Proceedings in
Informatics and Information Technologies

Student Research Conference 2012

Mária Bieliková (Ed.)

Keynote by Keith G. Jeffery

STU
FIIT

Proceedings in
Informatics and Information Technologies

IIT.SRC 2012
Student Research Conference

Mária Bieliková (Ed.)

IIT.SRC 2012: Student Research Conference

8th Student Research Conference
in Informatics and Information Technologies
Bratislava, April 25, 2012

Post-Conference Proceedings

Czechoslovakia Section

Slovakia Chapter

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
Faculty of Informatics and Information Technologies

Proceedings in
Informatics and Information Technologies

IIT.SRC 2012
Student Research Conference
Post-Conference Proceedings

Editor

Mária Bieliková
Faculty of Informatics and Information Technologies
Slovak University of Technology in Bratislava
Ilkovičova 3
842 16 Bratislava, Slovakia

Visit IIT.SRC on the Web: http://iit-src.stuba.sk

Executive Editors: Katarína Mršková, Anton Andrejko
Copy Editors: Jakub Breier, Andrej Fogelton, Peter Jombík, Michal Kasan,
Michal Kottman, Štefan Krištofík, Tomáš Kučečka, Martin Labaj,
Dominik Macko, Michal Olšovský, Štefan Sabo, Roman Šelmeci
FIIT STU
Cover Designer: Peter Kaminský

Published by:
Nakladateľstvo STU
Vazovova 5, Bratislava, Slovakia

ISBN 978-80-227-3837-8

Preface

This volume contains the keynote and comprehensive information on student papers selected for presentation and presented at IIT.SRC 2012, the 8th Student Research Conference in Informatics and Information Technologies, held on April 25, 2012 at the Faculty of Informatics and Information Technologies of the Slovak University of Technology in Bratislava.

We included in this volume abstracts of all 66 full papers presented at the conference, 33 of which are included also in their full version, 12 extended abstracts, and information on accompanying events. 13 full papers were already published in the Special Section on Student Research in Informatics and Information Technologies of the Information Sciences and Technologies in the Bulletin of the ACM Slovakia (Vol. 4, No. 2, 2012, slovakia.acm.org/bulletin/). Authors of 21 full papers politely declined our invitation to publish their paper in this volume as they have already acceptance or have submitted their papers to peer reviewed scientific journals or proceedings of mostly international scientific conferences. There are even cases of other authors who were able to write new papers based on a substantial expansion of their papers submitted to our student research conference and submit them elsewhere. Some of them have got their new paper already accepted for publication at time of publication of this volume. We included together with the abstract of each such paper the information on presentation elsewhere status available at time of publication of this volume.

Research has been one of the main priorities of the university education since its very beginning. It is the case also for our university – the Slovak University of Technology in Bratislava and its faculty – the Faculty of Informatics and Information Technologies. Close connection of research and education leads very naturally to a participation of students in research. This holds not only the students of doctoral study, where research is a substantial part of their study and one of their principal activities. A participation of students in research is "going down" to students of master, even bachelor study.

Universities of technology have a long tradition of students participating in a skilled labour where they have to apply their theoretical knowledge. The best of these results were usually presented at various students' competitions or exhibitions. The results were also combined with student research works. Our university has had a long tradition in such exhibition named ŠVOČ (abbreviation of the Student Scientific and Technical Activity). Eight years ago our faculty, FIIT STU, decided to transform former ŠVOČ into the Student Research Conference covering topics of Informatics and Information Technologies (IIT.SRC). IIT.SRC participants are students of all three levels of the study

- bachelor (Bc.),
- master (Ing.) and
- doctoral (PhD.) study.

The conference adopted a form of reviewing as at any other scientific conference, and presenting written version of the papers internally in a form of internal Proceedings printed in paper and distributed during the conference. These students' papers in most cases mean a first step towards later publishing the results on national or international established conferences or journals.

IIT.SRC 2012 attracted 92 student papers from which 78 were accepted and presented at the conference (18 bachelor, 40 master, 20 doctoral). The number of papers is rather stable. This year we have noticed an increase in bachelor category comparing to IIT.SRC 2011.

IIT.SRC 2012 was organized in five sections with papers in two categories – full papers and extended abstracts:

- Intelligent Information Processing,
- Web Technologies and Science,
- Software Engineering and Computer Science,
- Computer Systems, Computer Networks and Security,
- User Interaction, Computer Graphics, Image Processing.

The conference was opened by *Keith G. Jeffery* followed by a keynote titled *The Challenges in ICT: Debunking the Hype*. Keith is currently Director International Relations at STFC (Science and Technology Facilities Council). He previously had strategic and operational responsibility for ICT with 360,000 users, 1100 servers and 140 staff. His research interests include distributed computing with special emphasize to cloud computing, security and green computing.

Besides the 78 papers presented at the conference several accompanying events were organized. The *RoboCup Exhibition* is organised as a part of IIT.SRC since 2005. RoboCup is an attractive project with free participation, designed to support education and research in artificial intelligence, robotics and information technologies. Through several years, our students achieved interesting results, which were presented during the conference. RoboCup exhibition presented both the way the RoboCup simulated league is played and also the progress of current students' research in this field. Three years ago a new RoboCup league – three-dimensional (3D) robotic simulation was added. The extension of the simulation to the third dimension shows the continuous progress in RoboCup and in our students' skills.

This year we organized for the fourth time as part IIT.SRC a *showcase of TP-Cup projects*. TP-Cup is a competition of master students' teams aimed at excellence in development information technologies solutions within two semester long team project module. The competition has four stages. 12 teams managed to achieve this stage and presented their projects during the TP-Cup showcase. Extended abstracts of their projects are included in these proceedings.

Accompanying events included for fifth time also our *programming contest*. It follows a long tradition at the Slovak University of Technology in Bratislava and our faculty in organizing programming contests, especially the ACM International Collegiate Programming Contest like competitions. This year we have organized for the first time the final round of the ProFIIT programming contest for high school students in parallel with IIT.SRC. Our aim was to show our potential future students exciting research opportunities awaiting them at our university.

We continued this year with *FIITApixel exhibition*. FIITApixel brings together both students and staff of the Faculty as well as its potential students and alumni in an effort to create, share and judge pictures. It is organized as an ongoing event, where anyone can contribute pictures. The IIT.SRC FIITApixel exhibition presented the best pictures of this year contest.

As a part of IIT.SRC we organized again this year an *exhibition of three games with a purpose*. Games with a purpose represent a way of harnessing the power of the human brain for producing useful artefacts or solving computational problems through computer gaming. They are interesting not only for the research opportunity itself but also for research promotion and popularization.

Nokia Lab has presented its activities at its presentation spot via several interesting applications whose development has been supported by the FIIT STU Nokia Lab.

New accompanying event this year was *Junior IIT.SRC*. Junior IIT.SRC provides a room for presenting inventive high school student projects within the topics of the conference. This year, three submissions were selected, first two dealing with an actual topic of electronic parliamentary elections (presenting either the potential platform and result analysis apparatus), the third presenting a smart portal for delivery of IT news and updates, focused on young audience.

IIT.SRC 2012 was the result of considerable effort by a number of people. It is our pleasure to express our thanks to:

- the IIT.SRC 2012 Programme Committee who devoted effort to reviewing papers,
- the IIT.SRC 2012 Organising Committee for a smooth preparation of the event,
- the students – authors of the papers, for contributing good papers reporting their research and their supervisors for bringing the students to research community.

Special thanks go to:

- Anton Andrejko together with Katarína Mršková who did an excellent job in the completion of the proceedings,
- Zuzana Marušincová and the whole organizing committee for effective support of all activities and in making the conference happen.

Finally we highly appreciate the financial support of our sponsors which helped the organizers to provide excellent environment for presentation of the results of student research and valuable awards.

Bratislava, September 2012

Pavel Čičák and Mária Bieliková

Conference Organisation

The 8th Student Research Conference in Informatics and Information Technologies (IIT.SRC), held on April 25, 2012 in Bratislava, was organised by the Slovak University of Technology (and, in particular, its Faculty of Informatics and Information Technologies) in Bratislava.

IIT.SRC General Chair

Pavel Čičák (dean, Faculty of Informatics and Information Technologies,
Slovak University of Technology in Bratislava)

IIT.SRC Programme Chair

Mária Bieliková

IIT.SRC Programme Committee

Michal Barla
Vanda Benešová
Michal Čerňanský
Pavel Čičák
Peter Drahoš
Elena Gramatová
Pavol Horváth
Ladislav Hudec
Daniela Chudá
Katarína Jelemenská
Peter Kapec
Gabriela Kosková
Margaréta Kotočová
Ivan Kotuliak
Tibor Krajčovič
Vladimír Kvasnička
Peter Lacko
Michal Laclavík
Ján Lang
Marián Lekavý
Pavol Mederly
Ľudovít Molnár
Pavol Návrat
Ivan Polášek
Jiří Pospíchal
Viera Rozinajová
Petr Šaloun
Juraj Štefanovič
Jozef Tvarožek
Michal Tvarožek
Valentino Vranić

IIT.SRC Organising Committee

Alexandra Bieleková
Mária Bieliková
Ivan Kotuliak
Zuzana Marušincová, *Chair*
Katarína Mršková
Ľubica Palatinusová
Branislav Steinmüller
Roman Stovíček
Eva Urbaníková

all from FIIT STU in Bratislava, Slovakia

IIT.SRC Financial and Prizes Sponsors

- Abonus
- Hewlett-Packard Slovakia
- Informatics Development Foundation at FIIT STU
- NokiaLab

- PosAm
- Slovak Telekom
- Softec
- Soimco
- Tempest

Supporting Professional Societies

- Slovakia ACM Chapter
- Czechoslovakia Section of IEEE
- Slovak Society for Computer Science

Medial Partner

- PC Revue

Table of Contents

Keynote

Intelligent Information Processing

Bachelor Degree Program Students

Master Degree Program Students

Doctoral Degree Program Students

Web Science and Technologies

Software Engineering and Computer Science

Computer Systems, Computer Networks and Security

User Interaction, Computer Graphics, Image Processing

Extended abstracts

Accompanying Events

The Challenges in ICT: Debunking the Hype

Keith G JEFFERY

Science and Technology Facilities Council
Harwell Oxford, OX11 0QX UK
keith.jeffery@stfc.ac.uk

Abstract. ICT has – in the last 50 years – changed the world of business, learning and leisure more than any other technology or influence. Imagine if we took computers out of the world. It would take every man, woman and child in UK working 24/7/365 to manage the banking transactions. Transport would stop. Communications would stop. TV and radio would stop. Financial services would stop. Hospitals could not operate effectively. Manufacturing would stop. Retail would stop. Even your car, fridge, washing machine, home TV, central heating system would stop. The management of ICT and gaining the best cost-benefit (by hiding complexity using autonomic techniques) is a perpetual challenge. The newest concept is Cloud Computing. It follows (and to some extent incorporates) many previous concepts such as Grid computing, Cluster Computing, Distributed Computing, Client-Server computing, Service-oriented architecture, Model-driven software development and many more. We shall explore what Cloud computing is and what it means for us all in the context of the modern ICT environment. We shall also consider whether or not it provides a solution to the major underlying challenges in ICT. We shall also look forward to what is coming next.

1 Introduction

Since using computing for my Geology PhD in the 1960s I have been fascinated by the potential of ICT for research, business, management, learning and entertainment. I have been fortunate to have been involved in the earliest relational database systems, distributed systems, logic-based systems, systems development methods, the first WWW server outside CERN, various WWW standards, the standard for international research information (CERIF), mobile computing, open access to research results, the original e-Science concept, Grids and Clouds. This provides a special perspective on ICT (or particularly ICST where the S stands for science).

1.1 The Pervasiveness of ICT

ICT is everywhere. It is found not only in laptops and smartphones but in cars, planes, process plant, refrigerators, washing machines and TVs. It is part of the fabric of life, but in parts of Africa, Asia and South America there is not a sustainable power supply. Storage densities have improved in 20 years by 10**18, processor speeds by 10**15 but broadband by only 10**4. Large scale businesses communicate at Gb/s speed, the average mobile connection is <200Kb/s.

1.2 A Short History of ICT

In the 1960s an end-user described the requirement to an analyst who designs a system for programming by a programmer and when run the results are handed back to the end-user and – if necessary – explained by the analyst. Now an end-user expects to use 'off the shelf' software products to achieve their objectives. With vastly increasing data production, the trend is to move the software to the data rather than the data to the software (and computing resource). This has distributed system architectural implications realised through Grid computing. However, businesses still struggle to reconcile their management processes with the demands and capabilities of purchased software systems, to reduce ICT costs and increase productivity and to achieve on-demand scalable ICT resources. Paradoxically, this has led to ICT centralisation in in-house clusters and Cloud computing.

