osnovna stanja lahko nekoliko razlikujejo po energiji, posledica pa je tudi končen življenjski čas. Zaradi medsebojne fazne povezanosti teh bozonov lahko govorimo o koherenci v sistemu.

Kvantna teorija polja in živa materija

Skladno s temi spoznanji je Fröhlich kot delovno hipotezo predlagal, da fazne korelacije oziroma koherenca igrajo ključno vlogo pri organizaciji žive materije in njenih aktivnostih (Fröhlich 1988). Aplikacijo KTP na živo materijo je naprej razvijala skupina italijanskih znanstvenikov (Del Giudice, Doglia, Milani in Vitiello

1985, 1986a, Del Giudice in sod. 1988; za široko utemeljitev kvantne koherence v materiji glej Del Giudice in Preparata 1991, Preparata 1995). Ker je večina molekul, ki nastopajo v živi snovi, polarnih, začenši z vodo, so kot osnovne predlagali dipolne interakcije med le-temi. V pogojih zloma v tem primeru rotacijske simetrije se v vodi oz. ustreznem mediju pojavijo dipolni polarizacijski valovi (za samo vodo glej Del Giudice in sod. 1986b). Ti so nosilci korelacij dolgega dosega. Ker imajo različne biomolekule specifičen vpliv na ta proces, so zato v takem mediju možne selektivne interakcije dolgega dosega med njimi. V tako koreliranem mediju pride tudi do spremenjenega razširjanja elektromagnetnega (EM) polja, in sicer polje do določenega praga niti ne more prodreti v medij, nad določenim pragom pa prodira v medij v obliki filamentov (proces je v osnovi povsem analogen znanemu filamentoznemu prodiranju magnetnega polja v superprevodnik). V področju filamentov je prvotno korelirano stanje medija porušeno (Anderson 1984, Umezawa 1982, Del Giudice in sod. 1985). Obravnava filamentov je pomembna, ker močan gradient polja na njihovi površini lahko selektivno pritegne različne molekule. Ocena premera filamenta v popolnoma koreliranem vodnem mediju da vrednost 15nm (Del Giudice in sod. 1986a), kar je zelo blizu notranjemu premeru mikrotubulov, ki tvorijo t.i. citoskeleton v celicah. To kaže na možen izvor tega citoskeletona, ki je sicer ključen za celični metabolizem in je zelo dinamična struktura in ki s svojimi lastnostmi predstavlja pravo uganko za biokemijo. Velja še omeniti, da je urejeno stanje medija do določenega praga zaščiteno pred termalizacijo; ta se zgodi nad določeno temperaturo, ko urejeno stanje sistema izgine.

Kvantna teorija možganov

V času razvoja novih spoznanj glede spontanega zloma simetrije in pojava dolgega reda v okviru KTP so le-ta navdihnila tudi prvi kvantni model možganov (Ricciardi in Umezawa 1967, za celoten pregled te problematike glej Vitiello 1995). Osnovni elementi iz KTP, uporabljeni v tem modelu, so koherentna bozonska kondenzacija v nova urejena osnovna stanja, neskončno število teh unitarno neekvivalentnih osnovnih stanj in vloga korelacij dolgega dosega pri pojavu makroskopsko opazljivih urejenih vzorcev. Eksperimentalne raziskave kažejo, da se kot odziv na dražljaj pojavi aktivnost v možganih skoraj hkrati na več mestih in da tega ne moremo pripisati aktivnosti enega nevrona (Pribram 1971, 1991). Pomnjenje in priklic se kažeta kot difuzna, nelokalna aktivnost, ki se ne izgubi, tudi če deli sistema slabše oziroma ne funkcionirajo. Model na osnovi KTP je zato primeren za opis take vrste aktivnosti. Po tem modelu zunanji vpliv povzroči, da možgani (oziroma del njih) kot odziv nanj preidejo v drugo osnovno stanje. Ker je to osnovno stanje, je obenem stabilno, kar lahko razloži stabilnost spomina (kratkoročni spomin pa lahko razlagamo z vzbujenimi stanji, ki čez določen čas razpadejo). Analogen mehanizem razloži tudi priklic iz spomina. Ko so možgani izpostavljeni določenemu vzorcu, to v njih vzbudi določeno aktivnost, ki zaresonira z nekoč v preteklosti shranjenim vzorcem. Na osnovi ustreznega osnovnega stanja (ki se ga zavestno ne zavedamo) možgani preidejo v vzbujeno stanje, ki se ga zavemo.

Možgani dejansko delujejo na dveh nivojih, ena je klasična, elektrokemična, na tej se zgodi tudi prvi odziv na prihajajoči stimulus, druga je kvantno dinamska (Stuart, Takahashi in Umezawa 1978, 1979). Zaradi svoje robustnosti je red dolgega dosega zaščiten pred ves čas spremenljivo elektrokemično aktivnostjo možganov, po drugi strani pa mora biti sklopljen z njo, saj mora biti odziven na zunanje dražljaje, oziroma mora biti sposoben določene notranje procese odreflektirati na elektrokemični ravni (kot analogijo lahko navedemo interakcijo klasičnih akustičnih valov s fononi v kristalu). Ravno značilnost urejenega stanja, da ima makroskopsko značilno konfiguracijo, omogoča to interakcijo. Makroskopska urejenost se pokaže navzven kot opazljive klasične lastnosti, ki pa so utemeljene na kvantni dinamiki. Klasični elektrokemijski nivo igra torej vlogo prenosnika med zunanjimi vplivi in možgani.

Kot nosilci reda dolgega dosega so tudi v tem primeru predlagani Fröhlichovi električni dipolni nihajni načini (Jibu in Yasue (1992). Kot omrežje za prenos najverjetneje služi citoskeletonska mreža, ki povezuje med seboj vse dele možganov, saj jo najdemo tako v celičnem kot v medceličnem prostoru. Ne konča se na mejah celic, ampak se povezuje z zunanjostjo preko transmembranskih proteinov. Dejansko zadnje raziskave kažejo na veliko vlogo mikrotubulov v zaznavnem procesu. Tudi pri raznih degenerativnih možganskih boleznih so opazili močno spremenjen citoskeleton v prizadetem delu.

Citoskeletonska mreža se nahaja v vodnem okolju, sestavljena pa je iz polarnih monomerov. Zato spremembe v njej (signali, ki potujejo po njej) vplivajo na okoliške vodne molekule, kar lahko sproži proces bozonske kondenzacije v tem mediju in pojav koherentnih dipolnih polarizacijskih (KDP) valov. Ti KDP valovi lahko sedaj posredujejo interakcijo med različnimi deli citoskeletona in njegovimi ekscitacijami.

Možgani kot odprt sistem

Možgani so dejansko odprt sistem, ki z okolico ves čas izmenjujejo dražljaje, energijo in snov (ta izmenjava vključno z dražljaji poteka predvsem preko ostalega telesa). Če možgane obravnavamo okviru KTP na ta način, pridemo do nekaterih zanimivih ugotovitev. Tak skupen sistem možgani/okolica ima lastna stanja, ki so v bistvu podvojena lastna stanja samih možganov (Vitiello 1995; kako pride do podvojitve osnovnih stanj v šibko sklopljenem dvojnem sistemu –dvojnem resonatorju- je nazorno prikazano v Škarja, Mankoč-Borštnik, Löffler in Walther 1999). Ta podvojitev ima za posledico možnost neskončne superpozicije stanj, v katerem je lahko vsako posamezno osnovno stanje. To pa omogoča veliko spominsko kapaciteto in različna spominska stanja, ki lahko sedaj obstajajo neodvisno eden od drugega (brez tega je nov vtis možgane premaknil v novo osnovno stanje in staro je bilo prekrito, možna je bila le sekvenčna rekolekcija v obratnem vrstnem redu- ena od pomanjkljivosti prvotnega modela).

Možgani in zavest

Pojav zavesti je vprašanje, ki tudi znotraj KTP ne najde dokončnega odgovora. Glede na strukturo mikrotubulov je Hameroff (1987) predlagal, da na njih lahko poteka informacijsko procesiranje. V svojem modelu je predlagal, da je zavest povezana s t.i. redukcijo valovne funkcije, oziroma da lahko nastane v tem procesu. Za kvantno mehaniko je namreč značilno, da sistema, ki je v kvantni superpoziciji stanj, kot takega ne moremo opazovati. Akt opazovanja (oziroma merjenja) namreč povzroči, da se sistem znajde v enem od možnih stanj z določeno verjetnostjo. V Hameroffovem modelu to dejanje »merjenja« izvaja gravitacija, ki reducira superpozicije stanj znotraj mikrotubulov v posamezna stanja, ki pa se jih šele lahko zavemo.
Po drugi strni so opazili, da zunanji dražljaj najprej povzroči vzburjenost neke majhne skupine nevronov, a na tej stopnji se dražljaja še ne zavedamo. Šele ko se vzburjenost razširi na večje področje, pride do zavestne zaznave (Greenfield 1997).
Vitiello (1995, 2001) na osnovi modela možganov kot odprtega sistema ugotavlja, da drugi (zrcalni) del podvojenega lastnega sistema (glej zgoraj) deluje kot časovno zrcalo oziroma kot refleksija v času, to pomeni refleksijo dogajanja znotraj sebe. Na tej točki naj bi se pojavila tudi zavest. Izvor zavesti naj bi bil torej v disipativni (t.j. povezani z okoljem) kvantni dinamiki možganov.
Celoten model KTP z vsemi dejstvi pa močno kaže tudi na možnost, da KTP raven s svojo vpetostjo in tudi emergenco na osnovi fizične strukture možganov na eni in svojim bogastvom različnih stanj in zmožnostjo procesiranja in prilagajanja na drugi strani predstavlja dejanski povezovalni element med zavestjo in možgani. Hkrati pa kaže na to, da je zavest na določeni ravni tudi emergentna, brez ustrezne aktivnosti v tem primeru na elektrokemijski ravni tudi klasičnega zavedanja v možganih ni.

Literatura

- Anderson, P.W., *Basic notions of condensed matter physics*. Menlo Park: Benjamin, **1984**
- Austin, S.,Wu, T.M., Bose-Condensation in Biological Systems, *J. theor. Biol.* **1978**, 71, 209-214.
- Del Giudice E, Doglia S, Milani M, Vitiello G: A quantum field theoretical aproach to the collective behaviour of biological systems, *Nuclear Physics*, **1985**, B251(FS13), 375-400
- Del Giudice, E., Doglia, S., Milani, M., Vitiello, G. Electromagnetic field and spontaneous symmetry breakdown in biological matter. *Nucl. Phys.,* **1986a,** B275 (FS 17), 185-199.
- Del Giudice, E., Preparata, G., et al., Water as a Free Electric Dipole Laser, *Phys. Rev. Lett.*, **1986b**, 61, pp. 1085-1088.
- Del Giudice, E., Doglia, S. et al., Structures, Correlations and Electromagnetic Interactions in Living Matter: Theory And Applications, In Fröhlich, H., eds. *Biological Coherence and Response to External Stimuli*, Berlin, H. Springer Verlag, **1988**, pp.49-84.
- Del Giudice, E., Preparata, G.,A New QED Picture of water: Understanding a Few Fascinating Phenomenon, In Sassaroli, E., Srivastava, Y., et al., eds, Macroscopic Quantum Coherence, Singapore, London, New York, World Scientific, **1998**, pp. 108-129
- Fröhlich, H., Long-range Coherence and Energy Storage in Biological Systems, *Int. J. Quantum. Chem.*, **1968**, 2(5), 641-649
- Fröhlich, H., Selective Long Range Dispersion Forces between Large Systems, *Phys. Lett.*, **1972**, 39A(2), 153-154
- Fröhlich, H., Evidence for Bose Condensation-like Excitation of Coherent Modes in Biological Systems, *Phys. Lett.*, **1975**, 51A(1), 21-22
- Fröhlich H: Theoretical Physics and Biology In: Fröhlich H (ed.), *Biological Coherence and Response to External Stimuli*, Springer Verlag, Berlin, Heidelberg, New York, London, Paris, Tokyo, **1988**
- Hameroff, S.R., *Ultimate Computing:Biomolecular consciousness and nanotechnology*. Amsterdam: Elsevier North Holland, **1987**
- Greenfield, S.A., How might the bran generate consciousness?, *Communication and Cognition*, **1997**, 30, 285-300
- Itzykson, C., Zuber, Quantum Field Theory, New York: McGraw-Hill, **1980**
- Jibu, M., Yasue, K. A physical picture of Umezawa's quantum brain dynamics. In R. Trappl ed., *Cybernetics and System Research*, Singapore, World Scientific, **1992**, p.797-804.
- Preparata, G., *QED Coherence in Matter*, Singapore, London, New York, World Scientific, **1995**
- Pribram, K.H. *Languages of the brain*, Englewood Cliffs, N.J: Prentice-Hall, **1971**
- Pribram, K.H. *Brain and perception*, Hillsdale, N.J: Lawrence Erlbaum, **1991**
- Ricciardi, L. M., Umezawa, H. Brain and physics of many-body problems, *Kybernetik*, **1967**, 4, 44-48. Reprint in Globus, G. G., Pribram, K. H.,

Vitiello, G. eds. *Brain and Being*, Amsterdam, John Benjamins, **2005,** pp. 255-266.

