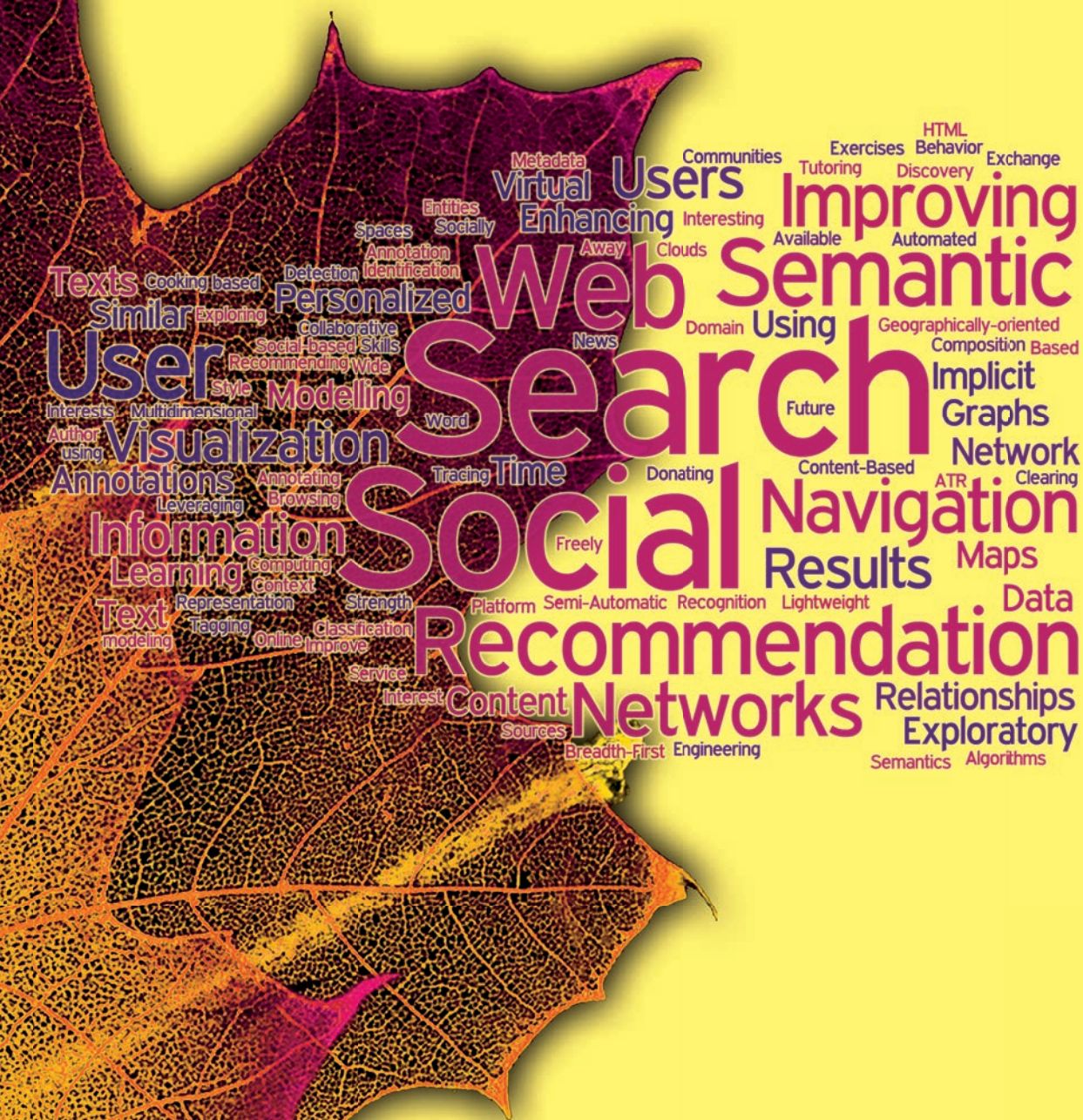
Personalized Web – Science, Technologies and Engineering

19th Spring 2016 PeWe Ontožúr,
Marianka, Slovakia, April 2016
Proceedings

**Mária Bieliková, Pavol Návrat,
Michal Barla, Michal Kompan, Jakub Šimko,
Marián Šimko, Jozef Tvarožek (Eds.)**



Proceedings in
Informatics and Information Technologies

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19th Spring 2016 PeWe Workshop

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Slovakia Chapter

PeWe Group

SLOVAK UNIVERSITY OF
TECHNOLOGY IN BRATISLAVA
FACULTY OF INFORMATICS
AND INFORMATION TECHNOLOGIES

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Informatics and Information Technologies

Personalized Web – Science, Technologies and Engineering
19th Spring 2016 PeWe Workshop

Editors

Mária Bieliková, Pavol Návrat,
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Marián Šimko, Jozef Tvarožek

Institute of Informatics, Information Systems and Software Engineering
Faculty of Informatics and Information Technologies
Slovak University of Technology in Bratislava
Ilkovičova 2, 842 16 Bratislava, Slovakia

Production of this publication was partially supported by

- the Gratex IT Institute, within the framework of GraFIIT Foundation (www.gratex.com)
- the Ministry of Education, Science, Research and Sport of the Slovak Republic within the Research and Development Operational Programme for the project "University Science Park of STU Bratislava", ITMS 26240220084, co-funded by the European Regional Development Fund
- the Scientific Grant Agency of Slovak Republic, grants No. VG 1/0752/14, VG 1/0646/15
- the Cultural and Educational Grant Agency of Slovak Republic, grant No. 009STU-4/2014.

Visit PeWe (Personalized Web Group) on the Web: pewe.sk

Cover Designer: Peter Kaminský

Published by:
Vydavateľstvo STU
Vazovova 5, Bratislava, Slovakia

ISBN 978-80-227-4546-8

Preface

The Web influences our lives for more than 25 years now. During these years, it has continuously been enjoying a growing popularity due to, among other things, its progressive change from passive data storage and presentation vehicle to the infrastructure for software applications and to the place for communication, interaction, discussions and generally collaboration. As the Web has an influence on our work, entertainment, friendships, it attracts more and more researchers who are interested in various aspects of the Web, seeing it from various perspectives – as a science, a place for inventing various technologies or engineering the whole process.

Research in the field of the Web has more than 15 years of tradition at the Institute of Informatics, Information Systems and Software Engineering, Slovak University of Technology in Bratislava. Topics related to the Web each year attract many students, which results to a number of interesting results achieved by enthusiastic and motivated students.

This volume is entirely devoted to students and their research. It contains short papers on students' research projects presented at the 19th PeWe (Personalized Web Group) Workshop on the Personalized Web, held on April 2, 2016 in Marianka (https://www.pewe.sk/spring-201516-april-2-2016/). All papers were reviewed by the editors of these proceedings. The workshop was organized by the Slovak University of Technology (and, in particular, its Faculty of Informatics and Information Technologies, Institute of Informatics, Information Systems and Software Engineering) in Bratislava as a part of several research projects mentioned in the proceedings. Participants were students of all three levels of the study – bachelor (Bc.), master (Ing.) or doctoral (PhD.), and their supervisors.

We organize PeWe workshop twice per year. Last academic year we started to invite our former PeWe members to give a keynote. Consequently, this volume starts with three keynotes. First two were presented by Marek Čatloš and Marian Hönsch in autumn 2015 PeWe workshop, which was held on December 2, 2015 in Marianka (https://www.pewe.sk/ autumn-201516-december-5-2015/). Marek's presentation was about the presentation itself. He showed a way how to prevent the statistics that nearly 90% of everything that have been presented is forgotten. He showed a presentation software called creedo, which supports the speaker to explain the content such that a listener understands it in a way that the attention of the audience is not lost and most of it can be remembered. As we all present quite often the keynote evoked life discussion.

Marian Hönsch presented a real cases towards the Internet of Things as approached by EnOcean. They create a scalable model, where the app developers can focus on the added value offered by their user interface and can control every connected device and device manufactures can focus on providing unique devices and

can rely on the scalable model to seamlessly integrate their devices into all existing applications. Workshop participants have seen real "Things" and could experience how such network can work in real environment.

Third keynote was presented by Richard Veselý and Oto Vozár in spring 2016 PeWe workshop. They discussed interesting topic of process mining. Monitoring, discovering and improving real processes by extracting knowledge from event logs available in an information system was showed on real system they developed and use in the production.

The workshop covered several broader topics related to the Web. We organized the proceedings according PeWe research subroups, which were established in beginning 2015 considering research topics and research projects we are involved in:

- Data Analysis, Mining and Machine Learning (PeWe.Data),
- Recommenders (PeWe.Rec),
- Semantics Acquisition and Domain Modeling (PeWe.DM),
- Text Processing and Search (PeWe.Text),
- User Experience and Implicit Feedback (PeWe.UX).

The progress of particular projects was at different levels mainly according to the study level (bachelor, master or doctoral) and the progress stage achieved in each particular project. Moreover, we invited to take part also four of our bachelor students who take an advantage of our research track offered within study programme Informatics – *Michal Hucko, Michal Kováčik, Branislav Pecher*, and *Andrej Vitek.* They were just about to start their bachelor projects. Michal Hucko is interested in analysis of user interaction with educational tool ASQ for live interactive presentations. The aim is to support teachers in real time analysis of students' responses. Andrej deals with automated generation of educational content, exercises and support for students for selected domain. Finally, Michal Kováčik and Branislav are about to start Imagine Cup project in either World Citizenship or Innovation categories.

Bachelor projects:

- *Veronika Balážová:* Usability Testing of Navigation on a Bank Website
- *Zuzana Beníčková:* Measuring Working Memory Capacity through the Use of Game Pexeso
- *Patrik Berger:* Mind-controlled Application
- *Matej Červenka:* Pupil Dilatation and Stress in User Studies
- *Ondrej Čičkán:* Automatic Text-checking for Slovak Language
- *Mária Dragúňová:* Evaluation of User Experience by Eye Tracking and Emotions Analysis
- *Veronika Gondová:* Support of Student's Activity in an e-Learning System
- *Mário Hunka:* Analysis of User Web Activities
- *Miroslav Hurajt:* Gaze-tracking Programmers' Activities in Web Browser: Revisitation and More
- *Patrik Januška:* Search Query Expansion based on User's Intent Derived from Eye Tracking
- *Tomáš Juhaniak:* Robust Detection of User's Cognitive Load Using Personalized Pupillary Response Model

- *Michal Kren:* Assignment of Educational Badges in CQA System Askalot
- *Rastislav Krchňavý:* Sentiment Analysis of Social Network Posts in Slovak
- *Ľudovít Labaj:* Machine Learning – a System for Automatic Creation and Testing of Derived Features
- *Martin Měkota:* Source Code Search Acknowledging Reputation of Developers
- *Martin Mokrý:* Sound Classification based on Feature Extraction
- *Martin Olejár:* Software Modelling Support for Small Teams
- *Adam Rafajdus:* Keyword Extraction in Slovak
- *Michal Randák:* Universal Tool to Assign Badges in Online Communities
- *Martina Redajová:* Universal Tool to Assign Badges in Online Communities
- *Metod Rybár:* Explicit User Input Quality Determination Based on Implicit User Input
- *Matúš Salát:* Personal Computer Assistant for Supporting University Study
- *Peter Uherek:* Application of Machine Learning for Sequential Data

Master junior projects:

- *Martin Borák:* Detection of Anti-social Behaviour in Online Communities
- *Matúš Cimerman:* Stream Analysis of Incoming Events Using Different Data Analysis Methods
- *Ondrej Čerman:* Personalized Recommendation of TV Program
- *Peter Dubec:* Towards Automating Analysis of Eye Tracking User Studies
- *Adrián Huňa:* Supporting Online Student Communities by Utilization of Questions and Answers Archives
- *Tomáš Chovaňák:* Recognition of Web user's Behavioural Patterns
- *Lenka Kutlíková:* Automatic Evaluating Usability of Applications with Eye-tracking Technique
- *Jakub Mačina:* Recommendation of New Questions in Online Student Communities
- *Jakub Benjamín Vrba:* Automatic Segmentation of a Screen Recording for Scene Identification

Master senior projects:

- *Peter Gašpar:* Linking Multimedia to Microblogs for Metadata Extraction
- *Peter Kiš:* Learning by Playing: Generated Programming Exercises to Teach Programming the Innovative Way
- *Matej Kloska:* Support for Domain Model Authoring
- *Viktória Lovasová:* Recommendation of Solved Questions from Archives in CQA Systems
- *Tomáš Matlovič:* Emotion Detection using EPOC EEG Device
- *Jakub Ondik:* Software Modelling Support for Small Teams
- *Matúš Pikuliak:* Relationship Extraction using Word Embeddings
- *Martin Svrček:* Presentation of Personalized Recommendation via Web
- *Jakub Ševcech:* Stream Data Processing
- *Martin Štrbák:* Analysis of Reading Difficulty in Web Environment
- *Peter Truchan:* Prediction of User Behavior in a Web Application of the Bank

Doctoral projects:

- *Patrik Hlaváč:* Impact of Characteristics of Individuals on Evaluating the Quantitative Studies
- *Michal Holub:* Identification of Similar Entities in the Web of Data
- *Ondrej Kaššák:* User Model Specialized for Session Exit Intent Prediction Task
- *Eduard Kuric:* Automatic Estimation of Software Developer's Expertise
- *Vladimír Ľalík:* Evaluating the Usability of Applications Using Gaze Tracking
- *Róbert Móro:* Navigation Leads for Exploratory Search and Navigation in Digital Libraries
- *Marek Roštár:* Similarities in Source Code
- *Ivan Srba:* The Next Step of CQA Systems' Utilization in Educational Domain: MOOCs

Considerable part of our research meeting this year was devoted to the experimentation session. Experimental evaluation represents one of the most important phases of our research projects as it confirms (or sometimes also rejects) the proposed methods or solutions. Encouraged by the enthusiasm, results and positive feedback from experimenters during the experimentation sessions at the Spring 2013, 2014 and 2015 PeWe workshops, we decided to continue in this tradition. The members of PeWe group helped their peers by providing not only constructive criticism and advice for experiment design; they also actively participated on the announced experiments. Conducting experiments even in our small group is always useful, in particular for initial evaluation, to verify preconditions of proposed methods, or locate errors in the design that helps in the end to achieve better results. The experimentation session consisted of six experiments that together resulted in hours of active participation of many workshop attendees. The experiments were very diverse and some of them even utilize the state-of-the-art devices for UX studies (e.g. eyetrackers or devices for measuring EEG signal). In particular, participants during the experimental session measured their working memory, cognitive load while solving math tasks or even EEG signal while watching short music videos. Other participants created a domain model of mammals, were looking for the worst comment evaluated by a service for low-quality content detection or test usability of different web interfaces. The session lasted for several hours and officially ended at 1 a.m.

Our workshop hosted for the 14th time recessive activity organized by the *SeBe (Semantic Beer) initiative* chaired by Marián Šimko, Róbert Móro, Jakub Šimko, and Michal Barla. It was aimed this year at educational activities supported by Academia SeBeana. The academy aims at spreading knowledge about such noble topics as Beer Driven Research (BDR) or Game with a Beer (GWAB). This year, in addition to bachelor degree (programmes *Beerformatics*, *Tapping systems and piping networks*) and master degree (programmes *Beergeneering*, *Hop systems*, *Tapping systems and piping networks*), Academia SeBeana continued in doctoral studies in the programme *Bottling systems*. The following research topics were offered: Beersourcing: a Phenomenon of Global Bottle Collecting (supervisor: Prof. Jakub Šimko) and Impact of Human-Beer Interfaces on Beer Savouring Experience (supervisor: Prof. Róbert Móro).

More information on the PeWe workshop activities including presentations is available in the PeWe group web site at pewe.sk. Photo documentation is available at mariabielik.zenfolio.com/ontozur2016-04.

PeWe workshop was the result of considerable effort by our students. It is our pleasure to express our thanks to the *students* – authors of the abstracts and main actors in the workshop show for contributing interesting and inspiring research ideas. Special thanks go to Katka Mršková and Zuzana Kozíková for their effective organizational support of the workshop.

April 2016

Mária Bieliková, Pavol Návrat,
Michal Barla, Michal Kompan, Jakub Šimko,
Marián Šimko, Jozef Tvarožek

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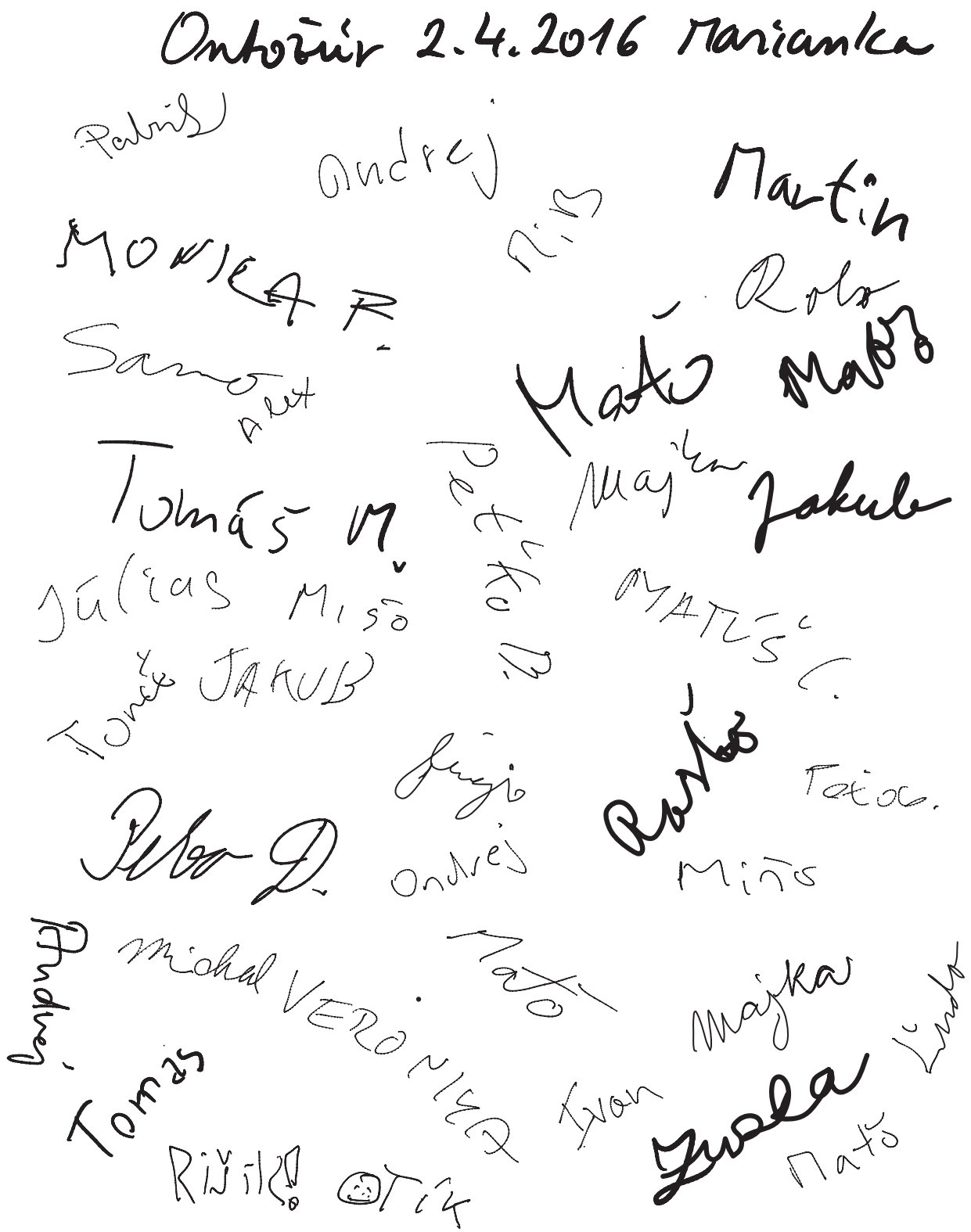

Spring 2016 PeWe Ontožúr Participants

Keynotes

Presentation that Sells

Marek ČATLOŠ[1]

Slovak University of Technology in Bratislava
Faculty if Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia

Nearly 90% of everything that have been presented is forgotten. Why is it so? How to prevent this waste of time for presenter and audience?

During the past years we were focusing on the audience perception of the presentations, on the quality of the materials, quality of the speech and quality of the speakers. What I have seen very often is that on average conference there are only few (one or two) sessions that I have remembered (this might be true for any other people in audience).Let us dig deeper. What content of those one – two sessions have remained in my (average) memory? Is that the impression that the speaker was funny or clever? Or the technology he spoke about was the right one for me? Or just speakers funny gestures?

I believe that every presenter wants to achieve some kind of action as a reward to his energy that he spent by preparing and giving the presentation. Potential user in audience can decide for the proposed product or can chose the right technology in his company or just call the presenter to another conference. If the user should make the "right" decision or right action he must have it deep in his mind. However, the desired user's decision is the last successful step that might come after fulfilling important preconditions:

1. Relevant content. There must be content that is interesting for the audience
2. Explaining. User must understand the presentation
3. Attention. The speaker should not lose the attention of the audience
4. Remembering. To change user's decision user should not forget about what he have heard.

Our goal in the last three years was to analyse the audience perception of the presentations as well as presenters' habits and needs. We have created creedoo (creedoo.com) - presentation software that supports the speaker in the points above.

Relevant content is the basic precondition of every presenter. If there is no valuable content in presentation all other steps are obsolete. Guys Kawasaki simplifies it to "no content - shut up" [2]. In addition, the usual listener in audience forgets 90% of the average presentation [1]. Up to the speaker is to define the key message in his

[1] FIIT STUBA alumni

valuable content, his 10% that is worth to remember and then focus to those 10% during the presentation.

Explaining the content in the form that will be understood by the audience is the first step to memorable presentation. If audience does not understand they will not remember. People can either read or hear. It is hardly possible to multitask both of the activities. One way how to overcome reading from slides, is to avoid text and specially bullet points at all. Simple slides lead to attention to the speaker not to slides themselves.

Getting the attention is usually easy, but enjoying the attention through the whole presentation is more difficult. Every speaker should fight with the habituation process in our brains. Our mind works better if we receive combination of information that we already know with the information that are both new and unexpected. The other way what leads to memorable experiences is to hear stories. Since the beginning of the mankind people are fascinated with stories and information connected within the story remains deeper in the brain.

Remembering. Neurotransmitter Dopamine is in general connected with the rewards and expectation together with our memories and process of remembering. To offer reward, that is not precisely defined increases the expectations, thus generates more dopamine in our brain. Including the emotions into the experiences in combination with storytelling, rewards, associations and memory hooks supports the speaker's ideas, so the probability to remember more than 10 % of the presentation grows rapidly.

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EnOcean becoming Things

Marian HÖNSCH[1]

EnOcean GmbH
Kolpingring 18a, 82041 Oberhaching, Germany
marian.honsch@enocean.com

With the introduction of the Internet of Things (IoT) and the idea of automated nodes, the landscape of building and home automation is changing. Regardless the used technology, radio and manufacturer, the Things need to comply with common usability requirements to be accepted by the market and the end users. The EnOcean Alliance, a non-profit organisation and technical leader in wireless building automation with energy harvesting [1], has rich experience in incorporating devices from many manufacturers with different features and use cases into one interoperable, standard-based solution [2]. Now, the EnOcean Alliance[2] will also cope with the challenge to introduce energy harvesting Things to the Internet. Thus, interoperability is no longer considered as a feature of individual solutions but it becomes a brand philosophy.

The user gets access the IoT in building automation via an application available on his embedded device (e.g. smart phone). In addition, there are new major players on the market, such as "Homekit" by Apple or "AllJoyn" by the Allseen Alliance. Those act as game changers, transforming interoperable hubs into true interoperability by separating the Apps world from the Device world. See Figure 1.

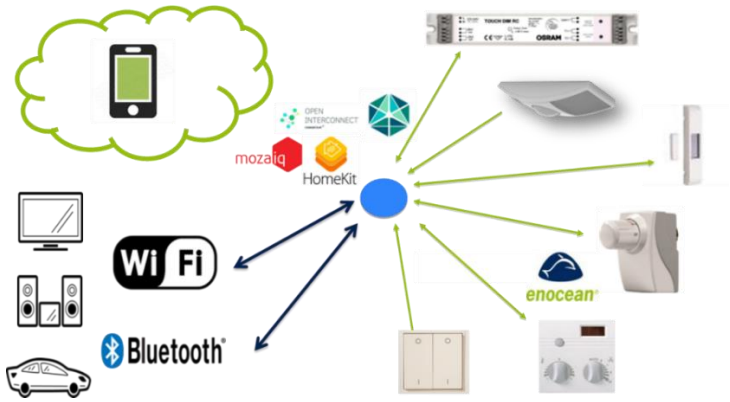

Figure 1. Internet of Things Concept.

[1] PeWe alumni
[2] EnOcean Alliance: www.enocean-alliance.org

They create a scalable model, where the:

- App developers can focus on the added value offered by their user interface and can control every connected device.
- Device manufactures can focus on providing unique devices and can rely on the scalable model to seamlessly integrate their devices intoall existing applications.

The core question of this paper is: “What are the necessary changes for the energy harvesting devices to become Things in the IoT and make the scalable model work?” Three key points must be considered:

1. *Moving from distributed logic to cloud-based logic*

   Every device participating in the IoT must provide transparent decision making and automatic function access. To create a seamless user interface, App developers need to know everything about the controlled device; therefore the device cannot hide functions or make decisions without proper reporting (e.g. once a decision is made to stop the heating, App developers must be aware of it and comprehend the decision).

2. *Specific end-application reference and description*

   Once a device is created, its communication profile and overall feature description must be recorded in an electronically standardized way (e.g. XML). The reference to the electronic datasheet is available in printed form on the device itself and on demand via the radio protocol.

3. *On demand localisation in the field and remote commissioning*

   The devices’ presence can be detected via radio communication, but their physical localisation in the field requires a dedicated process. This point is important during the device’s first installation and later for network configuration changes (e.g. distinguish five identical light controllers by making them blink individually).

By following the above design rules, we believe a scalable model is possible, where App developers can perfectly design user interfaces for all connected devices from multiple vendors, using different radio technologies.