2 Cloud Computing

2.1 Characteristics

Many consider Cloud computing to be just marketing hype. Indeed, in the Gartner hypecycle graph, 2011 is the year when the Cloud hype is unsustainable and we move for some time into disillusionment with the technology. Cloud Computing is, in fact, a combination of pre-existing technologies together with a managed business model. The major types of Cloud offerings are determine by their customer base: private (in-house), hybrid and public (outsourced). The next discriminant is the offering; IaaS: infrastructure as a service for system architects, PaaS: platform as a service for systems developers and SaaS: software as a service for end-users.

The technologies utilised are in general shared across both the above discriminations and include cluster computing (from datacentres) and autonomic computing (from Grids). It is no accident that the major public cloud offerings are from large companies that needed to invest heavily in ICT to support infrequent peak demands in their core business leaving expensive capital investment idle for much of the time. Cloud Computing opened a way to make money on this idle capital investment without risking its availability for in-house requirements.

The business model offered to end-user customers is 'pay as you go' thus reducing capital expenditure and investment and increasing operational expenditure. This is attractive both to users of a public cloud and to users of a private cloud – in both cases encouraging a stronger management of ICT expenditure.

A further claimed advantage of Cloud computing is its environmental ('green') credentials. A centralised datacentre is more energy-efficient than multiple distributed departmental centres especially if the capacity switched on at any time is managed autonomically. There are also opportunities for utilising the heat generated in associated buildings.

2.2 Problems

Cloud computing has its problems. The Cloud centre is potentially vulnerable to disablement by intended or unintended actions. Shipping data to the centre may be impractical because of available bandwidth or legal issues concerning privacy and security. Despite the promise of autonomicity, there remain problems with horizontal and vertical scaling. The design of software services to take advantage of the elastic scalability (by dynamic re-composition based on metadata) has not yet been achieved and the attendant systems development methods have not been provided.

Additionally there are a host of challenges in ICST that need to be addressed – and have needed to be addressed for many years. These challenges are present in the Cloud environment as in any other although with subtly changed / emphasised characteristics.

3 Challenges

3.1 Metadata

Metadata describes objects so they can be used. However, what is metadata to one application is data to another: a library catalogue card is metadata pointing to the book on the shelf but data for a librarian counting the number of books on a given subject. As ICT become increasingly autonomic, the autonomic managers rely upon metadata to describe the data to be processed, the software services to do the processing and the computing resources desired or available. Packaged services are advertised via metadata to end-users. Unfortunately existing metadata standards either do not exist or are woefully inadequate for the requirements.

3.2 Management of State

The representation accurately within the ICT system of the state of the real world is a key objective. As things change in the real world so they should also in the system (observation) and conversely, as things change in the system they should change in the real world (control). Database technology has developed appropriate transactions to maintain database state. However, as the volume and rapidity of changes increases the system may not be able to react quickly enough, particularly with streamed data and particularly if it is multimedia. In a distributed system things become more complex and if the global state is represented by multiple local states the integrity of the global state is fragile or even unsustainable.

3.3 Data Representativity

Objects in the real world have great complexity, subtlety and usually dynamism. Representations in computer systems consist of a representative encoding (character set, media type), a syntax (structure) and semantics (meaning). It is common for the same object in the real world to have in different ICT systems – with increasing probability - different encoding, syntax and semantics. This has two important aspects for ICT: (a) the real-world object may not be represented faithfully in the ICT system; (b) interoperation of ICT systems representing the same or similar objects becomes complex

3.4 Data Quality, Veracity and Permanency

Data quality relates to the accuracy and precision of the way the ICT system represents the real-world object. Usually this can only be verified by comparison with the real world object, or by ensuring the entity/attribute values stored in the ICT system conform to metadata constraints. Permanency (and related considerations of provenance which also gives some guarantee of quality) depends on an appropriate digital preservation strategy. This will include media conversion rewriting (to ensure the data is readable) and maintenance of the associated metadata and – if necessary – software or software specifications.

3.5 Trust, Security and Privacy

Privacy concerns the management of data stored and used concerning an individual person. Most countries have legislation which balances freedom of access to information with the privacy rights of the individual. Security concerns assurance of data availability for those authorised to access it and prevention of availability for others. Trust relies on security and privacy and concerns the representation of an organisation, product, service or resource within an ICT system such that e-business transactions can be performed.

3.6 Management of Service Levels and Quality of Service

In general an end user neither knows nor cares where and how the ICT system provides the required information or computation. The concern is the time to obtain results and the quality of those results. This is managed by SLAs (service level agreements) and QoS (quality of service) guarantees – usually related to payments for improved service. In a virtualised environment such as a cluster, Grid or Cloud the management of resource availability (supply-side) against SLAs and QoS (demand-side) is critical to success.

3.7 Systems Design, Development, Maintenance and Decommissioning

Systems development methods have developed slowly and their origins in the 1960s are evident. The world is changing; the problem is now much less to develop new software but to (re-)use existing software components. The problem is to find a systems development method which allows for such automated composition based on declared requirements and then provides an execution environment appropriately distributed and autonomic allowing dynamic re-composition to exploit the available resources optimally to satisfy SLA and QoS constraints. Such an environment implies software modules with metadata describing their characteristics in sufficient detail for automated composition and execution, and equally such metadata for data, services and resources.

4 Conclusion

So, is Cloud Computing just hype? The answer is complex. For some offerings it certainly is – either rebranded well-known offerings or novel offerings claiming to be Cloud-based even if they are not. However, there is emerging some experience of the use of private (in-house) Cloud computing with derived benefits in management of resources. There is also experience of successful utilisation of public Cloud services, either for exceptional, one-off peak demands that would be too expensive to resource in-house by capital purchases or for experimenting with new software in an environment separated from the in-house ICT production facility. Of course public Clouds can also be used for office functions and for social networking – but with some loss of privacy and potential targeted advertising.

The real challenge is to provide seamless elasticity from private to public Clouds so that appropriate ICT tasks can be offloaded to the scalable and pay-as-you-go resources. This could also encourage the use of public clouds as a marketplace for inter-company trading. However, for this to become a reality the challenges outlined above need to be solved.

There is plenty of advanced R&D yet to be done.

Intelligent Information Processing

Validation of Music Metadata via Game with a Purpose

Peter DULAČKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
dulacka@gmail.com

Abstract. Quantity of music metadata on the Web is sufficient, music recommendation and online repository systems are proof of it. However it became a real challenge to keep quality of metadata at reasonable level. Automatic approaches are fast but inaccurate; the cost of human computation is too high. In this paper we present a Game with a purpose called City Lights – a music metadata validation game which lowers the cost of human computation and makes validation fun. Our goal is to get rid of wrong user-submitted metadata or metadata not usable at global scale. We describe various approaches used in the game and evaluate the game results in conclusion.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 30-31.
A paper based in part on this paper was published in Proc. of the 8th Int. Conf. on Semantic Systems (I-SEMANTICS '12), ACM, New York, NY, USA, 177-180.

* Bachelor degree study programme in field: Informatics
Supervisor: Jakub Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Email Events: Extracting and Adding to Calendar

Ivan JANOVIC*, Filip OGURČÁK†

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
janovicivn@gmail.com, filip.ogurcak@gmail.com

Abstract. In this paper, we discuss event detection from email communication. We focus on detecting and extracting main event data such as time, place and name of the event. We test and evaluate our approach on selection of emails from Enron email corpus. In addition we describe thunderbird plug-in, which supports the event detection functionality and its integration with Google calendar.

1 Introduction

Email as a means of communication becomes main technology for every day exchange of information. Everyday usage of email has become inseparable part of both work and personal live.

Information exchanged by email is mostly written in natural language, therefore not understandable for computers. We can use specified software to include tasks or meeting requests in email message. Time consumption while using this software can be great and it is more comfortable to write message in natural language rather than spent time using extra software.

Email events are being sent in different form and languages. Therefore we focused on English language and domain containing events with time and activity. We have decided to integrate our approach for event extraction with Thunderbird email client and Google Calendar.

Event detection is supported to some extend in email clients, but only if events are shared in standardized way, using hCalendar[1] or iCalendar[2] microformat standards.

2 Email events extraction

Based on domain, we can focus on extracting events related to places, actions, time etc. We focus on extracting time based events. Based on [1] event can be described as relationship between objects that are connected by action. We are looking at event parts separately and trying to identify event parts as separate words or words sequences.

---

* Master degree study programme in field: Software Engineering

† Bachelor degree study programme in field: Informatics
Supervisor: Dr. Michal Laclavík, Slovak Academy of Sciences, Institute of Informatics

[1] http://microformats.org/wiki/hcalendar

[2] http://microformats.org/wiki/icalendar-implementations

2.1 Event Extractions

2.1.1 Event structure

We identify basic parts of event as follows:

- Event topic, that represents activity connected with event.
- Event date, which represents time of an event.
- Event location representing place connected with an event.

We are using collections of possible topics and locations, because later in process of importing files into calendar, we allow user to choose from these or to enter different value (see section 3.2).

2.1.2 Event extraction process

After extracting email message body, first step is to preprocess text. We perform part of speech tagging on email message body and store it in object representing email message.

Method used to identify event parts is based on part of speech preprocessing of email message body. We are trying to find specific parts of speech sequences using regular expressions.

Context identification

We focus on events containing date therefore sentences or lines with date information are considered as relevant context for further analysis. For each sentence with identified date from email body we create one event and process this sentence further.

Data resolution

Date can be sending in different formats. In natural language date formats are dependent on country and language. Date can also contain relative date information like tomorrow, the day after tomorrow, next Monday etc. We take send date information from email as reference date. Therefore tomorrow is day after an email was sent.

Location and topic identification

Location is identified as sequence of preposition followed by noun or proper noun that also can be sequence:

```
PROPERWITHPREPOSITION (“(\\s[a-zA-Z]+/IN\\s[a-zA-Z]+/NNP)”, 5),
NOUNWITHPREPOSITION (“(\\s[a-zA-Z]+/IN\\s[a-zA-Z]+/NN)”, 4),
NOUNSEQUENSE (“(\\s[a-zA-Z]+/NN[P]?)+”, 2),
NOUN (“(\\s[a-zA-Z]+/NN[P]?)”, 1);
```

Topic is considered as activity. Therefore we are looking for sequence of verbs followed by nouns:

```
PROPPERVERBNOUN (“(\\s[a-zA-Z]+/VB\\s?([a-zA-Z]+/DT\\s)?([a-zA-
Z]+/IN\\s)?[a-zA-Z]+/NNP)”, 5),
VERBNOUN (“(\\s[a-zA-Z]+/VB\\s([a-zA-Z]+/DT\\s)?([a-zA-
Z]+/IN\\s)?[a-zA-Z]+/NN)”, 4),
PROPPERNOUNSEQUENCE (“(\\s[a-zA-Z]+/NNP)+”, 3),
NOUNSEQUENSE (“(\\s[a-zA-Z]+/NN)+”, 2),
VERB (“(\\s[a-zA-Z]+/VB[DGNPZ]?)”, 1);
```

Extracted data sorting

Due to possibility for user to choose topic, location or date, we extract more representations. Based on regular expressions, we assign weight to every extracted part of event. This weight is determined based on regular expression used for event part extraction. For example sequence of preposition and proper noun is more relevant location than only proper noun. Same principle is

used when identifying topic and date of event. Weight of event itself is than determined as sum of parts with most weight.

2.1.3 Used technologies

For preprocessing of email body we used Stanford Log-linear Part-Of-Speech Tagger[3]. This tool inserts markups abbreviations for each word – like token into processed text:

```
Meet/VBP me/PRP tomorrow/WB at/IN my/PRP$ office/NNP ./.
```

This fact allows us to use regular expressions based on these abbreviations. For annotating identified context we used UIMA[4] annotator engine with defined regular expressions.

2.2 Experiments and Evaluation

We did experiments on Enron dataset[5] in two steps. But before testing, we decided to test if Enron corpus is suitable for domain – containing time and task events. Because of our focus on importing extracted events into calendar we need to find out if we have suitable dataset.

In first phase we picked randomly 10,000 messages from Enron dataset and we were looking for date, time, and task patterns in email message body. Results are shown in Table 1.

Table 1. Enron dataset statistics.