- Umezawa, H., Matsumoto H. in Tachiki M., 1982, *Thermo Field Dynamics and Condensed States*. Amsterdam: North-Holland, **1982**
- Stuart, C.I.J., Y. Takahashi in H. Umezawa. On the stability and non-local properties of memory, *J. Theor. Biol.,* **1978**, 71, 605-618.
- Stuart, C.I.J., Y. Takahashi in H. Umezawa. Mixed system brain dynamics: neural memory as a macroscopic ordered state, *Found. Phys.,* **1979**, 9, 301-327.
- Škarja M., N. Mankoč Borštnik, M. Löffler in H. Walther, Quantum interference and atom-atom entanglement in a two-mode, two-cavity micromaser. **1999**, *Phys. Rev. A* 60, 3229-3232.
- Vitiello, G. Dissipation and memory capacity in the quantum brain model, *Int. J. Mod. Phys.,* **1995**, B9, 973-989.
- Vitiello, G. *My Double Unveiled*. Amsterdam, John Benjamins, **2001**.

K POJMU STROJNEGA MIŠLJENJA

Tomaž Strgar
Univerza v Ljubljani
Filozofska fakulteta; Oddelek za filozofijo
e-mail: *strgart@hotmail.com*

I propose to consider the question, ***»Can machines think?«***

Alan M. Turing, 1950

ABSTRACT

In this proceeding, the 'initial question' of the field of Artificial Intelligence is trying to be revived, a question posed to the scientific community in 1950 by A.M.Turing: "*Can machines think?*" In it, it is proposed, that this question should be viewed from a new perspective, namely, through the use of the results of the Comparative and Historical Linguistics. This is done, firstly, through a brief consideration of common English and Russian words for the concept of 'thinking', and subsequently through the etymologically aided comparison of words, used to denote the concept of 'digital computer' in different languages. Finally, the claim of etymologist's about the negation, which is in Slavic languages contained in the concept of 'something' (e.g. in Slov. 'nekaj', lit. 'not-what') is suggested as a sort of 'Archimedes' point' of this otherwise a bit uncertain science.

*** *** ***

»Ali stroji lahko mislijo?« Leta 1950 je bilo tako rekoč vsakomur jasno, da je edini pravi odgovor na takšno vprašanje: *»Ne.«* Danes, dobrega pol stoletja kasneje, so mnenja glede tega nekoliko manj enoznačna, odgovori pa bolj previdni. Ob izpeljavi javnomnenjske raziskave s ponujenimi odgovori 'da', 'mogoče' in 'ne', bi nezanemarljiv delež izpraševancev bržkone izbral srednjo možnost, najverjetneje pa bi dobili tudi kakšno pritrdilno sodbo. Vprašanje torej zasluži pozornost.

***

Psihološko vzeto sta póti do odgovora v splošnem dve. Prva je takojšen, neposreden, čustven, instinktiven, intuitiven odziv. Glede na v tem času prevladujočo podobo strojev ter ustaljeno rabo besed bi bil ta v našem primeru večinoma negativen. Druga možnost je odgovor po premisleku; izhodiščno vprašanje v tem primeru razpade na podvprašanja glede pomena besed 'stroj' in 'misliti'. Ko si posameznik te reči do neke mere razjasni, sledi sodba, ki pa je tokrat težje kategorična.

*

Premislek lahko vodi tudi k neki novi, dodatni možnosti, namreč k zavrnitvi ustreznosti, smiselnosti samega vprašanja.[1] Takšen pogled se zdi precej razširjen ravno med strokovnjaki za 'misleče stroje', oziroma, če uporabimo mednarodno uveljavljen naziv tega znanstveno-tehnološkega področja, 'umetno inteligenco' – UI.

»Toda filozofe zanima problem primerjave dveh arhitektur – človeka in stroja«, beremo v poglavju o filozofskih temeljih UI v sodobnem, svetovno priznanem priročniku UI tehnologij.[2] V dokaz, da je kljub tovrstnemu interesu »tradicionalno filozofsko vprašanje 'Ali stroji lahko mislijo?' žal napačno postavljeno (*ill-defined*)«, predlagata avtorja razmislek o naslednjem paru vprašanj:

- »Ali stroji lahko letijo? *(Can machines fly?)*«
- »Ali stroji lahko plavajo? *(Can machines swim?)*«

Poglejmo si njun argument. »Večina ljudi se strinja, da je odgovor na prvo vprašanje 'da', letala lahko letijo, na drugo pa 'ne': ladje in podmornice se res gibljejo v vodi, a temu ne rečemo plavanje (*swimming*).« Lahko se (vsaj pogojno) strinjamo, da »ne vprašanji niti odgovora nimajo kakega vpliva na delo letalskih in pomorskih inženirjev ali na uporabnike njihovih izdelkov« ter da imajo dalje ti »zelo malo opravka z načrtovanjem ali zmožnostmi (*design or capabilities*) letal in podmornic, precej več pa z načinom uporabe besed (*the way we have chosen to use words*).«

Vtis poljubnosti pomena posameznih besed, ki nam ga (v svoji angleški verziji) sugerira zgornja sintagma je omiljen v nadaljevanju argumenta. »Beseda 'plavati' (*'swim'*) se uporablja za označevanje (*has come to mean*) 'premikov po vodi z premikanjem delov telesa,' medtem ko beseda 'leteti' nima omejitev glede sredstev za samo premikanje.« Zadnji stavek avtorja opremita z opombo pod črto:

[1] Takšen pristop k zadanemu vprašanju lahko navežemo na znani 'matematični ugovor', ki ga v sestavku *Computing Machinery and Intelligence* navaja Turing; da namreč za vsak stroj obstajajo vprašanja, na katera le-ta bodisi ne da odgovora, bodisi je odgovor napačen....

[2] Russel, S.J., Norvig, P., *Artificial Intelligence: A Modern Approach, 2nd ed.*, New Jersey: Prentice-Hall, 2003, str.948.

»In Russian, the equivalent of 'swim' *does* apply to ships.«[3]

V ruščini se torej ustreznica besede 'plavati' ('swim' - 'плавать') nanaša tudi na ladje.[4] Po analogiji je potemtakem potrebno dopustiti možnost, da se v ruskem jeziku ustreznica besede 'misliti' nanaša tudi na stroje:

In Russian, the equivalent of 'think' might *apply to machines.*

Slovarska literatura sicer kot osnovne ruske variante 'mišljenja' - 'thinking' - ponuja 'думать' ('think, reflect, meditate...'), 'мыслить' ('think, imagine, cerebrate...') in 'считать' ('consider, regard, reckon...'),[5] a v obravnavanem kontekstu se 'думать' pojavlja zelo redko, 'считать' pa sploh ne,[6] saj bi bil namreč odgovor v tem primeru neposredno pozitiven. Beseda 'считать' se namreč uporablja tudi kot prevod računalniškega tehničnega izraza 'read' - 'beri'.[7]

Gornja izpeljava seveda ne pomeni, da v ruskem jeziku lahko rečemo, da stroji lahko mislijo, medtem ko po angleško tega ne smemo zatrditi - oziroma obratno; tu želimo izpostaviti predvsem nujnost pripoznanja razlike: vprašanja »*Can machines think?*«, »*Ali stroji lahko mislijo?*« in, denimo, »*Может ли машина думать?*« so, vidimo, različna vprašanja; različni so tudi odgovori, pa čeravno, paradoksno, v vseh treh vprašanjih v bistvu nastopata eno in isto mišljenje ter enaki stroji.

***

Stroj, ki kot subjekt nastopa v izhodiščnem vprašanju, je sicer precej širok pojem, a ga je - v nasprotju s pojmom mišljenja, ki se sicer zdi precej bolj enovit - moč dovolj natančno formalno opisati. Kandidat za naziv 'mislečega stroja' je nek fizičen, realen sistem, katerega osrednji in bistveni element je *univerzalni digitalni računalnik*. Ta v analogiji »človek : stroj« po funkciji zavzema mesto možganov ali dela možganov, preostali del sistema pa skrbi za povezavo oziroma komunikacijo teh 'možganov' z njihovo okolico, s fizičnim svetom.

*

Po tej osnovni opredelitvi stroja bi bilo nadalje potrebno pojasniti v njej uporabljene besede in besedne zveze - v našem primeru bi denimo lahko problematizirali 'fizično', 'realno', 'svet' in še kaj. Da pa se ne ujamemo v začaran krog jezika, se bomo zatekli k vsakdanjemu, intersubjektivno konstituiranemu pomenu besed ter k empiriji: naš predmet so računalniški oziroma računalniško vodeni sistemi, katerih konstrukcija ob nadaljnjem razvoju tehnologij in kombiniranju različnih pristopov po bistvu ostaja v okvirih dosedanjih teoretskih in praktičnih zastavitev prizadevanj za izgradnjo umetnih inteligentnih sistemov.

Kakor je, kot rečeno, univerzalni digitalni računalnik ključni element 'mislečega stroja', tako je bistvena lastnost digitalnega računalnika možnost vzpostavitve *povratne zanke*, česar posledica je *sposobnost učenja*. Kot se je izrazil Charles Babbage, izumitelj koncepta tovrstnega stroja, lahko le-ta namreč 'žre svoj lasten rep'. Računalnik je, v nasprotju z vsemi ostalimi stroji, *stroj za obdelavo podatkov*: 'obdelovanec', 'snov', 'materija', ki jo takšen stroj obdeluje, namreč ni nekaj stvarnega, snovnega, materijalnega - je le abstraktna reprezentacija nečesa v nekem jeziku.

Nadalje je vsak 'izdelek' tega stroja hkrati vedno tudi le 'polizdelek', primeren za nadaljnjo obdelavo - za nadaljnjo obdelavo tudi s strani *istega* stroja. Digitalni računalnik lahko torej, na podlagi ustrezno koncipirane začetne zunanje spodbude, *programa*, v nadaljnjem samemu sebi *spreminja način delovanja*. 'Svet' v katerem stroj deluje je ob tem determiniran s konstrukcijo njegovih 'vhodno-izhodnih naprav' - torej s sposobnostmi in zmožnostmi njegovega 'telesa'.