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Process Discovery and Optimization with Process Mining

Richard VESELÝ, Oto VOZÁR[1]

Softea, s. r. o.
Furdekova 16, 851 04 Bratislava, Slovakia
richard.vesely@softea.sk

Most information systems collect, process and store increasingly larger amounts of data. Beyond primary line of business, significant proportion of stored records is made of chronological log entries of various user activities or other notable events. This data collection is motivated by the ability to diagnose malfunctions or investigate security incidents. Recently, however, new business intelligence technique called process mining [1] emerged, which makes data collection all the more useful.

Process mining is a relatively young research discipline that sits between computational intelligence and data mining on the one hand, and process modeling and analysis on the other hand. The idea of process mining is to discover, monitor and improve real processes (i.e., not assumed processes) by extracting knowledge from event logs readily available in today's (information) systems. Process mining includes (automated) process discovery (i.e., extracting process models from an event log), conformance checking (i.e., monitoring deviations by comparing model and log), social network/ organizational mining, automated construction of simulation models, model extension, model repair, case prediction, and history-based recommendations [2].

Process mining inputs consist of single or multiple information system logs, which are process-related, such as domain-specific information system and the associated CRM, order, time and attendance, reservation, accounting or other systems. Collected data can be in various data formats like database tables, XML, CSV or JSON files or sometimes even in custom proprietary formats which necessitates a preparation phase involving cleansing and wrangling of data to eliminate errors or merge multiple representations of the same identity to avoid unintended duplicates. It is also desirable to store resulting data more efficiently to improve subsequent processing performance.

Prerequisite for mining is a semantic annotation of attributes which determines how mining algorithm accesses the underlying process data. Most essential attributes are:

- Case identifier: groups process events into individual process cases in terms of a particular business domain such as eshop orders, package identifiers in logistic systems, loan request identifiers in banking systems, etc.

[1] PeWe alumni

- Activity (what): identifies a business activity, e.g. sent order or invoice payment.
- Timestamp (when): most usually represents start of event, but can also denote the end or event duration, which enables more accurate identification of process parallelisms.
- Resource (who): represents a user, role or agency which is responsible for or associated with an event activity often supported by other attributes enabling detailed analysis of qualitative and quantitative process characteristics like process (in)efficiencies.

Annotation is followed by the process mining itself which produces a map based on the selected process attribute, typically activity for process map (figure 1) or resource for social map.

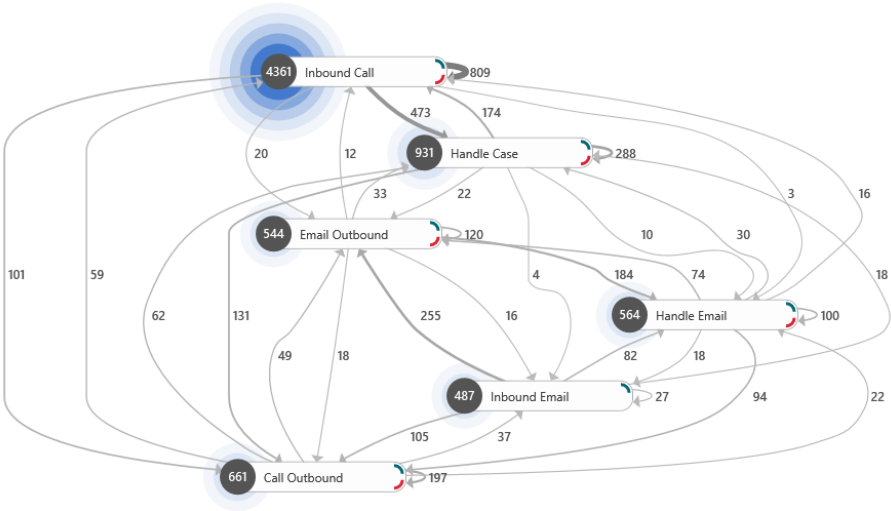

Figure 1. Process map produced by the Minit process mining tool.

Process map is a directed graph with event attributes (e.g. activity) represented by vertices and event transitions represented by edges. Figures on the edges and vertices denote a frequency of occurrence. Most process mining tools support various filters and settings to further refine the map to show the least or the most frequent process cases, also called the process backbone.

Resulting process represented by process map is then used for further analysis driven by perceived lack of process efficiency in terms of time, financial costs or conformance with existing process model.

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Data Analysis, Mining and Machine Learning (PeWe.Data)

Detection of Anti-social Behaviour in Online Communities

Martin BORÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xborakm@stuba.sk

During the past decade, the Web has changed dramatically. It is no longer just about finding information or private and work related communication. Online communities have been gaining on importance and popularity in places like social networks, CQA (Community Question Answering) systems, online games and news and entertainment portals. Immediate communication with an unlimited number of users on a variety of topics has become part of everyday life for hundreds of millions of people worldwide.

Due to the high number of members of these communities, the content of such communications is rather diverse. From sophisticated, evidence-based arguments on serious political issues in discussion sections of news portals, to informal discussions that are often useless, in comments below YouTube videos. However, there are people everywhere, who try to undermine the course of these communications at any cost. Whether it is by writing meaningless messages, share links to pages that have nothing to do with the discussed topic or unnecessary sarcasm, direct aggressiveness and harsh verbal attacks. Such behaviour is most widespread in sites, where users have the opportunity to act anonymously (YouTube, forums, etc.), but it has recently spread to systems where the contribution is associated with the real name of the author, possibly even a photograph and other personal information (e.g. Facebook). That causes content with higher quality to be surrounded by low quality content and thus makes it less likely to be read by other users. Sites often set policy against such content, since they have a legal responsibility for all content that can be viewed on their pages.

In our work we focus on a very frequent type of anti-social behaviour called "trolling". Trolling has various definitions. Trolls are people who participate in negatively marked online behaviour. They are also referred to as creatures who take pleasure in annoying other people and cause them anger and suffering [1]. They often initially pretend to be regular members of community, but later they try to disrupt it. The identification of trolls is a challenging task because many posts made by users who have

* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

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less experience in online communication, or those possibly suffering from mental illness, show signs of troll posts, but without any intention to harm anyone [2].

A few dedicated researchers have already made contributions towards automated detection of anti-social behaviour in the past. Dinakar et al. [3] attempted to detect anti-social behaviour in YouTube comments. Specifically, they focused on comments with offensive or humiliating nature. For classification of such comments they used analysis of textual features and SVM (Support Vector Machines) algorithm. Dadvar et al. [4] focused on a similar thing over a similar dataset from YouTube, but for detection they also used users' history (e.g. previous comments, reputation), what helped them in achieving better results. That gives us a perspective of improving their work even more, if we were able to find other significant features. We have already contacted the authors of both articles, in order to obtain their datasets that we would use in our work.

Our goal is to be able to detect the content created by trolls. Text analysis is not sufficient for us, since trolls are known to often use sarcasm and act like ordinary users in order to provoke discussion, but simultaneously they try to cause conflicts. Therefore, in our work we also want to use sentiment analysis, user history and the analysis of community response. Based on these features and by using an appropriate machine learning algorithm, a model will be developed, which will be able to detect posts created by trolls. We believe that the result of our work has great potential to be useful for sites with user generated content, which could facilitate the work of moderators, who are currently responsible for filtering inappropriate content manually.

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Stream Analysis of Incoming Events Using Different Data Analysis Methods

Matúš CIMERMAN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xcimermanm@stuba.sk

Nowadays we often need to process and analyse massive amounts of data, popularly called Big Data. Big Data is often related to its three *V's*: *velocity, volume* and *variety* [1]. In last two decades there was a lot of research on parallel batch processing models and algorithms. This approach effectively deals with stationary massive data. When it comes streaming data, we need to think of stream as data evolving continuously and deal with all three characteristics of Big Data. Fourth, especially in streams, arrives as *variability of change* when our world changing rapidly in real time.

Lots of methods and research interests have been focused on knowledge discovery in stationary Big Data. We also name such methods *batch processing* suitable methods. However, today we are facing streaming data coming from different sources such as: *social media, sensors, network devices in large world networks* or *logging files.* Since these sources serving data in an unlimited manner and are potentially infinite, methods for batch processing often fail when it comes to stream processing [1].

In our work we focus on task *trend detection* in a data stream using different methods. We aim to make method *applicable* and *simple* to interpret for domain experts without having detail knowledge how model or used method works. When serving results and answers to domain expert, we focus to make visualization easy to interpret and understand.

Trend detection have concerned many analysts and mainly marketers to be able react and predict what is happening or will happen in future. Trends are typically driven by emerging events that attracts attention large fractions users [4]. Real-time trend detection is a crucial when we want to perform actions according to current trends fast. It makes sense detecting trends in real-time because its changes dynamically in time in natural manner.

* Supervisor: Jakub Ševcech, Institute of Informatics, Information Systems and Software Engineering

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Some methods specific for domain have been proposed and published for detecting trends, e.g. in social networks like Twitter. When detecting trend, we need take into account [2, 3]:

- *concept drift and change detection* as a process of identifying differences in the state of an object by observing it at different times. While in streaming context this presents process of segmenting data stream into different segments by identifying the points where stream dynamics change.
- *seasonal effects* can be short-term and long-term. Methods like *Holt-Winter* have been developed to deal with trend detection while consider seasonal component.
- *anomalies and spam* can be caused by data transmission errors or targeted violation, thus the these generally errors need to be identified because it can significantly affect data's value for real-time trend detection.
- *segmentation* and trend detection only for a chosen segment of users or categories.
- *forecasting and prediction* if there will be a trend or how will currently detected trend perform in future.

Our ultimate goal is to propose method which will provide semi-automatically selection of appropriate methods for trend detection in current domain. There are many techniques for detecting trends in batch manner. For example, methods like *Naive Bayes* or *decision trees* are not applicable as we know them in streaming data problems. We will try to appropriately alter selected well-known methods for streaming data problems. Core characteristic of such method are: *one-pass* on data, *real-time* answers and adjusting model, *horizontally scalable* and *in memory* to handle massive volume of data.

Finally, we propose to produce visualization for easy and fast understanding of detected trend. This visualization must be evaluated by user study for example using Eye-Tracking hardware. Evaluation of proposed method will be performed using synthetic dataset and source of real-time data.

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Recognition of Web user's Behavioural Patterns

Tomáš CHOVAŇÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xchovanak@stuba.sk

User's behavioural patterns represent typical repeating behaviour of website users. Identified behavioural patterns may be used to reveal bottleneck of website, to predict behaviour of many users or revealing their intentions. Existing approaches are mainly focused on finding global behaviour patterns for large groups of users.

Our work conforms to actual trend of Web personalization and focusation on needs of individual users. We don't search only for behaviour patterns common to wide community of website users, but also behaviour patterns common to smaller groups of users with similar interests and individual behaviour patterns of users differing from global behaviour patterns. In proposed method we examine influence of combined usage of these behaviour patterns on next user's action prediction.

Web logs can be considered as transactional datasets where each session represents transaction. Many methods of finding frequent sequence patterns and frequent itemsets were proposed. In our proposed method we focus on task of finding navigation patterns which are better suited for individual users. We transform web session logs dataset into undirected graph with nodes representing individual sites of website and inter-node links weight being specified by number of different attributes.

We extend method defined in [1]. Beyond time connectivity and frequencies of coocurence of pages in sessions we use contentual similarity inspired by [2] to affect inter-node weights. In first phase which is being executed offline, navigation patterns are extracted. We don't extract navigation patterns from one graph specified for all users, but first we use clustering to find groups of users with similar interests and belonging to same stereotypes. For each group individual graph is being built from input sessions of group member's. Meanwhile also global graph is being built from all input sessions. Lastly different sets of navigation patterns are created for each group of users by combining group graph and global graph with predefined weights and applying graph partitioning algorithm which removes links with weight under specified threshold. The

* Supervisor: Ondej Kaššák, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 7–8.

result is set of isolated subgraphs each representing one navigation pattern. We evaluate quality of these navigation patterns by using them to recommend items in second phase which is executed online. LCS (Least Common Subsequence) algorithm is used to classify actual session window with predefined size to one of the found navigation patterns for group actual user belongs to. Prediction list is generated by subtracting items in session window from navigation pattern. Furthermore this list is sorted by degree of connectivity of each item in prediction list.

Proposed model will be evaluated by standard metrics and compared with former WebPUM method and with baseline models using different well-known method for finding frequent itemsets from transaction like Apriori or FP-Growth.

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User Model Specialized for Session Exit Intent Prediction Task

Ondrej KAŠŠÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
ondrej.kassak@stuba.sk

Nowadays, there can be seen increasing number of web sites, with the dynamically created web pages, which are up to date only for short time periods after which they become uninteresting for users. While pages are active, their content is continuously updated.

When modelling user behaviour on these sites, the biggest challenge is to capture the user interests and be able to react to frequent changes. An example of such changes is the news domain, where it is typical that hundreds of pages are updated in every minute. This however opens questions as how to deal with dynamically changing user behaviour, how to model drift of his/her interests, its weakening, forgetting, etc.

The user behaviour on the web site is influenced by multiple noisy factors. User have some actual informational intent (e.g., learn some topic, read today news, find concrete information), external context conditions (e.g., time available, upcoming test, actual trendy topics) and personal characteristic (e.g., previous knowledge, preferences). Together, these factors form user short-term behaviour. It is, however, typically noisy and offer only limited possibilities for user modelling.

To be able to model user typical behaviour or preferences, it is needed to model his behaviour also for longer time period. This way it is possible to eliminate short-term noise and to mine user's long-term behaviour. Both of mentioned views on user behaviour, however, offer valuable information and together help to estimate user future behaviour.

The two level modelling variant is nowadays generally used [2] [3]. These authors identically divide used model into long- and short-term components. In addition, there exist more complex solutions. Zhou et al. added third level of medium-term preferences [4], which is used to soften the transition between long- and short term components.

Mentioned approaches model user actions based on a time window [2] or a forgetting curve approach [1]. The time window consider actions based only on time in

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 9–10.

which they were performed, which despite of its simplicity, reaches quite satisfying results [2]. The forgetting curve typically considers multiple behaviour aspects as a time spend on pages, measure of scrolling, clicking etc, which are based on time considered with decreasing importance.

As we mentioned, the common part of the user preferences modelling on the dynamic web sites is the division on multiple time levels. Approaches, however, differ in the attributes, which are actually modelled. The selection depends on the task, the model will be used for. In case of personalized recommendation, there are modelled user preferences in topics or concepts, there is watched similarity between user preferences or between items content. In case of customer loss task or learning course fail, there is watched intensity and regularity of user visits, fulfilment of his tasks, etc. Based on this, we can conclude that a user model has to be specialized for the task it will be used for.

In our actual research, we focus on the task of prediction of the user's exit intent from sessions. To be able to predict in advance that user has intent to leave from the session and leave the web site in next action or actions, it is needed to be able to model his preferences, typical behaviour etc.

Our idea is to enrich user actions by information about actual user session (short-term behaviour) and its comparison with previous user sessions (long-term behaviour). We propose multilayer user model describing user actual behaviour in comparison with his previous behaviour performed for several different time periods (e.g., day, week, month). This way we will be able to predict user future behaviour (concretely exit intent) and also dynamically react to changes and drifts in user's behaviour.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Assignment of Educational Badges in CQA System Askalot

Michal KREN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
kren13@fiit.stuba.sk

One of the most used platforms for sharing knowledge and information are Community Question Answering systems (CQA), such as Yahoo Answers or Stack Overflow. Unlike search engines, CQA systems are highly dependent on constant activity of their user base to be effective. Intensive research is being made in addressing the problem of maintaining user activity in online communities. One promising approach to solve the problem of user engagement is gamification. Huotari and Hamari [1] defined gamification as a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation. These affordances include mainly badges, points, leaderboards etc.

In our work, we focus on badges and their effect on user's motivation in online communities and learning environment. Badges are one of the most popular forms of gamification used in online communities, affecting mainly the user's extrinsic motivation. They serve as a summarization of one's achievements, skills and effort [2]. Unlike points and leaderboards, which tend to compare users' progress to one another, badges do not give rise to competitiveness among users. This is crucial especially in educational domain, because extreme external influence, such as a competition, may harm student's intrinsic motivation, what can finally result into a negative impact on the process of learning.

The main goal of our work is to propose new types of badges utilizing the characteristics of educational domain and implement them in CQA system Askalot. Askalot is an educational and organizational CQA system [3] and unlike Stack Overflow, it is not open to general public. This means that its user base is considerably smaller and thus increasing the overall user activity is essential to fully utilize all of Askalot's potential. Considering the specifics of educational domain, we added three novel attributes to the design of regular badges:

* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 11–12.

1. *Topic scope.* Different courses and subjects have different requirements on students and we want to give teachers the ability to design badges accordingly.
2. *Time scope.* User's progress with these kinds of badges is reset after each interval, meaning these badges can be earned multiple times. We focus mainly on badges awarded on a weekly basis, to reflect the term which is divided into 12 weeks.
3. *User limitation.* Badges can be awarded only to a limited number of users based on how many activities of a certain condition they have carried out. To earn this badge it is not enough to fulfill all the conditions, but to fulfill them better than others.

Each badge belongs to a specific badge collection, which groups badges of a similar context, i.e. "Database Systems Contributor". Badges within a collection have different ranks which indicate the difficulty of earning the badge. Each badge has one or more conditions, consisting of a topic tag, activity and a threshold.

To test the success of our novel badges, we work with a teacher of Database Systems in order to perform a live uncontrolled experiment. Over the course of several weeks, we collect data about student activity in Askalot. We compare the overall activity in Database Systems before and after we implemented our badges and also with data from previous terms to determine the effects our badges on students' engagement and whether the effects were positive.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Source Code Search Acknowledging Reputation of Developers

Martin MĚKOTA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
martin.mekota@gmail.com

Newcomers in big software development teams can be assigned to work on a difficult tasks right from the start. From a new member's perspective finding the right person to get an advice from may prove to be both time consuming and challenging since they might not be acquainted with other team members.

A prerequisite of an effective communication is the ability to identify a colleague to communicate with. The research of this area has helped to clarify, how much time do the developers spend communicating with colleagues. It is estimated that developers spend about 16% of their work time communicating. At the beginning of a software project this number rises to 50% [1].

Another study identified the key factors which people take into consideration when they are asking for help. People are afraid that they will look incompetent when they ask for help. They prefer private conversation when asking for help. They also want to spend as little time as possible looking for a person who can help them. In another words, they want to ask the right person on the first try. The last point will be focus of our work [2].

In our work we are attempting to solve this problem by gathering and analyzing information from version control and issue tracking systems and presenting reputable experts. However, we do not want to force developers to do any additional work like filling questionnaire or rating like in other similar work [3]. We want to assess their reputation and expertize by analyzing data which they produce in their current workflow. The end result of my thesis will recommend these experts in certain parts of the source code therefore new members will spend less time find them and more time discussing the problem. The reputation of the experts will be based on their activity in the issue tracking system and in version control system where code reviews take place.

At the first we used open source code repositories of Eclipse foundation to collect data about the developers. We used Node.js based web scraper to scrape relevant information from all the commits pushed to the repository since the project's beginning.

* Supervisor: Eduard Kuric, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 13–14.

The main information we are interested in is who made the commit, which files does the commit contain and link to the Gerrit Code Review. We will use all of these data to assess the reputation of a developer as well as show his activity in the project. From the Gerrit Code Review, we can extract information about, who was the code reviewer, what rating did he give to a change request and how many patches needed to be submitted to accept the change. From the data from the Gerrit Code Review tool, we will try to access reputation of members of the team. All of these data is produced by developers in their day to day work, no extra effort on the developers' part is required. This is the key idea behind our work.

To present the information from analysing the data we will implement a plugin to the Eclipse IDE showing our results. A person will be able to search the source files using Hound source code search engine. The results of a Hound search will be display in the plugin in addition to the information about who has been making changes to individual file and their reputation.

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Sound Classification based on Feature Extraction

Martin MOKRÝ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xmokry@fiit.stuba.sk

Voice control of a computer is relatively new concept. It is no surprise, that it is becoming very popular, considering the fact, that it is the most comfortable and effective way of communication between people. It has become a subject of study for many researchers in past years. However real life applications use mostly words, which are quite long voice commands and executing more commands in a row can feel tedious.

Our work focus on application control by short articulate (e.g. syllable) and inarticulate (e.g. clap, whistle) sounds. This makes application control more effective, although not very intuitive at start.

Real life application usage creates problems, we need to be prepared to deal with. The most significant ones are [1]: environment noises (e.g. people talking in the background) and different speakers (e.g. dependence on gender or age). Because of these problems, the proposed approach needs a data representation, which has low sensitivity to noise and allows slight variations between the tested sequence and the template. That is why, we decided to find similarities between sounds through sound features, which have been proven to perform well in a noisy environment and also have small memory requirements [2].

Features extracted from the recorded sound during test phase need to be classified in real-time in order to ensure quick response. For this purpose we chose to test two classifiers: Naive Bayes, k-Nearest Neighbors.

We believe that high accuracy of real time classification of articulate and inarticulate sounds can be achieved by following these steps:

1. Segmentation - division into the windows of the same length.
2. Feature extraction - calculation of characteristic values of sound for each window.
3. Feature normalization - transformation of real values into intervals and normalization using z-score.

* Supervisor: Jakub Ševcech, Institute of Informatics, Information Systems and Software Engineering

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4. Classification - class determination for every window, followed by labeling of the whole sound by class name.

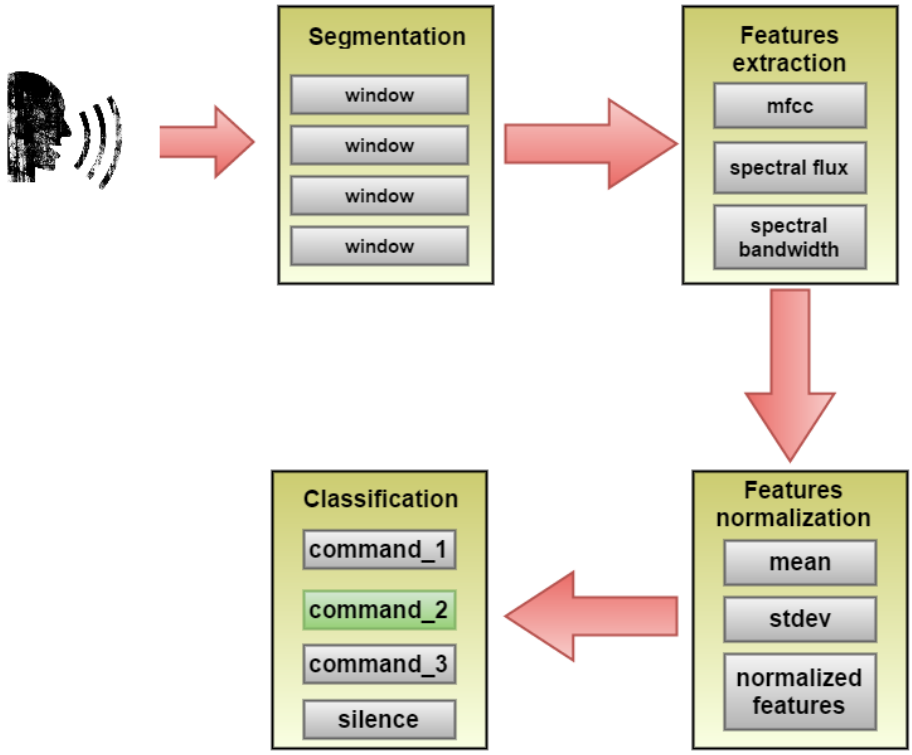

Figure 1. Illustration of steps of proposed method.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement: This contribution was created with kind support of ČSOB Foundation and is partial result of the project University Science Park of STU Bratislava, ITMS 26240220084, co-funded by the ERDF.

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Machine Learning – a System for Automatic Creation and Testing of Derived Features

Ludovít LABAJ[1*]

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xlabajl1@stuba.sk

Creating programs using machine learning is nowadays becoming more and more attractive. It can be described as programs created (learned) from data. This method is especially useful in areas where there is too much data for manual processing or is too difficult for humans to formulate precise rules, according to which the program is managed.

The process of creating such programs is not simple at all and is accompanied by a number of problems, such as overfitting, high variance, high number of dimensions, and others. For these problems there is a solution in the form of feature engineering – search and removal of irrelevant parameters and extracting new parameters of existing ones.

Currently, there are many algorithms for machine learning. These algorithms are often implemented in the form of libraries in different programming languages or as external programs. Whole process of creating program is mostly not a one-shot process of building a dataset and running a learner, but rather an iterative process of running the learner, analyzing the results, modifying the data and/or the learner, and repeating. Learning is often the quickest part of this, but that is because we have already mastered it pretty well!

Feature engineering is specific to each area, making them more complex and time consuming. For these reasons, automatization of feature engineering is in progress. The aim of this project is to create a prototype for automatic filtering, the derivation and testing parameters and thus improve the accuracy of predictions.

This project consists of three main parts:

- Parameter tuning
- Feature derivation
- Meta-library

[*] Supervisor: Marek Ciglan, Slovak Academy of Sciences

Spring 2016 PeWe Workshop, April 2, 2016, pp. 17–18.

Machine learning algorithms require not only dataset they can work with, but also set of input parameters, such as regularization, learning rate and more. These parameters can influence the outcome of a large extent. For example, regularization is used to prevent overfitting, since it decreases constants before high polynomials in polynomial function, thus preventing using high polynomial function to problem which requires only low polynomial function.

Feature derivation is used to discover relationship among features. It consists of two parts – feature transformation and feature interaction. Feature transformation transforms a numeric feature. For example, using linear regression to dataset with quadratic distribution would not give us accurate predictions, but if we transformed the data using square root, they would be linear and predictions would be much more accurate. For feature interaction, the most common use is to multiply numeric features or to combine categorical ones.

The last part of the project is meta-library. The entire process is being run in parallel several libraries. This makes the verification of correctness of both parameter tuning and feature derivation. If a derived feature increases accuracy of predictions using all libraries, it is considered relevant. Besides verification, it also helps to choose correct library/algorithm for a particular problem, because every library may have different results for the same dataset.

Output of meta-library is a report, showing effects of changing various parameters and adding individual derived features. This report should reduce time spent on studying dataset and choosing parameters and derived features manually.

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Software Modelling Support for Small Teams

Martin OLEJÁR*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xolejarm1@stuba.sk

Currently, teams comprising many people participate in software modelling and despite usage of different tools for software modelling using UML they have to face problems such as model inconsistency, the determination of the authorship of model parts, fast detecting, identification and correction of defects in models and model synchronization.