	Number of occurrences
Date pattern	3668
Time pattern	3412
Task pattern	3961
Combination of patterns	2595

As Table 1 shows, there are more than 25% of emails that contains combination of date, time or task in Enron dataset, therefore we find it suitable for testing of our approach.

In second phase we picked 30 email messages from Enron dataset and applied our method on them. During evaluation we encounter situation, where topic or date were identified only partially.

Evaluation was made for two different approaches. In first we picked event with greatest weight and evaluate precision and recall for location, topic and date with greatest weight (Table 2). In second approach we picked as relevant not only parts and events with greatest weight, but we consider top three weights as relevant (Table 2). Location recall is one and precision is quite low, because in many emails location was not present, but our approach detected some part of sentence.

Table 2. Precision and Recall top1 and top3.

	Precision @ 1	**Recall @ 1**	**Precision @ 3**	**Recall @ 3**
Date	0.91	0.82	0.95	0.96
Topic	0.86	0.75	0.89	0.77
Location	0.29	1	0.27	1

2.2.1 Email examples from Enron corpus

Now we will show processing of concrete messages and demonstrate event identification.

```
Please join us for a farewell party for Kristian & Monica Lande
today 5:00 PM in Bar
```

[3] http://nlp.stanford.edu/software/tagger.shtml
[4] http://uima.apache.org/
[5] http://www.cs.cmu.edu/~enron/

The date is the word today. Therefore we assume this message contain date based event. In next step we use part of speech tagging, that results into following text:

```
Please/VB join/VB us/PRP for/IN a/DT farewell/NN party/NN for/IN
Kristian/NNP&/CC Monica/NNP Lande/NNP today/NN 5:00/CD PM/NNP in/IN
Bar/NNP
```

In the next step, we apply regular expressions and try to extract event parts. Results with weight are as follows (Message 1 was sent on Wed Feb 21 16:05:00 CET 2001):

```
Topic: Lande w: 2| Monica Lande w: 3| join w: 1| Bar w: 3| farewell
party w: 2| Monica w: 2| PM w: 2| Kristian w: 2|
Date: Wed Feb 21 16:05:00 CET 2001
Location: farewell party w: 2| Monica Lande w: 2| in Bar w: 5| Bar
w: 1| Kristian w: 2| Lande w: 1| for Kristian w: 5| PM w: 2| Monica
w: 1| party w: 1| farewell w: 1|
Description: today
Please join us for a farewell party for Kristian & Monica Lande
#DATE# 5:00 PM in Bar
```

3 Thunderbird plugin

Thunderbird[6] is free of charge, platform-independent and open source email client, which is for advanced features in email processing a popular choice in the email client selection. Great advantage for users is amount of plugins[7] existence, and for developers clearly written manuals[8] and friendly programing languages: JavaScript and XUL.

In this project, Thunderbird plugin makes the client part of the developed application. Main function of this plugin is connecting Thunderbird with server part and Google calendar.

3.1 Plug-in architecture

The main functionality of this plug-in can be described by the following sequence: Plugin sends email text to extraction server, and then get back structured data (name, time, location and description). Next step is user authorization on Google OAuth 2.0[9] authorization server. Finally is send request to Google Calendar API server, which create event and add it to user's calendar.

Communication is based on REST[10] requests and receives with specified sequence of dates.

3.1.1 Connection with extraction server

Text of email message is send for processing to extraction server, and then gets back JSON data, which uniquely define event (name, time, location and description):

```
{"Name":["Monica Lande","Monica"],"Place":["for
Kristian"],"DateTo":["2001-02-21"],"Description":"today\rPlease join
us for a farewell party for Kristian #DATE# 5:00
PM","TimeFrom":["16:05"],"DateFrom":["2001-02-
21"],"TimeTo":["17:05"]}
```

This part makes the heart of this plug-in. Next two parts (authorization and calendar) could be modified or completely exchanged, according to the required calendar or authorization.

---

[6] http://www.mozilla.org/sk/thunderbird/features/
[7] https://addons.mozilla.org/en-US/thunderbird/
[8] https://developer.mozilla.org/en-US/
[9] http://code.google.com/intl/sk-SK/apis/accounts/docs/OAuth2Login.html
[10] http://www.xfront.com/REST-Web-Services.html

3.1.2 Google OAuth 2.0 authorization

Due to the connection with Google Calendar API[11] needs user authorization, we use OAuth 2.0 technology to do it. This technology needs user interaction, where user must allow access to manipulate with his data. Server then generates unique code, which user copy to the plugin. At the end of authorization, plugin sends this code to server and receives access and refresh tokens.

For higher user comfort, these tokens are saved in Windows registry, so user could not authorize application all the time. Next advantage of this authorization is using refresh token, which could be used every time, when access token is expired.

3.1.3 Creating event to calendar

The final part is used to create new event in calendar due to Google Calendar API. This functionality is based on REST requests, and needs authorization (paragraph 3.1.2).

Due to the extraction is focused to extract only name, place and time of event, calendar saves only this information. Other Google API functionality is not interesting to our purpose.

REST requests have specific structure, but on the other hand, it is easy to convert it to any calendar standard and use it with any Calendar.

3.2 Plug-in GUI

Plug-in runs the last item in the context menu (Figure 2 left), or pressing the key "G". After start, plug-in consists of two GUI windows – first for authorization, and second for create an event.

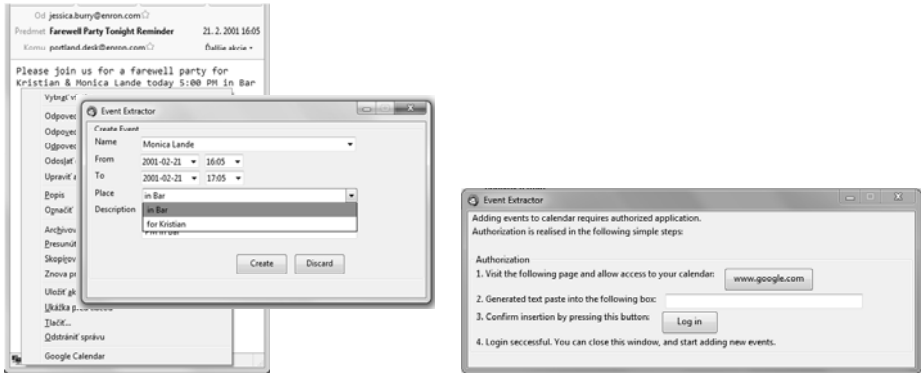

Figure 2. Event Extractor plugin.

Authorization window (Figure 2 right) is showing only when plug-in runs for the first time. Main window for create an event (Figure 2 top window on left) is showing every time user runs the plug-in and this window contains only necessary components to create event: name, duration, place and description. Whereas web service provides several results, every text box offers to choose the most relevant entry. If none is relevant enough, you can also overwrite it.

4 Related Work

4.1 Event Detection

Event extraction is according to [2, 3] topics not solved yet with satisfactory results. Based on results presented in [4] is event identification in text mostly dependant on how we define event

[11] http://code.google.com/intl/sk-SK/apis/calendar/v3/reference.html

itself. According to [1] we can define event as a relationship between objects and actions. It can be represented by verb or verbs sequence. These relationships in sentence are according to [1] represented as tree, where leafs are objects and other nodes are verbs, or words describing actions. We represent parts of event as separate tokens, which make our approach less accurate in identifying event parts, on the other hand we are not bound by tree structure and we are able to suggest more options for user. In [5] two basic approaches for information extraction were presented. The first is knowledge based systems that requires experts knowledge about domain, but changes in specification can be difficult to implement. Second approach is focused on trainable systems that do not require expert knowledge, but training data. We decided to use knowledge based approach, because obtaining data in sufficient amount and quality can be difficult in everyday usage of our solution.

4.2 NLP

Since we are using knowledge engineering approach we have considered solutions like GATE[12], Ontea[13], UIMA or plain regular expressions.

GATE support various NLP tools and advanced JAPE rules for information extraction tasks. Ontea is simple tool based on regular expressions, gazetteers and their combination, but it supports email parsing. UIMA is well documented and extensible apache project, so we used it for developing and testing regular expressions and for annotating processed texts. Besides environment providing annotation engine it provides tools for identifying date, time and locations as rooms. In addition we needed to support POS tagging. We decided to use Stanford Log-linear Part-Of-Speech Tagger[14] because is still being improved and provide 96.97% accuracy[15].

5 Conclusion

In this paper we have presented our approach for event detection in email based on part of speech tagging and regular expression extraction. Our approach tries to extract event parts as suggestions with different weights. We focused on provide more data by cost of accuracy and let user to choose. We hold to knowledge based system approach based on defined regular expression.

We have tested and evaluated it on Enron email corpus. We have also created Thunderbird plug-in, which integrates extraction methods with widely used open source email client and with Google Calendar.

References

[1] Fillmore, C. J., Narayanan, S., Baker, C. F. (2006), What Can Linguistics Contribute to Event Extraction?, In *2006 AAAI Workshop on EventExtraction and Synthesis*, 2006, pp. 18–23.

[2] Peck, F: The Parts of the Sentence. University of Ottawa. [Online] November 2011. http://www.writingcentre.uottawa.ca/hypergrammar/partse.html

[3] Natural Language and Information Processing Research Group: NLIP Group. Computer Laboratory. [Online] http://www.cl.cam.ac.uk/research/nl/.

[4] AAAI 2006 Workshop on Event Extraction and Synthesis. Boston: s.n., 2006

[5] Appelt, D. E., Israel, D. J.: Introduction to Information Extraction Technology, A tutorial prepared for {IJCAI-99}, Stockholm, Schweden (1999).

[12] http://gate.ac.uk/
[13] http://ontea.sourceforge.net/
[14] http://nlp.stanford.edu/software/tagger.shtml
[15] http://nlp.stanford.edu/software/pos-tagger-faq.shtml#h

Named Entity Recognition for Slovak and Related Languages

Ondrej KAŠŠÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
ondrej.kassak@gmail.com

Abstract. In this paper we describe a proposal of the method for recognizing and extraction of named entities in texts. We primarily deal with methods designed for the Slovak language, but we also describe possibilities of application for other flective languages. The goal of the described method is to identify potential entities occurring in the processed text, determine its scope and consequently identify the category to which they belong. Proposed approach can be used in various tasks, where the text pre-processing is required as information search or content-based recommendation etc.

1 Introduction

Nowadays we are literally overwhelmed with information. It is served to user from all sides and we are also acquiring the necessary knowledge from many sources. It is impossible for users to process all the information they find and that is the reason for the huge research interest for the information overload. Although information is now available in many various forms, much of it is stored in a text form. This is a very traditional way of storing knowledge and in the digital age it acquires an unprecedented dimension because of the simplicity with which the text can be created, distributed and stored.

Due to these facts, an area for many methods used for finding information arises there. Various approaches for information gaining have been proposed as personalized recommendations [10] or search methods. The search methods provide results in varying levels depending on the manner in which information is gained. In addition of searching methods, there are methods used for text recommendation. Recommendations based on the content of the text or searching methods using key entities from the texts assume the named entities appearing in the text for their working as an input. It can either directly identify entities in the text or create some form of metadata, data bearing on these entities. Based on them, recommendation algorithms can search and work then more efficiently in comparison with methods working only with the text titles or with the most frequent words in the text.

* Bachelor degree study programme in field: Informatics
Supervisor: Michal Kompan, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 15–20.

The aim of our proposed method is to recognize entities in the text and assign them the correct type. We primarily focus on texts in Slovak language because a comprehensive tool for this language that would identify all entities classified according to the MUC-6 (6th Message understand conference) [1] is missing. The paper also describes the options for deployment of the method in related Slavic languages that have free sentence structure and words inflection. Similar methods for the majority of world languages already exist. Depending on the language, the issue is managed with a variety of high success rate. For German up to 70%, for English about 90%.The best tools for Slavic languages achieve success just around 70% [2].

2 Related Work

We have no information about an existing tool recognizing all types of entities for the Slovak language, but several approaches have been proposed for the related Slavic languages. The best presented solution for the Czech language achieves the success rate between 68% and 72% [2]. Most of methods use the statistical approach as the Semantic spaces or the Maximum entropy method [2], but we can find the linguistic solutions respectively.

Affinity between Czech and Polish is, similarly, proved by the similarity of the presented results. These are very close to the Czech. In specializing of recognizing only persons in a specific domain of stock exchange messages and police reports was achieved the success rate of 72% using Hidden Markov Models method and even 89% after linguistic optimization [4]. The question is how good results can be reached by this method when used on bigger scale of texts or for recognition of other types of entities.