Prej zastavljeno vprašanje »*Can machines swim?*« pa v povezavi z 'vhodno-izhodnimi napravami' stroja kaže na za obravnavo možnosti 'strojnega mišljenja' še en pomemben moment. Če namreč namesto 'ladje' na mesto 'stroja' postavimo 'humanoidnega robota', ki bi plaval na način kot plava človek, bi tudi angleško govoreči ljudje bržda lahko rekli, da gre za 'swimming'. Za uporabo besed je torej pomemben *videz*.[8] Paradigmatično je 'videz mišljenja' *človek*. Zdi se, da bo stroju, ki bo po svojem zunanjem videzu podoben človeku, marsikdo precej lažje pripisal sposobnost 'mišljenja', pa četudi bodo 'mislili' le 'možgani' takšnega stroja - digitalni računalnik.

***

Na tej podlagi preoblikujmo izhodiščno vprašanje na način, da bo to dopuščalo kar najmanj možnosti za napačno razumevanje ali celo zavrnitev njegove smiselnosti: »*V kakšnem smislu, če sploh, je beseda 'mišljenje' primerna za poimenovanje procesov, ki se oziroma se še bodo odvijali v umetno izdelanih sistemih, katerih osrednji element je univerzalni digitalni računalnik?*«

*

[3] *Ibid.*

[4] Slovenščina je glede tega nekje vmes: ladja sicer tudi 'plava', a običajno rečemo da 'pluje'.

[5] Vrstni red opisov navajam po prosto dostopni internetni zbirki slovarjev: http://www.multitran.ru/

[6] Internetni iskalnik Google vrne na poizvedbo po sintagmi »Может ли машина думать« dobrih 200 zadetkov, medtem ko je zadetkov za »Может ли машина мыслить« več kot 13,000. Kot najprimernejši prevod za 'think', pa tudi za denimo slovensko 'misliti', se v slovarjih sicer praviloma pojavlja ' думать '.

[7] Vir: http://www.multitran.ru/

[8] »*Bit je videz*«, celo zapiše Hegel v drugi knjigi svoje *Logike* z naslovom *Nauk o bistvu*. *Cf.* Hegel, G.W.F., *Znanost Logike II*, Ljubljana: Društvo za teoretsko psihoanalizo, 1994, str. 16.

Odgovor na takšno vprašanje je sicer morda res najbolj odvisen od razvitja pojma mišljenja, a gre za precej težaven pojem, katerega opredelitve so podvržene spremembam v času, precej raznolike pa so praviloma tudi njegove sočasne opredelitve. Poglejmo si zato raje še nekoliko podrobneje pojem 'digitalni računalnik'; tokrat preko navezave na njegova *poimenovanja*. Pomembna prednost, ki jo, vsaj za potrebe stroge formalno-znanstvene obravnave, le-ta ima pred pojmom 'mišljenje' je, da je naš stroj - kot smo to že poudarili - strogo formalno opisljiv.

Vrnimo se k že poprej zastavljeni obravnavi angloameriško-ruskih jezikovnih odnosov, zamenjajmo objekt 'mišljenje' z objektom 'digitalni računalnik' ter naredimo še korak naprej. Kitajci označujejo računalnik (*computer*) kot 電腦, kar dobesedno pomeni 'električni možgani'. Zelo zanimiva in informativna je tudi konstrukcija pismenk, torej nekakšna 'etimološka analiza ideografa'. Z razgradnjo pismenk dobimo približno nekaj takšnega kot 'pameten-del-telesa-čigar-tok-žene-tisto-kar-je-v-strelah-z-deževnega-neba'.[9]

Ob tem nam niti ne gre za natančno, strogo znanstveno pojasnitev pomena pismenk; opozoriti želimo predvsem na pomen notranje logike posameznega jezika (oziroma, v našem primeru, *zapisa*) za razumevanje, interpretacijo, oceno lastnosti predmetov sveta. Vsekakor zveni bolj sprejemljivo, logično, naravno, da mislijo 'električni možgani', kot pa da takšno aktivnost gosti '*digital computer*', ki je, če ga poskusimo razstaviti analogno razgradnji kitajskih pismenk, na prvi pogled le nekakšen 'sopostavljalec-števil', sestavljen iz besed '*digit*' ter '*putter*', kateri je ob združitvi s predpono '*com-*' izgubil en 't'.

A vzet etimološko, *computer* ni tako daleč od 'mišljenja'. Iz lat. *com-putāre* 'računati, seštevati' se je v angl. razvilo *count* 'šteti', že v 17. stoletju pa tudi *computer* 'oseba, ki dela izračune'. Lat. *putāre* pomeni najprej 'očistiti, odstraniti odvečno, urediti', pa tudi 'misliti, meniti, soditi, (pre)račun(av)ati'. Iz iste osnove so na primer še angl. *amputate* 'odrezati', *dispute* 'razprava, spor' *putative* 'dozdeven', *reputation* 'sloves'. Slovenski jezik tvori *računalnik* po zgledu nem. *Rechner* oz. angl. *computer*, torej v navezavi na *računanje*. Ob tem je nem. *rechnen* soroden z ang. *reckon*, iz iste osnove pa je denimo tudi nem. *Recht* oz. ang. *right* 'pravica, pravo'. *Račun* je, po drugi strani, prevzet iz neke romanske predloge, ki se je razvila iz pomensko bogatega lat. *ratiō*, iz česar je tudi ang. *reason* 'razlog, vzrok, povod, motiv; argument, utemeljitev; um, razum, razumnost, razsodnost, uvidevnost, razumevanje, logika...'

Z etimologijami je sicer potrebno ravnati zelo previdno, sicer lahko iz njih izpeljemo precej več, kot le-te dejansko nosijo v sebi. Poleg tega etimologija tudi ni povsem zanesljiva veda, saj izhaja predvsem iz zgodovinskih dejstev - ta pa so, še posebej v območju jezika kot nekakšne fiktivne bitnosti, večkrat precej zamegljena. A dá se pokazati, da imajo etimologi *zagotovo* prav vsaj v nečem: da je namreč predpona 'ne-' v slovanskih izrazih za 'nekaj' negacija.[10] Na prvi pogled to sicer ni ravno mnogo, a vendarle: v primeru 'nečesa' gre za najuniverzalnejšo kategorijo indoevropskih jezikov, kamor pogojno ne sodita le 'nič' na eni, ter 'vse' kot presežna stopnja kvantitativnega stopnjevanja česa na drugi strani.[11]

***

Računanje je oziroma je vsaj do pred nekaj desetletji nedvomno bilo pojmovano kot neka niti ne najmanj pomembna oblika mišljenja. Stroj imenovan npr. *računalnik* ali *Rechner, počítač*, *computer* ali *компьютер*, 電腦 po svojih imenih bolj ali manj sovpada z vsaj nekaterimi oblikami mišljenja; subjekt in predikat izhodiščnega vprašanja se, vidimo, vsaj deloma prekrivata. Po drugi strani je seveda možno, da imena ne ustrezajo dejanskosti. V tem smislu se bo komu še posebej sumljiva zazdela sicer nedvomno najbolj informativna kitajska verzija; sam menim, da se ravno ta tudi kar najbolje prilega bistvu obravnavane vrste stroja.

*** *** ***

Turing A. M., začetnik 'filozofije umetne inteligence', sicer velja za človeka, ki zagovarja če že ne superiornost stroja nad človekom pa nedvomno vsaj globoko smiselnost pojma 'strojno mišljenje'. Edini od ugovorov k takšni zmožnosti strojev, kjer Turing priznava nek presežek človeka nad strojem, t.i. 'ugovor glede zunajčutne zaznave', naj bi bil po večini interpretacij zgolj nekakšna 'diskretna šala'.

V podrobnejšo obravnavo tega občutljivega vprašanja se tu seveda ne moremo spuščati, dá pa se dovolj prepričljivo pokazati, da leta 1950 Turing strogo ločuje med pojmoma 'sposobnost mišljenja' na eni ter 'inteligenca' na drugi strani: inteligenca je za Turinga zgolj atribut človeka, nikakor pa ne tudi stroja. In če si pogledamo slovarske definicije obeh besed, gre res preko vsakih razumnih in potencialnih zmožnosti strojev le pomen inteligence v opisu »1 b. *Christian Science*: the basic eternal quality of divine Mind«.[12]

[9] Povzeto po http://www.halfhill.com/ebrain.html

[10] Zavrnitev tega namreč vodi v neskončni progres. Možnost za zavrnitev je še absolutna skepsa, a v takšnem primeru je vsakršno razpravljanje bolj kot ne izguba časa.

[11] Tako 'nič' kot 'vse' namreč, v trenutku ko sta izrečena - ali celo zgolj mišljena - *eo ipso* postaneta 'nekaj'.

[12] *Merriam-Webster's Collegiate Dictionary, 10th edition*, Merriam-Webster: Springfield, Massachusetts, U.S.A., 1994. gsl. '*intelligence*'.

CENTER ZAVESTI IN SVOBODNA VOLJA

Toma Strle
Oddelek za filozofijo
Univerza v ljubljani
Aškerčeva 2, 1000 Ljubljana, Slovenija
e-mail: toma.strle@guest.arnes.si

ABSTRACT

Kartezijanski materializem trdi, da v možganih obstaja nek center oziroma glavni štab, v katerem vse mentalne vsebine 'pridejo skupaj' na nekakšen gledališki oder (kartezijansko gledališče), kjer so dostopne zavestnemu opazovalcu. Zavrnitev obstoja takega centra pomeni, da moramo zavrniti tudi trenutek nastanka zavestne izkušnje. Nikoli ne moremo določiti, kdaj neka mentalna vsebina postane zavestna izkušnja, saj so le preizkusi pripovednega toka zavesti tisti, ki to določajo. Če hočemo ohraniti svobodno voljo, moramo zavestno dejavnost razporediti po prostoru in času v možganih ter spremeniti naše pojmovanje zavestnega dejavnika.

1 UVOD

»... sama misel je mislec ...« (James, 1980: pogl. X: The Consciousness of Self)

Občutek nam pravi, da se nahajamo nekje v naši glavi, na nekem privilegiranem mestu, od koder gledamo, se srečujemo s svetom, upravljamo telo in lastne misli. A ko poizkusimo to mesto zagrabiti in nanj pokazati, se nam vedno nekako izmakne. Morda zato, ker takega mesta, kjer bi 'prebival' jaz, sploh ni, ker je to le predstava, ki ji ne ustreza prav nič. Že Hume je v svojih *Treatise of Human Nature* govoril o 'izmuzljivosti' jaza:
»Ko sam najbolj intimno vstopim v to, čemur pravim jaz, vedno naletim na tako ali drugačno zaznavo; na zaznavo toplote ali mraza, svetlobe ali sence, ljubezni ali sovraštva, bolečine ali užitka. Nikoli pa ne morem samega sebe ujeti brez zaznave in ne morem opaziti ničesar drugega, razen zaznave.« (Dennett 1984; Hume, Treaties, I, IV, iv)
Hume sicer govori o jazu, Dennett pa o skupni točki, kjer se v možganih združijo različne informacije, kar sta (lahko) dve različni stvari. Vendar sta metafori podobni: obe opisujeta nek glavni center oz. stičišče; naj bodo to jaz, proces centralnega nadzora ali pa neka točka, kjer nastane zavest in kjer mentalne vsebine postanejo dostopne. Ko smo pozorni na to, kje se nahaja nek center, na vrhu katerega smo mi, tega ne moremo in ne moremo najti. Ko pa spet normalno delujemo (ko zavzamemo zunanjo perspektivo), se nam zdi taka točka, središče, kjer se zgodi zavest, nekaj povsem samoumevnega. To najbrž izhaja iz občutka, da smo mi oziroma naš jaz nekaj posebnega, neka ločena entiteta, ki sedi na privilegiranem mestu, od koder podeljuje ukaze. Zdi se nam, da mora obstajati tak center, kjer se povežejo možganski procesi in duševnost (Descartes je to mesto našel v češariki).