In our thesis, we analyse small teams comprising 2-3 members that encounter software modelling techniques for the first time. We focus our attention primarily on model synchronization and secondarily on detection, identification and correction of defects in models. In comparison with large teams, small teams can analyse the mentioned problems in more details and solve them at a lower level.

For the purpose of analysis of small teams' work, we have made an analysis of 20 projects worked out in the course *Principles of Software Engineering* at our faculty. We have found 2 types of defects. On the one hand, there are defects directly concerning software model, for instance missing specific item or useless item. On the other side, there are syntactic defects, for example missing name of item or filling incorrect caption. The most frequent defects for each type of diagram are in the Table 1.

Table 1. The most frequent defects in UML diagrams.

Type of diagram	The most frequent defect
Activity diagram	*Missing merge node*
Use case diagram	*Use case at a low abstraction level*
Class diagram	*Incorrect cardinality*
Sequence diagram	*Incorrect message type*
State machine diagram	*Missing transition trigger*

The mentioned defects could be also a consequence of missing model synchronization. That´s why our aim is to propose a method for model synchronization and support small teams of 2-3 students by implementing this method as an add-in for the tool *Enterprise Architect* that is used in the course.

* Supervisor: Karol Rástočný, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 19–20.

Our method for model synchronization is based on graph analysis and on the algorithm of incremental model synchronization [1]. This algorithm starts the synchronization process directly at the nodes of the correspondence model that belong to the modified elements. The correspondence model contains the nodes that maintain information about identifiers of the corresponding elements in models. Our method for model synchronization is described in the next paragraphs.

All modifications that have been made in model are saved and processed. Each modification contains basic information about modification, identifier of modified element, identifier of team member, who has made it, and time stamp of modification. In general, we can divide possible modifications into addition, change, transfer and deletion of the item. For the purpose of fast and optimized model synchronization, the method processes modifications immediately after they were made.

Model synchronization comes after processing modifications. Depending on a type of a modification, required operation is provided in the target model according to its parameters and identifiers. After completion of all operations, the whole model is refreshed for a current display of all items.

For the needs of the next model synchronization, it is necessary to update the correspondence model. After each addition of an element, we need to add the identifier of just created item to the correspondence model. This operation is not required after other modifications.

In order to optimize our method, we identify the modifications that we do not have to synchronize. In case of a deletion of an item, it is possible to ignore the whole sequence of modifications of this item. We merge multiple modifications of the same element that are of the same type. It is enough to consider only the last modification and ignore all modifications of the same type made before.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement. This contribution is the partial result of the project Research of methods for acquisition, analysis and personalized conveying of information and knowledge, ITMS 26240220039, co-funded by the ERDF.

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Software Modelling Support for Small Teams

Jakub ONDIK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
jakubondik@gmail.com

Small teams face various problems during software modeling process, such as model synchronization, authorship assessment of model parts and model defects identification. These problems are present both in working and educational environment [1][2].

In our thesis we focus on educational aspect of software modelling. We propose the method for fast detection and correction of defect in UML diagrams of students. We believe, that early feedback on students' actions during software modeling can result in lower amount of defects in their models and in better modelling habits. We focus on small teams consisting of two to three members, specifically on small teams of students.

As a basis for our work we analyzed software models of students enrolled in course named *Principles of Software Engineering* at our faculty. We identified frequent defects in activity, use case, class, sequence and state diagrams. These defect include missing names for initial and final nodes in activity diagrams, missing extend and include relationships between use cases and their references in scenarios descriptions in use case diagrams, wrongly named classes, missing associations names and cardinalities in class diagrams, wrong or misplaced combined fragments in sequence diagrams and missing triggers of transitions in state diagrams.

These types of defects require specific method of detection and correction. Therefore, we propose the method based on rules specifically crafted to detect and correct these types of problems. Example of such a rule can be seen on Figure 1.
This rule consists of multiple elements, each describing a significant part of element this rule is bound to, with an exception of *name*. This rule is bound to name attribute of element of type class with any possible stereotype. It contains a checking expression, which checks for validity of specified element's attribute, in this case the name of the class element. This is checked by searching the name of class in embedded dictionary. If this name is not present in the dictionary, the checking expression returns *false*, which means this name is not valid. Defect message specified in rule element *defectMsg* is then shown to student, with *{0}* parameter replaced by defective class name. Student is presented with option to highlight defective class in his diagram, to hide this defect and

* Supervisor: Karol Rástočný, Institute of Informatics, Information Systems and Software Engineering

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to automatically correct it. If student chooses to correct it, correction method is executed. This method is specified in *correct* part of the rule. If the defect is corrected by the student on his own, the defect message disappears. Activations of the rules is based on student's actions such as addition, removal and modification of elements in model.

```
{
name: 'Class name should be noun',
element: {
                  type: 'Class',
                  stereotype: '*'
   },
attribute: {
         type: 'Name',
         stereotype: '-'
     },
content: {
     defectMsg: 'Nespravny nazov pre triedu "{0}".',
       valid: 'dict.getWord(Name).isNoun',
       correct: 'setName(dict.getBaseNoun(Name))'
   }
}
```

Figure 1. Example of rule used to detect wrongly named classes.

We implemented this method as an extension for the modelling tool named Sparx Enterprise Architect. We also provide it to students of *Principles of Software Engineering* course to observe, if quality of their models improves. As a side result we collect data about their actions. This data can serve as a basis for future work, such as defect prediction in software models using neural networks [3].

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement. This contribution is the partial result of the project Research of methods for acquisition, analysis and personalized conveying of information and knowledge, ITMS 26240220039, co-funded by the ERDF.

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Universal Tool to Assign Badges in Online Communities

Michal RANDÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
randak13@fiit.stuba.sk

Nowadays, it is common to use game elements and mechanics in many different software systems. This phenomenon is usually called gamification. There is no generally accepted definition of this term though [1]. Most of all, it is used in online communities like Stack Overflow or Khan Academy, but its use is much wider. There are many different game elements, but the most common used are points, badges, reputation, leaderboards and challenges. All of them help motivating users in using the system and thus increasing their activity. The implementation of such functionality can be difficult and risky. That is the reason for need of universal and reusable solution.

The goal of our bachelor thesis is to analyze current situation in the area followed by creating an universal tool that would enable defining a set of rules for achieving badges and effectively evaluate which badges should be granted to users. Badges were already used in many domains, for example education, sport and news service [2]. They support extrinsic and also intrinsic motivation and should not have negative impact if they are optional [3]. The concept of this tool is showed on the Img 1. It consists of four components:

- *Online community system* represents any system using our tool. Users perform activities in it and they expect badges for some of them.
- *Client side* is the user interface of our tool. It enables the designer to comfortably define badges and view different statistical visualizations. This component is out of scope of this work.
- *Server side* represents the application logic of the tool. It provides two interfaces. One for receiving events from online community system and one for communicating with client side.
- *Database* serves as the ordinary data storage.

* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 23–24.

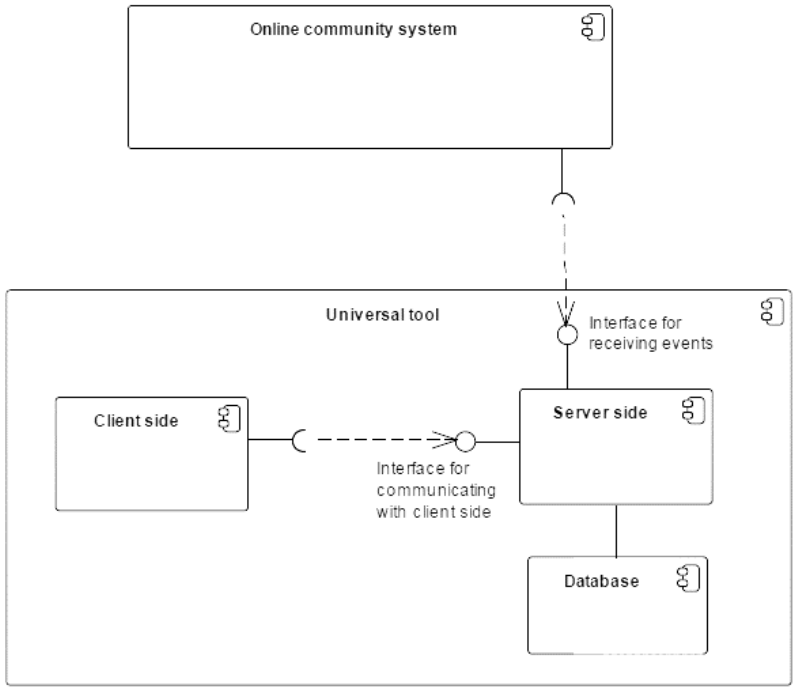

Figure 1. Component diagram of the tool concept.

The server side is implemented in Java as a web service. The communication with it works through simple REST API. It uses three different databases that were tested separately. The databases are Oracle XE, PostgreSQL and a combination of Oracle XE with Redis.

The effectiveness of this tool was evaluated by utilization of a dataset from the Wikipedia system with the size of fifteen million events. While the performance of first two cases was decreasing significantly with the amount of received events, in the case of Oracle + Redis hybrid, the performance was constant for the whole test run. The results show, the use of NoSQL database was the right choice for this project. The average time of processing one event is around 1ms in this case.

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Similarities in Source Code

Marek ROŠTÁR*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
rostarmarek@gmail.com

In current day and age with the development of software there is an increase of problems concerning plagiarism, but also it is quite common to see repeated use of parts of source code. These two issues are the main reasons to look into source code comparison, since it can detect most of plagiarism attempts and also highlight which parts of our source code are we using repeatedly. Such parts we may consider o turn into some sort of library or plugin to improve our source code quality.

Plagiarism is these days one of the main problems of the academia, affecting not only text documents but also most of intellectual property including source codes. It is not uncommon that students inspire themselves with some work they found on the Internet.

In this work we focus on detecting plagiarism in source code specifically (considering its special features in comparison to the standard text documents). Methods used to detect plagiarism in source code differ from methods used to detect plagiarism in text documents [1, 2], since the text in source code does not carry only meaning but some sort of function as well.

Plagiarists try to deceive anyone viewing their work with a multitude of different plagiarism attacks, which for plagiarism in source codes, the basic ones are as follows: altering comments in source code, altering whitespaces present in source code, altering names of variables, altering the order of parts of the source code, altering algebraic expressions in source code, translating source code into another programming language and extracting parts of source code.

We detect these attacks using different methods that we divide into four groups: text based methods, token based methods, tree based methods and semantic based methods. These methods vary in their vulnerability to different attacks, with text based methods being most vulnerable and semantic based methods being least vulnerable to the attacks mentioned before.

In this work we focus on tree based methods, since we are using them in our proposed solution. Tree based methods are based on converting source code into a data

* Supervisor: Michal Kompan, Institute of Informatics, Information Systems and Software Engineering

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structure of tree and after the conversion comparing the trees instead of source codes themselves. This is achieved by doing a lexical analysis on the source code to tokenize it and after the lexical analysis comes syntactical analysis that takes blocks of source code and transforms them into nodes. The nodes are hashed and then compared by node to node basis.

Advantages of this method are that it is resistant to plagiarism attacks and it can find behavioral changes, which can be used for finding malicious source code [3]. Its disadvantages are time consumption and addition of new data structures.

When we are working with source code we can remove for us unimportant parts and thus create an abstract source code. We use this sort of preprocessing often when we compare source code to find similarities in given source codes. There are multiple levels of abstraction, and we can determine how strong abstraction we need based on how big is the source code [4]. Thanks to abstraction we can vastly reduce the volume of the source code and with that speed up the process of comparing the source code.

Our proposed solution is to compare source codes using abstract syntax tree and evaluate if abstracting source code before comparing it with this method is viable. There will be three levels, ranging from removing only comments and unifying white spaces to the highest level, in which we will replace strings values, remove variable declarations, unify the names of variables and greatly reduce the volume of the source code.

Amended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Stream Data Processing

Jakub ŠEVCECH*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
jakub.sevcech@stuba.sk

When processing streams of data, we often encounter data composed of repeating sequences of similar values. Such repeating patterns are present for example in highly seasonal data such as counting metrics running on production or consumption data. As these repeating patterns sketch the outline of the data, we could use them as an approximate representation of the raw data [4]. Such representation could be used for significant dimensionality reduction and could allow application of methods and algorithms not directly applicable on the original form of the data.

However, if we transform evolving data streams into sequence of repeating patterns, the number of patterns could grow indefinitely as more and more data is transformed. This could lead to a rapid growth of the transformed data size (disrupting the effort for dimensionality reduction) and to inability to apply various algorithms relying on limited size of the processed alphabet. In such cases, we would need methods for reduction of the alphabet and to guarantee the maximal size of the alphabet.

In our work, we focus on methods for alphabet size control for Incremental Subsequence Clustering (ISC) [4] time series representation, we proposed in our previous work. However, we propose an alphabet size control approach to be applicable to other methods using subsequence clustering or repeating patterns for data representation as well.

The time series representation, we build on, transforms time series incrementally into a sequence of shapes. Shapes are formed as clusters of subsequences of defined length and overlap. These clusters are defined by an identifier, a time series subsequence in its centre and a limit distance, forming a border for other subsequences to be associated with the cluster.

We proposed the alphabet size control approach as a result of a sequence of improvements of a single basic idea of removing symbols from the alphabet. We only forget old and rarely used symbols to minimize the impact of their loss on reconstruction error. Forgetting of any symbols results in the inability to restore the original form of the time series from the transformed representation. However, since in general in stream

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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data processing we are often most interested in recent parts of the data streams, this can be an acceptable limitation in some domains.

By introducing the symbol occurrence frequency into the alphabet management process, we introduce the requirement for a method for frequent symbol mining. We propose the alphabet size control approaches to be straightforwardly adaptable to any frequent item mining method used as symbol occurrence count estimation. An arbitrary counter based and most sketch based [2] frequent item mining methods could be used, but for the purpose of our experiments, we use the Frequent algorithm [3] due to its simplicity and good results even when relatively small number of counters is used to find frequent items.

To evaluate the effectiveness of the proposed alphabet reduction scheme, we use electricity consumption dataset [1] from Belgian electricity transmission operator. The dataset comprises grid load values sampled in 15 minutes intervals between years 2005 and 2015 forming a time series of more than 370 000 data points. We chose this dataset as representative for very long time series, where multiple seasonal effects are present (daily, weekly and yearly) and where multiple frequent patterns are repeating.

The proposed approach is able to maintain stable size of the alphabet and acceptable reconstruction error, but it also has several limitations. The most important one is slow response to changes in the processed data. As the evaluated approach was not able to immediately replace old symbols with newly appearing symbols, in the transitional part of the dataset. An algorithm using some kind of decay would be appreciated for the symbol count estimation as it might be faster to respond to significant changes in the course of the transformed data. As we proposed this approach to be independent from the method used for frequent item mining, as long as it uses a set of counters, this change should be straightforward.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement. This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG 1/0774/16.

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Prediction of User Behavior in a Web Application of the Bank

Peter TRUCHAN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
truchan@swips.sk

In this work, we propose possibilities in measurement and prediction of user behavior and evaluation of measurable users' characteristic metrics. We chose machine-learning algorithms that suited our needs and with the help of these algorithms, we designed model for prediction of user behavior. Input data contain actions and activities made by user in a web application of the bank. We measured more than 130 000 users in the period of three years. We enriched measured data with data from internal database, which contain information about sex and age of the registered users. We used singular value decomposition for dimensionality reduction. Then we used clustering and sequence algorithms to build prediction model. The main contribution of this paper is the proposal of method for building segments of customers that can work with large data in various domains. The only requirement is to build matrix with users' characteristics, visited pages, and sequence of their actions.

In the field of data analysis, there were identified seven different levels of maturity. They are based on the subject's attitude to the data it gathers and the use of this data. The first one is to use only raw data, the second are cleaned data, third are standard, regular reports, the fourth are ad hoc reports and OLAP, the fifth is generic predictive analytics and finally the sixth and seventh are predictive modelling and optimization analysis [1]. First five levels of maturity are usually implemented in all bigger companies. The other levels are not used at all, or only in a limited way. We think that the main reason for that is lack of knowledge, research and established practice in this field. Our aim is to make research in this area and to make predictive modelling better and more accessible. In the field of the predictive modelling there exists a lot of scientific work, but only few of them are related to web data in this form. Server logs and browser extensions are much more widely used than analytical scripts. On the other hand, for the real use in the companies, the server logs are unusable, because of the security concerns.

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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Browser extensions are suited only for limited amount of test users. The only option for company is to use analytical scripts.

The scientific papers with the subject of web user behavior analysis and prediction usually predict the next steps that user is going to take in a application or churn prediction of the user [2]. Usually they use only one artificial intelligence method which is domain depended and not reusable for other website or applications [3]. We gathered data about more than 130 000 users in the period of three years, in the application of internet banking and info site of the bank. Our model is suited for data with little information value – the data we usually get from the website usage. In general, it is the information about visited pages by user, about their time spent, their action, and some long-term characteristic of user as browser, operation system and so on.

Our model is especially suited for prediction of the effect of the change on the visitors. The goal of the model is to answer questions how some change will affect visitors of the webpage. The principle is that we try to find affected segments of users and we predict how they will behave, if we make changes on the webpage. Another usage is to find segments of users, who do not behave according to expectations and then try to predict, what is the best way, and how to change their behavior (this is the part of the optimization analysis). Inputs are data about website usage and user's characteristics and outputs are segments of users and their typical next actions. If we choose only one segment and we know that one part of the segment behave same, we suspect, that if we remove option for them to behave this way (or add option to behave as the other users in the same segment), they will behave as the other users in the same segment.

High level concept is as follows: 1. data gathering by analytical scripts, 2. Data cleaning and preparing for machine learning algorithms, 3. Dimensionality reduction using Singular Value Decomposition, 4. Hierarchical clustering using BIRCH, 5. Representation of sequence of actions, 6. Final data manipulation and visualization

We have proposed a method, which has potential to improve the state of predictive modeling for website owners and web companies. It is based on innovative ways of cleaning and segmenting visitors of web application. We built this model with new approach to combination of machine learning. The results are promising and we expect that we will be able to use it in real world application.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Application of Machine Learning for Sequential Data

Peter UHEREK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
peteruherek@gmail.com

Nowadays Artificial Neural Networks (ANN) gain an increasing interest after periods of disappointments and several cycles of hype. They are being used in ordinary real life applications, dealing with various types of problems such as natural language processing, handwriting recognition and loans applications. Every year new forms of ANNs applications are being brought into practice. There is still a potential to discover new applications based on ANNs, especially when combined with interesting data.

In our study we are focusing on using ANNs with data that originates from the paywall of foreign news portal. These data are sequentially storing user history of the web browsing. They also are storing information about user's payments for articles. According to these data, we want to research the possibilities of the various predictions in different approaches. Our major object of interest is in the predictions of the user's payments for articles.

Our approach for this problem is based on supervised machine learning, especially Recurrent Neural Networks (RNN). We designed model of RNNs with using the Long Short Term Memory (LSTM) architecture. This type of architecture consists of several cell memories which can help when there are very long time lags of unknown size between important events [1]. Design of our network can be seen on the figure 1.

Our network has 2 hidden layers. The LSTM block is located on the second hidden layer, enclosed by two hidden linear layers. The final layer is Softmax with 2 outputs, which represent a probability distribution of the user's payments for articles. An error in model is defined by cross entropy. There is also applied the dropout technique for all connections.

We have made several experiments to evaluate our solution. We researched the effect of the entries into our model and the effect of the LSTM block on the outcome. Our train dataset was composed from history of 7250 users. There were 721 payers and

* Supervisor: Michal Barla, Institute of Informatics, Information Systems and Software Engineering

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6529 non-payers. For this reason, we had to use oversampling and duplicated paying users. Test dataset consisted from 100 payers and 100 non-payers.

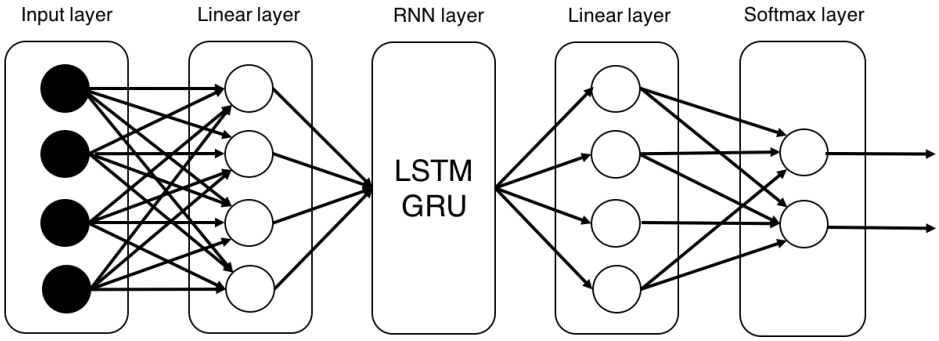

Figure 1. The architecture of our ANN for prediction user's payments for articles.

We identified the most appropriate inputs by several experiments. We also found out that stacked several LSTM block in row can help minimalizing error of the model. The different between using of 1 LSTM block and 3 LSTM block is 2 % in the error in test dataset. We also experimented with simpler type of the LSTM architecture, the Gated Recurrent Unit (GRU) architecture. We replaced the LSTM block with the GRU block and simple RNN block in several experiments. Results from experiments can be seen on the table 1.

Table 1. The comparison of multiple type of architectures.

MODEL	TRAIN	TEST	ACCURACCY	PRECISION	RECALL	FNR	EPOCH
RNN	0,37	0,39	0,79	0,83	0,8	0,2	4
1 GRU	0,35	0,36	0,82	0,86	0,76	0,24	5
1 LSTM	0,32	0,36	0,81	0,86	0,74	0,26	6
2 GRU	0,35	0,35	0,82	0,87	0,75	0,25	5
2 LSTM	0,32	0,35	0,81	0,87	0,73	0,27	8
3 GRU	0,36	0,34	0,83	0,94	0,72	0,28	5
3 LSTM	0,32	0,34	0,82	0,88	0,75	0,25	14

In our study we also research two other problems. First one is the prediction of the popularity of articles. Second one is the predictions of articles that user visited. In the same way we use similar architecture of network with LSTM, GRU or RNN blocks like in the figure 1.

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Recommenders (PeWe.Rec)

Personalized Recommendation of TV Program

Ondrej ČERMAN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
Ondrej.cerman@gmail.com

There are hundreds of TV stations broadcasting thousands of programs every day. Because of this large amounts of data, it is really hard for the viewers to find new good programs to watch. Our task is to make a personalized recommendation to help out these people.

We are focusing on free mobile application released on Google Play platform for Android smartphones and other Android devices. The application currently provide actual TV program for multiple TV stations and already recommends some programs, however its recommendation is not personalized.

Most research in this area is focused on recommendation for electronic program guide[1], recommendation for video-on-demand[2] or similar services. Because uniqueness of our dataset we are expecting different results compared to electronic program guide and video-on-demand recommendations.

When we compare our data to data available from set-top boxes for EPG recommendation, or to data from VOD services, our data are closer to EPG, because:

- EPG is recommending for Live TV programs (to contrariety with VOD) and live TV programs are new, so recommendation algorithms cannot use historical data. Also live TV programs mostly do not have so detailed metadata compared to VOD. [1] Our app is also designed for live program.
- Most people are watching live TV in time-based patterns, so they are interested in different content in weekends, in evenings, etc. [1] EPG has to deal with this fact (to contrariety to VOD), as we have to too.
- EPG data do not have explicit feedback, but they have a lot of implicit feedback like watching times, channels switching, recording times, etc. However, quite a lot of data are irrelevant. Our app do not have explicit feedback, but have a lot of implicit one [1] – like EPG, however we the quantity of the feedback vary,

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

[1] Also known as EPG

[2] Also known as VOD

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because a lot of relevant data (for our needs) are not recorded automatically, but users have to enter it manually. Type of data also vary, see next paragraph.

Our dataset is sets of logs from application that contains these types of logs:

- Program was added to watch list
- Program was removed from watch list
- User choose to be notified for some program
- User canceled notification for some program
- User showed certain program list
- User scrolled certain program list
- User searched some query
- User launched the app
- User changed type of selection
- User choose certain time
- User changed channel selection
- User answered to questionnaire

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Support of Student's Activity in an e-Learning System

Veronika GONDOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xgondovav@stuba.sk

Education is an essential part of life for young people. The main problem in this field is a low motivation of students associated with a low activity of students. In accordance with this fact that motivation is the source of any human activity it is necessary to support it in this domain too. Gamification by Zichermann and Cunningham can increase student's motivation until 40% [3]. Whereas our aim is to increasing the activity of students, we provide game mechanics that will correspond to the needs of students. Personalization of game mechanics can cause an increase in student's satisfaction [1,2] and reduction of student's cognitive load that has an impact in the number of the overall activity of students.

The concept of gamification is not new. There are many systems that use gamification to support a motivation of users. For this purpose they use different mechanisms such as leaderboards, points, levels or badges.

Existing approaches use levels as a means to expression of progress, however, there is also the potential for use them as a tool for navigation while the original concept is exactly used for the motivation. In order to support the activity of students in the system we propose the method of navigation in personalized items. Our method is based on dynamic personalized distribution of items into smaller groups called rooms and navigation between these groups. Selection of items into the rooms is realized through personalized recommendation of items.

Our concept of navigation based on rooms supports the principles of gamification. The groups of items are the equivalents of levels in games. The rooms are perceived as complete complex tasks that are prepared to be solved. The navigation itself is an essential part of gameplay design. Advancement to the next room is conditional on obtaining the necessary success and activity in the current room.

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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Our approach is based on two smaller concepts that complement each other and together they create gameplay design. This includes the concept of rooms and concepts of navigation.

Our main aim is to increase the activity of students in an educational system. For this reason we propose a distribution of items into smaller sets called rooms which reduce cognitive overload and in consideration of their gaming character they support the activity of students. The distribution of items is realized dynamically in response to the activity of the student and it is based on personalized recommendation of items rooms separately for each student top N items for a particular recommenders.