As the English is one of the most used languages plenty of approaches have been proposed. This language belongs to the group of languages with constant form of words, where dominate statistical methods before linguistic. Three standard methods are the most used for English language: Maximum entropy method [5], Hidden Markov models [7] and Conditional random fields [3]. The actual state of art approaches in the field of named entity extraction for English do not outperform 90%, for German are achieved results aprox. 70% [2]. Both of these languages belong to the group of Germanic languages, but there are different rules for making sentences and different capitalization, thus there is quiet big difference in results for these languages.

3 Named Entities

The concept of named entities was gradually defined in MUC 1 to 6. It means word entities that are important for us in some way. After recognition of the entity it is marked by well-defined brands. We distinguish between these types of entities:

- Persons – marked <ENAMEX TYPE="PERSON"> and </ENAMEX>
- Locations – marked <ENAMEX TYPE="LOCATION"> and </ENAMEX>
- Organizations – marked <ENAMEX TYPE="ORGANIZATION"> and </ENAMEX>
- Dates – marked <TIMEX> and </TIMEX>
- Numbers – marked <NUMEX TYPE="NUM"> and </NUMEX>
- Percents – marked <NUMEX TYPE="PERC"> and </NUMEX>
- Sums of money – marked <NUMEX TYPE="MONEY"> and </NUMEX>
- Miscellaneous entity types – marked <MISC> and </MISC>

The process of identifying entities in the text consists of two parts – the initial part of pre-processing of the text and then the recognition of the named entities.

4 Text Pre-processing

As mentioned above, along with other Slavic languages, the Slovak belongs to the group of flective languages which means that most of its words are inflected according to certain grammatical rules. Because of that nouns, adjectives and verbs acquire several different forms and make it impossible to identify the entities directly form the specified text [9].

The words should therefore be first processed by a certain way. Our method uses a form of stemming. The regular stemming method consists of obtaining the word formation root of each word. This is done by removing prefixes and suffixes of words. For our purposes, we decided to remove only the word suffix caused by inflection. The result is an original form of words which is not the word formation root but, with only a few exceptions, we get the uniform forms of words with which can be used in further computation. Larger text editing process would unnecessarily slow down the algorithm. In some cases it would make exactly the same roots of similar words. That would be even counterproductive for named entity recognition.

Suffixes are identified by comparison each word with the set of Slovak word endings. We proceed from the longest to shorter ones to verify the suffixes, so we always remove the entire suffix. We do not change abbreviations made only form capitals, because they are not inflected.

The text pre-processing also divides the text into individual words and we separate the punctuation marks like full stops, quotation marks, commas, etc. from the words. Some of the punctuation marks are used as full-stop symbols. In this case it is clear that they cannot belong to the entity and the entity scope can be identified easily.

5 Named Entity Recognition

Slavic languages have a rich morphology and transform words to their basic form or find the root is algorithmically difficult and can not be provided universally. This makes low level extracting information, where we advise the named entity recognition, highly demanding and for computer processing disadvantageous [6]. We propose the named entity extraction (Figure 1), which consists of several steps.

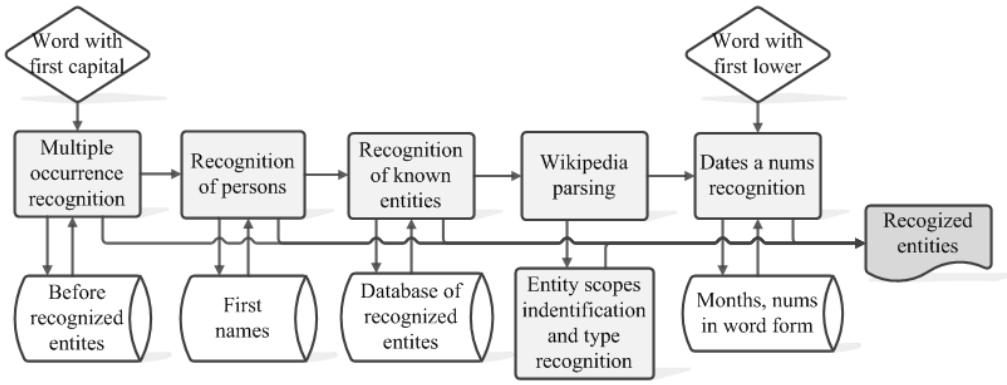

Figure 1. Sequence of steps describing proposed method.

The process of recognizing entities in the pre-processed text written in Slovak is slightly easier because of the fact that the entities always start with a capital letter. Due to this fact, for most types of entities we have just to search for the capital letters in the text. If we then sort out the beginnings of sentences or quotations that are not entities at the same time, we get a set of entity beginnings. Thus we are able to identify persons, organizations, locations and miscellaneous entities.

When found the beginning of the entity we recognize its scope through comparing the word and next words from the text with the list of before recognized entities, dictionaries or finally web parsing. If found the scope we try to recognize entity type through this compared expression.

After recognizing and marking the entities of these types, we store them into a special list. At the beginning, every new entity is compared with all the stored entities on the list, so we can simply identify entities that have already been recognized before without the long process of standard recognition of a new entity. In case of persons, we also store a surname separately because it is very common to mention the full name of the person at first and then, for simplicity, write only the surname. There is a chance that we do not recognize the surname in the text properly if we identify it by the standard way. For example, let us name a person with the surname "Pekný" standing at the beginning of the sentence.

Peoples' names may appear in different forms in the text. The basic form is to write a name and a surname. But the order of them can be changed or one of the parts can be replaced by initials. There can by two names or surnames in the one person's name. They can be written separately or linked by a hyphen. Person can by directly identified by titles or contextual words. Persons with a Slovak name can by identified by comparing their name with a dictionary of names. In recognition of context words we can avoid incorrect marking if we labelled a company named by its founder incorrectly by ignoring that after the person's name there are words such as "s.r.o." and the like.

We identify locations and organizations the most through dictionaries but if the entity is not in the dictionary, it should be found by parsing the Wikipedia[1] page. We search for scope of entity and the category it belongs to by the keywords gained from Wikipedia article. It is also helpful to determine the type entity by the contextual words such as the already mentioned "s.r.o." or "n.o."

It is necessary to find scopes for the miscellaneous entities, too. That means how many words from the text actually make the entity. We have to avoid a situation when recognize the word "Bratislava" in the text of "Dni Bratislavy" as a location and then wrongly ignore the rest.

In addition to entities beginning with capital letters, our method identifies also date and numeric entities. The numeric ones distinguish between money amount, percentage and a number itself. In identifying the type of numerical entities the context words are the most significant. They are also the most dependent on the language.

5.1 Dictionaries

Our method uses several forms of dictionaries. There are the alphabetically arranged arrays of words, word arrays primarily arranged according to length and then alphabetically arranged ones and bigger database of entities consisting of more words. Elements stored in these dictionaries are always prepared by stemming to be directly comparable with a modified processed text.

The only specific dictionary is the one of word endings. We use it to pre-process texts. This list is sorted by suffixes form the longest to the shortest ones and only then by the alphabet. When editing the input text we sequentially compare each word with the all elements of the dictionary until we get the match or go through the whole dictionary.

Similarly, in the form of an alphabetically sorted array other smaller dictionaries with relatively unchanging content are made such as a list of calendar months, or a list of Slovak names. These dictionaries are for time reasons searched by our quicksort implementation which is the reason why elements must be sorted alphabetically.

Large vocabulary of recognized entities is implemented as a database. It provides faster identification of entities which seek to reduce the need for time-consuming verification of the existence of entities using the Wikipedia.

[1] http://sk.wikipedia.org/

5.2 Web Parsing

If we come across the beginning of an entity we could not identify through dictionaries, we try to identify it using querying Wikipedia. There we enter an increasing number of words following the first word in text and look for the article with identical name. We try to find the longest match, so for example if found matches "Slovakia" and "Slovakia Hockey Hall of Fame", we choose second one. In case we find an article, we get the keywords from it and try to find the entity category from them.

Besides working with the Wikipedia we use the Slovak National Corpus [8]. In this manner we verify if the beginnings of sentences or quotations are common words or entities. We put the name of the potential entity into the corpus. Entity scopes have been identified earlier. We are looking for the term written with a small starting letter. If we get an empty set as a result (e.g., "slovenská technická univerzita" you will look for it uselessly), or the majority of results shows the first capital letter (e.g. "trenčiansky hrad"), it is an entity. Otherwise it is a common word.

6 Evaluation

To evaluate proposed approach we processed 20 articles from SME.sk[2], 20 from HNonline.sk[3] and 20 from topky.sk[4]. For achieved results (see Table 1) we identify Precision (number of correct results divided by the number of all returned results), Recall (number of correct results divided by the number of results that should have been returned), and F-measure (harmonic mean of precision and recall).

The current version of method reads input in the form of directly entered text or a link to the article available on the Internet. This link is processed through the Readability service (part of the Metall[5] service), which obtain the text of the article.

Using text pre-processing method we divide input text into the array of modified words, in which we recognize named entities. For recognition we use database of before recognized entities and dictionaries implemented directly as part of a method and can not be changed (e.g. vocabulary of calendar months or first names). We use them to compare and recognize potential entities.

Table 1. Achieved results of proposed method.

Type	Precision	Recall	F-measure
Persons	0.97	0.80	0.88
Organizations	0.94	0.67	0.78
Locations	0.83	0.73	0.78
Dates	0.97	0.76	0.85
Numbers	0.90	0.87	0.88
Percents	0.83	0.68	0.75
Sums of Money	1.00	0.76	0.86
Miscellaneous	0.50	0.66	0.57
Total	**0.84**	**0.74**	**0.79**

Results were obtained based on very small dataset, which was created and annotated manually by expert. Total we correctly recognized 1204 entities of 1620. We wrong identified 232. These results are used for the first concept evaluation and after finishing proposed method; it will be tested on bigger and more complex dataset, in order to obtain the more reliable results. Similarly,

[2] http://www.sme.sk/
[3] http://hnonline.sk/
[4] http://topky.sk/
[5] http://peweproxy.fiit.stuba.sk/metall/

the comparison to existing approaches for several languages will be performed, because of method language dependency exploration.

7 Discussion and Conclusions

In this paper we described a method for recognizing of named entities in the texts. We focused on Slovak language, where obtained result of 79% F-measure seems to be a promising result, but we expect slight improvement after completion of method and its tuning after more complex testing.

The method can be used, after slight modifications, also for other languages with a similar style of making sentences and the type of word inflection. Especially Slavic languages fulfil these conditions. After replacing dictionaries by a new dictionary containing data in the language with which we are going to work, we expect to obtain similar results like for the Slovak language. The method implementation is not complete yet. For example we don't parse the English version of Wikipedia if we didn't find some entity in the Slovak version. After completing the implementation and testing method more complexly we would like to put it as part of the Metall service, to be freely available to users.

The method was developed as a support tool for recommendation or search methods which can benefit in their work from our acquired named entities. The method can be used directly as a standalone tool to graphical highlight important entities in the text which will be then clearer for the reader. Other option is use it as a tool describing the important terms of texts which can serve as a very brief summary or to get keywords and then show them to the user so he can decide whether he will deal with the text.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0971/11.

References

[1] Grishman, R., Sundheim, B.: Message understanding conference-6: A brief history. In: *Proceedings of COLING*, 96, (1996), pp. 466–471.

[2] Konkol, M., Konopík, M.: Maximum entropy named entity recognition for Czech language. In: *Text, Speech and Dialogue*, Springer, (2011), pp. 203–210.

[3] Lafferty, J., McCallum, A., & Pereira, F. C. N.: Conditional random fields: Probabilistic models for segmenting and labeling sequence data. In: *Computer*, (2001).

[4] Marcińczuk, M., Piasecki, M.: Study on named entity recognition for Polish based on hidden Markov models. In: *Text, Speech and Dialogue*, Springer, (2011), pp. 142–149.

[5] Nigam, K., Lafferty, J., McCallum, A.: Using maximum entropy for text classification. In: *IJCAI-99 workshop on machine learning for information filtering*, (1999), pp. 61–67.

[6] Przepiórkowski, A.: Slavonic Information Extraction and Partial Parsing. In: *Computational Linguistics*, (June 2007), pp. 1–10.

[7] Rabiner L. R., Juang, B. H.: An introduction to hidden Markov models. In: *Current protocols in bioinformatics*, (January 2007).