2 KARTEZIJANSKO GLEDALIŠČE

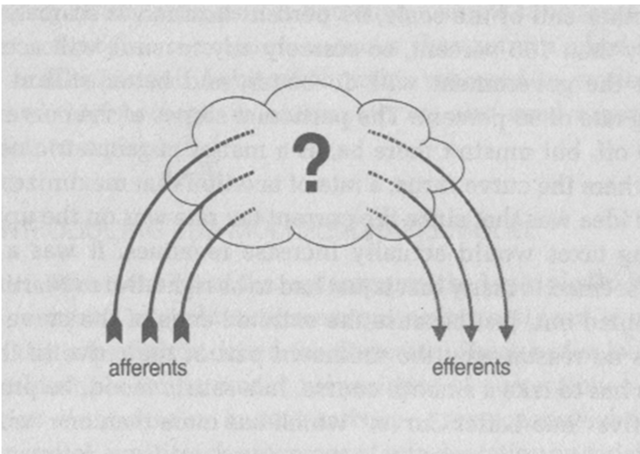
Ta princip so po Dennettu povzele prenekatere materialistične pozicije (med drugim Libetova in Wegnerjeva), ki sicer zanikajo razliko med duhom in telesom (vsaj v močnem Descartesovem smislu) in zagovarjajo naturalistično pozicijo, vendar kljub temu predpostavljajo nek center v možganih, kjer bi se lahko odvijala povezava med nezavednimi in zavestnimi mentalnimi procesi. Tako stališče Dennett poimenuje kartezijanski materializem. Kartezijanski materializem v možganih poskuša pokazati na prostor, kjer bi se v nekakšnem gledališču misli združile vse mentalne vsebine in bi nastala zavest (kartezijansko gledališče). Vendar Dennett misli, da je takšno stališče močno zgrešeno. 'Kartezijanski materialisti' se ne zavedajo, da so s tem, ko so zavrnili Descartesovo razliko med *res cogitans* in *res extensas*, posledično priznali tudi nekaj drugega:
»Da ni več vloge za osrednji portal ali kakršenkoli funkcionalni center možganov. Češarika ni nekakšen faks do duše, nekakšna ovalna pisarna, niti to niso katerikoli drugi deli možganov. Sami možgani so glavni centralni štab, kjer se nahaja končni opazovalec, toda ni nikakršnega razloga, da bi verjeli v obstoj še kakšnih globljih centralnih štabov, v nekakšno notranje svetišče, prihod v katerega je nujni ali zadostni pogoj za zavestno izkušnjo. Z eno besedo, opazovalec v možganih ne obstaja.« (Dennett, 1991: 106)
Kartezijanski materializem (ki je po Dennettu naslednik Descartesovega dualizma) poleg centralne točke, kjer naj bi se nahajala zavest (ali pa kjer naj bi prišlo do zavesti), predpostavlja še nekakšnega opazovalca, ki z duhovnim očesom opazuje celotno dogajanje, ki se prikazuje na nekakšnem platnu oz. centralnem prostoru.:

»Kartezijaski materializem je mnenje, da nekje v možganih obstaja kritična končna črta ali meja, ki označuje prostor, kjer je v izkušnji razpored prihoda enak razporedu 'predstave', kajti kar se zgodi tam, je tisto, česar se zavedaš.« (Dennett, 1991: 107)
Pri Libetu (ta je po Dennettu kartezijanski materialist) se pojavi problem, ko hoče definirati mikroskopske časovne intervale in jih razdeliti v dve skupini: na »še ne opažene« in »že opažene«. To vodi v predpostavko neke centralne točke,

kjer se nahaja opazovalec. Šele predpostavka prostora, kjer se zgodi zavestna izkušnja, Libetu omogoči, da določi čas, ki ga potrebuje informacija, da pripotuje 'v zavest'; glede na točko, kjer se nahaja zavestni opazovalec. Ko pa poizkusimo razložiti nek pojav, ki se razteza v zelo kratkem časovnem intervalu (550 msek), se srečamo z logično težavo, pravi Dennett:

»Če mora biti 'točka' gledišča opazovalca razmazana po velikem obsegu opazovalčevih možganov, mora biti opazovalčev subjektivni občutek sekvence in simultanosti določen z nečim drugim kot 'razporedom prihoda', saj je razpored prihoda definiran nepopolno, vse dokler ni določen relevanten cilj. Kateri rezultat določi subjektivno sekvenco v zavesti, če A prehiti B do ene končne črte, a B prehiti A do druge? (Cf. Minsky, 1985: 61)« (Dennett, 1991: 107 – 108)

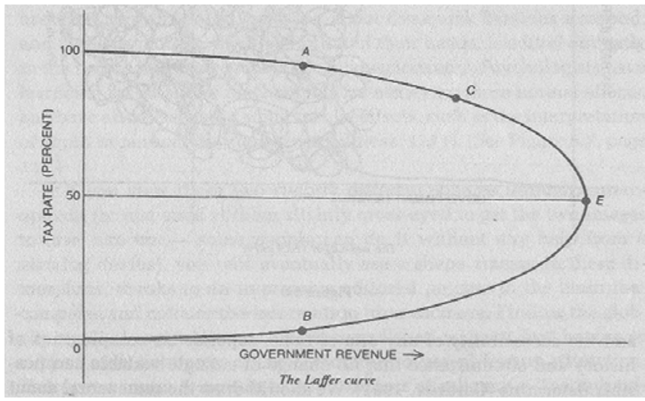
Se morda naša zavest ne nahaja ravno na meji med procesi, ki prihajajo v možgane, in procesi, ki iz možganov odhajajo *(glej Slika 1)*, se sprašuje Dennett.



SLIKA 1: Meja med potjo v možgane in potjo iz možganov. Vir: Dennett, 1991: 109

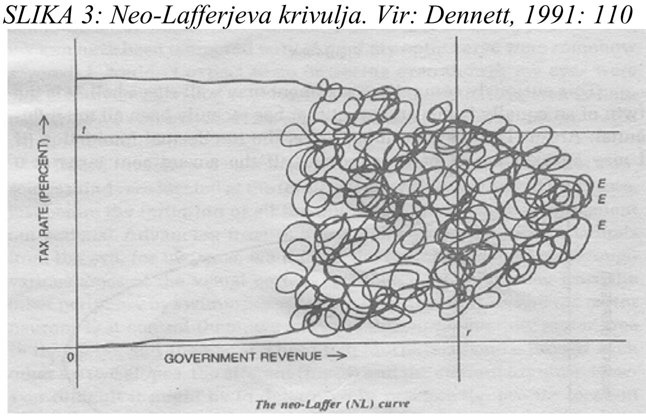
Podobno predstavo zbuja Lafferjeva krivulja, ki jo je v kontekstu ekonomije izumil Arthur Laffer. *(glej Slika 2)*

Krivulja prikazuje razmerje med davčno stopnjo in davčnim dohodkom, ki ga pobere vlada. Ko se povečajo davki, se poveča tudi dohodek od davkov. Povečanje davkov ima po neki določeni točki za posledico nepripravljenost ljudi, da bi delali, kar povzroči znižanje dohodka od davkov. Če bi se davki povečali na 100 %, nihče ne bi bil več pripravljen delati, dohodek od davkov pa bi bil ničen. Vendar pa Martin Gardner kritizira tako predstavo. Čeprav poznamo skrajne konce krivulje (davek je 0 % ali 100 %) nimamo nobenega razloga za prepričanje, da vmesne točke predstavljajo enakomerno krivuljo. Gardner predstavi svojo alternativno »neo-Lafferjevo krivuljo«, ki ima več kot en maksimum *(glej Slika 3)*.



SLIKA 2: Lafferjeva krivulja. Vir: Dennett, 1991:109

SLIKA 3: Neo-Lafferjeva krivulja. Vir: Dennett, 1991: 110



Različni maksimumi se lahko pojavijo zaradi mnogo okoliščin, ki jih prav vseh ne moremo upoštevati: podnebje, zgodovina nekega ljudstva ali države, državna ureditev, socialni status itd. Isto pa moramo reči o zavesti in možganih.

3 MODEL VEČVRSTNIH OSNUTKOV

»… sredina ne more obstajati. Vprašajmo se na primer, ali je aktivnost v Wernickovem področju na poti noter ali na poti ven? Ali pa tista v področju V1 ali V5 ali v temporalnem režnju. V resnici ni le enega toka nevronske aktivnosti, ki bi prihajal v sredino in ven pošiljal nov tok; je masivno, paralelno procesiranje. So povratne zanke, kompleksna združenja celic, ki se formirajo in razpadajo, medsebojne interakcije med oddaljenimi deli in tako naprej. Je veliko integracije, a ni sredine. Podobno ni posebnega časa, ko bi se morala zgoditi zavest. Informacija vsekakor najprej vstopi, potem pa se zgodi dejanje, a med njima so večvrstni, paralelni tokovi procesiranja in nikakršnega magičnega trenutka, v katerem bi se input spremenil v output ali v katerem bi se zgodila zavest.« (Blackmore, 2003: 67)

Ko sledimo notranjim občutkom, se vprašamo, kje in kdaj na poti obdelave informacij se pojavi zavest. Mislimo, da mora obstajati trenutek, ko smo se nečesa zavedli, in trenutek, ko smo se nečesa prenehali zavedati. A kot smo videli, je samo vprašanje po trenutku napačno. Vprašanje predpostavlja, da lahko določimo trenutek, ko je nek proces pristal na končni točki, ki vodi do zavestne izkušnje. Model večvrstnih osnutkov pa ravno to zanika:

»Glede na model večvrstnih osnutkov možgani dosežejo vse raznotere zaznave – vse raznotere misli ali mentalne aktivnosti – s paralelnimi, večvrstnimi procesi interpretacije in obdelovanjem vizualnih inputov. Informacije, ki vstopijo v nevronski sistem, so podvržene nenehnemu 'uredniškemu popravljanju'.« (Dennett, 1991: 111)

Celotni notranji mentalni svet je podvržen nenehnemu popravljanju, spreminjanju in preurejanju. Kadarkoli pogledamo možgane, vidimo mnogovrstne osnutke fragmentov pripovedi (ang.: *narrative*), ki so hkrati v različnih stadijih urejanja, ki je razpršeno na različne dele možganov. Zavestno nikoli ne izkusimo procesov urejanja, ki dodajajo, združujejo, popravljajo, izboljšujejo in prepisujejo vsebino. Podobno nikoli ne izkusimo, kaj se dogaja na naših očesnih mrežnicah. *»Kar dejansko izkusimo, je izdelek mnogih procesov interpretacije – v bistvu uredniških procesov.« (Dennett, 1991: 112)* S tem opisom se strinjajo skoraj vse teorije percepcije, a Dennettov model mnogovrstnih osnutkov vsebuje neko pomembno novost:

»Detekcija oziroma diskriminacija značilnosti mora biti narejena le enkrat. To pomeni, ko je specializiran, lokaliziran del možganov naredil določeno 'opazovanje' nekih značilnosti, ni potrebno, da je informacijska vsebina, ki je tako postala določena, poslana nekam drugam, kjer bi jo razločil nek 'glavni' razločevalec. Z drugimi besedami, razločevanje ne vodi do reprezentacije že razločene značilnosti v korist občinstva v kartezijanskem gledališču – kajti kartezijanskega gledališča sploh ni.« (Dennett, 1991: 113)

4 PRIPOVEDNI TOK ZAVESTI

Lahko sicer ugotovimo čas in prostor določitve vsebine, a začetek določitve vsebine ni enak začetku zavesti te vsebine. Za to, da se neka vsebina pojavi kot zavestna izkušnja, ni pomembno, kdaj možgani neko vsebino razločijo, ampak je nastanek zavestne izkušnje odvisen od posameznih preizkusov (ang.: *probe*)[1] toka pripovedi**.** Preizkusi določajo tisto, kar dejansko izkušamo v nekem obdobju (ne trenutku – tega ne moremo določiti), a to kar izkušamo, je le delček našega toka zavesti. Je le ena od možnih zgodb, ki jo določajo preizkusi. Dennett pravi, da *»... ni določenih dejstev o toku zavesti, ki bi bili neodvisni od določenih preizkusov.« (Dennett, 1991: 138)* Različne vsebine, ki se nahajajo v možganih, moramo razumeti kot pripovedni tok (ang.: *narrative stream)*, ki je podvržen nenehnemu urejanju (proces traja v neskončnost, vse dokler so aktivni možgani – tudi v sanjah). Opravljajo ga najrazličnejši procesi, ki so porazdeljeni po možganih.