The navigation between the rooms is created with rooms as a basis for the gameplay principle, where the main motivation element is based on the gradual opening of rooms. At the beginning of the week each student has available the only room. Achieving the necessary success rate and activity in the current room is a condition for the opening of the next room. Each room can be used to open a new one no more than once. The student has always available no more than just one room which is suitable for opening the new room and the set of open rooms from the actual week. When a student answers all the items in the room then the evaluation of try is shown to the student. If the student is active enough he opens a new room otherwise he has to answer the items in the room again (Figure 1). The actual progress in activity is shown to students through a progress bar. Success of try is determined by comparing the two types of scores: limit score and score of current try.

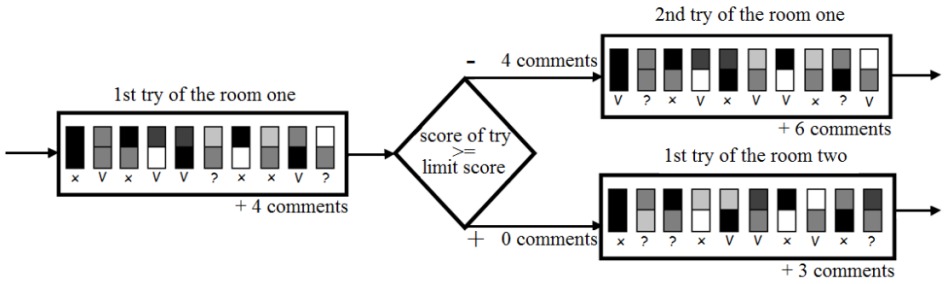

Figure 1. Principle of personalized navigation between the rooms.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Supporting Online Student Communities by Utilization of Questions and Answers Archives

Adrián HUŇA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xhunaa@stuba.sk

Recently Massive Open Online Courses (MOOCs) attracted a lot of attention as they represent a new educational trend with potential to transform education as we know it nowadays. The leading MOOC providers have millions of users nowadays. The main success behind MOOCs is their availability – anyone can join for free, and online nature – all one needs for participating in a course is a device with Internet connection. Many MOOCs are provided by world's top universities and delivered to thousands of users worldwide. These aspects bring new challenges into educational process, especially in managing the massive amount of learners.

Communication between students and course instructors is usually realised in discussion forums that are part of courses in MOOC platforms. However, due to the large number of users instructors play a secondary role, since they cannot address all students' questions [1]. Other students of the course often assist their partners and keep discussions alive. This model of knowledge exchange among community is on the open World Wide Web best represented in Community Question Answering (CQA) systems. Some well-known CQA systems are Yahoo! Answers, StackOverflow, and Quora.

CQA systems emerged as a way to get personalized answers for questions that are too specific or complex to be understood by search engines. Both discussion forums in MOOCs and CQA systems contain a large repository of knowledge stored in questions and answers archives. In our work we focus on utilization of the archives for automatic question answering. Occurrence of duplicated questions in CQA systems is common. Authors in [2] identified that in certain categories in Yahoo! Answers CQA system, 25% of questions are recurrent. This problem is even more visible in MOOCs as similar questions are naturally repeating during each iteration of a course.

Our main goal is improve question matching model for finding similar questions by exploiting specifics of online student communities. The most important specifics identified are: recurrence of questions in similar time from beginning of courses; natural

* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

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authorities in form of course instructors; and connection between courses' content and content of related questions.

The most important part of our model is, however, finding similar questions on lexical level. We identified multiple models for question retrieval based on lexical similarity in related work: vector space model, language model, translation model, translation-based language model, syntactical tree structures, and LDA model. In our work we plan to employ word2vec model and compare its performance with LDA.

Because our ultimate goal is to automatically answer new question with answers from archive of answers, we must also take answers quality into account. Answer quality can be measured by simple means such as community feedback, but in our work will also exploit user role (e.g. course instructor) to rank their answers as more suitable. The last important component of our matching model is information about posting time since the course started. The complete matching model is shown in Figure 1.

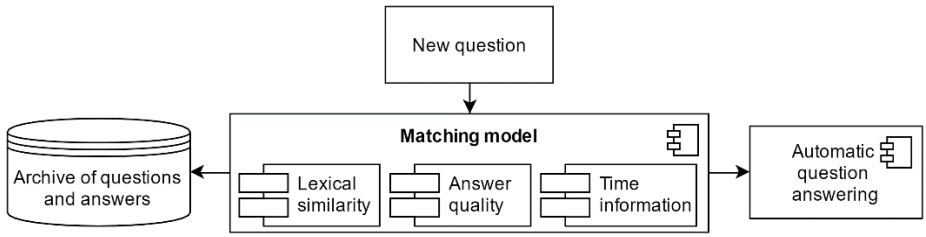

Figure 1. Components of our model for automatic question answering.

There are multiple sources from which latent topics can be learned. It has been argued that text of answers should not be used for learning translation probabilities in translation based models. However, if we take advantage of only quality answers, performance of topic modelling methods is improved [3].

We plan to evaluate our method both offline and online. The online experiment would be performed in MOOCs provided on educational platform edX – one of the leading MOOCs providers.

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Recommendation of Solved Questions from Archives in CQA Systems

Viktória LOVASOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
mrkvicka@fiit.stuba.sk

Community Question Answering (CQA) sites such as Yahoo! Answers or Stack Overflow have become valuable platforms to create, share and seek a massive volume of human knowledge. To prevent information overload of users, we propose a method for personalized recommendation of already solved questions by personalized prediction of questions' information value which is usually expressed by favouring these questions.

The primary role of CQA systems is to answer new questions. In general, there are two main sources of knowledge for answering new questions:

- Community – CQA systems can recommend expert users who would know the answer on a new question for the user who asked the question, so he/she gets the best possible response.
- Archives of solved questions – CQA systems can search for similar questions that have been already solved and thus the user does not have to wait for the answer.

CQA systems such as Stack Overflow and Quora have users who have an extensive knowledge in the domain they participate in. One of the implications is that these systems contain content that has long-term value (information value) and can be recommended to people looking for answers to such questions. Authors in [1] worked on predicting long-term value of the questions and found out that the typical question answering consists of fast and slow phase. In the fast phase, it gains answers and votes and in the slow phase, members of the community indicate the question's long-term value by two events: visiting the question and by the mechanism of favouring the question. In the experiment described in [1], a number of question views with its answers served as an indicator of long-term value.

Predicting the question's long term value was also investigated in [3]. Authors designed a family of algorithms to solve prediction problem by modelling three key aspects: non-linearity, question/answer coupling and dynamics. They chose for their

* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

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work user score because they did a survey in which they asked various users what they consider as the best indicator of long-term value in a CQA system.

In both studies [1] and [3], the authors considered the votes, favorites and question views as expression of interest from users. We took favorites in this analysis to see when users favor a question and to validate that a question contains a high information value for a particular user who favored it. Our goal is to propose a method which provides a user with recommendation of questions which have information value for him/her what he/she usually expresses by favorites. We decided for an offline evaluation on the data from CQA Android Stack Exchange because the authors from the earlier works [1] and [2] used frequently the data from the Stack Overflow to validate their methods. The first prototype of the method (with limited number of input features) was verified in two phases:

1. Problem of classification. In the first phase, we predict whether a user would favor a particular question or not. The questions were divided into two groups and we predicted class to which the questions belong to. We used precision, recall and accuracy as metrics. In precision we achieved 1.0, recall 0.97833 and accuracy 0. 9891. The obtained results indicate high successfulness of prediction, however, it is partially the result of the extreme cases (user favors or votes for close) that we have classified and their different values of features.
2. Learning to rank problem. From the first phase we evaluated that we can identify the favorite questions with a high precision so in the second phase, we simulated a real usage of our proposed method in the CQA system. A typical scenario for recommendation would be that the users would every week get recommendations with top 10 questions that have information value for them. The recommendations would be calculated correctly, if the list of recommended questions contain the question which the user really favored. In this scenario, the results did not achieve so high performance, we managed to generate 74% correct newsletters (question which the user favored was present in the list).

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Recommendation of New Questions in Online Student Communities

Jakub MAČINA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xmacina@stuba.sk

Community question answering (CQA) systems are successfully used on the open Web and in enterprise environments. There is an opportunity for the CQA systems to help students in the online learning communities as well. Boom in MOOCs in recent years have caused that quality education is now easily accessible online for everybody with an internet connection. The idea of MOOCs is to provide university-like education with open access via the web. For every online course within MOOCs domain, thousands of people all around the world are associated into huge and diverse online learning communities. Every online courses provides built-in or external social tools for collaboration of the student's, e.g. discussion board, chat or social network groups.

Question routing represents one type of approach that gain an interest in the CQA systems research in the recent years. Question routing refers to recommendation of new questions to best potential answerers in order to prevent new question of being unanswered for a long time. Previous research in question routing in CQA systems indicates promising results in increasing number of questions answered in a shorter time and in an engagement of larger part of the community in the question answering process.

In contrast to traditional CQA systems, students in educational community are learning about the particular topic throughout the course and therefore they are not experts in the particular field yet. It is essential in educational domain to support whole community of students to ask, answer and discuss about the problems and thus support their learning. While the traditional CQA systems stressed the importance of the question and answer quality, it is not critical part for CQA systems in educational domain. Vital issue of educational domain is limited students' time for contribution. Matching of students' interest and expertise also plays an important role. Existing collaboration support mechanism in MOOCs shows that they are productive for learning and they gain promising results in decreasing dropout rate in MOOCs. Based on the success of question routing in CQA systems, we are going to apply it as a collaboration support tool to the educational domain.

* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 43–44.

From the analysis of question routing in CQA systems, we are inspired by work of [1] as they applied question routing in another specific domain – enterprise environment. Moreover, they engage both experts and inactive users and try to involve whole community in question answering. The paper of [2] represents a unique framework that takes into account constraints that appear naturally in education domain.

Our goal is to propose question routing focused on answerers' preferences and to effectively utilize the knowledge of student community in question answering. Our contribution is question routing specifically designed for educational domain, which consider specifics and constraints of the domain. First constraint is students limited work capacity, their restricted time for participation in question answering. Second constraint is various level of expertise of students, because they are continuously learning throughout the time about related topics of the course. Our main objective is by effective utilization of community knowledge increase the number of questions answered.

Our proposed method is focused on the answerers, so it will be recommending questions that match their interest and level of expertise. Furthermore, open questions will be routed to students capable of answering them while majority of the community will be involved in question answering based on the question difficulty. We plan to use so called knowledge gap phenomenon [3] (i.e. expert users tend to ask more difficult questions while the opposite is true for less experienced users) for question difficulty estimation.

As our baseline, we are going to use asker oriented question routing based on user expertise which is very popular for CQA system. Our goal is to evaluate the method offline, fine tune the parameters and validate our method. Next step, which is the vital part of our work, is to conduct an online experiment in the EdX platform, one of the most well-known MOOCs provider.

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Personal Computer Assistant for Supporting University Study

Matúš SALÁT*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
matus.salat@gmail.com

Our main goal is to create method for prediction of event preparation duration and recommendation of priority events that helps with effective time organization. Students then can allocate sufficient preparation time for semester events. Time organization is a factor that influences stress level of a student [1]. If we eliminate this problem, students would have lower stress level so they can study much more effectively.

We design web-based application for students. It is used to gather all necessary inputs from students. These inputs can be categorized to two main sections – estimations and real values.

Estimations consist of:

- Estimated complexity of events (five-point scale)
- Estimated complexity of courses (five-point scale)
- Estimated time of preparation duration in hours
- Estimated time of preparation duration in days

Real values consist of:

- Real preparation duration in hours
- Gained course points
- Date of preparation ending (if the event is an exam, the date of preparation duration is the deadline of the exam)
- Logical information about current student priority of event

The aim of our work is to find relationship between various inputs and real preparation duration and between individual inputs too. These inputs are important for predicting preparation duration of event for each student. For searching any correlation, we use linear regression model. We evaluate this model with R squared measure, which

* Supervisor: Jozef Tvarožek, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 45–46.

represents the percentage of the variability in Y that is explained by using X to predict Y [2].

After analyzing all inputs data for prediction preparation duration, we start with modelling recommendation of events. Collected data contains subjective ranks about events, subject complexity and logical value about current priority for all of events. These ranked inputs are typical for domain of recommendations. From dataset we train collaborative recommender for recommendation of top three subject, which should be considered as priority events. We compare this recommender with recommendation of events based on ordering by deadline or rank values (naive recommendation). Recommenders are evaluated in offline experiments.

Web application is not primary goal in our work, but it is necessary to evaluate it at least with questionnaire for users (students) about idea of project. Answers should be considered in potential future work in a similar domain.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement. This work was partially supported by the Cultural and Educational Grant Agency of the Slovak Republic, grant No. KEGA 009STU-4/2014.

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The Next Step of CQA Systems' Utilization in Educational Domain: MOOCs

Ivan SRBA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
ivan.srba@stuba.sk

In our previous work [1], we proposed a concept of educational and organizational Community Question Answering systems (CQA) system which takes organizational specifics (e.g. closed community) as well as educational specifics (e.g. presence of a teacher) into consideration. In order to verify this concept, we implemented CQA system Askalot (demo of Askalot is available at https://askalot.fiit.stuba.sk/demo. Askalot is currently deployed at our faculty for the third year and it is used by a community which consists of about 1000 students and teachers.

Motivated by positive outcomes as well as feedback from the involved students and teachers in our educational CQA systems Askalot, we plan to deploy Askalot at University of Lugano as a part of cooperation project in SCOPES programme. Moreover, we started another cooperation with Harvard University in order to transform Askalot into a tool that can be used as a plugin to MOOC system edX. The goal of our ongoing cooperation is to replace the standard discussion with a tool that can be used by students to share their knowledge more effectively by means of course-related questions. At the same time, it will provide a possibility for researchers to perform A/B experiments (in the design of Askalot we follow a concept of MOOCLets proposed in [2]). Consequently, our plan is to deploy this MOOC version of Askalot at selected courses provided by Harvard University, which are enrolled by several thousands of students each year, with a possibility for further expansion at additional courses.

The original design of Askalot was proposed specifically for our university (e.g. it sup-ported only simple non-hierarchical categorization of questions which reflected our subjects' structure). Therefore, it did not provide sufficient flexibility and scalability which is necessary to deploy Askalot in additional various settings. In spite of the same educational domain, edX differs significantly from university environments as well as both universities differs from each other (in terms of their formal educational process,

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 47–48.

structure, etc.). As the result, we had to rebuilt the original system design and following this process, we provide several design recommendations in [3].

The main changes in Askalot include modular system architecture, flexible user management integration or adaptable self-managed content organization. The new environment affected also user interface - in contrast to university version of Askalot, MOOC version provides two views on questions:

1. Unit view, which contains only questions related to particular learning object and is provided directly side by side with learning materials, and
2. Global view, which contains all questions as well as overview of categories, tags, users and their social profiles in the similar way as in university version.

We are aware that application of CQA concepts in educational domain (i.e. at universities and in MOOCs) affects not only design of the system and its primary functions (i.e. essential functions dedicated to the question answering process), but also characteristics of necessary adaptive collaboration support (so far we focused especially on the design of the CQA educational systems). The existing approaches to collaboration support in standard CQA systems are in many cases not applicable here because additional constraints should be satisfied (e.g. a student cannot be overloaded with too many questions or a difficulty of recommended questions should match student's knowledge level). Therefore, supplementing the university as well as MOOC version of Askalot with novel methods for appropriate adaptive support (mainly question routing and question retrieval) represent a promising direction for our future work.

In addition, we aim to address also the problem with students' motivation and lack of the trust which we observe currently at our university. It would be possible to employ additional gamification mechanisms (e.g. badges) that will be designed specifically for educational environment. This gamification can be interconnected with various organizational rewards, which are one of possible motivational factors. Moreover, version of Askalot deployed at University of Lugano will allow students to contribute to this system completely anonymously (without any interconnection to real students' identities). It will allow us to determine the attitude of students to question answering in a different environment with a different settings and compare it with results obtained from experimental evaluation at our university.

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Presentation of Personalized Recommendation via Web

Martin SVRČEK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
mato.svrcek@gmail.com

Recommender systems are software tools and techniques which are designed to provide a suitable items that may be helpful to the user [1] and thus simplified the selection of appropriate information. However, a serious problem that prevents even more widespread of recommendations is often distrust of users. An interesting approach to reduce such a problem is the form of explanation of recommendations.

Explanations are oriented directly to users and trying to provide the reasons why the recommendation could be useful to them [2] and they also focus on building trust of users. Our main goal is therefore to reduce the distrust of users in recommendation systems and also to increase transparency and attractiveness of recommendations. In the context of these goals, we have decided to propose our explanation method whose characteristics are:

- Method is a personalized type of explanation of recommendations directed to user.
- Method is independent to recommendation technique.

Proposed method is hybrid type of personalized explanation. This means that this method combines different approaches for explanation in order to achieve the best result. For each recommended article is necessary to find explanation that is suitable in the context of characteristics of this article and which is also suitable for the user.

Method uses two basic sources of data (Figure 1). The first are recommended articles together with their characteristics or keywords. The second are information about users represent by user model. The actual explanations are generated based on the method of personalized explanation which use three approaches:

- Explanation based on collaboration
- Explanation based on the content of articles
- Explanation based on the knowledge of users

* Supervisor: Michal Kompan, Institute of Informatics, Information Systems and Software Engineering

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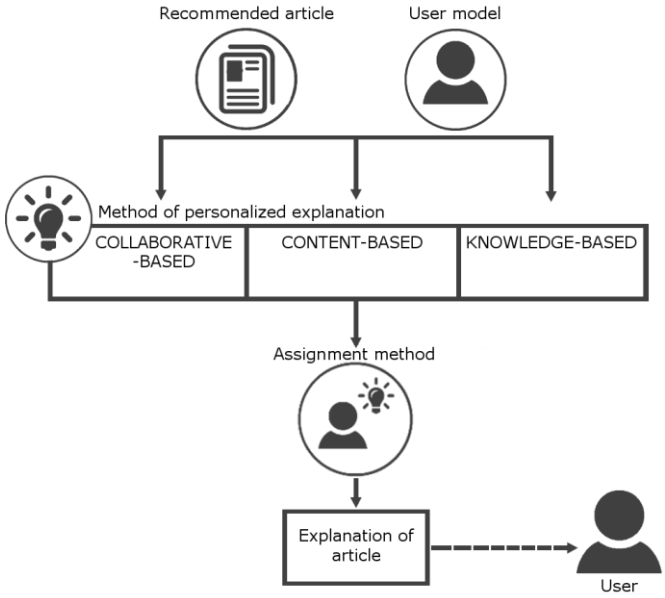

Figure 1. Model of personalized explanation.

The next step of proposed approach is to decide which type of explanation is appropriate for the current user. This is the task for the assignment method. The basic phase of this step is a learning phase where we select all explanation approaches in the same ratio. In this phase, we ordered the results of these approaches in a standard way called the interleaving. Our goal is to learn which type of explanation is preferred by each user.

The main goal of the personalized explanation is mainly to reduce the distrust of users in recommendation systems. However a necessary condition to achieve the goal is also to generate explanations suitable for the user. In order to evaluate our approach, we will conduct an uncontrolled long-term experiment motivating the participants to read articles in our system.

In case of reduction of distrust we want to evaluate our approach in a simple way by compare the results of standard and personalized explanations. We will evaluate which of the articles (explained standard or personalized way) were viewed more. In case of accuracy of personalization of explanations we want to verify our approach by interleaving the results of three different approaches to personalized explanations. Thus we will learn which type of explanation is preferred by each user.

Acknowledgement. This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG 1/0774/16.

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Semantics Acquisition and Domain Modeling (PeWe.DM)

Linking Multimedia to Microblogs for Metadata Extraction

Peter GAŠPAR*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
peter_gaspar@stuba.sk

With the expansion of the open Web, information overload has become a huge problem. Many information retrieval approaches are trying to deal with retrieving, representation, searching and storing of large datasets. Metadata are widely used to describe instances - especially in the domain of multimedia. They are usually generated from the related content. However, many sources of related content do not provide efficient and complete related content. It is also difficult to find the sources, which we can consider reliable enough.

If we are talking about related content, we should distinguish between the static and the dynamic one. From the user's point of view, a *dynamic related content* might be more attractive. Gathering dynamic related content usually involves processing a *user-generated content*: reviews, ratings or even page-visits. Nowadays one of the most popular sources of dynamic related content is microblogs. Each instance of content is called *post* and it covers for example statuses (or thoughts), pictures, videos and external links.

Many researchers were trying to map the general knowledge base (i.e. Wikipedia) to posts from microblogs. Cremonesi et al. in [1] focused on analysing tweets about the TV content. They mapped tweets using exact word match, free match (similar to n-grams) with TV shows' title, but they also introduced a one-class SVM classifier. Another approach that was combining multiple ideas was proposed by Gattani et al. in [2]. They were using a knowledge base (Wikipedia) as the main source of information for mapping. Additionally, they included the context of social posts and the user's activity to classify posts that did not contain any named entities.

We are introducing a mapping approach, which is using the titles of TV shows from the TV schedule. The main idea is to find the similarity between the titles of TV shows and the posts from the microblog. This similarity is based on the patterns used by the producers of the content in the microblog's posts. We have analysed the social content

* Supervisor: Jakub Šimko, Institute of Informatics, Information Systems and Software Engineering

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posted by 11 TV channels (Slovak and worldwide). Based on our analysis we have identified three key features of the posts that are frequently used by the authors of the posts: *named entities*, *hashtags*, *external links*. The process of our mapping consists of these main steps:

1. Normalize TV shows' titles by removing all diacritical marks (e.g. á, é, ů), removing any information about TV series (series number, current episode), and lowercasing all the capital characters.
2. Generate the list of *prefix words* from the TV shows' titles.
3. Generate candidate named entities and hashtags from the titles of TV shows.
4. Extract named entities, hashtags and external links from the microblog post.
5. Find the relationship between the extracted and generated sets using n-gram similarity. Final similarity between the TV show and the microblog post is an average of all particular n-gram similarities.

A *Prefix word* contains up to 4 characters from the first word of the title. We use prefix words in the process of candidate entities generation to eliminate words that are not suitable to be candidates (e.g. the first word in the sentence often starts with the capital letter even if it is not a named entity).

To evaluate our solution, we collected Facebook posts from Slovak TV stations (Markiza, JOJ) and manually labelled 520 of them with the corresponding related TV shows. We have also introduced a threshold parameter rel_{THRES}, which allows us to dismiss mapping results that are supposed to be false positives. For $rel_{THRES} \in [60,70]$ we have scored in average precision 88%, recall 73%, and F1-measure 80%.

In our work we have analysed behaviour of users on microblogs. We have proposed a new method to map shows from the TV schedule to the posts from the microblogs. To evaluate our solution, we have made several experiments. Our results are promising and comparable to related works. In our future work we will try to find a solution for the case, when the microblog post does not contain any named entities, hashtags, nor external links.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Identification of Similar Entities in the Web of Data

Michal HOLUB*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
michal.holub@stuba.sk

The Semantic Web presumes structured, machine-readable data published in widely accepted open standards on the Web. Once this becomes true, new automated applications will emerge that will automate many of our tasks. So, the key to this lies in high quality semantic data.

Already, such data is being created and linked together, thus forming the Linked Data cloud or the Web of Data. Currently, there are few hundreds of such datasets covering wide range of domains (public domain, music, movies, biology, bibliography, etc.). However, so far only few attempts were made to actually pursue the idea of wider adoption of such datasets in various web-based applications (e.g. search, recommendation, and navigation).

In our research we focus on discovering links between various entities in the Linked Data cloud. Our method can also be used for automatic concept map construction which has applications in the knowledge management domain. For this purpose we use unstructured data from the Web, which we transform to concepts and discover links between them. We proposed such solution in the domain of programming languages and related technologies [6]. Resulting concept map is usable for recording the technical knowledge and skills of software engineers.

We examine the utilization of such concept maps and Linked Data utilization in order to 1) improve the navigation in a digital library based on what the user has already visited [8], 2) find similarities between scientists and authors of research papers and recommend them to the readers browsing a digital library [2], 3) analyze Linked Data graphs and find identical entities [5], 4) enhance the displayed articles based on linking entities to DBpedia [4] and recommend additional interesting information to the reader within a digital library, 5) enable users to search using queries in English language [3].

Linked Data are being used in various datasets forming a Linked Data Cloud. In the center of this cloud there are two main datasets: DBpedia [1] and YAGO [7]. Both

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

Spring 2016 PeWe Workshop, April 2, 2016, pp. 55–56.

use Wikipedia as their primary source of information. The goal of these datasets is to extract and define as many entities as possible, so that others can link to them.

For the purpose of describing the knowledge of software developers we propose the creation of a concept map. The map is composed of a set of concepts representing various technologies and principles the developers are familiar with.

Building an adaptive web-based application using a domain model based on linked data enables us to utilize the relationships to recommend related entities (e.g. in the domain of learning materials), or to help the user navigate in a large information space (e.g. in large digital libraries containing millions of authors, papers and conferences which may overwhelm the user). We can also use the relationships to help the user in the search process. Since the Linked Data cloud has the form of a large graph we are able to answer complex queries, which are difficult to solve using traditional keyword-based approach.

We evaluate the models and methods of their creation directly by comparing them to existing ones or by evaluating facts from them using domain experts. Moreover, we evaluate the models indirectly by incorporating them in adaptive personalized web-based systems and measure the improvement in the experience of users (i.e. they get better recommendations, search results, etc.).

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Support for Domain Model Authoring

Matej KLOSKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
matej.kloska@gmail.com

We live in times when people use information technology through which they produce many information. This fact is powered by using the Internet as a universal tool for communication. Due to this fact, a need for an intelligent and quick search, visualization and last but not least navigation across the digital space created from the data arises. An approach to the problem area appears to be semantics. Ontologies, as representatives of semantics, are often seen as a response to the need for an interoperable semantics in modern information systems. In many cases, they act as an important tool for the organization and representation of knowledge in context, particularly in scientific research and organizations with specific requirements. The aim of our work is to promote the creation of domain model and help to facilitate many other processes of everyday life.

Complexity of our method leads to numerous approaches to solve particular parts of method such as navigation, layouting, marking, model basal hierarchy formation and creation of graphs in general. During the last two decades, there were many surveys [1,2] and case studies [3] in field of domain model creation focusing on general techniques of ontologies creation.

With respect to our point of interest, there were also made more specific works focused on domain model creation and administration.