[8] Slovak National Corpus – prim-5.0-public-all. Bratislava: Ľ. Štúr Institute of Linguistics SAV 2011. Available at WWW: http://korpus.juls.savba.sk/index_en.html.

[9] Slovake. About the language – Form and structure. [Online; accessed November 24, 2011] Available at: http://slovake.eu/en/intro/language/form.

[10] Suchal, J., Návrat, P. Full text search engine as scalable k-nearest neighbor recommendation system. In: *AI 2010*, IFIP AICT 331, Springer, (2010), pp. 165–173.

Building Domain Model via Game with a Purpose

Marek KIŠŠ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
keramssik@gmail.com

Abstract. In this paper we present a game with a purpose for building domain models. The game is designed for the domain of an adaptive learning system for software engineering. It is able to motivate students to contribute to creation of a lightweight term relationship network for a domain of their studies. In the game, players aim to find pairs of terms that have a lot in common. The number of points they obtain for their choice is based on a number of occurrences of this pair in a corpus of domain documents.

1 Introduction

The Web brings many possibilities to improve learning processes. A part of them is represented by adaptive learning systems. These systems try to determine the level of students' current knowledge of particular concepts in order to adapt to his needs and make the learning for him more effective [2]. Prerequisite for a working adaptive system is the existence of the domain model to provide basis for modelling both user knowledge and semantics of domain documents. Despite the use of conventional, heavy-weight ontologies, simple domain model represented as a concept relationship networks and easier to create, also proved to be efficient for this task in certain systems [1]. However, even the creation of such a simple model cannot be fully automated and it is usually a work for authors of contents. Today's learning systems behave as collaborative dynamic environments and allow their users to participate on authoring. Students can for example add comments to existing learning objects or create new content. But there is still need for processing this new content and updating existing domain model. That is kind of work, that users as new authors do not want to participate on.

Every day, the Web becomes a playground for millions of people that play simple online games. However, they are looking for abreaction from work, they enjoy mental stimulation that games provide and while their brain is still working. Games with a purpose are games that are designed to harness this idle power of human brain for solving tasks, that can't be fully automated. Tasks have to be incorporated into a game mechanism in a way that results created by playing this game are valuable. Games with a purpose adopt the "wisdom of crowds" paradigm: "If many say that A is an instance of B, A is likely an instance of B" [5].

---

* Bachelor degree study programme in field: Informatics
Supervisor: Jakub Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 21–26.

Building a domain model for adaptive learning system is a task that is suitable for creating a game with a purpose. Game can motivate students to contribute on creating of a lightweight term relationship network for a domain model for the same system they are using for learning. The idea is to make from this boring work an enjoyable part of a learning process.

2 Related work

A number of different approaches were devised for automatic creation of domain models in a domain of adaptive learning [2, 7]. They differ in a level of their automation, technique for concept extraction and creation of relations between concepts. Quality of created models is diverse too, but always inferior to human produced models. Cristea and Mooij's approach does not try to create domain model, it just create suggestions for authors to support their decisions. They calculate relatedness between manually selected concepts, based on the number of occurrences of the keywords of one concept in the attributes of the second concept. Calculated relatedness is displayed to authors, which have to manually determine the accuracy of each proposed relation [2]. In opposed to this approach, in our method authors does not need to decide which relations are correct. This part of the task is solved by players.

First who came with the idea of using games with a purpose was Louis von Ahn. In 2004 he created first game called ESP Game for annotating images [8]. Game had been licensed by Google and between 2006 and 2011 was used under the name Google Image Labeller. It was collecting labels to images for improving image search. It´s success was so high, that in next few years were created many new games with a purpose. Most of them were designed for annotating multimedia or semantics acquisition.

PlayCoref is a game that works with text [3]. Its' purpose is obtaining annotated coreferences from text. Coreferences discovered by this game can be used by many applications working with text. PlayCoref is a game for 2 players. They try to mark as much coreferential pairs in time limit and beat each other. When a player is done with currently available text, he can ask for new sentences and continue marking until round end. Phased addition of sentences tries keeps game dynamics, and avoids overloading with a long text. Score obtained by player depends from the total number of pairs he marked, number of pairs on which he concur with his opponent and an automatic evaluating function. Since this game has not many players, authors developed a single player version of it. Despite the effort to create dynamic and attractive game, this game is not very popular.

GuesWhat?! is a game with a purpose for mining linked data [4]. Players try to find new concepts that fit generated restrictions. These restrictions are a description of a concrete concept in existing domain model, so there is always a correct solution for each game. There can be found more suitable concepts, which can extend existing domain model. This game is for at least two players, which means that there might be problems connected with a lack of players, since they have to validate their solutions to each other. Authors believe in clean-handedness of them, but this can be the main pitfall of the game. In our game, we have a player independent scoring system.

Little Search Game is another game with a purpose for a term network acquisition [6]. This one is a single player game working with Google search queries. Game starts with a term and a number of total results of its query. Player tries to write negative terms, that will reduce this number of results. The number of points he obtain for each term depend from cut-down of results, so the player writes words that have a lot in common. He can eventually come up with a couple of words, that have a strong relation, but they don´t occur much together. He won´t be awarded with a great deal of points for this move, but his choice can be very valuable, because automatic extraction of this kind of relationship (called "hidden relationships") is impossible. This game's main advantage is that it is a single player game, a contrast to usual games with a purpose. A disadvantage is that players have to use keyboard and write words manually, which is not the

most comfortable way to interact with a game. Curiosity of this game is that amount of points obtained for the same player input will change over a time. This is caused by using the web search tool for evaluation of player's inputs, but for players it can seem as a bug and they may think, that that game is broken. We tried to design a more dynamic game. In our game, player interacts with a game by a mouse. Instead of writing text he just clicks on displayed words. Also player always obtain the same number of points for the same move.

3 Game for domain model building overview

We created a new game with a purpose for building a domain model. Our game works in a domain of adaptive learning system – ALEF[1], but it is able to work in many different domains. As input we use documents from online course Principles of Software Engineering. Outputs are pairs of linked concepts connected by players.

Our game is based on similar principles as Little Search Game [6]. It´s an online single player game working with search queries and creating a lightweight term network. Its player interface is depicted in the Figure 1. At the start a player gets a term and tries to find the most related term to it. Game designed by us differs from Little Search Game in a way how the player interacts with a game. Instead of thinking out the best term and writing it to the input form, he has to choose the best one from terms offered by the game. They appear in colourful bubbles, blowing up upon selecting, yielding the number of points received by the player by that action.

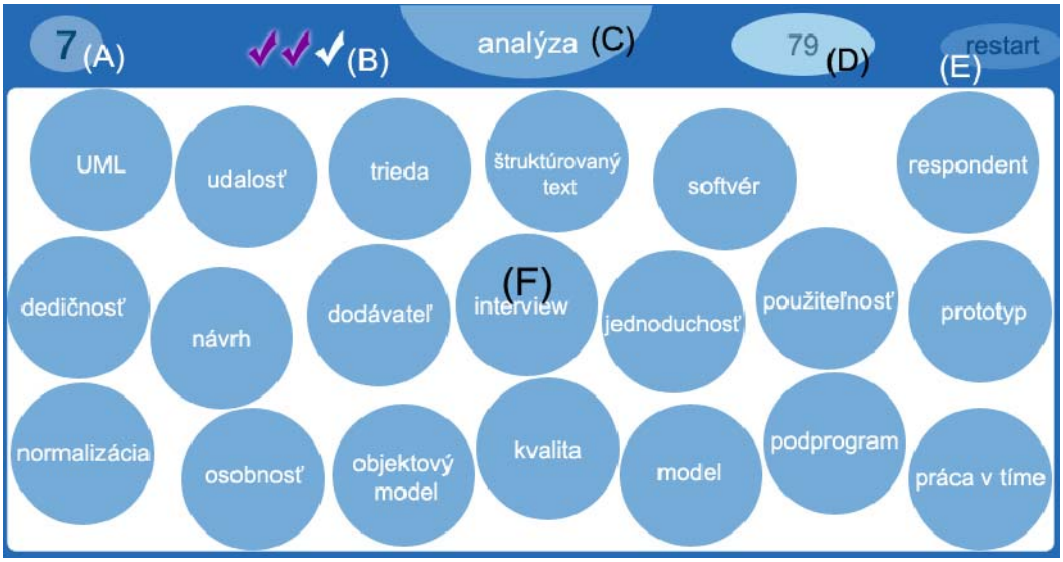

Figure 1. GUI of our game: timer(A), shot counter(B), game specific term(C), current score(D), restart button(E) and cloud of bubbles(F).

Terms, which will appear in "cloud of bubbles" are chosen by the game itself and their presence is influenced by the number of occurrences in corpus of documents containing round specific term. There are rules for choosing terms in to bubbles:

- One third of used terms is randomly chosen from 10% of terms with highest co-occurrence with a round specific term.
- Second third is chosen from the set of 30% terms with lowest co-occurrence.

[1] http://alef.fiit.stuba.sk/

- Last third is chosen from the remaining set of terms.
- Choosing terms into the game, except those with highest co-occurrence is affected by their effect in previous games. Terms that are evaluated have a less chance to by chosen.

The last rule means, that our game works just with a subset of all terms that fit in each category. Game monitors behaving of players in games and evaluates displayed terms. If many players have not chosen a certain word in the same round, it realize that there is probably not any kind of strong "hidden relationship" between this term and round specific term, remove it from the set of terms it works with and replace it with another one. A term is replaced similarly, when many players choose it and relatedness to round specific term is confirmed. If the popularity of our game increase and it will have more players, than will be these restrictions in choosing terms for a new round unnecessary. But now it helps us to obtain results fast even if we do not have many players.

Terms used in our game are manually created concepts for this domain. They have connections to domain documents. Those connections we use to calculate co-occurrences between them. Second method that we use for calculation of co-occurrences is by search queries. We use for this purpose search server Solr[2]. We have saved the values of co-occurrences with every potential game specific term to every term in database. Calculation of this value is very time-consuming work and must be done at advance.

When a player blows out a bubble with a term he has chosen, he obtains some points. The number of received points depends from co-occurrence of the term he clicked on and the round specific term in corpus of domain content. It is calculated as a proportion between number of documents containing both terms and all documents in which round term occurs. The result is multiplied by 100, because we believe that integer numbers are for this purpose more suitable than decimal numbers. For example, when a player plays a round with specific term that occurs in 10 documents and he blows up a bubble with a word that occurs in a half of them he obtains 50 points, representing 50% of documents with both words.

Every game starts with generating a specific term and "cloud of bubbles". Player has a time limit to blow out three bubbles. For every term he had clicked on, obtains points, which count together. After he finished the game, he can see the high score table. If he is not satisfied with his score, he can start a new round with the same specific term. The "cloud of terms in bubbles" is for every new round generated again. He can play up to 3 rounds in every game and only the best of this attempts counts.

Besides logging the information needed for relationship extraction, our game logs many other details about played games which we intend to use further for improvements in gameplay (ergonomics) and also the relationship extraction analysis itself. For each round we save all terms that appear on screen. For each term we save its position on screen and for chosen terms we save time, when player clicked on them. We save time of start and end of every game and round. Considering the time aspect in the future work, we aim to disclose more about the level of certainty of the player about his decisions, this way we can modify the weights assigned to term relationships by a primary extraction method and possibly save some player attempts needed to confirm the yet uncertain relationships.

4 Evaluation

We have prepared an experiment to confirm our method for building domain model using a game with a purpose. We measure the correctness of outputs produced by our game and make a survey to get a feedback from players.

Hypotheses and questions. We aim to assess the answers to following questions:

[2] http://lucene.apache.org/solr/

1. Are relationships produced by players of our game correct?
2. Will players detect hidden relationships too, just as in the original version of the game?
3. What types of relationships dominate in produced term network?

Participants. Players of our game are students of the Principles of Software Engineering course. Playing this game is an optionally activity for them and they may obtain a few bonus points if they achieve good results in the game. For evaluation outputs produced by the game, we have two independent experts familiar with the domain.

Data. We test our game in the domain of Principles of Software Engineering course and as input we use its documents from learning system ALEF comprising tens of textual learning objects (few pages each). We manually choose some terms from these documents and mark them as potential game specific terms. For faster data processing we affect choosing terms into bubbles. We start an experiment preferring a subset of them. It helps us to faster detect possible relationships. We monitor and analyze games with terms from this subset and gradually replace them.