Tok vsebine Dennett primerja s pripovedjo zaradi njenega nenehnega spreminjanja, popravljanja in – najpomembnejše – zaradi njene mnogoterosti. Vendar pa vprašanje, kaj sedajle izkušamo, po Dennettu nima odgovora. Če se vprašamo, česa se zavedamo ta trenutek, bo že samo vprašanje določilo ta tok zavesti; izločila se bo neka vsebina.

Poanta Dennetta je v tem, da ne obstaja neka pravilna, dokončna in edina pripoved, ki bi od nekega trenutka veljala za kanonično. (kot je recimo v preteklosti za kanonično veljala končna in objavljena verzija članka). Končna, dejanska pripoved, tista pravilna, na katero naj bi se nanašali vsi možganski procesi, po modelu večvrstnih osnutkov ne obstaja. V možganih se zgodi neko razločevanje informacij, te postanejo vsebina, ki pa nikoli ne doseže končne verzije, ker se neprekinjeno spreminja. Ta vsebina vpliva na vedenje, v spominu pušča sledi, kjer ostane, ali pa je kasneje izrinjena z drugimi vtisi.

Ko vizualni dražljaj pride na mrežnico, potuje do korteksa, kjer povzroči bolj specifična razločevanja zunanjega predmeta. Po Dennettu se dogajajo različne 'sodbe' in odločitve; različni deli možganov se povzročeni, da gredo v različna stanja. Razločujejo različne dražljaje: najprej začetek dražljaja, kasneje lokacijo, obliko, barve, gibanje, na koncu pa sledi 'celostno' prepoznanje objekta. Ta lokalna razločevalna stanja posredujejo učinke na druga mesta, kar prispeva k nadaljnjim razločevanjem itd. Vsebine se pojavljajo, so spreminjane, prispevajo k interpretaciji drugih vsebin, igrajo različne vloge v spreminjanju notranjih stanj, vplivajo na ustna poročila, na emocionalno stanje in vedenjska nagnjenja. Nekatere se celo zapišejo v spomin, medtem ko nekatere izginejo brez opaznih sledi in vplivov na vedenje ali druga notranja stanja.[2]

Preko preizkusov nastane zavestna izkušnja in tudi tisti, ki zavestno izkuša. Takšen preizkus je lahko vprašanje, o čem razmišljamo, polet ptice pred našimi očmi, bolečina, ko se urežemo z nožem v prst ali ko se spotaknemo ob pogledu na očarljivo osebo, ki nam pritegne pozornost. Različni preizkusi tega toka imajo za posledico različne učinke in zavestne zaznave različnih vsebin, ki se nahajajo v subjektu. Tudi notranje vprašanje samemu sebi, notranji pogovor s samim seboj, je lahko takšen preizkus toka zavesti in ima za posledico različne učinke in zavestne zaznave.

Po Dennettu je tak subjekt, ki samemu sebi postavlja vprašanje ali pa se mu nekaj le zgodi, le teoretski izmislek, napačna metafora, ki pa se ji v govoru o zavesti težko izognemo. Nek realni subjekt, za katerega naj bi možgani retrospektivno ustvarjali vsebino, ne obstaja; je le

»... teoretski izmislek. ... V čigavo korist se izvaja vse to animirano risankovanje? Za gledalce kartezijanskega gledališča. A ker ni takega gledališča, tudi ni občinstva.« (Dennett, 1991: 128)

---

1 Preizkusi so najbrž lahko tudi nezavedni (ali vsaj pozabljeni, kot na primer v sanjah) in lahko vplivajo na nezavedne in zavestne procese, vendar je to vprašanje, ki bi rabilo posebno obravnavo.

[2] Vendar ostaja vprašljivo, ali si ne moremo morda zamisliti možganskih procesov, ki so sicer večvrstni in paralelni, ampak v njih (na različnih mestih hkrati) obstaja kriterij, ki pove, kdaj je neka vsebina postala del zavestne izkušnje in je nujni pogoj za nastanek zavesti. Na primer določena frekvenca oscilacij. Tak kriterij za nastanek zavesti ne predpostavlja ne skupnega opazovalca, ne ciljne črte, ne jaza, ampak le neko določeno značilnost fizične materije, ki bi omogočila zavest.

Sam notranji govor pa ni nekakšna iluzija; zaradi zavestnega notranjega govora (morda je to pogovarjanje različnih procesov z drugimi procesi) je možna samo-refleksija, ki pa je nujni pogoj za zavestno voljo ter moralno odgovornost, saj omogoča spreminjanje in kontrolo.

4 VLOGA ZAVESTI[3]

A še vedno ne vemo prav dobro, kakšno vlogo ima pri vsem skupaj zavest, vendar mislim, da moramo zavesti najti neko vlogo, če hočemo ohraniti svobodno voljo, razen če smo pripravljeni pristati na pred-zavestno svobodno voljo, vendar mislim, da bi kaj takega težko sprejeli.

Mislim, da bi eno izmed pomembnih funkcij zavesti, ki je potrebna za zavestno, svobodno voljo, našli v Dennettovih samo-preizkusih, ki so močno povezani z refleksijo in samo-nadzorovanjem. Zavestni samo-preizkusi se dogajajo preko notranjega govora (lahko bi rekli, da se možgani pogovarjajo sami s seboj) in omogočajo samo-opazovanje, samo-kontrolo in samo-refleksijo, ki so ključne za zmožnost samo-spremembe. Rečeno v skladu z Dennettom ima možganski sistem sposobnost, da samega sebe spreminja, to pa mu omogoča veliko prednosti v kompleksnem okolju, na katerega se mora vseskozi prilagajati. *»... narejen je bil tako, da nenehno spreminja samega sebe.« (Dennett, 1984: 30)* Da pa se samo-spreminjanje lahko izvršuje učinkovito, je potrebna zavest, saj ta šele omogoča notranji govor in samo-preizkuse, ki lahko resnično posegajo v notranje dogajanje 'subjekta'.

Pozornost bi lahko bilo 'orodje', ki omogoča še bolj učinkovito izvajanje funkcij zavesti. Mislim, da pozornost omogoča, da ima več procesov dostop do drugih procesov; da lahko procesi dostopajo do 'globljih' procesov, ki so bili pred tem 'skriti v temi'; da je lahko neka specifična mentalna vsebina/proces dlje časa zavestna izkušnja, kar možganom omogoča, da jo lahko bolje preučijo. Preko zavestne pozornosti lahko možgani neko specifično vsebino/proces bolj efektivno povežejo z drugimi vsebinami/procesi. Vidijo, s katerimi se že povezuje, ali pa jo postavijo v perspektivo drugih vsebin/procesov. To omogoča kreativno reševanje problemov, ugotavljanje vzrokov za neko mentalno vsebino/proces ipd. Zadnji primer je zelo pomemben del različnih psihoterapij. Večja pozornost pomeni večjo zmožnost dostopa do vsebin/procesov, ki so bili prej 'skriti' zavestni izkušnji in tako omogočijo večjo samo-kontrolo in svobodno voljo.

5 ZAKLJUČEK

Če hočemo ohraniti zavestno dejavnost, svobodno voljo in moralno odgovornost, moramo po Dennettu vse razpršiti po prostoru in času v možganih. Prav tako se moramo odreči klasični predstavi o zavestnem dejavniku, nekem jazu, ki kot 'negibni gibalec' prosto lebdi nad možganskimi procesi, od koder ima popolno kontrolo nad dogajanjem. Sprejeti moramo, da zavestnega dejavnika v tem smislu ni; so le raznoteri procesi, ki so včasih zavestni, včasih pa ne. Mi pa smo prav ti možganski procesi. Morda bi nam preko razvijanja pozornosti mentalno kraljestvo postalo tako prosojno, kot nam postane prosojen labirint, ki smo ga že velikokrat prehodili. Svobodna volja ni nek pojav, ki je ali pa ga ni. Svobodna volja je lahko večja ali manjša: prihaja v 'stopnjah'. In mislim, da lahko svojo svobodo povečamo, če se za to zavestno odločimo.

Reference

[1] **Baars Bernard J., McGovern Katharine (1996)**, *Cognitive views of consciousness: What are the facts? How can we explain them?*; v: Velmans Max (ured.), *The Science of Consciousness: Psychological, Neuropsychological, and Clinical Reviews*, London, Routledge; http://cogprints.org/944/00/BKintro.htm; nazadnje dostopno: 19.7. 2006

[2] **Blackmore Susan (2003)**, *Consciousness, An Introduction*, London, Hodder & Stoughton Educational

[3] **Dennett C. Daniel (2003\2004)**, *Freedom Evolves*, London, Penguin Books (Penguin Science and Philosophy)

[4] **Dennett C. Daniel (1991\12.izd.)**, *Consciousness Explained*, London, Penguin Books (Penguin Science Philosophy)

[5] **Dennett C. Daniel (1984\2002)**, *Elbow Room, The Varieties of Free Will Worth Wanting*, New York, Oxford University Press

[6] **Libet Benjamin (2004)**, *Mind Time, The Temporal Factor in Consciousness*, Cambridge, Harward University Press

[7] **Libet Benjamin (1985)**, *Unconscious cerebral initiative and the role of conscious will in voluntary action*, The Behaviour and Brain Sciences 8, str. 529 – 566L

[8] **William James (1890)**, The Principles of Psychology, Vol 1 in 2; http://psychclassics.yorku.ca/James/Principles/; nazadnje dostopno: 7.6.2006

[3] Baars, McGovern *(1996)* predlagata naslednje funkcije zavesti: Opredeljevanje in določevanje konteksta, Adaptacija in učenje, Ustvarjanje prednosti in kontrola dostopa, Rekrutiranje in kontrola mentalnih in fizičnih dejanj, Odločanje in izvrševanje, Odkrivanje napak in urejanje, Refleksija in samo-nadzorovanje, Optimiziranje ravnotežja med organizacijo in fleksibilnostjo.

KOGNTIVNA ZNANOST IN UČENJE: SPREMEMBA PARADIGME

Simona Tancig
Pedagoška fakulteta
Univerza v Ljubljani
Kardeljeva pl. 16, 1000 Ljubljana, Slovenia
Tel: +386 1 5892 200; fax: +386 1 5892 233
e-mail: simona.tancig@guest.arnes.si

POVZETEK

Tradicionalno se kognitivna znanost osredotoča na kognitivne strukture in procese, ne da bi upoštevala širši socialni kontekst, v katerem se učenje odvija. Na ta način ni mogoče celovito pojasniti učenja. To omogoča šele sociokulturni, socio-konstruktivistični, situacijski ali ekološki pristop k učenju, pri katerem je poudarek na vsebinskih vidikih učenja in tudi na participatorni aktivnosti posameznika. Tako se je antropološka in socialna perspektiva razširila na kognitivno znanost. Na pomen te spremembe paradigme v kognitivni znanosti je opozorila tudi nedavna druga Evropska konferenca kognitivne znanosti. V prispevku so predstavljeni nekateri primeri kolaborativnega učenja, ki temeljijo na kompleksnih socialnih in tehnoloških okoljih.