Given the existing publicly available tools, which were the subject of our analysis, we consider the current status as insufficient. The only potentially suitable instrument is Protégé, which is, thanks to broad awareness and interest from researchers is an ecosystem, composed in addition to the system itself also of a set of expansion modules that offer advanced features.

Based on the analysis of recent surveys, case studies and even more our customer product survey, we identified two key scenarios necessary to involve in design of our method:

creation of new model: our goal is to support authoring of a new model without any pre-generated entities,

* Supervisor: Marián Šimko, Institute of Informatics, Information Systems and Software Engineering

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modification and verification of existing model: our goal is to support user during further stages of model development.

Identified scenarios seem to be almost identical but their meaning is different with respect to the sub-tasks. They involve different amount of workload for different actions based on the different state of model completeness. Creation of a new model rely heavily on the features supporting the creation of new concepts and relationships. On the other hand, modification and verification of an existing model primarily rely on modification of relationships, marking significant parts of the model, searching concepts and identification of issues such as circular dependency between concepts.

Along with identifying the abovementioned scenarios, we get a list of key features that put customers on the interface: creation of the model hierarchy, bulk addition of concepts, model tagging, search over model concepts, model segmentation.

In our work we focus on solving the problem of intelligent information processing by supporting the domain model creation. During analysis of the problem area we gained a clear conviction and the need to think about the problem, particularly in view of the very process of creation. Domain model authoring is constantly faced with certain challenges that have not yet been resolved in terms of tools for creating domain models. An important step in our work was the user's study that helped us gather together the key issues and proposed solutions directly from users dealing with creation of domain models. Given the analysis and our study we defined elementary functions of our interface that we developed to functional tool. During development, we made a number of iterations in which partial results of development were presented to the end users, thus we acquired the continuous feedback on our tool. By implementing a pilot experiment, we verified the functionality and accuracy of our features together with proposals for major experiment. The main benefits of our work are user elaborate study of the basic steps of creating domain model and unified tool for supporting domain model authoring. According to our ongoing experiments with real users, we support creation of domain model, especially in terms of faster creation of model concepts hierarchy, tagging and segmentation.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Relationship Extraction using Word Embeddings

Matúš PIKULIAK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
matus.pikuliak@gmail.com

The Web currently contains the largest collection of documents the humanity has ever seen. Dealing with the documents written in natural languages is subject of intensive research. The quantity and nature of this unstructured data make it difficult to process for machines. There are numerous tasks concerned with extracting knowledge from such data. In this paper we are dealing with extraction of relationships, particularly with discovering semantic relations between lexical units such as words or phrases. Example of such relation can be a relation between countries and their capital cities.

Extracting such information manually is very arduous and error-prone task. Our aim is to partially automatize this task and help engineers build knowledge bases in various expert systems. Existing methods for such extraction were usually tailored only for extracting one concrete type of relation, e.g. taxonomic one [2]. In addition, they usually involve the necessity of manually creating exact rules used to find new relations. These rules are being specifically tailored to one specific type of relation and cannot be easily modified to fit another.

We propose new method with an aim to considerably decrease time and cognitive difficulty of relationship extraction for generic semantic relations. Our method requires only a handful of examples to define a relation. I.e. we expect our method to expand given set of pairs. If we supply our system with pairs like *France-Paris*, *Italy-Rome*, *Russia-Moscow*; we expect it to return new pairs with the same semantic relation. We think this kind of interaction with system is very simple and straight-forward. The set can be assembled manually by human users or automatically by machines extracting existing knowledge from structures such as ontologies.

We are using deep learning algorithm to create vector space for lexical units [1]. This algorithm project units into high-dimensional space based on the contexts the words are being used in text corpus. Words that are being used in similar contexts have similar vectors, thus making this algorithm an application of Harris' hypothesis stating that

* Supervisor: Marián Šimko, Institute of Informatics, Information Systems and Software Engineering

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words used in similar sentences are semantically similar. This method of representation of units became popular recently and was already successfully used in variety of NLP tasks [3].

We project the pairs examples given as input into this space and we utilize machine learning algorithms to learn about the patterns they leave in this space. Existence of these patterns were already proved empirically [4]. We then apply this knowledge to rate set of selected candidates. The higher the rating these candidates have the higher the chance they should have desired relation. Technique called PU Learning looks very promising solving this task. It is essentially variant of binary classification that can work only with positive and unlabelled data. Other techniques based on similarity calculations were also evaluated.

Result of our method is a list of pairs sorted by their chance of having the same relationship as the pairs in seed set. We have evaluated results for several semantic relations with seed sets consisting of 25 examples pre relation. We judged the relevancy to seed set for first 100 results from each list. In average approximately 20% of these results are correct while our best result is 52%. We consider these results very promising as it shows that our method was able to learn about semantic relations based only on handful of examples. We believe this approach can be further researched and ultimately used in real life knowledge engineering applications.

We were surprised that different measures for scoring pairs did not differ only quantitatively but also qualitatively. It seems that each measure has its own strategy for scoring. We think that we could use this phenomenon and further improve the efficiency of our method by combining several unique scoring methods. We are also looking for ways to enrich existing space with more and better defined concepts other than words. This could simplify the knowledge extraction layer of our task.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Text Processing and Search (PeWe.Text)

Automatic Text-checking for Slovak Language

Ondrej ČIČKÁN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xcickano@fiit.stuba.sk

We encounter text-checking almost in every word processing program, web browser or other applications. Late detection of spelling mistakes in the curriculum vitae, book or diploma work can be unpleasant for the author. The function of text-checking tool is to automatically detect these errors and propose corrections. It may also be useful in other programs, which require that the input text is written correctly.

Our goal is to offer a tool that automatically checks a text in the Slovak language and detects the largest possible percentage of error. We decided to use a statistical method, where we use language and error model. These models will help us to choose the correct word from list of multiple suggested corrections for misspelled word. This method also allows us to correct the real-word errors.

Our solution is based on existing tools for the text-checking *Korektor* developed at Charles University in Prague by Michal Richter [1]. This tool provides modularity for adding support for other languages. Original authors set free access to various script and tutorials that are necessary for incorporating new language to this tool.

We have to create language models and error model for Slovak language. Process of creating language model needs a lot of text, preferably with no errors. We collected newspaper articles published online, which have been already proofread. *Korektor* also supports use of multiple different language models. Therefore, we decided to use combination of language models based on word forms, lemmas and morphological tags (defined part of speech of the word) which should contribute to better results [2].

In our solution, we clear the collected text in Slovak language and then assign lemma and morphological tag to each word using annotated dictionary. After we have prepared texts, we use a toolkit for building statistical language models *SriLM*.

Very important is also error model, which reflect probabilities of making certain mistakes in text. In contrast to the language model, process of creating error model needs the text corpus, which contains as much errors as possible. Various blogs published on the Internet meet this condition. In these texts, we identify spelling errors.

* Supervisor: Marián Šimko, Institute of Informatics, Information Systems and Software Engineering

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When all models are created, we set it up to work with *Korektor* following instructions published on official website.

Part of our work is to develop freely available web service. We will create REST API that can be accessed directly via web browser or via any programming tool that support standard HTTP request methods and JSON for output handling. This API will provide web services for auto correction, spelling suggestions and diacritics completion for any given input text.

An important aspect of our work is to state how good our models incorporated in Korektor are in correcting text. We evaluate the accuracy, precision and recall of our solution on different sets of test data. There was not found any text in Slovak language with annotated errors, which could be used for easy evaluation. Therefore, we chose two approaches to create our own testing data:

- Test data created by rewriting text, which was read aloud
- Test data created by a script making random mistakes in words

We compare result of *Korektor* to results achieved by existing tools for automatic text-checking for Slovak language like Hunspell and build-in spellchecker in Microsoft Word.

We also examine result of our solution only on real-words errors, because today there is no freely available spellchecker that correct these types of error effectively. We also evaluate the influence of different types of language models on results, especially on real word errors.

Our contribution is creation of language and error models for Slovak language and incorporate it to existing text-checking tool *Korektor*. This tool using statistical method for word correction has potential to achieve better result than any public known spellchecker for Slovak language. We also create public accessed API for error correction that can be used in future projects.

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Sentiment Analysis of Social Network Posts in Slovak

Rastislav KRCHŇAVÝ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
Rastislav.krchnavy@gmail.com

Sentiment analysis is part of Natural Language Processing problem. In sentiment analysis text is classified into categories, which describes several states of sentiment. Our data for training and validation are Fecebook posts from pages managed by Seesame (Slovak PR agency collaborating with us on this work). The texts from dataset are written in Slovak and many of them have grammar mistakes, missing diacritics and contain a lot of emoticons and emojis. In sentiment analysis the main goal is to determine whether the text is positive or negative, eventually neutral.

There has not been any existing solution developed for Slovak language yet, but for other languages some research has been done. In Czech language, which is similar to Slovak, a machine learning solution achieved 72 % in three class classification [1].

In sentiment analysis there are two main approaches – machine learning and lexicon based approach. In our work we will compare different approaches and we will also try to build a classifier which combines both of them for achieving the best accuracy. In each approach we can analyse text on sentence, document and aspect level.

First step of our solution is pre-processing the text. In the phase of pre-processing the original raw texts are transformed into set of features which comes to training and testing the classifier. The most important steps of pre-processing are extracting the emoticons and emojis, lemmatizing the words, segmentation and deleting stop words[1].

Extraction of emoticons and emojis means, that these figures in text are replaced by their name, because in further processing there are allowed only alphanumerical characters. In phase of lemmatizing, all words are converted to their lemas, which contains information about semantic meaning of words but not about their forms. This step is very important for Slovak language. By removing stop words, we can choose

* Supervisor: Marián Šimko, Institute of Informatics, Information Systems and Software Engineering

[1] Words with no semantic value

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between using a list of stop words or removing words based on their grammatical categories.

After pre-processing we will build the classifier. We use a NLTK[2] library, where the machine learning classifiers been implemented yet. In our research we will compare these algorithms:

- Naïve Bayes classifier – machine learning approach
- Maximal Entropy classifier – machine learning approach
- Lexicon based approach based on Slovak Sentiment Lexicon[3]
- Classifier based on combination of machine learning and lexicon based approach

Last step of our experiment is validation. Data in our dataset are divided into five categories (strongly negative, negative, neutral, positive, and strongly positive) and contains over 1200 posts[4]. The main metric we focus in our experiment is accuracy, but we also measure precision and recall for each class.

The best results are about 80 % accuracy in two classes Naïve Bayes classifier and about 81.5 % in combination of Naïve Bayes and lexicon bases classifier. With increasing number of classes Naïve Bayes shows the best preforming classifier with about 59 % in three classes, about 45 % in four classes and about 40 % in five classes.

The exact results will be published in May 2016, but now we can say that in two class classification the results are good, because human raters can agree in 79 % [2].

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Navigation Leads for Exploratory Search and Navigation in Digital Libraries

Róbert MÓRO*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
robert.moro@stuba.sk

One of the fundamental problems in search in general is how to support the users in formulating their initial as well as any of the subsequent queries. This is even more pronounced in exploratory search where the users can have only a very vague idea of what it is what they want to find in order to solve their problem at hand. Therefore, an exploratory search system needs to support *query formulation* by providing (*i*) *global overview* of the domain that enables users to quickly comprehend the basic structure of the underlying information space and the possible directions that they can take, and (ii) *means of following different paths* employing the browsing techniques.

In order to support exploratory search and navigation we proposed an approach of exploratory navigation using the *navigation leads*, which represent important words automatically extracted from the documents present in the information space. We distinguish two types of navigation leads:

1. *View navigation leads* which provide a global overview of the domain—what the most important concepts or the most promising leads (paths) to follow are—before the initial query and an overview of the generated view of the domain consisting of the documents of the filtered information subspace at the later stages of search. They are usually placed in a cloud and play a crucial role in formulating an initial query.
2. *Document navigation leads* which highlight terms (keywords) relevant in the context of a single document (search result) as well as the terms with the highest navigational value. They are placed directly in a summary (or abstract) of a document or under it in order for the users to perceive them in their context. They represent navigation starting points allowing to follow a specific path by filtering only documents pertinent to the selected lead. They play crucial role in query

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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refinement and add an aspect of serendipity by allowing the users to follow also unexpected new paths.

The navigation leads augment the result set retrieved by the search engine. The process of augmentation of the search results with the navigation leads consists of three main steps [4]:

1. *Identification of the navigation lead candidates* – in this step, keywords are automatically extracted from the documents and their document relevance is assessed [4].
2. *Selection of the navigation* – besides the document relevance of the individual keywords, their navigational value is computed. It reflects how relevant the lead candidates are for the whole information subspace [3].
3. *Presentation of the leads with the search results* – the selected navigation leads are presented with the search results list, either under the summaries (abstracts) of the search results or in a cloud of terms next to the whole list (in case of the view navigation leads) [2].

The selection of a navigation lead (both view-related and document-related) by a user results in a query refinement and subsequently in a construction of a new partial view of the information space.

Although our proposed approach can be applied in any domain, we focused on its application in the domain of digital libraries, namely in the *researcher novice scenario*. The goal of a researcher novice is not to find specific facts, but to *learn* about the given domain and *investigate* the topics and existing approaches as well as the gaps in the current state of knowledge. We evaluated our approach in the web-based bookmarking service *Annota*[1] [1], which allows the users to organize, collaboratively annotate, and share their bookmarked Web resources with the special focus on research articles. We conducted synthetic experiments on its dataset as well as live experiment with its users as participants.

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Keyword Extraction in Slovak

Adam RAFAJDUS*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
adam.rafajdus@gmail.sk

Keywords often represent important role in text documents, not only used for categorization, but also as a placeholder, since human can imagine the theme, the category and the content of the document based on the well-chosen keywords.

The process of keyword extraction used to be primarily manually evaluated, but as it is not very efficient method, more capable methods like TF-IDF with relative positions or distance-based metrics were successfully applied to extract keywords [2]. The main disadvantage of these new methods was that they were heavily dependent on special pre-processing of the text dataset, such as Part-of-Speech tags and/or using lemmas, which require additional time to process, since Slovak language is morphologically rich. This problem can be solved using the new methods in NLP, which are changing the way of processing words by changing them into word vectors, which are much better thanks to their vector properties. In vector space, we can perform various vector operations while keeping semantically close words together in the vector space.

Our approach is to implement a recurrent neural network based on LSTM – Long Short-Term Memory module, which thanks to its structure is working similarly to a person reading text and learning text's keywords and category by understanding similarities of texts. The proposed model is not only taking advantage of coherency of the text by processing words one after another, but also of word vectors that we use, which offer us another layer of information about text since it captures many semantic and syntactic regularities [3].

Our proposed architecture is created based on categorization architecture of LSTM and has 4 layers:

1. Latent feature vectors of input words
2. Main LSTM module
3. Keywords vectors processing
4. Softmax classifier

* Supervisor: Márius Šajgalík, Institute of Informatics, Information Systems and Software Engineering

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The first layer is using well pre-trained word vectors to initialize the lookup table, which is fed into the LSTM module. We use Word2vec tool to create our latent feature vectors. For initializing the lookup table we have corpus of pre-trained word embeddings with 3 types of word vectors - 80, 200 and 300 dimensional. Each offers different level of complexity and efficiency.

The LSTM module is currently very popular architecture of recurrent neural network in literature, referred to as vanilla LSTM, which have emerged as an efficient and scalable model for several problems related to sequential data [1]. The main idea behind using the LSTM architecture is a memory cell which can maintain its state over time, and non-linear gating units, which can regulate the information flow into and out of the cell. Although the initial version of LSTM block was different and struggled with the same problems as RNN, this version already includes many changes, mainly based on forget gate and output activation function, which are the critical components of LSTM block. It is performing reasonably well on various datasets [1].

Keyword processing is performed by transforming output of the LSTM module into form of n-keyword feature vectors and comparing them to n-word feature vectors. This should end up by transforming output into real word vectors with characteristic of processed text – keywords.

At the end, the softmax function is applied as a classifier to predict the probability distribution over the category set. Comparing prediction results with real categories of text, we can use regular backpropagation to apply supervised learning on network to train categorization over the training set, while extracting keywords from third layer.

As our next step, we plan to apply this method on Slovak Wikipedia - our corpus, thanks to its large database of articles with assigned categories, first testing efficiency of categorization and eventually of keyword extraction.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG 1/0646/15.

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User Experience and Implicit Feedback (PeWe.UX)

Usability Testing of Navigation on a Bank Website

Veronika BALÁŽOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
veronika@balazova.sk

Nowadays, when almost everything can be found on the Web, it is important for the websites to be as usable, user-friendly and easily searchable for what the users need as possible. In addition, it is now true more than ever before that "competition is just one click away from us". That means if a website does not give the users exactly what they need, they leave the page and look for the information somewhere else, or this experience makes them dissatisfied, angry, or frustrated.

A user interface of a website determines how the users will use the site - whether they will effectively reach their goals, less effectively, or not at all. Therefore, it is important to improve user experience of a website in order to find information in the most effective way. This may be also related to the fact, what kind of person the user is.

The main goal of our work is to test and improve user experience and usability of a website in the banking domain, mainly navigation which is on the website. According to [2], good navigation is one of the most important things on the website, because when people cannot find what they want, they will not stay on the website and maybe they will not came back again.

We conduct a study that aims to test the usability. Our first goal is to identify usability issues in the interface and then offer improvements, therefore we conduct a formative study. Secondly, after proposing sites improvements we try to implement the remedies to eliminate these errors. Newly designed version of the page is tested based on user studies and compared with the previous version. In both studies we use eye tracking to get a better understanding of the participants' actions . In addition, we assume that a type of users' personalities can influence the way, how they solve tasks and problems on the website. For this purpose, in both studies we collect also the information on the participants' personalities using the standardised Big Five questionnaire [1].

* Supervisor: Róbert Móro, Institute of Informatics, Information Systems and Software Engineering

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The initial results shown that there are some correlations between types of personalities and metrics, which are average time on task, average success and average number of mistakes and these correlations are shown in Figure 1.

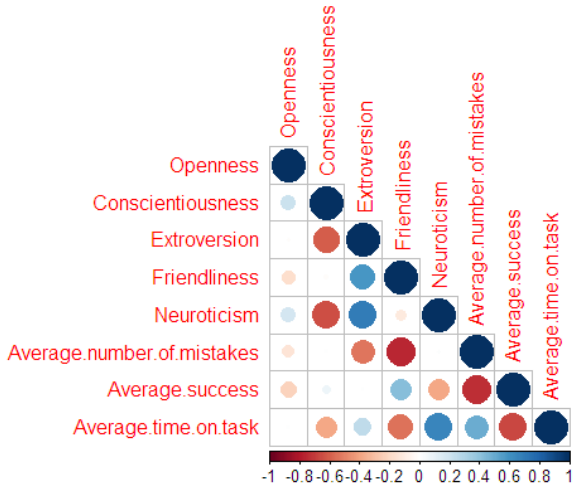

Figure 1. Correlation matrix showing correlations between the personal characteristic of the participants and some of the measured metrics.

To evaluate the value of our improvements we use appropriate metrics, such as time to first fixation, total fixation duration and also time on tasks, number of mistakes and success. We expect, that there will be higher success rates and lower time in solving the tasks.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava..

Acknowledgement. This contribution was created with kind support of ČSOB Foundation and is partial result of the project University Science Park of STU Bratislava, ITMS 26240220084, co-funded by the ERDF.

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Measuring Working Memory Capacity through the Use of Game Pexeso

Zuzana BENÍČKOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
zuzana.benicko@gmail.com

Working memory capacity plays an important role in our everyday life. The higher capacity of working memory we have, the more information we are able to process in a respective task and context. It can be said that working memory capacity (WMC) is a measure of comprehension in a given moment and is also highly in correlation with our fluid intelligence [1] and response to cognitive load. For these reasons, the capacity of the working memory is an important factor in many fields such as evaluation of respondents in experiments as well as when dealing with students in the context of teaching.

WMC can be measured through many different spans, for instance counting span, spatial span, complex span, etc. Principles of every WMC span test are to combine remembering of elements and cognitive load such as counting. Many of these tests are taken in person, and respondents and scientists spend many hours testing and evaluating the results. One of the few online and automatically resolving measures of WMC is test Aospan – automatic operation span [2] which is in this paper considered as the base score for respondent's WMC.

In this study, we aim to find a new way of measuring working memory by using a modified memory game Pexeso with mathematical problems as pairs to be looked for. The application will take less time for the respondent to fulfil its aim, gamified with the game principles of Pexeso, and educational in the subject of mathematic problems. We chose to study the correlation of WMC and Pexeso game because as a rule, it focuses on different parts of working memory. Visuo-spatial Sketchpad is responsible for remembering the position of the tile in a board, and Phonological Loop is responsible for remembering the element in the tile. When mathematical problems are added to the process, the Central Executive part of WM is also activated, as it is responsible for dealing with cognitive tasks and is also the central connector of all parts of working memory.

* Supervisor: Jozef Tvarožek, Institute of Informatics, Information Systems and Software Engineering

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The application will consist of several games of Pexeso without mathematical problems and the same number of games with mathematical problems. The game will have 3 different modes:

1. Regular Pexeso
2. Pexeso with firstly seeing one half of pairs for 3 seconds
3. Pexeso where after each successfully found pair, a letter will be shown and the respondent will have to remember the sequence of shown letters for the respective game.

Each mode will be set for five rounds in size of: 4x2, 6x2, 6x2, 8x2, and 8x2 tiles. If the first games' (4x2) results in each type will be out of measures, it can be considered a tutorial for the respondent and the data will not be included in the final valid results. The test will be carried out in 3 rounds of five games without mathematical problems and afterwards, 3 rounds of five games with mathematical problems, which altogether makes 30 games (3x5 and 3x5 games). The goal is also to find the smallest number of games needed to be played for valid results. During the experiment, the respondent has to take an Aospan test and insert the results into the form in the application.

The metrics I will study are the results of both the Aospan test and Pexeso game. The application records data from Pexeso such as the number of moves, the time each round takes, the number of remembered elements (if needed) and differentiations in time between clicks on tiles. Based on the number of moves, time of each round, and the remembered elements, I will aim to create two lists, one ranking the respondent's results in Pexeso game and the other in Aospan. If the lists correlate, it can be said that our application reflects WMC. Potential differences between clicks can show us the dynamic side of the user play and we can assume which moves were spontaneous and which were thought through ahead, which is also a quality of WMC we would like to consider. If we successfully prove our hypothesis that Pexeso with mathematical problems measure WMC, we would also like to study the participant's reaction in Pexeso through Eye tracker to look for patterns of play according to the volume of WMC.

The application was created in .NET technology as a Client-Server application with the use of SQL server. The client side was programmed in HTML, JavaScript with use of JQuery and Node.js functions in a form of ASPX. The server side was programmed in C# working with SQL database.

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Mind-controlled Application

Patrik BERGER*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xbergerp@fiit.stuba.sk

The computers have become a part of our everyday life, interaction with them is carried out mainly through the well-known ways that are mouse and keyboard. Recent progress in BCIs (brain-computer interfaces) offers an alternative. Most of the BCI systems nowadays use EEG devices to acquire the brain signal.

One of the major tasks for BCIs is to correctly interpret the acquired brain signal. The signal itself is the result of a very complex brain activity, which we do not fully understand yet. Furthermore, the acquiring ability of EEG device is limited and the signal contains a noise created by electric potentials from different parts of the body, such as eye blinks, muscle activity, or even heart beats [3].

Currently, there are three mental activities that can be presently identified with BCI applications [1]:

- concentration
- stimulus response
- imagined movement

Most of the research in that area and also our work is focused on the stimulus response. There is a technique called Oddball paradigm commonly used in the stimulus response based applications [2]. It uses target and non-target elements shown to a subject in a random order with about 80% probability of the non-target and 20% for the target element. A participant is instructed to do a mental activity such as counting occurrences every time the target element appears. That creates event-related potential (ERP) wave called P300.

In our work, we propose an EEG signal processing method in order to recognize P300 (see Figure 1). It includes selecting channels (electrodes), filtering the signal to get rid of the noise and final classification of the processed signal. We mainly focus on the channel selection part, where we propose a genetic algorithm (GA) combined with the linear discriminant analysis (LDA) to select the best subset of the channels. We want to find out whether our method will be effective enough to recognize P300 even

* Supervisor: Róbert Móro, Institute of Informatics, Information Systems and Software Engineering

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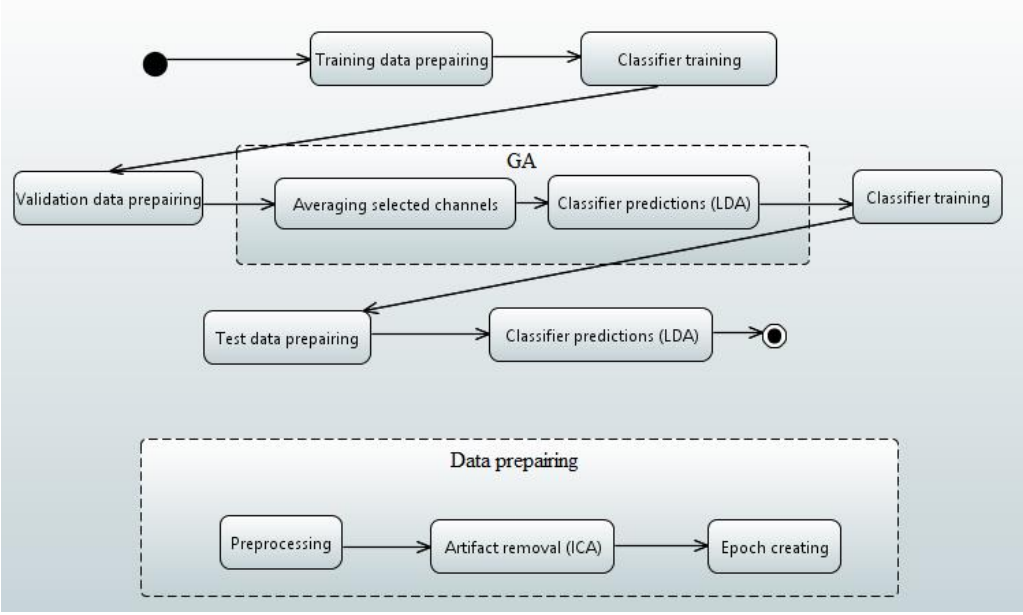
with a low-cost EEG device like Emotiv Epoc and if so, what accuracy we can get. We also want to compare our GA-based channel selection method with using all channels and with using the recursive channel elimination method, which should be able to find to the best subset (and, therefore, will be used as our baseline). We hypothesize that accuracy while using our channel selection method will be significantly better than using all channels and slightly worse but faster than recursive approach. We also assume that our method should be able to recognize P300 from the Epoc data.



Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement: This contribution was created with kind support of ČSOB Foundation and is partial result of the project University Science Park of STU Bratislava, ITMS 26240220084, co-funded by the ERDF.

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Pupil Dilatation and Stress in User Studies

Matej ČERVENKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xcervenka@stuba.sk

Internet offers more and more services and information via web pages to people. Thoughtless to complexity of content on web pages, user interface has to be intuitive, simple and users should have positive experience from using it. On the contrary, users can leave a web page and go over to the competitor. Therefore, it is really important to create pleasant user interface on any kind of application, which is used by masses.

This task is more difficult than it seems, because it requires many user experience tests of the web page, especially when the web page is upgraded to a new version with different design. There are many ways to find out if the user interface is good or bad. From simply survey on the web page to the detailed user experience testing with a participant in a laboratory. After testing in the laboratory, moderator has to analyze testing records manually. This analysis is very time-consuming process because if we want to find a problem in a user interface, it is necessary to watch whole record of the testing and focus on all its outputs. Based on experience of my supervisor, forms belong to the most problematic features of the user interface. As we assume that problematic forms have a negative effect on the mood of participant, we focus on the detection of problems during filling forms on web pages in our work. These phenomena are manifested by pupil dilation (*mydriasis*), which we are able to measure with eye tracker.

Pupil diameter is influenced by many factors. The most well-known factor is amount of light. Pupil diameter is contracted to about 1mm in bright environment, but it can dilate to 9mm, when the environment is dark. As the size of the pupil is individual, these values differ as well. In ordinary circumstances, the pupil constricts to light changes within 0.2 sec with peak from 0.5 sec to 1.0 sec [1]. Another factors are positive or negative sounds **Chyba! Nenašiel sa žiaden zdroj odkazov.**, age **Chyba! Nenašiel sa žiaden zdroj odkazov.**, cognitive load **Chyba! Nenašiel sa žiaden zdroj odkazov.**, changes in emotional state [4] and pain **Chyba! Nenašiel sa žiaden zdroj odkazov.**.

Our primary metric is pupil size. Alternatively we use emotions (using the tool Nodulus Face Reader) and skin conductance response (GSR). In our work we create forms, which should bring participants to following states:

* Supervisor: Martin Krupa ui42 spol s.r.o

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- stress
- cognitive load
- negative emotion

If we find a correlation between mydriasis and at least one of the mentioned states caused by problematic areas of forms, we will be able to determine time at which the participant had a problem. The goal is to develop a tool which determines times of problematic areas and saves moderator's time which he would spend on finding these areas.

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Evaluation of User Experience by Eye Tracking and Emotions Analysis

Mária DRAGÚŇOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xdragunova@stuba.sk

Evaluation of user experience is complex aggregate of many aspects. Since it is difficult to evaluate all of these aspects together, we focus only on the aspect of target findability on a website. Findability determines the simplicity of finding the content, which is assumed to be present on a website [2]. Efficiency and speed of the search can be measured by various visual search tasks. They are based on identifying the presence or absence of a target among several distracters. In standard laboratory search tasks, the reaction time (RT) and/or the accuracy is measured.

In our study, we examine how user's results in a visual search task are related to his results in measuring findability of an element on a website. We focus on the process of target localization on displayed screen. We assume that an accuracy of the target findability measures can be improved by taking into consideration an evaluation of visual search ability of the user.

Our aim is to create special visual search task and use it as kind of a calibration before the start of a UX testing. Our hypothesis is that the worse result in this visual search task would indicate worse visual search ability of a participant. We have to complete the following steps to prove our proposal:

1. Implementation of visual search tasks and tasks for measuring findability on the websites.
2. Realization of the controlled quantitative experiment in eye tracking laboratory using the implemented visual search tasks.
3. Evaluation of the participants' visual search abilities according to the results from the experiment.
4. Verification of the connection between participants' evaluations of their visual search abilities and their results in measuring findability on websites.

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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The quantitative experiment is planned for the UX Class laboratory[1], which has the capacity of 20 participants and all the work stations are equipped with Tobii X2-60 (60 Hz) eye trackers. Besides the eye tracking we use the recording of the mouse and keyboard events and also the events of displaying and hiding of the stimuli during the visual search tasks in our web application.

We use two measures. First, RT is a standard measure used in majority of existing visual search tasks. The second is the number of fixations prior to the indicating the end of the search. The fewer fixations to the first fixation on the target the user makes the quicker and more efficient the search is [1].

The experiment is composed of three parts, which are included in our developed web application. The two of these parts are the visual search tasks. The created standard visual search task a conjunction search for a blue triangle among blue squares and red triangles and squares. The second visual search task is our developed search task, in which participant searches for a blue round icon of the Google among other colourful icons of companies known from the web. The third part consists of the tasks on measuring findability of elements on different websites.

Collected data serve for evaluation of the visual search abilities of participants. We assume that the great range of RTs achieved on a stimulus indicate appropriateness for the purpose of evaluation of the human visual search ability. Therefore, we arrange stimuli in descending order according to the calculated ranges and we pick first N stimuli to the final visual search task (and we try to minimize N). We calculate elementary evaluations of participant for all the stimuli from experiment. These elementary evaluations express how good the participants' result on a stimulus is in compare to other participants in experiment. Median from these elementary evaluations is taken and used as a final evaluation of the visual search ability of this participant.

The better visual search ability the participant has, the higher weight is assigned. If out hypothesis is confirmed, we will be able to take participant's weight into consideration when evaluating the results of a user study. If the participant's weight is low and his results in the user study are worse than the results of people with higher weights, we will be able to suppose that his worse results are the consequence of his worse visual search ability, not the consequence of the bad usability design.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement. This contribution was created with kind support of ČSOB Foundation and is partial result of the project University Science Park of STU Bratislava, ITMS 26240220084, co-funded by the ERDF.

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Towards Automating Analysis of Eye Tracking User Studies

Peter DUBEC*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xdubecp1@fiit.stuba.sk

Usability is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to the methods for improving ease-of-use during the design process. The traditional usability testing demands testing in specialized usability laboratories and in many cases it requires test moderator or commenting work by the participant. During usability testing we are collecting wide range of data and then we analyse these data and evaluate various usability metrics in order to identify usability problems [1]. This analysis is mostly performed manually and therefore in many cases it can be very time consuming.

Nowadays usability testing of mobile applications with use of eye-tracking is realized as traditional usability testing. Therefore it requires specialized laboratory and test moderator. Also it is not possible to easily perform mobile usability testing on multiple participants simultaneously, therefore in most cases these tests are qualitative and not quantitative because we are able to collect only small amount of data. Biggest challenge during eye-tracking studies of mobile interfaces is that screens of mobile devices are very small. As study [2] suggests, at a distance of 50 cm which is typical distance from the eyes at which mobile device is held while using it, only one fixation is necessary for the brain to get an accurate image of approximately a quarter of the display. Therefore it is very difficult to use eye-tracker to collect detailed information about user behaviour during mobile application usability testing.

Although there are many factors which make usability testing of mobile applications more difficult there is different eye-tracking equipment being commercialized or investigated to make testing of mobile applications possible. Main techniques or setups applied to mobile usability testing are:

- head-mounted eye-trackers
- stand-alone eye-trackers

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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- the below table setup
- emulator setup

Our main goal is to make bulk testing of mobile applications possible. We are proposing method to achieve our goal by means of simulating mobile applications on PC and collecting data from PC. At current state testing of mobile applications is performed only with one tester at the time. We plan to use UX infrastructure available at our faculty, to make testing with 20 participants simultaneously possible.

Although interaction with PC is quite different than interaction with mobile device, we believe that we will be able to collect more precise data from eye-tracking thanks to bigger displaying screen. It is clear that there are some specific usability problems that can be identified only during testing on real mobile device, but we believe that we will be able to identify multiple usability problems also during emulation on PC, moreover thanks to better quality of eye-tracking data identify some problems that could not be identified during testing on mobile device. We plan to study correlations between quality of collected eye-tracking data and used size of projection. We are going to perform a usability study, where participants will test a mobile application in two main setups:

- testing on mobile device
- testing on PC using an emulator

During testing on PC multiple sizes of the projection screen will be used. After this study we will evaluate if there is aforementioned correlation between size of projection and quality of eye-tracking data and also if it is possible to identify usability problems also during the emulation of mobile application on PC.

Later thanks to better quality of collected data, we plan to perform automatic analysis of these data and automatically evaluate specified usability metrics.

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Impact of Characteristics of Individuals on Evaluating the Quantitative Studies

Patrik HLAVÁČ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
patrik.hlavac@stuba.sk

At present, usability tests and associated user studies are still in development. It is convenient and tempting to perform an experiment on a larger group of participants at the same time, especially only in a slight increase of time cost. Quantitative surveys are used for generalization of the results of the larger sample. When we consider that every user has different qualities, skills and experiences, we could expect that the results of testing will get different values. Recent usability studies in web domain are based on different metrics, but the question is how to apply metrics to evaluate a larger group.

Individuality, as a set of characteristics in a given establishment, distinguishing two people from each other, is considered as one of the important factors with great impact on the results of the studies [2]. Already in a study from 1989 were defined three variables most affecting the user experience: experience with the system, experience with computers in general and knowledge of the task domain. The user information behaviour is very individual and differs according to experiences, knowledge, goals, location and social contexts [1]. The basic characteristics: gender, age, position, experience, education level [3] also form behavioural change. One of the recent study about rethinking ICT (Information and Communication Technology) literacy [4] claims, that concept of ICT literacy has drastically changed in last twenty years from being very specific set of knowledge of these technologies, to its current definition of very general and transversal skill of this century. Such that, also previous simple measuring of computer use was replaced by integration the technology across educational areas and understanding it as a developmental progress in skills and thinking.

We assume that quantitative studies will provide more accurate results with information enriched with personality traits. In order to discover the different influences, we plan to conduct the qualitative experiment on a larger sample of participants. User testing could be simpler with additional information about user skills, e.g. for example web or computer literacy. In our work we try to reveal common relations between web

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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literacy and working in web environment. Especially differences in web usage by one of the groups of participants (either with higher web literacy or lower web literacy) should point us towards better understanding of basic principles of this topic.

Basic motive for the application of the method is in comparing participants with greater literacy and participants with lower web literacy. A prerequisite is to obtain information from the user's behaviour on the Web. We believe that we can discover suitable tasks to estimate web literacy of participants. Web literacy is estimated using questionnaires. We want to find basic patterns in searching for areas on the website where we take two groups of participants as a basis - experienced and less experienced. Subsequently, we plan to compare the differences in determining the position of an element, as further described in section Evaluation. We mainly focus on the variance in the response. We search for signs of correlation also in a time it takes to perform individual tasks. The duration of the experiment is unlikely to be significant because it can be affected by several factors such as the speed of comprehension, reading speed, and many others.

We have proposed an outlines for method of estimating web literacy based on the tracking of user behaviour in a web environment. This paper is dedicated to researching web literacy of ordinary users on the internet, especially on websites. User experience is verified through the questionnaire, while questionnaire consists of three parts. The first part examines literacy by selecting the proper icon. In the second part the user was asked to identify the various areas of website on examples of real web pages without content representation, so it examined literacy linked with the observation position of the various items, such as "cart" or "search by keyword". In the third part, we examined user knowledge used in practice through a questionnaire with alternative answers. Thanks to gaze tracking and speed of response we had the opportunity to evaluate their knowledge in various fields, as well as the topics that took greater amount of time.

Amended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

Acknowledgement: This contribution was created with kind support of ČSOB Foundation and is partial result of the project University Science Park of STU Bratislava, ITMS 26240220084, co-funded by the ERDF.

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Analysis of User Web Activities

Mário HUNKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
hunka.mario@gmail.com

Browsing the web is a common action for most people nowadays. People access web content via web browsers – *Google Chrome*, *Mozilla Firefox*, *Opera*, *Safari*, etc. – everybody can choose the most suitable means to browse the web. Mostly, the difference between web browsers is only in its interface and not the provided functionality. Regarding the basic functionality, according to [1], it has not changed for 19 years. Mainly, its navigation mechanisms – hyperlinks, back/forward button, URL address, bookmarks and history. However, there was one added functionality and it is browsing the web by tabs.

Tabbed browsing provides possibility of parallel browsing the web. Shortly, it means that users can work on several tasks at the same time. Considering the fact that time spent on the web is increasing [2] and its becoming more complex activity, users are expecting improvements that will ease their interaction with web browser. Complexity of the parallel browsing is supported by [3] where they analyze the time spent with 2/4/6/8 tabs opened at the same time.

Many people have a lot of tabs opened at one time. Often they keep their browser opened to not lose pages they had opened – this was reported by [1] where they found out that tabs are often used as a short-term bookmarks. While people have many tabs opened it gets messy sometimes and it is hard to navigate through them. These management of tabs can be categorized as a one of the problem of parallel browsing. We realized experiment using *RenameTab*[1] add-on to figure out if this can make parallel browsing faster and more comfortable.

There are some problems with navigation in tabs that can be removed by using this add-on:

1. Many pages have their title of the page static and no matter in which part of the page you are, the tab has the same name. This can be confusing when you have more tabs opened.

* Supervisor: Martin Labaj, Institute of Informatics, Information Systems and Software Engineering

[1] http://alexbate.co.uk/renametab

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2. Other problem can be that the title of the page is not clear for you. However by renaming the tab, you can rename it to more recognizable name, some key words for example, and by that you will be able to reach that tab much more faster when the tab is needed.

Based on these facts, we realized experiment in *Class of User Experience* with 12 people to get the data for analysis. Before that we had given a questionnaire to certain people, who were participants in our experiment, to obtain basic information about their way of browsing and to found out the topic we should have focused on.

Questionnaire was given to 14 people (8 males, 6 females) in range of 20-22 years old. All of them were students from different fields of study. There also were 4 students of informatics, others are studying fields like economy, photography, language related study etc. From the questionnaire we found out following useful information for us:

- The most used Web browser – *Google Chrome*.
- How they operate with tabs – creating, branching…
- Their own opinion about parallel browsing – advantages/disadvantages, what they are missing from web browser

In our experiment, we gather insight into navigation in tabs. Participants had to complete 2 tasks. First one was about finding the most suitable item to buy while they had limited budget. Participants were able to use *RenameTab* add-on, which can be helpful in orienting in opened tabs. In second one, they were shown several screenshots with multiple tabs opened and they have to find concrete tab according to an instruction.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava, 2016.

Acknowledgement. This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG 1/0774/16.

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Gaze-tracking Programmers' Activities in Web Browser: Revisitation and More

Miroslav HURAJT*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xhurajtm@stuba.sk

The current development of gaze-tracking methods enables us to enrich data about user work in web browser with in-depth gaze-tracking information, such as what user tracked on the screen before using some action, what were his main areas of interest, which parts of web browser he or she paid attention to and others. This missing part of information gives us new closer information about user behaviour and work in web browsers.

In our work, we have proposed and carried out an experiment with 9 participants, third and higher year bachelor students at FIIT STU, representing the sample of programmers observed while working in a web browser. In this experiment, we have found out how much time programmers spend with searching on the web while programming, which web pages they visit the most and what is the number of visited web pages while programming. We have also found out that revisitation rate corresponds with the revisitation level measured in other studies focused on common users.

The new method of measurement for revisitation in paper [1] shows, that more precise revisitation measurement and overall user activity observation can be achieved by gaze-tracking. The application of gaze-tracking brings new, more precise methods for user activity observation in compare with computer mouse and keyboard based or time observation methods which were mostly used in the past. We found that our revisitation values are approximate similar to revisitation rates in past studies. However, Figure 1 shows that revisitation values of participants who actively searched the web are higher than values in the past studies, and revisitation value level of 55% is caused by calculated average value, which includes two participants, who solved the task by heart and did not search the web a lot. Values of three remaining participants are higher because they compared two and more pages (their written code and existing solution found on the web) and revisited the pages after they had analysed the task closely. These two major causes show that revisitation values are dependent on developer's ability to solve specific task, which means the less is developer able to solve specific task, the

* Supervisor: Martin Labaj, Institute of Informatics, Information Systems and Software Engineering

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more he or she searches the web and his revisitation values are higher than revisitation values of developer, who solved specific task by heart or regular user, who searches the web more exploratively and compares less.

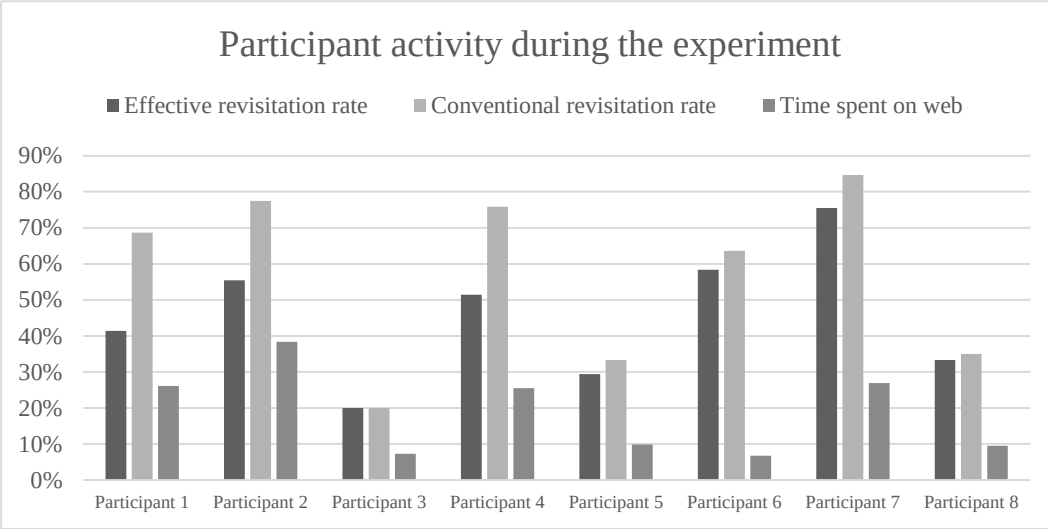

Figure 1. Revisitation rates and searching values of individual participants.

We further focus on research of revisitation mechanism method usage, supplement of revisitation method value computation and comparison of programmers with standard users. We also want to focus on web browser tabs and back button usage. We want to compare browser tab usage between regular users and developers and to focus on usage rate of back button in modern web browsers.

This analysis provides us the necessary base insight s into user activity and can help in web browser course of development in the future in the field of revisitation mechanisms such as tabs, back button, and the new ways of navigation as essential part of web browser usage.

Our results could also help in simplifying and speeding up user work in a web browser by offering detailed user behaviour analysis in web browser. This analysis can contribute to development and result in feature implementations focused on speeding up or simplifying web browser usage by providing information related to web browser components, namely revisitation mechanisms.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Search Query Expansion based on User's Intent Derived from Eye Tracking

Patrik JANUŠKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
januska.patrik@gmail.com

Internet has become an integral part of everyday human life. Millions of users interact with various search engines on a daily basis. Man as a user searches internet Web pages for required information. Queries, characterizing wanted information, are entered into browser interface by users. Search engine then returns list of relevant pages, based on its own database, containing wanted information. Users visit these pages, spend some time on them, click on ads, modify queries and perform other actions. Query represents key part of information retrieval. In this context, query is defined as word or group of words describing or characterizing retrieved information. Biggest problem we face is creation of said query, whose execution results in relevant information and thus retrieval success. Main goal of browser is to provide user with the most relevant information from query result. However, user doesn't always find resulting information relevant.

Recently, a wide variety of studies on information retrieval (IR) have focused on tracking users' eye movements, and the use of high-performance cameras or eye-trackers has made application of this technique much easier than before. The method we propose in this work can be regarded as a type of implicit relevance feedback because it estimates a user's search intent implicitly from data about where the user looked while browsing Web pages [1].

"In this work, we capture the precise query context by analyzing at what document parts the user looked immediately before issuing the query. Therefore, we implemented four different methods for extracting query expansion terms based on gaze-based feedback, and one baseline extraction method not considering such feedback. They are all based on term frequency and inverse document frequency (TF×IDF) scores of the document terms. The four variants described in the following are compared against each other in our evaluation.

* Supervisor: Eduard Kuric, Institute of Informatics, Information Systems and Software Engineering

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- The Baseline method simply uses TF×IDF on the entire document and extracts the highest scoring terms.
- The Gaze-Filter method applies the score calculation of the baseline method (TF×IDF) only on gaze-annotated document parts. So, it just ignores all document parts without a gaze-annotation.
- The Gaze-Length-Filter method is an extension of the Gaze-Filter method. It ignores all not gaze-annotated document parts and calculates an interest score for every viewed term t as follows:

$$\text{interest(t)} = \frac{\text{LA(t)}}{\text{LA(t)} + SA(t)}$$

SA(t) is the number of gaze-annotations shorter than 230 characters the term t appears in. LA(t) is the number of longer gaze-annotations containing t. The interest value for a term t is then multiplied by its TF×IDF value.

This heuristic takes a length of 230 characters for the differentiation between long and short annotations since we think that shorter text parts rarely convey sophisticated ideas and concepts to the reader. The heuristic assumes that a person reading a part of a text shorter than 230 characters (i.e., it is a way of scanning) is not interested in the contents of this part. Therefore, it assumes that terms also contained in short viewed text parts do not characterize the current interest of the user very well and gives them a lower interest value. [2]"

- The Gaze-Length-Filter-Extended method is an extension of the Gaze-Filter method. This method considers also number of fixation for a specific word and pupil size during this fixation.

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Robust Detection of User's Cognitive Load Using Personalized Pupillary Response Model

Tomáš JUHANIAK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
juhaniak.tomas@gmail.com

Measuring of cognitive load can be done by plenty of ways, but it is important to make it non-intrusive and in real time. If we want evaluate real applications, we need a tool with an ability to measure cognitive load in complex long-term tasks, with big amount of participants, without requirements of human expert or laboratory environment (except keeping eye-tracker). Moreover this all have to be done fully-automated for arbitrary real, non-preprocessed tasks.

Eye-tracking is non-intrusive method for evaluating in field of human-computer interaction, and if we admit less fidelity it is usable out of laboratory environment. Especially the pupil diameter provides information about the cognitive load in every moment instead of other cumulative methods [1]. This helps in situations, when we cannot define margins of tasks but only their center. This technique seems as a best-fit universal and robust candidate for non-intrusive measuring of the cognitive load.

Pupil dilation (as result achieved by eye-tracking) in its own accord does not need to signalize cognitive load, moreover under some special conditions, a situation can occur when the pupil will contract and the cognitive load increases concurrently. Among all factors influencing dilatation, the most problematic is the changing luminosity of the screen content [2]. If we want to successfully filter out luminosity, we have to know how the heterochromous parts of the stimuli influence the dilatation of a pupil depending on the fixation area. There has not been much effort put into researching this field so far.

The contribution of our work is a method for evaluating cognitive load based on personalized pupillary response model (PPR model) and absolute values of pupil diameter. This goal can be achieved with calibration of PPR model on many stimuli with different luminosity values. Next, while the tested person work on their tasks, we record the presented stimuli and compute their luminosity with consideration of the fixation area. With the help of PPR model, we predict the actual pupil diameter or the trend of

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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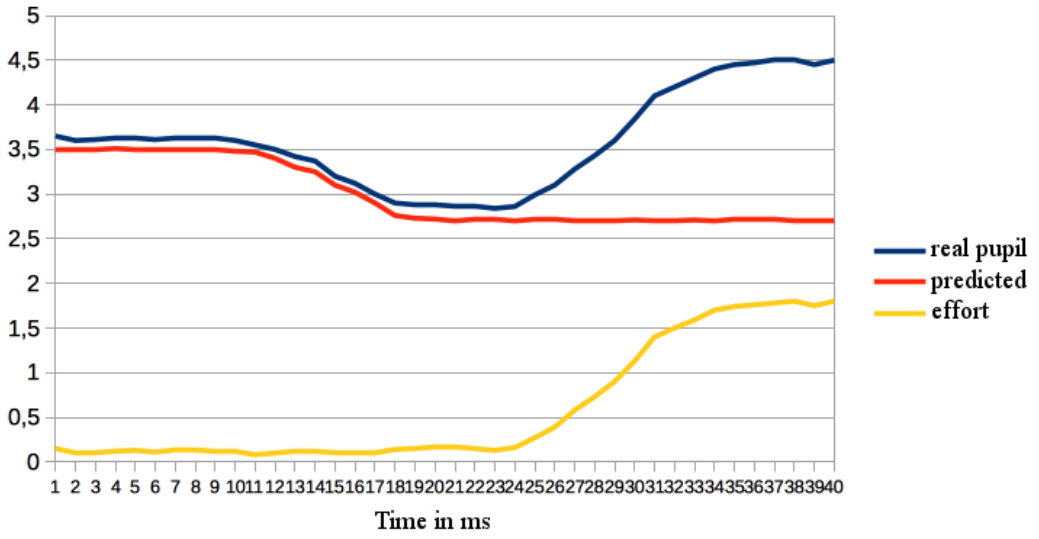
pupil dilation. The difference between measured and predicted values is filtered out according to psychological factors as is shown in figure below.



We found that the range of reference curve exceeded one millimeter for every tested person. We found, that standard error of predicted pupil diameters will not exceed 20% of the luminosity dilation range in plain and complex stimuli too and cognitive dilation range seems to be almost the same as the luminosity, our dynamic method can attempt to distinguish at best 5 levels of cognitive load.

Amended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Learning by Playing: Generated Programming Exercises to Teach Programming the Innovative Way

Peter KIŠ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
koritnak@gmail.com

Lack of motivation of students is one of the main barriers to efficient learning [1]. In the case of online learning there are also suppressed natural human and social aspects, so the lack of motivation causes even worse results. Therefore, research is still looking for new ways to increase students' motivation for learning online. Games and gaming principles improve entertainment and increase overall involvement of students [2]. Both of them are increasingly used in the online environment. Use of games and game principles, graphical visualization, and entertainment content for teaching programming opens the way to explore the impact of these elements in the learning process, the speed of acquiring new knowledge and the ability to select the most appropriate procedures for solving algorithmic problems [3].