Methodology. At first, we explain the rules of the game to our players. Then we ask them to play some games. We let them to repeat every game three times to maximize their score. Only the best round counts, but we save every their click during their attempts. We make this experiment with more classes of students in different times, in order to prevent them to share their experience and minimalize the effect of this drawback on produced data. We motivate them to compete. Only top players will gain points to semester, so they have motivation to beat each other. After game we ask them to answer a few questions about the gameplay.

Process. We evaluate obtained data against a gold standard using the precision and recall method. For this purpose is needed a set of all possible relationships between terms in our domain. This set was created by our experts. They take in to account only terms that appeared in game. By the value of points it was obtained for every pair of terms, we determine if it is a hidden relationship or not. We manually split the set of obtained relationships into the main categories and determine which type dominates.

5 Conclusion and further work

We presented our game with a purpose that is able to motivate users of the system to contribute on building a domain model for this system. We prepared an experiment that evaluates our method on domain of adaptive learning system. We believe that this method can be used for many different domains.

Advantage of our game is that it´s single player game, so we avoid many typical problems with a lack of players. They try to beat each other, so their motivation for collaboration is reduced. Despite of this, there is still chance they will share they experiences and we have to find solutions, how to avoid this unwanted behaviour.

Design of our game is based on Little Search Game. It differs in a way of interaction with a game. We limited user choice on a set of terms generated by our application. The Loss of absolute freedom in choice is compensated by more comfortable way of interacting with a game. This makes our game more dynamic.

Our primary future work is to perform the proposed experiments. By analysing data obtained by gameplay and feedback from players we want to continue with improving our method, namely the ergonomics of the game interface (we might reconsider the number of term bubbles appearing in each game) and also the term network extraction procedures, which could also consider the level of certainty of the player, expressed by the speed of his actions.

Acknowledgement: This work was partially supported by the Slovak Research and Development Agency under the contract No. APVV-0233-10.

References

[1] Bieliková, M., Šimko, M., Barla, M.: Personalized web-based learning 2.0. In: *Proc. of the 8th Int. Conference on Emerging eLearning Technologies and Applications,* (2010).

[2] Cristea, A.I., Mooij, A.D.: Designer Adaptation in Adaptive Hypermedia Authoring. In: *Proc. of ITCC*, (2003), pp. 444–448.

[3] Hladká, B., Mírovský, J., Schlesinger, P.: Designing a Language Game for Collecting Coreference Annotation. In: *Proc. of the Third Linguistic Annotation Workshop*, (2009), pp. 52–55.

[4] Markotschi, T., Völker, J.: Human Intelligence for Mining Linked Data. In *Proc. of the Workshop on Knowledge Injection into and Extraction from Linked Data (KIELD) at the International Conference on Knowledge Engineering and Knowledge Management*, (2010).

[5] Siorpaes, K., Hepp, M.: Games with a Purpose for the Semantic Web. In: *Proc. of IEEE Intelligent Systems*, (2008), pp. 50–60.

[6] Šimko, J., Tvarozek, M., Bieliková, M.: Little search game: term network acquisition via a human computation game. In: *Proc. of the 22nd ACM conference on Hypertext and hypermedia,* (2011), pp. 57–62.

[7] Šimko, M., Bieliková, M.: Automatic Concept Relationships Discovery for an Adaptive E-course. In: *Proceedings of 2nd Int. Conf. on Educational Data Mining EDM*, (2009), pp. 171–180.

[8] von Ahn, L., Dabbish, L.: Labeling images with a computer game. In: *Proc. of the SIGCHI conference on Human factors in computing systems*, (2004), pp. 319–326.

Using Trainable Duplicate Detection for Automated Public Data Refining

Martin LIPTÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
mliptak@gmail.com

Abstract. Public institutions share important data on the Web. These data are essential for public investigation and thus increase transparency. However, it is difficult to process them, since there are numerous mistypings, disambiguities and duplicates. In this paper we propose an automated approach for cleaning of these data, so that further querying result is reliable. We develop a duplicate detection method that can train weights of features on small amount of training samples and then predict duplicates on the rest of data. We evaluate our method on a real-world data set.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 51-55.

* Bachelor study programme in field: Informatics
Supervisor: Ján Suchal, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 27–32.

An Evaluation of Individual Matching with TRREE Reasoner and SPARQL Based Inference

Marek ŠUREK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
marek.surek@gmail.com

Abstract. The aim of this paper is to present an evaluation of an individual matching approach with the Triple Reasoning and Rule Entailment Engine (TRREE) and SPARQL query based reasoning. We discuss the differences and evaluate their performances on specific rules implementation of a business application. The intention of this evaluation is to improve performance of our individual matching process since it slows down rapidly as it grows amount of triples in semantic repository.

1 Introduction

Integration is a common task for any software product. Semantic technologies come with new ideas and techniques to make this process easier and more efficient. A big field of semantic research is devoted to ontology and individual matching [1]. In our work we focus on real estate matching process improvement which is a part of SESTATE (Semantic real ESTATEs), a semantic backend for real estate offers processing [2]. Sestate is as commercial product [3] developed by Datalan a.s Bratislava, Slovakia [2].

For the sake of the matching process we compare capabilities and performance of the TRREE reasoner, a native reasoner of OWLIM [4], with a SPARQL [5] based inferencing.

TRREE reasoner is implemented in Java and runs on SAIL layer in Sesame framework [6]. It is based on R-entailment defined by ter Horst [7] and it supports standardized rulesets/profiles [8]. The power of TRREE is that it supports forward-chaining reasoning which leads to total materialization of inferred triples. This approach allows using OWLIM semantic repository in various business scenarios when it is necessary to get a result of a query in time comparable with relational database. Therefore OWLIM storage engine is used as default storage in our comparison.

* Bachelor degree study programme in field: Informatics
Supervisor: Miroslav Líška, DATALAN, a.s., Bratislava, miroslav_liska@datalan.sk

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 33–38.

2 Individual matching

As we mentioned in previous section, our goal is to find efficient way at field of individual matching problems. For this purposes we use real data from Datalan product [3] which we import into our project Sestate. Basic idea of the project is to insert real estate offers into semantic repository and infer relationship between estates which are similar or equal. We achieve this goal by applying our custom ruleset at repository or by firing SPARQL queries.

Used ontology structure covers big range of attributes and relationships from real-estate world. Datalan has developed their own ontology. Currently Sestate does not include any public available open-source ontology.

2.1 Matching rules

Our matching rules reflect need of matching only individuals which are members of the same class. At the same time we want to create rules which reflect complicated relationships between entities and also straight forward relationships with fewer premises.

The integration process consists of 4 rules. We provided one of them bellow.

```
Id: sameAsCandidate_1
     x  <rdf:type> t
     y  <rdf:type> t                [Constraint x != y][Cut]
     x  <realestate:address> a
     y  <realestate:address> b      [Constraint x != y, a != b][Cut]
     a  <address:municipality> m
     b  <address:municipality> m    [Constraint a != b][Cut]
     a  <address:streetName> n
     b  <address:streetName> n      [Constraint a != b][Cut]
-----------------------------------------------------------------
     x  <realestate:sameAsCandidate> y
```

The second rule is variation of sameAsCandidate_1 rule with small differences due to ontology structure and type of data we have. The next rule can be identified in OWLIM built-in rulesets RDFS [4] under name rdfs13.

Special importance should be given to last rule which ends with realestate:sameAs predicate between identical individuals. As we mentioned, we do not use owl:sameAs implementation for our current work. Instead of it we use our predicate realestate:sameAs which have no additional semantics in comparison to owl:sameAs. In this paper we do not want to use advantage of owl:sameAs optimization and other things which are related to this predicate.

We realized that rdf:type matching could lead to obvious performance drops. Therefore we made some optimization techniques which lead to the same results but with using different amount of time. We created predicate realestate:type and added it to all individuals. Realestate:type connects individuals with literal value which represents individual's real (rdf:)type. This replacement occurs in 2 rules – sameAsCandidate_1, sameAsCandidate_2. We assume this replacement do not cause incorrect results, but could prevent significant performance drops during reasoning.

3 The evaluation

3.1 Methods of testing

Testing dataset consists of four owl files, each representing realestate offers created during a week. The additional statistics is illustrated in Table 1.

In both reasoning methods we achieved the same results. Data presented in Table 1 are equal for combined SPARQL and TRREE reasoning and also for exclusive TRREE reasoning.

Table 1. Test data for both inferencing methods.

File name	Number of new real estate offers	Number of new explicit statements	Number of new implicit statements	Total number of statements	Total number of estate individuals
1.owl	28 521	1 011 685	112 870	1 124 555	28 521
1.owl + 2.owl	34 272	1 249 962	290 780	2 665 297	62 793
1.owl + 2.owl + 3.owl	22 412	978 740	369 574	4 013 611	85 205
1.owl + 2.owl + 3.owl + 4.owl	22 862	904 483	506 222	5 424 316	108 067

3.1.1 Results measuring

We load owl files incrementally one by one. Measured results are written in result tables which are placed in next sections of this work. Time results in tables do not include previous effort necessary to achieve the final state – we do not count time of loading caused by previous files, we count only time of the last increment. The same technique is used in combined SPARQL and TRREE reasoning. We measure only time of last loaded owl file + runtime of all SPARQL queries which substitute TRREE rules in pie file.

In combined SPARQL and TRREE reasoning, we divide the rules in following way. Rule rdfs13 is reasoned with TRREE reasoner. All other rules are rewritten into SPARQL syntax and fired sequentially in Sesame Console. All results of SPARQL INSERT query are put into implicit graph. This technique is used to get exactly the same results as by using TRREE reasoner. We have to point out that we take advantage of SPARQL syntax expressivity and matching statements run only over explicit graph. We turn on query optimization for best optimization of queries before they are fired.

3.1.2 Testing machine

Processor: Intel Core 2 Duo P8600, 2.4Ghz per core
RAM: 4GB
HDD: 500GB 5400rpm
OS: Windows 7 64bit
OWLIM SE version: 4.3 running on Tomcat 6.0.35

We configure server memory management according configuration utility packed in OWLIM distribution and enable query optimization and indexes.

3.1.3 Using rdf:type

We ran those 4 rules for 24 hours only with 1.owl file and we still could not get end of loading. We investigated the problem only partially as it is not aim of the work. The realized facts indicate possible deadlock during reasoning. As the issue seems to be complicated we cannot make clear assumption about cause of the problem.

3.1.4 Using realestate:type

This test is based on replacement of rdf:type predicate in rules sameAsCandidate_1 and sameAsCandidate_2 with realestate:type.

Table 2. TRREE reasoning – rdf:type replaced with realestate:type.

Number of individuals	Time
28521	50sec
62793	86sec
85207	101sec
108067	122sec

3.2 SPARQL based matching

3.2.1 Using rdf:type

This set of tests is made by combining TRREE reasoner with simple SPARQL inferencing. Final results consist of counting TRREE reasoning/loading time + time of all SPARQL INSERT queries. The queries are complete rewriting of OWLIM rules into INSERT SPARQL syntax.

Table 3. Results of SPARQL inferencing on rdf:type property.

Number of individuals	Time
28521	63sec
62793	129sec
85207	254sec
108067	582sec

3.2.2 Using realestate:type

The last test also substitute rdf:type for realestate:type. All measured results are present in Table 4.

Table 4. SPARQL reasoning with realestate:type.

Number of individuals	Time
28521	63sec
62793	124sec
85207	191sec
108067	347sec

3.3 Result analysis

TRREE reasoner shows the highest performance in our tests. Significant differences occurred when number of triples in repository raises. TRREE engine scale better in bigger repositories in comparison to SPARQL inferencing. Other note worth fact is that replacing rdf:type in rules with our realestate:type provide significant performance boost.

Even the fact TRREE has the best performance, we should mention that in SPARQL inferencing we fired queries/rules sequentially and therefore we did not take advantage of multithread reasoning which is with SPARQL possible. Parallel query reasoning on multicore systems can lead to better results and could reduce difference between TRREE and SPARQL.

4 Realized limitations

4.1 Limitations of TRREE based matching

Despite of performance leadership of TRREE we have to mention negative sides which make matching harder. Matching problems needs wide variety of supported built-in functions which can

be used for better specification of relationships between individuals. In version 4.3 TRREE does not support any aggregate functions as COUNT, SUM or basic arithmetic which is natural for SPARQL. This leads to lower usability of this rule engine and therefore it is necessary to use also SPARQL in matching individual problems.