1 UVOD

V današnjih na znanju utemeljenih družbah je učinkovitost učenja še posebno izpostavljena. Površinsko učenje, t.j. memoriranje dejstev in procedur, ki je značilno za tradicionalne pristope k učenju, ki izhajajo iz behaviorističnih pozicij razumevanja učenja, ne odgovarjajo zahtevam in potrebam sodobnih družb. Kognitivizem in kognitivna znanost sta v nasprotju z behaviorizmom razvila globinske, višjenivojske oblike učenja, ki presegajo transmitivne poučevalne načine in temeljijo na konstruktivističnih učnih pristopih in aktivnemu učenju. Na znanju osnovane družbe zahtevajo poglobljeno deklarativno, proceduralno in strateško znanje, sposobnost ustvarjanja novega znanja v kolaborativnem učnem okolju. Poudarjeni so tudi kritično mišljenje, sposobnost refleksije in evalvacije lastnega učenja, sposobnost integriranja znanja in njegova uporaba v praksi ter prevzemanje odgovornosti za vseživljensko učenje.

Med nekatere pomembne ugotovitve kognitivne znanosti o učinkovitem učenju, ki so našle svoj prostor tudi v edukacijski praksi, gotovo sodijo naslednje:

- novo učenje mora temeljiti na predhodnem znanju – učenec mora nove informacije povezati s predhodnim znanjem in izkušnjami, tudi prepričanji, implicitnimi teorijami in predpostavkami;
- učenje mora temeljiti na konstrukciji znanja, principov in zakonitosti;
- poudarjena mora biti integracija znanja (dobro strukturirana in organizirana kognitivna baza);
- učinkovito učenje temelji na evalviranju novih idej;
- v učenju je pomembna refleksija lastnega razumevanja znanja in lastnega procesa učenja (metakognicija);
- pomembno je ustvarjanje skupnega znanja z dialogom, argumentacijo in kritičnim mišljenjem v kolaborativnih učnih okoljih.

2 SPREMEMBA PARADIGME

Po obdobju v 80-ih, ki ga zaznamuje "*AI winter*", so raziskovalci skušali odkriti, zakaj kognitivna znanost ni najbolj uspešna v razumevanju in simuliranju človekove inteligentnosti z računalniki. Odgovor na to vprašanje so dale študije, ki so uporabljale med seboj povezane raziskovalne pristope, in sicer sociokulturni, situacijski in pristop distribuirane kognicije. Pomembna je bila ugotovitev, da je inteligentno vedenje uresničeno v kompleksnem socialnem okolju (formalnem ali neformalnem). To so potrjevale razvojno-kognitivne raziskave, ki so odkrile, kako se otroci učijo in pridobivajo znanje v neformalnih učnih okoljih. Pomembne so bile tudi raziskave socialno

distrubuiranega znanja, ki so odkrile, da se izven formalnega šolanja skoraj vse učenje pojavlja v kompleksnih socialnih okoljih. To pomeni, da je učenje težko celovito pojasniti in odkriti učinkovite načine pridobivanja znanja, če ga pojmujemo le kot mentalne procese, ki se odvijajo pri posamezniku, ne da bi upoštevali širši socialni kontekst.
Tako tudi ekspertno znanje ni več pojmovano samo z vidika mentalnih procesov kot so odločanje, mišljenje, prepoznavanje vzorcev ipd., temveč tudi z vidika socialnega konteksta.

Sociokulturni pristop je imel pomemben vpliv na nekatere discipline kognitivne znanosti. Tako je kognitivna psihologija začela raziskovati timsko delo in učenje, kooperativno in kolaborativno učenje, skupinsko dinamiko in vlogo socialnega konteksta v kognitivnem razvoju. Raziskave umetne inteligence so začele poudarjati distribuirano kognicijo (deloma tudi zaradi razvoja medmrežne tehnologije). Raziskave v edukacijskih vedah so se usmerile v kolaborativni diskurz. Mnogi raziskovalci, ki so analizirali naravo znanstvenega znanja, so odkrivali, da znanstveno spoznanje ni preprosto sistem trditev (izjav) in logičnih operacij. Tako so zavrnili logični empiricizem. V znanosti se srečujemo z eksperimentiranjem, testiranjem hipotez, razprav-ljanjem, argumentiranjem, ki potekajo v skupinah in v kontekstu znanstvene skupnosti. Znanstveno spoznanje je situacijsko, socialno, praktično in kolaborativno konstruirano.

Raziskovalci umetne inteligence, ki so raziskovali ekspertno znanje in njegovo naravo (deklarativno, proceduralno, tacitno, metakognitivno in strateško znanje), so naredili pomemben korak. Iz raziskovanja, kaj je ekspertno znanje, so se osredotočili na vprašanja, kako eksperti pridobivajo znanje, katere so mentalne faze razvoja, ki začetnika privedejo do eksperta. Osnovo za odgovore na ta vprašanja sta dali razvojna in kognitivna psihologija, ki poudarjata, da je učinkovito učno okolje tisto, ki podpira konstrukcijo znanja v ustreznem socialnem okolju. To je učno okolje, ki omogoča eksternalizacijo in artikulacijo znanja in s tem refleksijo, razvoj metakognicije in razvoj višjenivojskega znanja. Pri tem igra pomembno vlogo tudi računalnik. Tako je razvita računalniška podpora za refleksijo, npr. recipročno poučevanje, forumi znanja in "*learning by design*", ki podpirajo tudi kolaborativno učenje.

V ospredje danes vedno bolj stopa vprašanje, kako uporabiti dosedanja spoznanja o kogniciji, in s tem, s kakšno raziskovalno metodologijo pristopiti k oblikovanju učnega okolja (kompleksnega socialnega in tehnološkega). Kaže se, da je smiselna kombinacija eksperimenta in raziskave socialne interakcije z uporabo sociološke in antropološke metodologije, npr. konverzacijske analize, interakcijske diskurzivne analize, etnografije, etnometodologije in tudi hibridne metodologije (*design research*).

3 KOLABORATIVNO UČENJE

Kolaborativno učenje je multidisciplinarno področje znanosti o učenju, ki vključuje vede, kot so psihologija, edukacijske vede, sociologija, antropologija, računalniške vede in komunikacijske vede. Vsaka od teh disciplin ima specifično teoretično izhodišče o kolaborativnem učenju, ki se odraža tudi v metodologiji njegovega raziskovanja. Te variacije se reflektirajo tudi metaforah kolaborativnega učenja. Lipponen, Hakkarainen in Paavola (2004) ločijo med metaforami pridobivanja, participacije in kreacije znanja. Pridobivanje znanje se osredotoča na individualno pridobivanje znanje (internalizacija znanja). Participacija poudarja interakcijo med posamezniki, participacijo v izkustveni skupnosti (*community of practice*) in distribuirano ekspertizo. V metafori ustvarjanja znanja je poudarjeno nenehno ustvarjanje novega skupnega znanja s kolaboracijo.
Raziskovalna metodologija je trihotomizirana. Uporabljajo se eksperimentalni, deskriptivni in iterativno oblikovani raziskovalni pristopi. Eksperimentalni raziskovalni pristop je usmerjen v identificiranje variabel, ki vplivajo na parametre kolaborativnega učenja. Etnometodološki pristopi so usmerjeni v identifikacijo skupinskih aktivnosti (interakcije, diskurzi itd.), tretji pristopi pa so usmerjeni v raziskovanje kreativnega adaptiranja informacijske tehnologije (učnega okolja). V ospredju so tudi raziskave, ki uporabljajo hibridne metodologije.

3.1. Računalniško podprto kolaborativno učenje

Danes je v ospredju raziskav posebna oblika kolaborativnega učenja, kjer se osebe v manjših skupinah (5-6) učijo po principih kolaborativnega učenja s pomočjo računalnika (*CSCL – Computer Supported Collaborative Learning*). Na področju edukacije se ta oblika učenja širi na vse ravni formalnega izobraževanja kot tudi neformalnega. V kolaborativnem učenju je učenje socialno-konstrukcijski proces. Posamezniki v skupini v skupinski interakciji ustvarjajo novo znanje.

Področje CSCL lahko primerjamo z zgodnjimi pristopi v uporabi računalnikov v edukaciji. Koschmann (1996) je ločil naslednje razvojno zaporedje pristopov:

- računalniško podprto poučevanje,
- inteligentni tutorski sistemi,
- Logo,
- CSCL – računalniško podprto kolaborativno učenje.

Računalniško podprto poučevanje je izhajalo iz behaviorističnega pristopa v poučevanju, ki je dominiral v zgodnjih letih uporabe računalnika v edukaciji. Sloni na domnevi, da je učenje memoriranje dejstev in na transmisijskem (instrumentalističnem) modelu poučevanja. Tu je bilo učno gradivo razdeljeno na posamezne dele, ki so bili učencem posredovani v logičnem zaporedju. Neredko še danes nekateri komercialni edukacijski računalniški programi slonijo na temu pristopu.

Druga, zahtevnejša uporaba računalnika v edukaciji so bili inteligentni tutorski sistemi. Ti so temeljili na kognitivističnem razumevanju učenja, ki izhaja iz kognitivne znanosti.

Tretjo uporabo računalnika v edukaciji označuje učenje programskega jezika Logo v 80-ih letih. Logo izhaja iz konstruktivističnega pristopa k učenju – učenci morajo sami konstruirati znanje s pomočjo računalnika.

Četrta faza razvoja, računalniško podprto kolaborativno učenje, je najnovejša uporaba računalnika v edukaciji, ki poteka v majhnih skupinah (*learning communities*) in temelji na socialno-konstruktivistični in dialoški teoriji. Učenci se skupaj učijo z usmerjenim diskurzom, ki omogoča konstrukcijo skupnega znanja. Z interakcijsko analizo skupinskega diskurza se raziskujejo različni vidiki interakcije. V novejših raziskavah so v ospredju študije argumentacije in kritičnega mišljenja, eksternalizacija in artikulacija znanja ter kako skupina nudi oporo posamezniku pri avtentičnem učenju. Sicer pa sta v ospredju raziskav interakcija kot tudi kognitivna vsebina kolaborativnega učenja.

3.2 Na primerih osnovano rezoniranje (*CBR –Case-Based Reasoning*)

CBR izhaja iz raziskav umetne inteligence in kognitivne znanosti. Predstavlja poskus narediti inteligentne sisteme, ki delujejo podobno kot eksperti. CBR je teorija uma, ki je nastala iz prvih raziskav v Schankovem laboratoriju in skuša razložiti, kako se skripti razvijajo in kakšen je odnos med skripti in spominom. CBR razloži, kako posameznik uporablja predhodne izkušnje za reševanje problemov v novih situacijah. Izgleda, da so CBR programi bolj fleksibilni kot drugi načini modeliranja ekspertize; ker se ti programi učijo iz izkušenj, postajajo vedno bolj inteligentni.

Ko so raziskovalci spoznali procese, ki posamezniku omogočajo, da rezonira za osnovi predhodnih izkušenj, je postalo jasno, da je vloga CBR pomembna na področju edukacije. Tako so raziskovalci začeli uporabljati principe CBR za oblikovanje učnega okolja na različnih ravneh izobraževanja. V nekaterih primerih je bil računalnik integriran v učno okolje kot sredstvo, ki omogoča dostop do informacij in nasvetov. Sicer pa je tako učno okolje spodbujalo uspešno projektno delo, refleksijo, učenje iz izkušenj ali služilo kot organizator učnega zaporedja. V nekaterih primerih je računalnik igral majhno ali pa sploh nobene vloge. V teh primerih je bil CBR kognitivni model uporabljen kot okvir za oblikovanje razrednih aktivnosti, razrednega skripta, vlog učiteljev in učencev.