Considering the typical source code writing exercises are already well implemented in teaching programming, we decided that in our work we will focus on creating novel types of programming exercises through the use of existing codes that students produced over the past years. For new students, we want to prepare a diverse range of tasks from these codes, aimed on the understanding, analysis and description of the code, the code refactoring and use of best practices in programming. We plan to include these innovative tasks into created environment, designed to let students compete against each other.

This work is focused on creating games or the use of gaming techniques and principles in the online environment to support learning. The main objective of this work was to create educative game, which by their nature and offered tasks propose new, engaging and students accepted form of education along conventional teaching style. We present motivation as one of the factors influencing the process of learning. As an option to achieve enhancing students' motivation for the study is an approach

* Supervisor: Jozef Tvarožek, Institute of Informatics, Information Systems and Software Engineering

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using games. We present games as support, but also as a source of motivation to learn new things. The result of the analysis is the creation of educational environment (Figure 1) with and interactive format tasks automatically generated from existing source code that students created for school assignments on selected subjects.

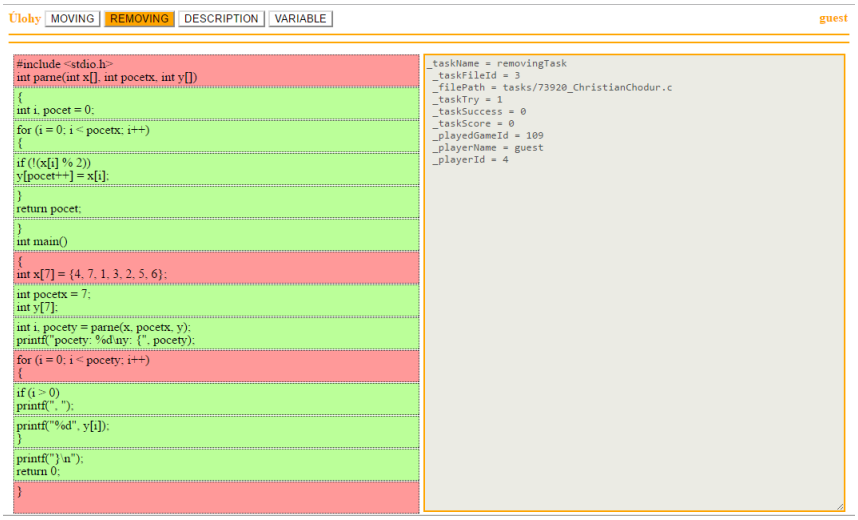

Figure 1. Screen of prototype while Removing task was played.

In the experiment, we plan to acquire multiple data describing level of students' knowledge of programming in language C and evaluate the benefits of our games on their knowledge. Likewise, we want to get feedback from students on individual tasks and identify those with the biggest benefit when used in the educational process.

Amended/Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Automatic Estimation of Software Developer's Expertise

Eduard KURIC*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
eduard.kuric@stuba.sk

Expert recommendation systems in software engineering help to locate (discover) and to recommend individuals (experts) who have appropriate expertise on a given source code artefact [2,3,4]. Estimation of developer's expertise can be a valuable asset for a software company. It can be beneficial in the planning of a software project, especially in assigning development tasks. The time required to implement a new functionality, to change an existing functionality, or to fix a bug can be significantly reduced if the (issue) task is assigned to a developer who knows corresponding source code.

Despite different automatic expertise metrics were proposed we are not able to determine which metrics most reliably reflect developer's expertise. The crucial problem in comparing expertise metrics is the lack of a clear baseline with which to compare the metrics to each other. Another problem is that there are many competing definitions of expertise in literature. Many determinants may influence developer's expertise, e.g., knowledge of programming language and technologies, abilities of applying design patterns, a level of testing, and familiarity with documentation. Different approaches are required for establishing specific knowledge and skills.

Developer's expertise can be defined as a degree of his/her familiarity with a software system (software project), respective to other developers of the system [1]. Existing approaches to estimate developer's expertise on a part of a software system rely on the assumption that a number of lines of code committed by a developer reflects his/her expertise on that part of the system. However, we believe that in addition to the amount of final code we should also consider how much effort he/she put into implementation of the code.

In our work we propose an automatic approach to identify and to recommend an expert for a given development task of a software project that considers both a degree of developer's familiarity with the task and its corresponding source code, and his/her development productivity.

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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A software system can be viewed as a body of knowledge decomposed into a set of fragments called conceptual concerns (topics). We estimate developer's familiarity with the software system at level of topics. We build a topic model to extract topics from codebase of the system. A degree of developer's familiarity with a topic is estimated from his/her code contributions to source code of the topic.

We estimate developer's productivity as complexity (size) of code changes performed by the developer per time and the amount of effort he/she spent to perform the changes measured through his/her development activities.

We also propose an approach that maps tasks in natural language to topics inferred from source code. To recommend an expert for a topic we combine developer's familiarity with this topic and his/her development productivity.

We evaluate our approach in three environments - an open environment (open-source projects), a commercial / closed environment, and an academic environment. The results indicate that by using our approach we are able to recommend developers who are competent to participate in and contribute to resolving newly created tasks. By recommending the right person to a given task we can reduce the overall time needed to resolve the task of the extra time that a developer would need to become familiar with the task and its corresponding code.

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Automatic Evaluating Usability of Applications with Eye-tracking Technique

Lenka KUTLÍKOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xkutlikova@stuba.sk

Nowadays working with computers is part of our lives. Every day we check new emails, read the news or find useful information for school or work. We visit the big amount of websites with different purpose. Some of them are better than the others. We can assess how good the website is by testing usability. It is very discussed topic nowadays. Applications with better usability are more interesting and useful for people. There are several ways how to test usability. Evaluating of these methods are mostly manual thus unsuitable for big experiments. One of the new techniques for testing is to track where the people are looking on screen. Eye-tracking is relatively modern technology and it is used in a lot of different areas in research. According to eye movements we can assess quality of interface, identify usability problems or diseases and a lot of more. Eye-tracking is also very promising for disabled people because they can control the user interface only by their eyes.

There are a lot of studies connected with usability testing. Researchers use a lot of different metrics to assess the application. These metrics differ a lot from one study to another. Researchers try to find connections between metrics and usability problems. It can be hard to find the right explanation. For example if the user is looking on the certain object for a long time it can mean that this object is important for him [1]. But this also can mean that this object is only hard to understand for him.

Other studies are focused on connection between eye movements and reading the text. Our work is focused on finding if the users read the text or not. From the perspective of eye-tracking reading is sequence of fixations on words linked by saccades from left to right (in some languages reversed) [2]. Difficulty of the text can be assessed by three eye-tracking metrics: fixation duration, saccade duration and number of regressions. Generally, long fixations, short saccades and many regressions signalize that the text is difficult for readers [2]. Related studies are focused on different reading comprehension tasks or impact of highlighting or alignment of text to eye-tracking metrics. According

* Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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to study [3] users are not reading. They are only pass their eyes through text and scanning for important information.

One of the goals of this work is to find new model of connections between eye-tracking metrics and reading text.

Pilot experiment is designed. It is focused on testing user behaviour during reading instructions. People usually do not read them. Even if there is an manual for product, game rules or instructions for filling questionnaire or doing an experiment people firstly try to do it on their own without reading instructions. They go back to them only if they do not know what to do. The goal of our research is to find if people read instructions. We suppose that eye-tracking metrics indicate that users read them.

The experiment consists of four tasks. For each task we can find if participants read instructions or not. For collecting data we plan to use eye-tracking technique. During experiments and also in real life users often don't read instructions. When they are doing experiments it can skew results and the experiment is discarded. The main goal of this experiment is to find if users read given instructions. It consists of four parts with different simple tasks. Before every part there are instructions. Tasks are well-known for people so they are able to do them also without reading them. The first one is Brick Breaker game in which users should move the paddle horizontally to the left and to the right in order to hit the ball. The second one is non-verbal reasoning test with 10 tasks. The third one is the crossword where users should mark only horizontal words. The last task for users is to play Snake where they should take 15 points and end the game. Results from this experiment can help researchers to identify biased results and achieve higher quality of them.

In our experiment we would like to find eye-tracking metrics which help us to identify if users read given instructions. For our experiment there is one hypothesis to confirm: Eye-tracking metrics indicate if users read given instructions. Because of eye-tracker produces the big amount of data we plan to find way how to process them automatically. According to results we would like to find an automatic way how to assess difficulty of instructions. Since we have two variants of experiment (with and without highlighted text) we can compare these variants and find if highlighted parts help people to read and understand instructions.

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Evaluating the Usability of Applications Using Gaze Tracking

Vladimír ĽALÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xlalikv@stuba.sk

An important part of software development is properly designed user interface, because poor usability is not tolerated by users who simply choose another application, especially in web applications. Users should be able to interact with application with ease, regardless of level of complexity of the application logic [1]. The best way how to determine level of usability in an application is user testing with real users, because it provides direct information about how people use application and it shows to us problems with the specific interface being tested. There are several usability methods that can be used to obtain data from testing. We can use this data to identify usability problems in interface design and then developers can perform the necessary changes in interface design [3].

Now we can use eye tracking to obtain more information on what draws the attention of users or where the users search for information in application. Eye tracking is technique which record eye movements while user is looking at stimulus. The eye tracking is an appropriate usability testing tool because of eye-mind hypothesis, which infers the link between what a person is looking at and their cognitive activities [2].

First step in our research was to conduct usability study which consist of 5 different tasks in web application of three mobile operators. We were using eye-tracking and also we were recording participants screen and mouse, keyboard events. Six participants joined this study and then we make a qualitative evaluation. Based on the results of this study and also based on another research in this area [1][5] we picked up few usability problems in web interfaces and eye-tracking metrics which we used to design rules for identifying this usability problems. We aimed on three usability problems which are action buttons or links which design or label is confusing for user and second problem is the wrong position or design of error page which appears after form validation, so is hard to notice this message for user. The third usability problem is the page in which user expect some information or functionality, but this page does not provides such

* Supervisor: Jakub Šimko, Institute of Informatics, Information Systems and Software Engineering

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information. This usability problems were also described in *Claudia Ehmke's* research [1]. For each of these three usability problems we define rules consist of eye-tracking metrics which creating patterns together with mouse and keyboard events and also positions of areas of interest. In our case areas of interests are DOM elements of webpage. In our method we are using large scale of metrics like time to first, fixation, duration of fixations, length of saccades, percentage of reverse saccades, convex hull area of scanpath, transition density[4] etc.

We conducted another experiment which was aimed on this three usability problems. Experiment have two versions with ten tasks and each of this task was in different web application. Half of the web applications was edited so it contains one of these usability problems. After each session with participants we show them a record of their screen with fixations and make retrospective think aloud to obtain more information about their decisions and behavior. We have 7 participants and we evaluated this study qualitative, but also quantitative with metrics which was computed by our method. Based on results we conclude that our method can identify proposed usability problems and we improved our method by creating more specific rules for identifying usability problems.

The final experiment which had quantitative character have same structure like the previous one, but it was coupled with more tasks. In this session fourteen participants take apart. Data which we obtain was analyzed by our method and it was able to identify confusing button with precision about 80%. Error message after unsuccessful validation which was harder to notice for participants because of design or wrong position was detected with precision 79%. We are also able to determine whether page have expected information or not, but not in all cases, because we notice similar behavior on homepages when users try to find demanding link in menu. Because of this it is hard to tell if it's right detection or not. We also make a statistic t-test to prove that metrics which we are using are significant or not. This t-test also prove that our hypothesis was correct and it is possible to identify quantitatively this usability problems with eye-tracking metrics which we proposed.

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Emotion Detection using EPOC EEG Device

Tomáš MATLOVIČ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
tomas.matlovic@gmail.com

Due to the growing need for computer applications capable of detecting the emotional state of the users [1], studying emotions in informatics has increased. The direct options of detecting the emotions are inquiries and questionnaires with specific questions which participants answer on the Likert scale. Because of the fact that every participant has to answer all the questions and those need to be manually evaluated, it is not a very efficient method. That is the reason for inventing new methods for classifying emotions for example through physiological responses.

Motivated by every day interaction among humans, a great part of the research in this area has explored detecting emotions from facial and voice information. One of the available software solutions is *Noldus FaceReader*[1], which can recognize six emotional states: joy, sadness, anger, surprise, fear, disgust, and a neutral state. However, it depends on good light conditions and the accuracy could be also decreased by an object covering part of a participant's face, e.g., glasses. In order to address these shortcomings, other approaches to detect emotions have been proposed which focus on different physiological information, such as heart rate, skin conductance, and pupil dilation [2].
A still relatively new field of research in affective brain-computer interaction attempts to detect emotions using electroencephalograms (EEGs) [3].

In our approach, we aim to evaluate EEG devices Emotiv EPOC and Emotiv Insight and classify emotions from the data captured by this devices. Our method is based on the method was used by the psychologists. In order to represent emotions we use dimensional approach [4] which is based on the fact that all subjective feelings could be projected into the 3D space where dimensions are: (*i*) *arousal* – positive/negative emotion, (*ii*) *valence* – strong/weak emotion, and (*iii*) *tension* – tensed/relieved emotion.

We omit the third dimension due to the difficulty of determining the amount of tension. When classifying emotions by this method, respondents identify how positive (valence) and how strong (arousal) was their emotion. These values are projected to 2D space, called Valence–Arousal model, which could be divided to four quadrants: strong-

* Supervisor: Róbert Móro, Institute of Informatics, Information Systems and Software Engineering

[1] http://www.noldus.com/human-behavior-research/products/facereader

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negative emotions, strong-positive emotions, weak-negative emotions and weak-positive emotions. We try to compute valence and arousal from EEG signal and use them as one of the features for machine learning algorithm to recognize specific emotions.

Our method could be divided into two steps. First we apply linear regression in order to predict valence and arousal from EEG data. Then we use support vector machines to classify six emotions: joy, surprise, sadness, fear, disgust, anger and neutral emotion. The preliminary results on an existing dataset show 37.72% accuracy of our approach. In addition, we replicated the experiment within the dataset was created, in which participants watched music videos and answered the questionnaires about emotions they were feeling. We used EEG devices to capture the electrical signal from their brains.

Firstly, we held a pilot study with two people. Then nine participants took part in our study with Emotiv EPOC and three people with Emotiv Insight. As we do not have enough date to split them into three sets, we used cross validation technique to evaluate our method. Results of analysis show performance 53% of classifying correct emotion with Emotiv EPOC and around 40% with Emotiv Insight. As the next step, in order to verify the potential of the Emotiv EEG devices for classification of the emotions, we plan to compare these results with one of the existing tools, namely Noldus FaceReader.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Universal Tool to Assign Badges in Online Communities

Martina REDAJOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xredajova@fiit.stuba.sk

The application of gamification is becoming a widely used technique of an activity motivation not only in learning process in educational domains, but also in other domains with no such purpose. The main goal of various gamification mechanics is to motivate users to visit a system, be active in this system and to have reason to come back regularly.

There are many types of game elements used to achieve this, such as leaderboards, storytelling, achievements and application of levels and badges.

In our work, we chose assigning badges as main mechanism to be used in domains improved by gamification. Badges are digital artefacts that have some visual representation, and which are awarded to users after completing specific activities [1]. It´s part of popular gamification pattern called *"ownership"*. Ownership allows user to own thing, such as badges, tokens, points, since it creates loyalty to the application or community [2]. Assigning badges means rewarding users by considering their level of activity in online community. The efficiency of badges is often doubted based on unsuccessful attempts to use it in certain communities. However, this efficiency is often affected by the initial set up of boundaries and choice of activities users should be rewarded for [3].

Unfortunately, current market is not providing adequate support for dealing with this problem. There is just a few tool created with intention to help creators of domains to add assigning badges to their site, creating their own design, and there´s even less tools which specify correct choice of activities or creating boundaries that increase efficiency of badges.

In our work, we focus on front-end development of universal tool for assigning badges. Our main intention is to create user interface that provides enough support for domains creators, focusing on creating correct rules for assigning badges and creating custom design of them.

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* Supervisor: Ivan Srba, Institute of Informatics, Information Systems and Software Engineering

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To provide this, we created user interface enriched by specifically proposed visualization of users´ activities. This visualization involves for example column charts displaying number of community members in relationship to executed amount of certain activity or visualization of popularity of specified activity during chosen period.

Our user interface of badge assigning web tool provides:

- Management of created badges
  - Display list of created badges involving basic details of individual badge
  - Display full detail of badge involving statistic results of efficiency and visualisation of it
  - Editing badges
- Removal of existing badges
- Creating badges
  - Creating new group of badges
  - Adding badge to existing group
  - Setting up boundaries manually or using interactive visualization
  - Creating basic details of badge, as choice of icon, name, description
- Management of activities
  - Adding new activity to system by its id
  - Assigning name to existing activity by its id

There is just a limited number of options for testing of our project.

First option is to test this user interface in universities´ UX Lab, using eye-tracker to measure usability of each part of the interface. However, for good results is necessary to test several subject with small amount of experience with gamification mechanisms and we considered this as not possible and insufficient in our conditions.

Second option is to test our interface with one testing subject, who has lot of experience with gamification mechanism. During completing simple tasks in our interface subject should consider usage of this tool and review its contribution to process of creating badge hierarchies or point out the places for improvement in it.

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Explicit User Input Quality Determination Based on Implicit User Input

Metod RYBÁR[1*]

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
metodrybar@gmail.sk

Implicit feedback can provide us with information that we can use to help us evaluate online questionnaires. Using this information, we could eliminate number of necessary explicit feedback and we can better evaluate the results. This would allow us to simplify the questionnaires and also improve the result quality. Explicit information from the user may be incomplete or misleading. This is currently being dealt with using complicated questionnaires and forms asking the same question multiple times differently, to avoid getting misleading information.

Using implicit measures as pupil dilation or eye-tracking we have created first model for deception detection in environment of online questionnaires. We are currently working on verifying of our first results and creation of new metrics, that can be used to improve our model, based on galvanic skin response or EKG.

Lying is part of everyday life. According to studies, people use lies at least once or twice a day. Most common are lies about personal preferences and feelings, but people are also lying about their actions and plans or achievements and pitfalls. People tend to lie more often if they can get psychological reward from the lie and less often if they are trying to avoid punishment [1].

According to meta-analysis which analyzed 116 of different studies with 120 of different samples, there are at least 158 different metrics that were tested if they can be used for deception detection. However most of these have only weak or none links to the deception detection [1].

To propose our method, we needed to collect implicit user data for analysis. Our criteria were, that these data should be good indicators of cognitive load and deception and should also be easily collectable from user when they are filling out online questionnaires. Based on our research we picked as our main source of data an eyetracker, which can provide us with information about the region of the screen user is looking at, his fixations and saccades, response times and also pupil dilation. It was

[*] Supervisor: Mária Bieliková, Institute of Informatics, Information Systems and Software Engineering

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demonstrated in [2] that eyetracking can serve as deception indicator. Pupil dilation is good indicator of deception and cognitive load according to several studies [3].

To collect the data, we used infrastructure available in Faculty of Informatics and Information Technologies of Slovak Technical University which consist of laboratory with 20 computers equipped with Tobii Pro X2-60. These eye-trackers are capable of collecting 60 information per second about each of the user eye position and pupil dilation.

The infrastructure also can collect data synchronously from eyetracker and questionnaire system. This was used to tag the eyetracker data with events and user interactions in questionnaire system. We also used more options that our infrastructure provided us with. Along with the eyetracker data, we were also collecting video from the users' screens and keyboard and mouse interaction with the computer.

Accuracy of our model is not yet sufficient for reliable deception detection, but with more metrics retrieved and added to our model we expect it to get better. It is important to point out, that we can rate every answer from questionnaire as truthful or deceptive, so if we want to tell if entire questionnaire is answered mostly truthfully, lower accuracy is needed as if we wanted to point to deception of concrete answers. In near future we therefore see more potential in using our or similar models to evaluate questionnaires as a whole.

Extended version was published in Proc. of the 12th Student Research Conference in Informatics and Information Technologies (IIT.SRC 2016), STU Bratislava.

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Analysis of Reading Difficulty in Web Environment

Martin ŠTRBÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xstrbak@fiit.stuba.sk

Software development is an ongoing process consisting of requirements gathering, design and implementation of individual modules of the system. Despite the best efforts the requirements all future users cannot be met. There is no best design or configuration. An important feature is to be able to understand users' needs and based on that, we can modify the content, appearance, and applications behaviour. For us, the most interesting are Web applications. Personalization of Web pages is done by collecting the characteristics of the individual, his hobbies and search queries, how he interacts and how long he has been on the page. Further information can be obtained using questionnaires, but they are perceived as annoying and also might not be objective.

Website also contains large amounts of text, which has a certain size, font and text density. One person prefer larger text written Serif font, another on the other hand dense writing, but more paragraphs. Reading analysis consists of recording the movement of the eye, from which we derive valuable information as subject reads. The process of reading is a cognitive activity, which can be recorded by EEG and processed. It can be assumed that a person reading the more difficult text demands a higher concentration than reading of a simple text. Analysis of measurements of multiple documents in different classes of complexity can provide us additional information to user modelling, which helps us to specify the content provided [1].

We assume that the amount of textual content on the Internet will only increase, and so will information congestion of readers. They do not know in advance whether the article he plans to read is written vaguely, if he expects scientific work. Different person might find the same article as satisfactory. If we can grade the text complexity, we could provide more accurate recommendation.

Textual complexity might be based on multiple factors [2]:

- Text structure

* Supervisor: Marián Šimko, Institute of Informatics, Information Systems and Software Engineering

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- Semantics
- Errors
  - Grammar
  - Typos

We will focus on errors, mainly typos, where few letters in words are mixed. Text will be simple by any other means, for example, using only frequent words with average length. As study [3] suggests, with EEG we can distinguish reading from other mentally not difficult activities. Next, they have find out that even different kinds of text content can be known. Some irregularities occurred due to face muscle inducted noise. We assume, that errors distract human reader, and any focus needed to regain text context, will result in more cognitive load.

EEG is device used to measure electrical impulses generated by brain. Unfortunately, this offers poor signal-to-noise ratio. We can use band pass filter to obtain only frequencies in 1 – 30 Hz, which is known to be the most important part of the signal. However, some artefacts will remain:

- Artefacts of heart activity
- Artefacts invoked by eye movement
- Artefacts invoked by muscle contraction

To get additional information about reading, eye-tracking device is being used. This way we can map EEG signal to text being read. After this study, we will better understand how errors correlate with cognitive load and user experience.

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Automatic Segmentation of a Screen Recording for Scene Identification

Jakub Benjamín VRBA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
xvrba@fiit.stuba.sk

Users are daily interacting with several application or websites, during their work with computer. Usability of these products represents how difficult is to use them. Nowadays it is really important to concentrate on creating interfaces, that are easy to use, because when users are having difficulties with reaching their goals, other solution is waiting just around the corner [1]. User experience is a term describing how users subjectively perceive these systems [2].

Usability testing allows us to evaluate to what extent are interfaces usable. Traditional method of testing applications demands user to be spectated and his behavior is evaluated by researcher manually. This approach may be applicable only with small number of participants – qualitative research. For quantitative test, in which tens of users participate, would be this type of evaluation challenging. In consequence, it is needed to gather data about user interaction from eye or mouse trackers and evaluate them afterwards.

In a phase before analysis, it is necessary for researcher to identify scenes in screen recordings. Scene represents time segment of a screen recording video, during which the examined application remains on a single screen and where monitored areas of interest can be considered static. Scenes are crucial for mapping individual occurrences of a particular application screen into a single entity, which allows the computation of aggregate eye-tracking metrics. At the present time, scenes are annotated manually, that means researcher must go through every recording.

Purpose of this thesis is automatic segmentation of a screen recording for scene identification, for the sake of making this process faster and easier. Our specific goal are usability tests, which were performed on mobile devices. Our data contains screen recordings of these devices and also users activity (fingers). Image processing is ideal technique for implementing this automation. To be specific two approaches were identified:

* Supervisor: Jakub Šimko, Institute of Informatics, Information Systems and Software Engineering

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1. supervised approach
2. unsupervised approach.

In supervised approach input from researcher is needed. Specifically, he needs to identify scenes from one video and these scenes will be found on other recordings. That means he does not need to go through all recordings, but one. For this purpose methods of image comparison are used, to determine how similar two images are. On the other hand the unsupervised approach is based on cut detection methods. In this case user will be presented with multiple scenes, where he will select which static image should be considered as a scene and which should be not.

In conclusion, this approach is not automatic too, but the problem of annotating scenes is too complex to be fully automated. The main reason behind this statement is, that what is considered to be a scene is very subjective and depends on what the researcher want to study (in one research it could be ads, in the other it could be menu). This is also related to definition of a scene, where area of interest cannot be interfered and area of interests differ from research to research and cannot be generalized.

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Accompanying Events

Experimentation Session Report

Ivan SRBA

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
{ivan.srba}@stuba.sk

1 Motivation

One of presentations given this year at PeWe Workshop was dedicated to discovering collective intelligence and wisdom of the crowds. We can consider our research group PeWe as an excellent example of small community where each member focuses on a specific topic and thus it is possible to gather an enormous collective intelligence. We utilize this phenomenon not only during regular weekly meetings, when we mutually try to help other PeWe members with their bachelor or master thesis, but also during PeWe Workhop. More specifically, it is a great possibility to employ crowdsourcing techniques in order to perform experiments with a larger group of participants.

Following three previous successful experiment sessions at the *Spring 2013 PeWe Workshop* [1], *Spring 2014 PeWe Workshop* [2] and *Spring 2015 PeWe Workshop* [3], we decided to continue in this tradition and organize another experimental session also this year. Similarly as in the previous session, our main aim was to turn PeWe Workshop into a real-world crowdsourcing platform. During several hours, experimenters had a possibility to conduct pilot experiments in order to collect preliminary results and useful feedback that will hopefully help them to prepare larger experiments and finish their theses with outstanding research results.

2 Experiments

The fourth experimentation session during the *Spring 2016 PeWe Workshop* consisted of 6 experiments that together resulted in hours of active participation of many workshop attendees. The experiments were very diverse and some of them even utilize the state-of-the-art devices for UX studies (e.g. eyetrackers or devices for measuring EEG signal). In particular, participants during the experimental session measured their working memory, cognitive load while solving math tasks or even EEG signal while watching short music videos. Other participants create a domain model of mammals, find the worst comment evaluated by a service for low-quality content detection or test usability of different web interfaces.