Another problem relates to only partial implementation of reasoning over specific graph. The main concept of OWLIM repository is based on two graphs which every repository should have. The first graph is graph of explicit statements. The second graph (implicit) contains only statements which were created as a product of reasoning. As number of implicit statements can be even higher as explicit it unnecessarily burdens reasoning because it has to go over bigger set of statements. OWLIM implementation does not allow reasoning over these graphs. Instead of it, we can use [Context] operator for creating and using auxiliary graphs [9]. This feature is efficient in rule chaining. The explanation of the process could be following. Output of Rule1 and Rule2 is stored into temporal graph and then it could be used as input for Rule3. This optimization technique can dramatically reduce reasoning complexity for chained rules. As the techniques can be cover certain problems full implementation of context would be more efficient.

Research paper published by the authors reveals the problem of implementing full context support in reasoning. TRREE was designed with R-entailment in mind where rules are applied directly to the entire graph of stored RDF triples [5]. As the necessity of feature is obvious authors plans to re-implement their engine to eliminate this disadvantage.

The next identified problem is that TRREE reasoning is only single threaded. This limitation can be very restrictive as common enterprise servers consists of multicore systems. Authors try to add some optimization techniques which can speed up reasoning process e.g. [Cut] operator in premises [9]. This operator can reduce number of variations in rule, but cannot be applied only in specific situations.

4.2 Limitations of SPARQL based matching

We identify one negative element of matching with SPARQL. Even sufficient expressivity of language cannot hide problem with performance. We make assumption based on our results, SPARQL scale worse than TRREE when higher number of triples is present in repository. This limitation is very important for commercial product and therefore it can be crucial in decision process which inferencing should be preferred.

5 Conclusion

TRREE reasoner is capable of great performance results. The negative side of thing is that we have to know his strong and weak sides. In some circumstances it offers outstanding performance, but in others we could not even get results in reasonable time. Authors of this product will have to work on stability of their product and optimize performance to make stable performance results in all areas. Lack of implementation details in documentation of TRREE do not allow us to make clear assumptions or create high performance rules.

Evaluating expressivity of rule syntax and capabilities of TRREE can be also questioned. Syntax offers good support for all standards and is sufficient for simpler rules. On the other hand, task like creating matching rules needs higher expressivity of language especially arithmetic operations will be very helpful.

OWLIM reasoner persuades us it could be good candidate for matching problems. We have to point out that there is a long way for improvement. Currently the best way is using SPARQL inferencing in cases of necessity arithmetic and built-in functions. In other cases TRREE can provide much better performance especially in growing datasets and therefore his usage should be preferred wherever it is possible. Referring to OWLIM roadmap [10], improvements in all insufficient areas could be implemented in a few months.

6 Future work

We will investigate improvements of OWLIM in next few releases. According to authors of this repository they plan to widely improve their inferencing engine and add better support for multithreading reasoning which is now implemented as experimental feature. For now authors do not recommend to use this experimental feature.

They also plan to add arithmetical functions and built-in functions especially those which are also present in SPARQL 1.1. In further future they plan add support for quad reasoning (reasoning over certain graph). It could help the product better handle matching problems used in this paper. Special caution we want to take on adding literal indexes which should come in next version of OWLIM. This feature can change results of combined SPARQL reasoning with TRREE using realestate:type. In combination with multithread query firing it could overperformed TRREE reasoner.

Except improvements provided by authors we will investigate the cause of problem with rdf:type matching in rules as it could be serious problem for commercial product.

References

[1] Euzenat, J., Shvaiko, P.:. *Ontology Matching.* Springer, 2007, p. l.

[2] Datalan. Datalan a.s. [Online] [Cited: February 22, 2012.] http://www.ontologia.sk/datalan/realestate.owl.

[3] Cenová mapa nehnuteľností. [Online] [Cited: February 22, 2012.] http://www.cmn.sk/.

[4] Ontotext. Ontotext. [Online] [Cited: February 22, 2012.] http://www.ontotext.com/owlim.

[5] W3C. SPARQL Query Language for RDF. [Online] [Cited: February 22, 2012.] http://www.w3.org/TR/rdf-sparql-query/.

[6] Openrdf. [Online] [Cited: February 22, 2012.] http://www.openrdf.org/.

[7] Kiryakov, Atanas. Openrdf.org. [Online] [Cited: February 22, 2012.] http://www.openrdf.org/conferences/eswc2006/OWLIM_SesameTutorialESWC06.pdf.

[8] W3C. OWL 2 Web Ontology Language. [Online] [Cited: February 22, 2012.] http://www.w3.org/TR/owl-profiles/.

[9] Ontotext. Owlim documentation. [Online] [Cited: February 22, 2012.] http://owlim.ontotext.com/display/OWLIMv43/OWLIM-SE.

[10] Ontotext. Ontotext roadmap. [Online] [Cited: February 22, 2012.] http://owlim.ontotext.com/display/OWLIMv43/OWLIM+Roadmap.

Association Rules Mining from Context-Enriched Server Logs

Juraj VIŠŇOVSKÝ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
visnovsky.j@gmail.com

Abstract. As users are browsing the Web, servers are recording millions of theirs actions to eventually offer better service. This paper describes the importance of server access logs analysis and the possibilities of the analysis results usage. The role of the context in the Web usability is described and description of a method of context-aware access logs analysis is provided with an example of enriching server logs by various contexts. This paper includes description of a method of association rules generation based on parallel FP-Growth algorithm. The application of this method is being applied on the logs of Adaptive proxy server.

1 Introduction

Most of the users' actions on the Web are being captured by servers. These records are called server access logs. By capturing users' requests the server providers gain large amounts of useful data. Although gathering knowledge out of such a high number of records is not a simple task.

By using web usage mining techniques we are able to discover interesting information about their behaviour. Resolving users' behavioural habits may be used in improving personalized recommendation and targeted advertising. For our purpose we are going to mine frequent patterns using FP-Growth algorithm and then generate association rules.

As mentioned above, mining knowledge in such a large dataset is a difficult computational task for most of the common devices. That is why we are going to speed up the process of computing by implementing parallel FP-Growth algorithm and moreover this algorithm will be run on distributed system SMART. This system consists of one master node, 16 slave nodes and uses a software framework called MapReduce.

In this paper we focus on the analysis of Adaptive proxy server [7] access logs. The goal of the Adaptive proxy server is to improve user's experience by personalising Web content. Our dataset consists of more than 3 million access logs describing the activity of 77 unique users.

When analysing server access logs, we have to bear in mind that these logs represent human actions and we have to consider many different contexts which could affect user's actions. That

* Bachelor degree study programme in field: Informatics
Supervisor: Dušan Zeleník, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 39–44.

is why we have to represent every item in FP-Growth algorithm's tree as a context-enriched access log.

The motivation of mining association rules from access logs is the variety of discovered knowledge usage. Not only will we be able to predict users' future actions, but we will also be able to contribute on the Web personalisation. Moreover, knowledge of users' habits may be very useful in the field of e-commerce.

2 Related work

Discovering interesting knowledge in association rules generated from server logs is a common task used in web usage mining. The mining can reveal much useful information and therefore a lot of research has been done on this topic. Hipp et al. introduced in their paper [5] association rules mining in the process of knowledge discovery using Apriori algorithm. Huang et al. in their work [6] also experienced generating association rules from a large collection of server's log data using Apriori algorithm. The mining of interesting association rules from the preprocessed Web logs has been described by Peng. He decided to use FP-Growth algorithm for fulfilling this task [9].

Enriching server logs by context information leads to developing context-aware and personalized applications (e.g. recommender systems or e-commerce) as described by Abbar et al. [1]. Context-aware query suggestion and recommendation in search engines has been proposed by Yan et al. [11] and Liao et al. [8] as well. In the first paper they used mining of query sequence patterns for building recommendations. However, in the second mentioned work an off-line implementation of a clustering method over the queries for generating suggestions was used. The task of discovering associations between user's action and contexts is widely developed in the domain of mobile devices. This field of research is called reality mining and the whole idea came up from Eagle and Pentland [4]. Cao et al. described a method of behavior pattern mining for the user of mobile device in their paper [2]. For this purpose they proposed using a modified Apriori algorithm for generating association rules.

3 The role of context

Expressing what the word context means can be difficult and so is to define it. Many researchers tried to define context by practical examples, but such definitions are not sufficient. Probably the best definition came up from Dey [3]. According to this definition context is any information that can be used to describe a state of an entity. The entity could be a person, an object or a place that is relevant to the interaction between an application and a user.

In this paper we consider only small amount of contextual information influencing user's actions. As we are slightly limited by using the access logs, neither user's current mood nor his exact location is able to be found out. Since we are able to gather user's IP and, thus we can get at least his approximate location. We use contexts as follows.

3.1 Time

Time is considered to be one of the dominant factors having influence on users' actions. It is a well known fact that users' behaviour is dependent on the part of the day, the day of the week or the time of the year. Time context may have a great influence on the results of our research and may lead to discovering the most useful and interesting knowledge.

3.2 Location and occupation

Location is another crucial context as users are, thanks to the mobile devices and many possibilities of connecting to the network, capable of browsing the Web almost everywhere. We

are, therefore, not only able to acquire users' current location but, by a set of accesses analysis we can estimate users' occupation as well. By occupation context we mean the fact whether user accesses the Web from home or from work.

3.3 Weather

Weather may be qualified as a questionable type of context. For instance, while user browses the Web indoors, weather does not affect directly the application or the user. On the other hand, it is common knowledge, that weather has impact on humans' mood and behaviour. Consequently, we consider it as relevant context.

3.4 Web domain category

Web domain categorization plays a vital role in the context-aware access logs analysis. This process in general consists of assigning web domain to a class from predefined set of categories. Unlike in Web page categorization, where we are able to fetch content of a page for classification, we propose a simplistic method for Web domain categorization. In this method, we only consider keywords acquired from many different sources and according to this result we are able to express whether the Web domain is related to information technology, research or study.

4 Method for generating association rules in contexts

In this section we are going to introduce a method for discovering association rules in context-enriched server logs. Our method (Figure 1) analyses logs gathered by Adaptive proxy server. This data are being processed by our method in three steps.

1. Data preprocessing
2. Frequent patterns mining
3. Association rules generation

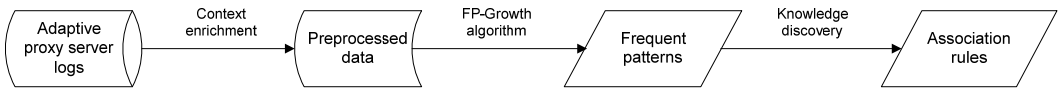

Figure 1. An overview of the method of association rules mining in access logs.

4.1 Context acquisition

Although server logs may be recorded in many different formats, there is always a field of timestamp. Timestamp represents current date and time at which the log has been recorded. Thanks to the timestamp we can easily acquire any kind of *time* context information.

Another field present at all log formats is user's IP address. Using IP geolocation services, similar to IPInfoDB[1], we are able to look up user's approximate *location*. It has to be mentioned that by using this kind of geolocation services we are unable to detect exact location, but as HTML 5.0 geolocation is not included in our dataset, we consider IPInfoDB's output acceptable.

Using combination of user's location and time we can acquire another context information – *weather*. For gathering historical weather data of particular location Wunderground's[2] services are used.

For *web domain categorization* we proposed simple method, which evaluates domain's relation to information technologies, study and research. For this purpose we use the combination

[1] Free IP address geolocation tool, http://www.ipinfodb.com/
[2] Commercial weather service, http://www.wunderground.com/

of Alchemy categorization service[3], Delicious tag suggestion[4] and keywords attribute of the HTML meta element.

In addition, we propose a simple method for defining user's *occupation*. In this method we merge already discovered knowledge of time and web domain category.

4.2 Discovering association rules in context-enriched data

In this section we are going to describe FP-Growth algorithm, which is being used to mine frequent patterns and association rules from large datasets. An association rule represents a correlation between two or more items which do not seem related at the first glance.

An association rule can be expressed as logical implication A ⇒ B with attributes of support and confidence. Support is the probability both A and B occur and the probability that B occurs when A is already present is called confidence.

For discovering association rules we propose a modification in FP-Growth algorithm. While we are seeking to discover context-aware association rules, every node of the FP-Tree will be represented by a context-enriched access log.

4.2.1 FP-Growth algorithm

Frequent pattern growth algorithm needs two scans of the access logs stored in database. At the first scan, algorithm evaluates occurrence of every context-enriched access log. Then the algorithm builds FP-Tree structure and inserts only the most frequent access logs as the tree nodes.

Minimum support threshold defines how many times a log has to be noticed during the scan to be considered a frequent item.

FP-Tree (Figure 1). The root of the FP-Tree is always null. Tree node consists of particular context-enriched access log from the database, its frequency (support) and link to the next node.