Prvi poskus uporabe CBR za izboljšanje edukacije je bil Schankov t.i. GBS (*Goal-Based Scenarios*). Zanj je značilno, da se je osredotočil na oblikovanje računalniškega programa, ki učencu omogoča učenje. Kasnejši pristop je bil LBD (*Learning By Design*) ali projektno zasnovan raziskovalni pristop, ki uporablja CBR teorijo učenja na načrtovanje celotnega učnega procesa v razredu. LBD pedagogika vključuje strukturo aktivnosti za celoten razred (razredni skript) ter vodič za vlogo učitelja in učencev, ki nudijo pomoč drug drugemu pri učenju iz izkušenj; vključuje tudi zaporedje aktivnosti za posameznika, za manjše skupine in za celoten razred kot tudi potrebna tekstovna gradiva. Izobraževalni smoter omenjenega pedagoškega pristopa je učencem omogočiti tiste izkušnje, ki spodbujajo globinsko učenje.

3.3. Kolaborativno na primerih osnovano učenje (*PBL – Problem-Based Learning*)

To je oblika učenja, ki je bila prvič uporabljena v medicini, pozneje tudi na drugih študijskih oz. poklicnih področjih. Osnovna zamisel tega pristopa je, da se študenti učijo z reševanjem realističnih problemov, tako da uporabijo različne vire. V prvotni zasnovi so z viri mišljeni učitelji, ostali študenti v skupini (običajno skupino sestavlja 5 do 6 študentov) in razna študijska gradiva. PBL je bil uporabljen na različne načine in danes neredko vključuje tudi računalniške simulacije in virtualna okolja. Glavna zahteva tega pristopa je, da učna vsebina omogoča transfer in je uporabna v podobnih življenjskih problemih realnega sveta. Pri tej obliki učenja posameznik sam spremlja svoj napredek in ugotavlja, katero znanje mora še pridobiti, sam tudi identificira uporabo znanja v praksi in razvija dispozicije za vseživljensko učenje.

PBL omogoča razvoj avtonomnega, za lasten razvoj odgovornega posameznika, ki ima razvite spretnosti refleksije, metakognicije in poseduje samouravnalne strategije.

3.4 Kolaborativna argumentacija in kritično mišljenje

Kolaborativna argumentacija je znana v znanosti. Je oblika kolaborativne diskusije, v kateri obe strani sodelujeta pri reševanju določene problematike, ki se zaključi s soglasjem obeh strani. Kolaborativna argumentacija omogoča učencem, da se naučijo kritičnega in neodvisnega razmišljanja, elaboriranja, logičnega sklepanja in refleksije. Poleg tega omogoča razvoj socialnih spretnosti, spretnosti kolaboracije kot tudi kompetentno udeležbo v različnih skupinah, kjer je potrebno poznavanje argumentiranega razpravljanja in dokazovanja. To je še posebno pomembno v družbah znanja.

Raziskovanje argumentiranja ima dolgo tradicijo v filozofiji, manj pa je prisotno v edukacijskih raziskavah. Kljub temu obstaja kar nekaj pomembnih raziskav o uporabi argumentacije v edukaciji – predvsem kolaborativne argumentacije in njene vloge v učenju. Tako je področje argumentiranja postalo predmet empiričnih, znanstvenih raziskav, ki ga obravnavajo kot dialog oz. diskurzivni pojav. Raziskave se ukvarjajo tudi z oblikovanjem učnega okolja, kjer argumentiranje poteka s pomočjo računalnika oz. medmrežja.

Namesto "gramatičnega" koncepta argumentacije, pri katerem je v ospredju zaporedna struktura argumentacije, ki ne omogoča obravnave argumentacije kot diskurzivnega pojava (ki se dogaja v specifičnem socialnem kontekstu) in prav tako ne omogoča obravnave obeh strani (proponenta in oponenta), se je poleg formalne dialektike, ki opisuje argumentiranje kot dialog, razvila pragma dialektika (van Eemeren & Grootendorst, 1999). Pragma dialektika je usmerjena v interakcije med obema stranema, pri tem pa so v ospredju predvsem pogoji za kritično diskusijo, manj pa pravila za generiranje razprave. V danes zelo aktualni dialoški teoriji (Walton, 2000) se argument obravnava kot "poteza" v dialogu, v katerem obe strani poskušata razmišljati skupaj. To pomeni, da udeleženci v tej obliki učenja niso osredotočeni na prepričevanje drug drugega. Namesto tega so vključeni v kooperativno raziskovanje dialoškega prostora in iskanje rešitev. Evalvacija argumentacije se presoja predvsem z vidika njene kolaborativne vrednosti ali kot prispevek k konverzaciji.

Viri

Koschmann, T. (1996). Paradigm shifts and instructional technology. V T. Koschmann (ur.), *CSCL: Theory and practice of an emerging paradigm.* Mahwah, NJ: Lawrence Erlbaum.

Lipponen, L., Hakkarainen, K. & Paavola, S. (2004). Practices and orientations of CSCL. V J.-W. Srijbos, P. Kirschner & R. Martens (ur.), *What do we know about CSCL: And implementing it in higher education*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Van Eemeren, F., Grootendorst, R. (1999). Developments in argumentation theory. V J. Andriesen & P. Coirier (ur.). *Foundations of argumentative text processing*. Amsterdam: Amsterdam University Press.

Walton, D. (2000). The place of dialogue theory in logic, computer science and communication studies. *Synthese*, 123.

DRUŽBENO PORAZDELJENA KOGNICIJA KOT RAZISKOVALNI IZZIV

Andrej Ule
Filozofska fakulteta
Univerza v Ljubljani
Aškerčeva 2, 1000 Ljubljana
Tel: +3861 2411104
Fax: +3861 2411495
andrej.ule@guest.arnes.si

Abstrakt:

Predstavljam glavna področja svojega raziskovanja v polju družbeno porazdeljene kognicije in dajem nekaj tez: 'Wittgensteinska' kritika tradicionalnih komputacijskih modelov kognicije, porazdeljeno znanje in drugi modeli kolektivnega znanja, razširitev pojma implicitnega/eksplicitnega znanja na kolektivno znanje (in verjetje), pridobivanje netrivialnega skupnega znanja v znanstveni kogniciji, porazdeljeno in skupno znanje kot konstitutivna dela kolektivne racionalnosti.

Ključne besede: porazdeljena kognicija, kolektivno znanje, skupno znanje, implicitno-eksplicitno znanje, racionalnost

V svojem raziskovanju kognitivnih procesov že dlje časa raziskujem družbene vidike kognicije in socialno epistemologijo. Predvsem me zanima preseganje monadičnega pristopa k raziskovanju kognicije, ki motri kognitivne pojave zgolj v "mejah" posameznika ali posameznega kognitivnega organizma in jih skuša razložiti z mehanizmi, algoritmi delovanja, komputacijami ali nevralnimi procesi, ki potekajo v njem. Pri tem se predpostavlja, da so ti procesi in algoritmi samozadostni in z njimi lahko razložimo vso ali vsaj večji del kognitivnih procesov pri človeku. Ta pristop se je izkazal za plodnega v začetku razvoja kognitivne znanosti, danes pa se kaže kot preozek. Na to kažejo tako kritike komputacijskega modela duha kot tudi alternative, ki se pojavljajo, kot so koncepti 'nesimbolne' in 'porazdeljene' (distribuirane) kognicije, socialno deljene kognicije in socialne epistemologije, timskega mišljenja (in odločanja), kolektivnega prepričanja in znanja, kolektivne intencionalnosti in to v navezi na nekatere že uveljavljene teoretične koncepte o družbeni naravi mišljenja, zavesti, učenja, sledenja pravilom idr.

Raziskovanje družbenih oblik in družbenih vidikov kognicije gre v mnogo smeri, mene pa zanimajo predvsem tiste teme, ki omogočajo epistemsko-epistemološko analizo "otelešene" (embodied) in "odružbene" (ensocialized) kognicije v in obratno, kognitivno modeliranje spoznavnega procesa ljudi, kot ta poteka v družbenem kontekstu ([1], [2], [3], [6], [20]). Na kratko predstavljam nekaj tem v mojem raziskovanju družbeno deljene in družbeno konstruirane kognicije. Predstavil jih bom v nekaj temah.:

1) *»wittgensteinska« kritika tradicionalnih komputacijskih ali paralelističnih modelov kognicije.*

Vodilni zagovorniki komputacijskih modelov duha po mojem mnenju niso resno vzeli Wittgensteinovih kritik "notranjih procesov" (in stanj) in dokaj pogosto zamenjujejo vprašanja "kako kaj deluje" (how it works) z vprašanjem "kaj to počne" (how it works), podobno zamenjujejo vzročno razlago z operacijami v simbolnem modelu oz. splošneje s sledenjem pravil ter podobno zamenjujejo ravnanje v skladu s pravilom s sledenjem pravilu. Predvsem pa je pomembno zamenjavanje notranjih komputacijskih (ali paralelističnih) procesov v možganih, ki morda pozvzročajo mentalna stanja z zunanjimi, socialno utemeljenimi vsakodnevnimi kriteriji prepoznavanja, klasifikacije in poznavanja vsebine mentalnih stanj ([12], [17], [21]).

2) *Porazdeljeno znanje in drugi modeli kolektivnega znanja.*

Ena osrednjih tem sodobnih kognitivističnih raziskovanj socialne kognicije predstavlja koncept in pojav družbeno porazdeljene kognicije.

Koncept porazdeljene kognicije je dobro predstavljen v Hutchinsovemu modelu: posameznik predstavlja družbo v malem, v lastni glavi (in telesu) preigrava družbo ([8]). Šele kot takšna družba v malem, ki že v sebi deluje vzporedno porazdeljeno, vstopa posameznik v komuniciranje in sodelovanje z drugimi osebami. O tem sem pisal že v lanskem referatu o alternativah monadičnemu konceptu kognicije ([19]). Porazdeljena kognicija je vsajena v mikro (omrežje komunikacije med nevroni v možganih posameznika) in makro komunikacijsko omrežje (komuniciranje med ljudmi kot tudi med ljudmi, računalniki in drugimi informacijskimi artefakti), tako da predstavlja celotno komuniciranje v neki skupini oseb omrežje omrežij. Ob tem različne osebe komunicirajo med seboj po različnih kanalih hkrati. Komuniciranje po posameznem kanalu povezuje posamezne kognitivne ali delovanjske podsisteme posameznikov. Kognitivni proces je porazdeljen na več načinov: med člani skupine, med notranjimi in zunanjimi strukturami, v članih skupine (notranje kognitivno omrežje nevralnih procesorjev) ter v času (prejšnji dogodki lahko spreminjajo kasnejše dogodke). Hutchins meni (v [8]), da je časovni vidik porazdeljene kognicije najpomembnejši za razvoj človekovih spoznavnih in miselnih zmožnosti, pa tudi za dinamiko skupinskega delovanja, mišljenja in odločanja.

Kognitivni vidiki družbenega delovanja se povezujejo z drugimi psihološkimi in socialnimi vidiki v kompleksne celote "porazdeljenih učinkov", tako nastajajo na primer kognitivno-emocionalni timi ali pa v kompleksne oblike povezav med ljudmi, računalniki in drugimi artefakti (gl. [13]). Pri tem se oblikujejo razni sistemi implicitnega in eksplicitnega znanja, tako v posameznikih kot v skupinah.