Results of this experimentation session will contribute to the successful bachelor and master theses finalization. We believe that it will help the students not only to finalize

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their work on theses, but also to prepare their main research contributions in form of research papers and submit them to the international conferences or peer reviewed scientific international journals.

2.1 Playing Pexeso in different modes and Aospan test

Experimenter: Zuzana Beníčková, Experiment supervisor: Jozef Tvarožek

The aim of the experiment was to collect results from test Aospan together with data from several games of Pexeso. Experiment was anonymous; data were combined only through ID of measure. The experiment was conducted in order to evaluate our research on bachelor project named Measuring Working Memory Capacity through the Use of Game Pexeso. After game, we asked participants personally for thoughts and improvements.

The application consists of 15 games of Pexeso in different size without mathematical problems and the same amount with mathematical problems. Together 30 games in 3 different modes:

1. Regular Pexeso;
2. Pexeso with firstly seeing one half of pairs for 3 seconds;
3. Pexeso, where after each successfully found pair, letter will show and respondent needs to remember sequence of letters for particular game.

Each mode is set for five rounds in size of: 4x2, 6x2, 6x2, 8x2, and 8x2 tiles. The goal is also to find the smallest amount of games needed to play for valid results. During the experiment respondent made Aospan test (extern test) and inserted results into the form in application, after that, Pexeso was played (see Figure 1). In Pexeso game we were recording time of the round, number of moves, number of remembered elements (if needed), time differentiations between moves and combining these results with result in Aospan.

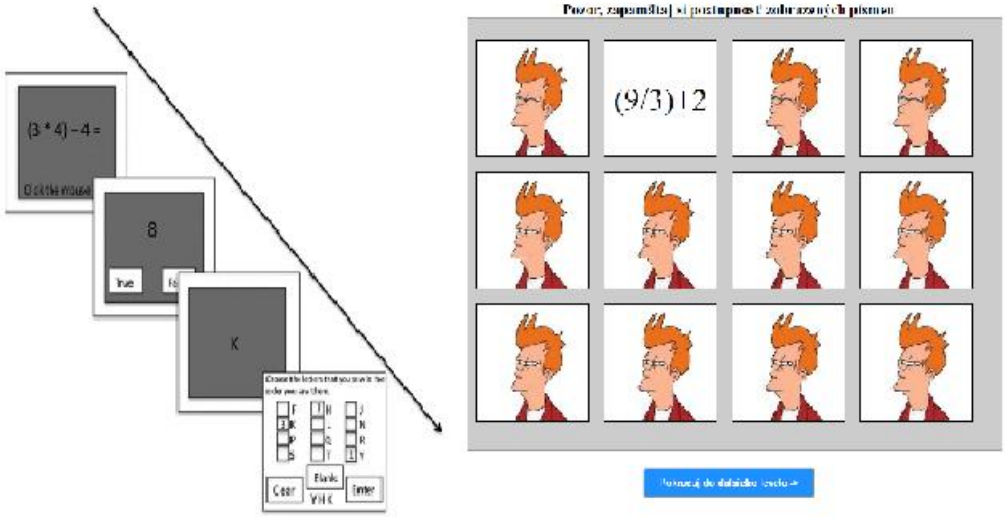

Figure 1. Aospan test and Pexeso game.

The experiment had 19 participants who performed together more than 570 rounds of Pexeso and spent almost 4 hours playing. As a result of experiment, we collected many useful suggestions for additional improvements in future experiments, such as prolonging time of flipping back pairs after second click on tail, including specific instructions before each type of game played, to change showing inputted remembered letters from stars to letters, to remove button and blank button for inputting not remembered letters or to alter the order of Aospan test and Pexeso. Data from test and games were included in further analysis of working capacity measurements also represent a starting point for additional research.

2.2 Mind-controlled application

Experimenter: Tomáš Matlovič, Experiment supervisor: Róbert Móro

In our experiment, we measured participants' EEG signal with Emotiv Insight device, while they were watching music videos. Purpose of our experiment was to create a dataset, so we can use it to classify emotions from EEG signal and then compare our results with performance of another EEG device, Emotiv EPOC, and with existing tool for classifying emotions from face expressions, namely Noldus Facereader.

Three participant took part in our experiment. Every participant watched 20 one-minute-long music video highlights in the same order, but we try not to present similar videos in a row. Every video should evoke one dominant emotion. Before each video, fixation cross was projected for five seconds and after each video participant answered questionnaire with 3 questions:

1. How strong was the emotion that you felt?
2. How positive was the emotion that you felt?
3. What emotion did you feel the most?

In the first two questions participants could answer on the scale 1-10 and for the last question these options were proposed: joy, sadness, anger, disgust, fear, surprise and neutral emotion. First results of analysis show performance around 40% of classifying correct emotion using our approach. This results were achieved by combination of machine learning algorithms: linear regression and support vector machines.

2.3 Support for domain model authoring

Experimenter: Matej Kloska, Experiment supervisor: Marián Šimko

The main purpose of our experiment was to verify impact of proposed user interface advancements on domain model authoring. The experiment was set up as a web application (see Figure 2).

The main task of our experiment was to create domain model of mammals. Before the main task, a participant was given the idea about what is a domain model, how to create it and use our web application. After that participant created the domain model for a set of given 8 documents about mammals in general and selected subclasses.

The experiment was made one by one and took 40-50 min per participant. All participants were able to complete given task (without introduction and demo task) in average in 35 min. We collected data from 3 participants consisting of domain models, interaction logs with interface, answers to qualitative questionnaire and NASA TLX

questionnaire. The results show that the participants were able to create the domain model using our tool with defined functionalities more quickly and with less interactions as without them. The main goal of our experiment was to gather domain models with interaction logs from various users, therefore the experiment fulfilled our objectives.

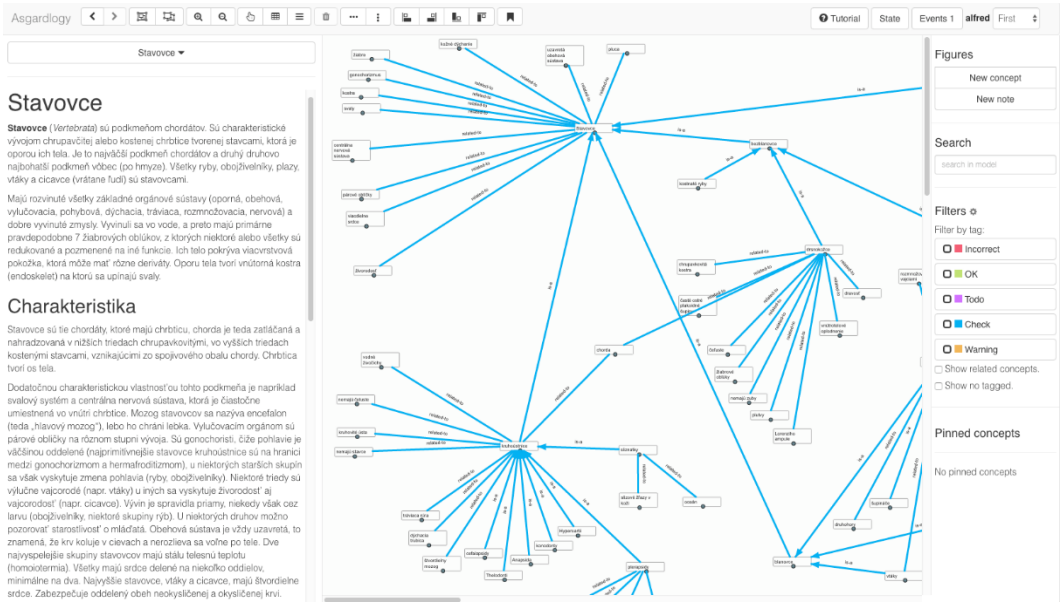

Figure 2. Screenshot of the proposed interface for creating domain models.

2.4 Cognitive load detection

Experimenter: Tomáš Juhaniak, Experiment supervisor: Mária Bieliková

We did a pilot experiment, to detect presence and multiple levels of cognitive load in math tasks showed on real web-interfaces with help of pupil dilation. Participants were resolving tasks consecutively, because we had only one eyetracker available. Experiment was composed of pupil dilation calibration and of 3 training and 16 measured html pages, which were consecutively showing four numbers (see Figure 3). Participants had to memorize them and then choose that option, which contained sum of them. Background of these html pages, contained complex - real web interfaces which influence to pupil dilation we tried to filtrate.

We have gained seven participants and we worked in exported data to whole dataset with total amount of 25 participants. This pilot experiment helped to reveal some problems in the experiment flow. The main contribution of this pilot test is a finding that people subconsciously can look to the top wall while they meditate, what can be harmful for data validity.

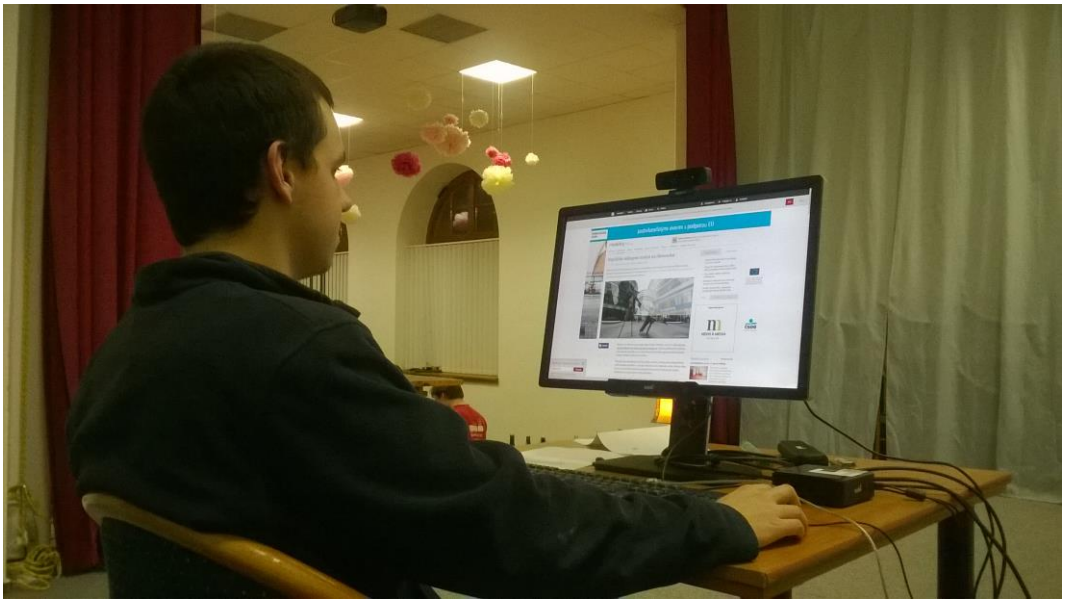

Figure 3. One of participants is looking at the web interface, while number projection is in progress.

2.5 Identification of low-quality comments in online discussion

Experimenters: Monika Filipčíková, Jakub Adam, Andrej Švec and Filip Vozár, Experiment supervisor: Jakub Šimko

Goal of our project moderateIT is to detect inappropriate comments in online discussions (see Figure 4). In order to have better classification results, we came up with following experiment. People were submitting comments for analysis and our service evaluated them. The goal of experiment was to find the worst comment that our service would classify as good. There were many comments submitted and experiment revealed multiple types of comments that we need to work on.

We also discovered that our pre-processing and feature extraction was sometimes causing comment to be classified incorrectly. It mainly included issues with spaces and newlines, which should not be considered as significant in analysis.

During the experiment we also experienced some technical issues associated with our database. As there were many people submitting comments at the same time, it was also a performance test for us. We discovered multiple bottlenecks, some of them even caused the service to be unavailable. But we had all of these issues in our log and thanks to these we were able to find the bottlenecks in our service which were removed afterwards. We evaluate this experiment as successful because we fixed issues that we did not even know about. Our service is now more efficient and stable.

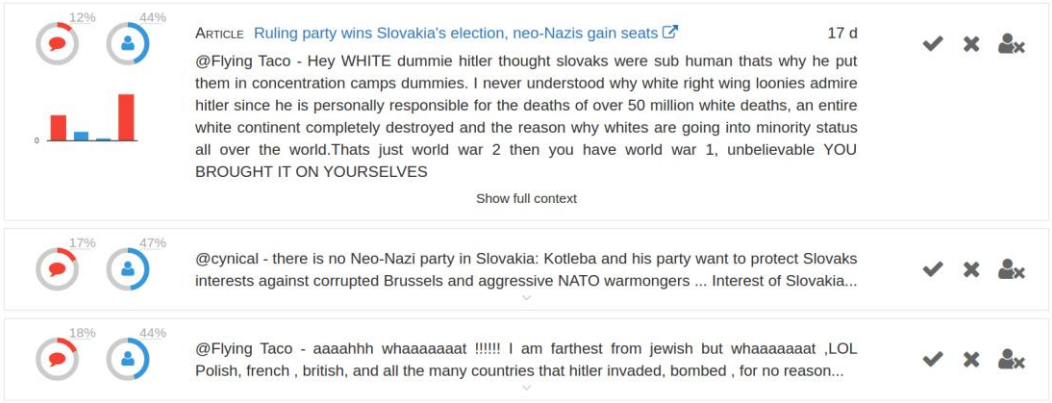

Figure 4. A detail of article and a list of associated comments with statistics about their quality.

2.6 Automation of analysing data from usability study with eye-tracking

Experimenters: Vladimír Ľalík, Experiment supervisor: Jakub Šimko

The purpose of this experiment was to verify design of the experimentation tasks before the main one which we plan to conduct in future. Also it was a great possibility to collect a preliminary dataset. With this dataset we can test our method which try to automatically identify usability problems of websites from data gained through usability testing with eye-tracking. Our method is based on relationship between metrics and patterns in eye-tracking data and specific usability problems.

In our experiment, we were testing usability of different web interfaces. We prepared two different versions of tasks with different usability problems. Each version consists of 10 tasks and each of this task is in different real web application. Every task began with instruction which was design to act as from real world. When participants were done with instruction, they hit button "next" and it took them right to web application. We changed some of these interfaces so they have one or more usability problems (see Figure 5). We used eye-tracker to record gaze of participants and we have also record mouse and keyboard events together with positions of DOM elements on web page in real time because of scrolling and dynamic elements.

This experiment was pilot for a quantitative experiment which we will conduct with 15 or 20 participants at once. The participant spent about 20 minutes to complete all the tasks. We made pilot with one participant who successfully finished all of tasks and also confirmed us that he encountered some usability problems, which we expected. The result of this pilot experiment is that we proved that design of our tasks do the trick. Also we have dataset which we will use in evaluation of our method.

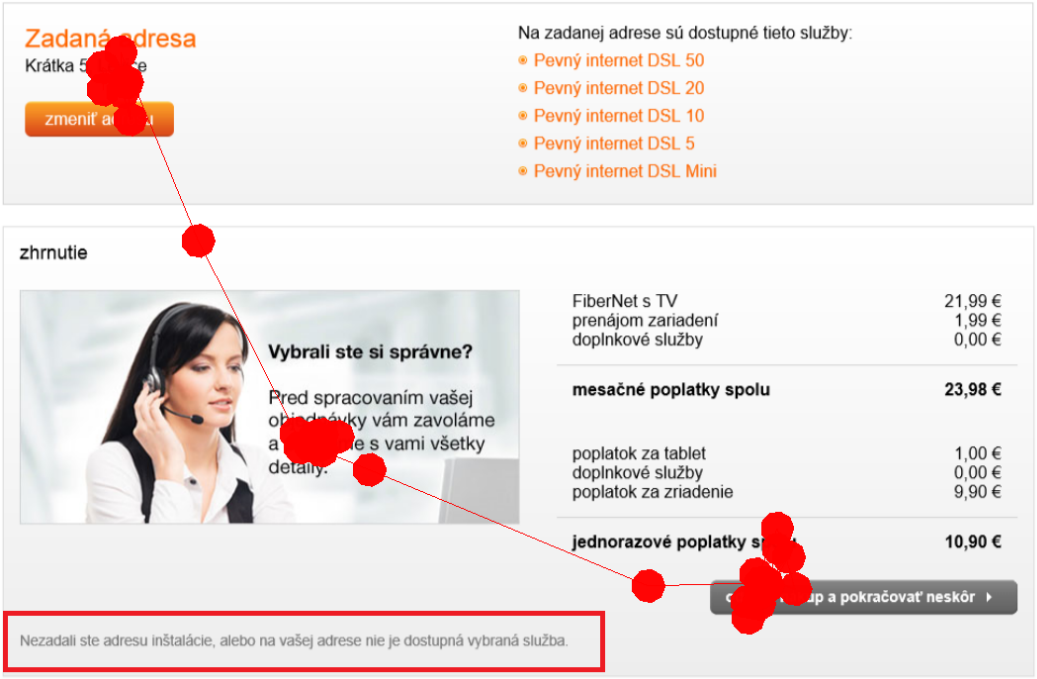

Figure 5. An example of tested web interface.

3 Summary

We are proud to conclude that the fourth experimentation session followed its successful preceding years. We were able to witness a high involvement of all PeWe members in the conducted experiments as many of them participated even in several experiments in a row. This was surely due to the experimenters, who came up with well-prepared experiments that were fun and interesting to attend. We hope that the session helped all the experimenters to gain valuable feedback or preliminary data. We are looking forward to the next year in which, probably, the most of current participants will change their role to experimenters and we will have an opportunity to reciprocally return their help back.

Acknowledgement. The author wishes to extend his thanks to all the experiments' participants. Special thanks go to ČSOB Foundation for support our UXI Centre and to SeBe organizers for providing motivation in the form of prizes for the most active participation. Lastly, we would like to thank our professor Mária Bieliková for organizing this whole event; without her effort and motivation it would not be possible.

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Academia SeBeana: The Shrine of Beer Knowledge

Marián ŠIMKO, Róbert MÓRO, Michal BARLA, Jakub ŠIMKO,
Ondrej KAŠŠÁK*, Márius ŠAJGALÍK♣

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 2, 842 16 Bratislava, Slovakia
{name.surname}@stuba.sk

Academia SeBeana opened its gates in the spring beermester of its third year by following the success of preceding academic's years [1, 2]. The academy aims at spreading knowledge about such noble topics as Beer Driven Research (BDR) or Beertificial Intelligence (BI). The academia continues to offer high quality study programmes at three degrees (bachelor degree programmes *Beerformatics*, *Tapping systems and piping networks*, master degree programmes *Beergeneering*, *Hop systems*, *Tapping systems and piping networks* and doctoral degree programme *Bottling systems)*, being a rarity in current educational ecosystem.

At this academic year, we continue to improve and expand our human beersources. Two professor titles were granted to two of our high-quality beersearchers – (Cerevisiae) Dr. Jakub Šimko and (Cerevisiae) Dr. Róbert Móro. Furthermore, there were honourable doctorates granted to a deserving pioneer of BDR Marián Hönsch for his outstanding multinational research work in Beergineering, which spans across the nations of the Middle-earth, from Slovakia to Germany. These acts were closely observed by the Beergineering community and BDR enthusiasts and served as an example of great success for the academy. They were of particular significance for the students, young minds hungering to sip from the tap of knowledge.

During the academic year, students were allowed to enter various courses, which helped them to improve their research skills. At the end of the first beermester, best student works competed at the BEER.SRC (Student Research Conference on BEEr-driven Research, pronounced as [bír srk] from Slovak srkať (upíjať si) – to sip). The goal of the conference was to inspire original student submissions in the form of a glass bottle of beer that represent a contribution to the current state of beer knowledge corresponding to the given level of study. The contributions were perceived as the students' results so far; a special focus was given on the evaluation in the form of their

* Supervisor: Marián Šimko, Academia SeBeana
♣ Supervisor: Michal Barla, Academia SeBeana

Spring 2016 PeWe Workshop, April 7, 2016, pp. 123–125.

own experiments or case studies. After the competition, the academic committee decided to award Metod Rybár the Dean's award and Július Bystričan and Peter Kiš with the Best Bottle award for their outstanding contribution.

The second part of the academic year was focused on the evaluation of students' research works, since the most of study credits could be obtained for participation in multiple experiments. We, once again, witnessed the terrific impact of so called SeBe peak phenomenon on the both quality and quantity of research work performed on site. The best achievement in contribution to the ongoing experiments was earned by Peter Kiš, who was awarded the Most Valuable Experiment Contributor award.

As the hops are harvested on sunny plains at the right moment in the season, so are the student's study results in our academy. Seven students fought bravely during the bachelor studies, proved necessary beer-related knowledge and skills during the final exams and successfully defended their bachelor theses and became the Bachelors of Beergineering. Two additional students did the same at the master level and became the Masters of Beergineering. See Appendix A for the complete list. Martin Borák and Július Bystričan earned the Dean's award for excellent results of their studies. Two doctoral students continue to pursue the cognition of beerverse and conduct and nourish their research day by day.

Academia SeBeana, only three years after the foundation, became a source of prominent young beersearchers. Not men and women of theory and abstraction, but men and women of action and practice! This achievement, extraordinary as the academia itself, shines vividly on the sky of education. It made the academia to become the shrine of beer knowledge.

Extended version of this paper is published in every bottle and every keg. It is born with each young barley sprout; it grows in every hop flower, within each cell of yeast. It is present in the heart of each fellow SeBe researcher.

Acknowledgement. This work was partially supported by the SeBe secret sponsors and the SeBe coin initiative.

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Appendix A: List of Graduates

Master's degree
(Study programmes: Beergeneering, Hop systems, Draft systems and pipes)

MBeng. Martin Borák
MBeng. Peter Kiš

Bachelor's degree
(Study programmes: Beerformatics, Draft systems and pipes)

BBeng. Peter Belai
BBeng. Zuzana Beníčková
BBeng. Július Bystričan
BBeng. Matej Červenka
BBeng. Matej Kloska
BBeng. Rastislav Krchňavý
BBeng. Martin Mokrý

Appendix B: List of Doctoral Students

Study programme: Bottling systems
Started in April 2015:

MBeng. Márius Šajgalík (supervisor: Prof. Michal Barla, CeD.)
MBeng. Ondrej Kaššák (supervisor: Prof. Marián Šimko, CeD.)

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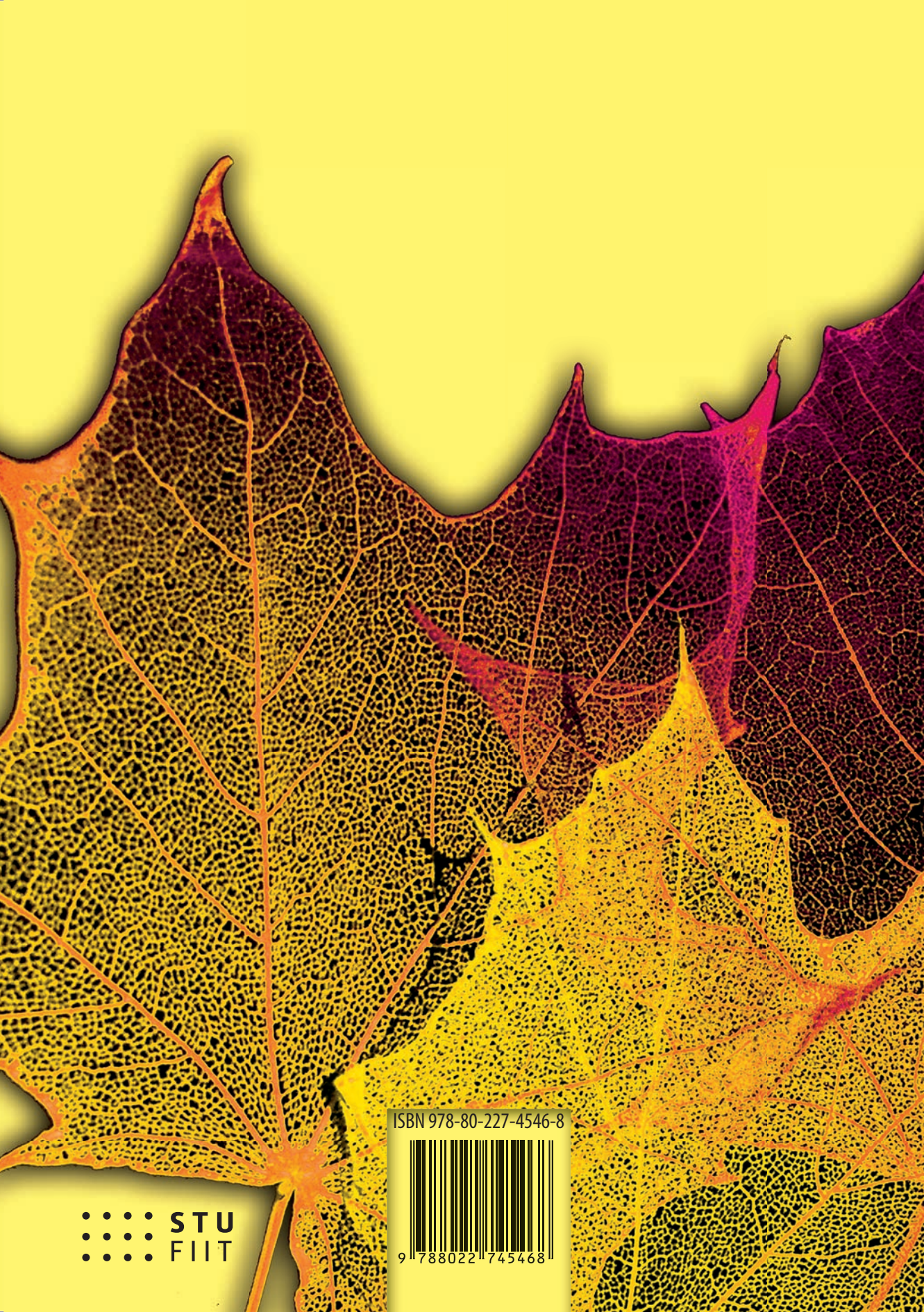
Personalized Web – Science, Technologies and Engineering
19th Spring 2016 PeWe Workshop

1st Edition, Published by
Slovak University of Technology in Bratislava

154 pages
Available at www.pewe.sk/spring-201516-april-2-2016/
Print Vydavateľstvo STU Bratislava
2016

ISBN 978-80-227-4546-8



ISBN 978-80-227-4546-8

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