Zame še zlasti pomembno raziskovanje razmerij med implicitnimi in eksplicitnimi sestavinami kognicije, kjer pa manjka model kognicije, ki bi na formalni ravni lahko povezal razne oblike kognicij in znanja (implicitno in eksplicitno znanje, proceduralno in deklerativno znanje, poznavanje itd.) ([4]). Predpostavka, da je deklerativno (propozionalno) znanje tista oblika, na katero se lahko reducirajo vse druge oblike znanja, ne drži, a to ne pomeni, da med njimi ni globokih konceptualnih povezav, ki jih lahko tudi formalno predstavimo in morda formuliramo nekaj osnovnih algoritmov prehoda med njimi.

3) *razširitev konceptov implicitnega/ eksplicitnega znanja na skupinsko znanje (in prepričanja)*

Najpomembnejši je prehod iz porazdeljenih kognicij v eksplicitno skupno (common) prepričanje oz. znanje. Domnevam, da je za pridobivanje novega, netrivialnega skupnega znanja potrebnih nekaj nujnih pogojev: skupno znanje o obstoju zanesljive komunikacije med člani skupine, skupno znanje o medsebojno primerljivih načinih pridobivanja informacij o svetu zunaj skupine, skupno znanje o obstoju aktivnega jedra skupine, ki raziskuje svet ob pomoči navedenih načinov pridobivanja informacij o svetu ([15], [18]).

Implicitno znanje posameznika ali skupine razumem kot idealno celoto vseh logičnih posledic (implikacij) tistih situacij, ki so bile podlaga za nastanek danega znanja, eksplicitno znanje pa znanje, ki se ga epistemski agenti zavedajo ali ga prepoznavno artikulirajo v svojih mislih, jeziku ali delovanju. Razlika med implicitnim in eksplicitnim znanjem se torej ne ujema z razliko nezavedno-zavestno znanje, res pa, da je model zavestnega eksplicitnega znanja posameznika ali skupine naš spoznavni ideal, ki je le redko scela uresničen. Tu so možni razni odtenki eksplicitnosti, glede na to, ali zahtevamo, da se implicitno znanje artikulira pri vseh članih skupine, pri večini članov ali morda le pri ustreznih reprezentantih skupine (slednja opredelitev je primerna zlasti za organizirane skupine in institucije). Eksplicitnost in podobno implicitnost znanja torej nista absolutni, temveč stopenjski kvaliteti. ([14], [18]).

4) *pridobivanje netrivialnega skupnega znanja v znanstveni kogniciji*

Pri tem je potrebno razširiti pojem skupnega prepričanja in skupnega znanja iz območja razmeroma trivialnih aplikacij, npr. v teorijah iger na območje netrivialnega znanja, kot je znanstveno znanje. Znanstveno znanje sestoji iz razmeroma utečenega »paradigmatskega znanja« znanstvenih skupnostih in netrivialnega skupnega znanja. Paradigmatsko znanje je sicer formalno eksplicirano v temeljnih tekstih, učbenikih, poljudnih knjigah ipd., vendar se večina delujočih znanstvenikov le občasno eksplicitno nanaša na te sestavine v svojem delu, največkrat pa obstaja zgolj kot implicitno skupno znanje znanstvene skupnost ([9], [7]). Za doseganje netrivialnega skupnega znanja je potrebna zanesljiva komunikacija med člani skupine, skupni in medsebojno primerljivi načini raziskovanja in razlage ter obstoj aktivnega jedra skupin, ki vzporedno in v produktivni konkurenci raziskujejo določeno območje sveta ([5], [15], [18]). Pri tem je težava v tem, da v znanosti ni enoličnih razlik med racionalnim prepričanjem in znanjem, v glavnem se ta razlika kaže kot razlika med območjem hipotez, ki so še v postopkih testiranja in območjem trdno preverjenih dejstev ter znanstvenih zakonov, a to je relativna razlika, med drugim je odvisna tudi od časa in drugih okoliščin raziskovanja in od ti. vodilnih teoretskih in metodoloških paradigem posameznih strok ([11], [9]). Vendar domnevam, da lahko vsaj v okviru znanstvenih paradigem teorijsko in metodološko dobro urejenih znanosti razmeroma razlikujemo med kognicijami, ki so še bolj ali manj upravičena prepričanja in onimi, ki predstavljajo znanje. Ena od "vidnih" razlik med njimi je tudi v tem, da se prepričanja s širjenjem "obrabljajo" in izgubljajo na veljavi, (znanstveno) znanje pa se s širjenjem poglablja. Druga pomembna razlika je, da se znanstvena znanja kljub morebitnim razlikam v formulaciji in poudarkih medsebojno povezujejo in gradijo drug na drugem, medtem ko v sferi prepričanj kljub navidezni trdnosti prihaja do konfliktov, ki na ravni prepričanj največkrat niso rešljiva. Te razlike se poznajo tudi v načinu porazdeljevaja kognitinvega dela med ljudmi (kot tudi med ljudmi in kognitivnimi artefakti) ([10]).

5) *Porazdeljeno in skupno znanje kot sestavina kolektivne racionalnosti.*

Pojem skupnega znanja dopušča zanimivo razširiitev na *univerzalno skupno znanje* (krajše "univerzalno znanje") ([18]). To je hipotetično (in idealizirano) skupno znanje vseh oseb, ki lahko razpolagajo s potrebnimi informacijami, bazičnim znanjem in kognitivnimi sposobnostmi za to, da lahko razumno presodijo, ali dani podatki, ugotovitve in trditve predstavljajo dejansko znanje. Vsaj za del sodobnega znanstvenega znanja lahko domnevamo, da predstavlja tudi univerzalno znanje. Univerzalno znanje je idealizacija aktualnega skupnega znanja, kadar to predstavlja implicitno normo racionalnosti. Če namreč člani kake skupine verjamejo, da kako njihovo skupno prepričanje predstavlja univerzalno znanje, potem jim to prepričanje predstavlja tudi implicitno *pričakovanje o racionalnosti* vseh, ki bi sprejeli njihovo prepričanje na podlagi podanih razlogov. Tako se koncept skupnega znanja povezuje s pričakovanji o racionalnosti akterjev, kar predstavlja vzpodbudo za navezo med socialno epistemologijo in teorijo racionalnega delovanja ([16]).

V novejših teorijah kolektivne racionalnosti manjka razmislek o tem, kje je "mesto" implicitne kolektivne racionalnosti, ki se nam kaže vsaj v primerih uspešnih kolektivnih dejanj: ali med premisami presoje (praktičnega sklepanja), med implicitnimi predpostavkami celotne situacije, med skupno sprejetimi normami delovanja ali med še kaj manj opaznega. Zagovarjam misel, da se kolektivna racionalnost primerno umešča med neke vrste pravila sklepanja po shemah praktičnih sklepanj, torej sklepanj iz (individualnih ali kolektivnih) namer in znanja (ali prepričanj) posameznikov o tem, kako lahko uspešno uresničijo namere ([16]). Deluje kot inferencialno načelo, ki nam omogoča sklicevanje na namere, prepričanja in znanje kot razumne razloge individualnih ali skupinskih dejanj. Možno je oblikovati splošna načela racionalnosti, ki mejijo na, oz. prehajajo v etična načela, vendar pa ta načela praviloma nastopajo kot neke vrste implicitne intelektualne žariščne točke razsojanja in vrednotenja, ne pa kot eksplicitne zahteve ali norme. To po mojem mnenju priča o tem, da je kolektivna racionalnost (in prav tako kolektivna ne-racionalnost) prvenstveno sestavina družbeno porazdeljenega delovanja in družbeno porazdeljenih kognicij, ne pa zavestne refleksije posameznikov, njihovega načrtovanja in poskusov normiranja človeškega početja.

BIBLIOGRAFIJA:

[1] Clancey, W. (1997): *Situated Cognition: On Human Knowledge and Computer Representations*. Cambridge, MA: Cambridge University Press.

[2] Clark, A. (1997): *Being There: Putting Brain, Body and World Together Again*. Cambridge/MA: MIT Press.

[3] Conte, R., Castelfranchi, C. (1995): *Cognitive and Social Action*. London: UCL.

[4] Dienes, Z., Perner, J. (1999): A Theory of Implicit and Explicit Knowledge. *Behavioral and Brain Sciences*, 22: 735–808.

[5] Fagin, R., Halpern, J. Y., Moses, Yardi, M. Y. (1995): *Reasoning About Knowledge*, MIT Press, Cambridge/M.

[6] Freeman, W.J. (1995): *Societies of Brains: A Study in the Neuroscience of Love and Hate*. Hillsdale/NJ: Lawrence Erlbaum Associates.

[7] Giere, R. (12002): 'Scientific Cognition as Distributed Cognition,' in P. Carruthers, S. Stich, M. Segal (ur.), *The Cognitive Basis of Science*. Cambridge: Cambridge Univ. Press: 285-299.

[8] Hutchins, E. (1995): *Cognition in the Wild*. Cambridge/M: MIT Press

[9] Kuhn, T. (1970): *The Structure of Scientific Revoluttions. The Univ. of Chicago Press, Chicago.*

[10]Norman, D. A. (1993): *Things that Make Us Smart*. Addison-Welay, Reading/MA.

[11]Popper, K. (1967): *The Logic of Scientific Knowledge*. London: Hutchinson

[12] Proudfoot, D., Copeland, B. J. (2004): ‘Turing, Wittgenstein and the Sciences of the Mind. A critical Notice of Justin Leiber “An Invitation to Cognitive Science”,’ *Australasian Journal of Philosophy*, vol. 74, p. 497-519.

[13]Resnick, L. B., Levine, J. M., Teasley, S. D. (ur.) (1993). *Perspectives on Socially Shared Cognition*. Washington, DC: American Psychological Association.

[14]Ule, A. (1998): Awareness as a Logical Operator. V: Detela, A., Kordeš, U., Ule, A. (ur.), IS'98. *Kognitivna znanost : zbornik konference : Proceedings of the Conference*. IJS, Ljubljana, str. 33-35.

[15] Ule, A. (2002): Common Knowledge in Science. V: Meggle, G. (ur.): *Social Facts and CollectiveIintentionality*, (Deutsche Bibliothek der Wissenschaften, Bd. 1). : Hänsel-Hohenhausen, Frankfurt /M, str. 437-457.

[16]Ule, A. (2003): Kako doseči zaupanje in kooperacijo? *Dialogi* (Maribor), št. 9: 65-80.

[17] Ule, A. (2005): 'How Can One Catch a Thought-Birs? Some Wittgensteinian Comments to Computational Modeling pf Mind.' *Synthesis Philosophica*. Vol. 20, št. 2, Zagreb: 373-388.

[18]Ule, A. (2006a): *Znanost, družba in vrednote*. Aristej, Maribor.

[19]Ule, A. (2006b): 'Alternativa »monadični« paradigmi kognicije: koncept socialno porazdeljene kognicije.' *Proceedings of the 9th International Multi-Conference Information Society IS' 2006*, IJS, Ljubljana.

[20] Varela, F., Thompson, E., Rosch, E. (1991): *The Embodied Mind*. Cambridge/MA: MIT Press.

[21]Williams, M. (1999): *Wittgenstein, Mind, and Meaning: Toward a Social Conception of Mind. London*: Routledge.

Indeks avtorjev / Author index

Conference / Konferenca

Edited by / Uredili

Intelligent systems
Inteligentni sistemi

Marko Bohanec, Matjaž Gams

Education in Information Society
Vzgoja in izobraževanje v informacijski družbi

Vladislav Rajkovič, Tanja Urbančič, Mojca Bernik

Data Mining and Data Warehouses (SiKDD 2007)
Izkopavanje znanja in podatkovna skladišča

Dunja Mladenić, Marko Grobelnik

Collaboration, Software and Services in Information Society
Sodelovanje, programi in storitve v informacijski družbi

Marjan Heričko

Cognitive Sciences
Kognitivne znanosti

Urban Kordeš, Matjaž Gams, Olga Markič