The FP-Tree is build in two steps:

1. The database is scanned for the first time. A list of frequent access logs, which consists of the most frequent logs and theirs support, is created. The list is ordered in support descending order.
2. Null FP-Tree root is created. Each transaction from database is then inserted into tree as a node. If node already exists its frequency is incremented by 1.

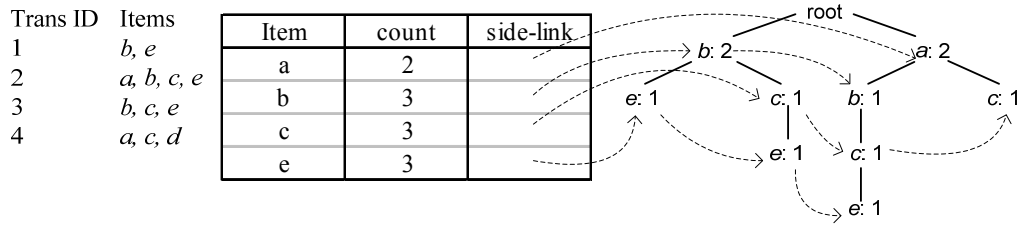

Figure 1. An example of FP-Tree [10].

FP-Growth. FP-Growth algorithm analyses FP-Tree representation of database and it results in a set of frequent patterns. The process of frequent pattern mining consists of browsing unique node keys in FP-Tree and according to paths to the root from this node we are able to identify frequent patterns. Support of the pattern is given by node's attribute – frequency.

[3] AlchemyAPI topic categorization, http://www.alchemyapi.com/api/categ/
[4] Fetching popular and recommended tags, http://www.delicious.com/developers/

4.2.2 Generating association rules

FP-Growth algorithm handling large amounts of access logs may produce a high number of frequent patterns. The results may consist of strong related association rules. These can, however, be misleading. In order to improve our result-set we have to get rid of misleading, obvious or redundant association rules.

5 Evaluation and experiments

To evaluate our predictions of future events, access logs in our database will be split into two parts. The first larger part represents training interval of context-enriched access logs. Based on knowledge gathered from this data interval we are going to make predictions of the future events. The prediction has to consist of the combination of context data and access logs, as we are not interested in misleading, obvious or uninteresting statements (e.g. "It is Saturday." ⇒ "It is raining."). The second data interval is a set of logs which will be used for calculating the accuracy of our prediction. For measuring the accuracy of the prediction we use a simple evaluation method:

$$Precision_{Prediction} = \frac{Correct\ predictions}{Total\ number\ of\ predictions} \tag{1}$$

Besides prediction accuracy it is very important to evaluate particular frequent patterns. As our method treats many different types of contexts, we specify an acceptance rate of 80% for the prediction. Precision of frequent pattern is defined as:

$$Precision_{Frequent\ Pattern} = \frac{Correctly\ predicted\ items}{Total\ number\ of\ items} \tag{2}$$

Our experiments focus on comparing different parameters of FP-Growth algorithm and their impact on generated association rules. We have to minimize presence of unprofitable and misleading association rules.

We present results of an experiment (Table 1) with a sample dataset consisting of 147 100 access logs. Our method has produced 246 association rules with a success rate of 43,9%. As we have mentioned before, the FP-Growth algorithm is processing many kinds of contexts. Different values of contexts may cause producing thousands of various combinations and therefore our prediction precision of 43,9% could be considered satisfactory. Although there is room for improvement in our method.

Table 1. A preview of association rules generation.

	Frequent pattern	Occurrence	Conclusion	$Precision_{FP}$	Correctness
1	*userid=81560d, work=1*	*719*	*domain= www.citeulike.org*	*0,5*	*false*
2	*userid=08b8e8, work=0*	*553*	*location=Trnava*	*1,0*	*true*
3	*userid=27079f, month=4*	*477*	*domain= www.google.sk*	*1,0*	*true*
4	*userid=5ba6af, weekday=0*	*346*	*location=Čadca*	*0,0*	*false*

6 Conclusions and future work

In this paper we described context and its role in the Web. We also introduced different types of contexts which can be applied to server access logs. Then we showed how to enrich access logs with much context information and we described how these contexts can be acquired.

Furthermore, we described FP-Growth algorithm and its application on discovering association rules in context-enriched logs.

Our further work on this topic will be directed towards parallelization of the FP-Growth algorithm as we are analyzing large amounts of data. For even faster performance we are going to modify our algorithm to utilize it for MapReduce programming framework. Furthermore, we are going to evaluate our method for generating association rules as we proposed and prove its contribution to the field of enriching data.

The main goals for future method improvements are to better evaluate unwanted association rules in the result set and to set weight to particular items in the process of measuring frequent pattern accuracy.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0675/11.

Preferences

[1] Abbar, S., Bouzeghoub, M., Lopes, S.: Introducing contexts into personalized web applications. In *Proceedings of the 12th International Conference on Information Integration and Web-based Applications & Services*, ACM, (2010), pp. 155–162.

[2] Cao, H., Bao, T., Yang, Q., Chen, E., Tian, J.: An effective approach for mining mobile user habits. In *Proceedings of the 19th ACM international conference on Information and knowledge management*, ACM, (2010), pp. 1677–1680.

[3] Dey, A. K.: Understanding and Using Context. *Personal and Ubiquitous Computing,* (2001), pp. 4–7.

[4] Eagle, N., Pentland, A. S.: Reality mining: sensing complex social systems. *Personal and Ubiquitous Computing,* (2005), pp. 255–268.

[5] Hipp, J., Gűntzer, U., Nakhaeizadeh, G.: Data mining of association rules and the process of knowledge discovery in databases. *Advances in Data Mining,* (2002), pp. 15–36.

[6] Huang, X., An, A., Cercone, N., Promhouse, G.: Discovery of Interesting Association Rules from Livelink Web Log Data. *Data Mining. ICDM 2002. Proceedings.* (2002), pp. 763–766.

[7] Kramár, T., Barla, M., Bieliková, M.: PeWeProxy: A Platform for Ubiquitous Personalization of the "Wild" Web. In: UMAP 2011. Adjunct *Proceedings of the 19th International Conference on User Modeling, Adaptation and Personalization*, (2011), pp. 7–9.

[8] Liao, Z., Jiang, D., Chen, E., Pei, J., Cao, H., Li, H.: Mining Concept Sequences from Large-Scale Search Logs for Context-Aware Query Suggestion. *ACM Transactions on Intelligent Systems and Technology (TIST)*, (2011).

[9] Peng, H.: Discovery of Interesting Association Rules Based on Web Usage Mining. *2010 International Conference on Multimedia Communications,* (2010), pp. 272–275.

[10] Wang, K., Liu, T., Han, J., Liu, J.: Top Down FP-Growth for Association Rule Mining. *Proceedings of the 6th Pacific-Asia Conference on Advances in Knowledge Discovery and Data Mining,* (2002), pp. 334–340.

[11] Yan, X., Guo, J., Cheng, X.: Context-Aware Query Recommendation by Learning High-Order Relation in Query Logs. *Proceedings of the 20th ACM international conference on Information and knowledge management,* (2011), pp. 2073–2076.

Action Recommendation Based on Situation Rules

Anton BENČIČ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
bencican@live.com

Abstract. In this paper we describe our novel method to learning users' preferences. Preferences are described with situations the users encounter throughout the time and rules that are created over time based on either implicit or explicit feedback from the users. The focus of this paper is on the method itself. We introduce a few usage scenarios, which create a basis for our rule-based method, show what models are created and how are those models created. We discuss characteristics and limits of our method. We experimented with our method and present a synthetic experiment where we simulate different types of users and scenarios and evaluated on the performance of our method in these scenarios.

A paper based in part on this paper was accepted for publication in Proc. of 7th Int. Workshop on Semantic and Social Media Adaptation and Personalization (SMAP'12), IEEE Computer Society Press.

* Master degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Using Wi-Fi Mobility Classification on a Mobile Phone for Energy Efficient Activity Tracking

Pavol BIELIK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
pbielik@acm.org

Abstract. Tracking user location and physical activity is quite common especially among fitness and utility applications on modern smartphones. However, use of GPS and accelerometer sensors to obtain such data is energy consuming and in general cannot be used for extended periods of time. In this paper we describe an approach to detect mobility states and thus turn on and off these energy consuming sensors using Wi-Fi analysis, which compared to GPS and accelerometer is much less power consuming. This allows us not only to save battery life but also to perform activity measurements throughout the whole day.

Amended version published in Information Sciences and Technologies
Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 21-24.

* Master study programme in field: Software Engineering
Supervisor: Dr. Michal Barla, Institute of Informatics and Software Engineering

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 51–56.

Personalized Text Summarization

Róbert MÓRO*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xmoror@stuba.sk

Abstract. Automatic text summarization aims to address the information overload problem by extracting the most important information from a document, which can help a reader to decide, whether it is relevant or not. In this paper we propose a method of personalized text summarization, which unlike the conventional automatic text summarization methods takes into account the differences in readers' characteristics. We use annotations added by readers as one of the sources of personalization. We have experimentally evaluated the proposed method in the domain of learning, obtaining better summaries capable of extracting important concepts explained in the document, when considering the domain-relevant terms in the process of summarization.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 56-58.
A paper based in part on this paper was published in Proc. of the 23rd Int. Workshop on Database and Expert Systems Applications (DEXA'12), IEEE Computer Society Press, Los Alamitos, 131-135.

* Master degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Achieving Interoperability among Heterogeneous Data Sources in Cultural Heritage Domain

Matúš NOVOTNÝ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
matusnovotny@gmail.com

Abstract. The heterogeneity of data from various sources represents a discussed topic in many areas where we need to process big data volumes. An area in which this problem is particularly notable is the domain of cultural heritage. The goal of this paper is to present a contribution in processing data from various sources, and thus allowing the user to get the information which was not accessible in single data sources. Moreover by means of reasoning we offer him the information that was not explicitly interposed into the original systems. Using the tool of semantic web, i.e. CIDOC ontology we are able to provide the user with more intelligent system of requesting for new useful information about cultural heritage objects.

1 Introduction

Information is nowadays considered to be the most valuable asset. Because of that also our society is characterized as information society. It is necessary to acquire, process, use and store information in all the areas of science, research, industry, business and plenty of other fields. Many organizations even specialize in working with information. Institutions from cultural heritage domain belong also to them. They process information from this area to be able to use them, exchange them among each other and offer them to the users. Working with huge amount of heterogeneous data makes these tasks very difficult. However the user requirements are more and more demanding and the cultural heritage organizations have to adapt to that. For them, it is often necessary to combine information from more data sources to fulfil their needs and by that to enable retrieving new useful information.

2 Problem Statement

Here we provide a simple example of the situation, which can happen quite often. We have two different data sources. In the first one the data about historical landmark properties and their

* Master degree study programme in field: Software Engineering
Supervisor: Assoc. Professor Viera Rozinajová, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

enlistment to cadastre of properties are stored. In the second data source are stored the data describing reconstructions of these historical landmarks. Our goal is to find all the properties belonging to Trnava cadastre which have been reconstructed from the beginning of the 18th century. To get an answer to this query we need to search the first data source for the historical landmarks belonging to Trnava cadastre and next for all answers search the second data source for the properties reconstructions realized from the beginning of the 18th century. It is obvious that this method is too complicated and there is a room for improvement. In this paper we try to present the solution for the introduced problem.

It is already evident from the previous example that we will deal with the problem of interoperability among heterogeneous data sources for the purpose of retrieving new useful information which are not available in a single data sources. To achieve this, it is possible to use several methods. Their application depends on how the data are stored and in which way we need to work with them. By correct choice and application of steps it is possible to create the data representation which allows the effective use of interconnected data sources. Further it is possible to use system like this as a mean for deductive information retrieval.

3 Related work

During the long time of their existence the institutions in cultural heritage domain have developed many different metadata schemes which are specifically adapted to their needs. These differences are the main problem of achieving interoperability among their systems and data sources. Many organizations try to solve this situation. They usually create the metadata scheme which satisfies the needs of certain subarea in cultural heritage domain. Example of such project is NSDL Metadata Repository [5] which collected metadata from various institutions and converted them to DC schema. Picture Australia [4] is the name of another similar project which connected multiple libraries and archives converting their content to DC [6] schema. Very interesting is eChase [8] project which creates multimedia database by semantic integration of data from various sources. They developed tools for metadata harvesting, cleaning and transformation. The most important part of this project is unified metadata repository which design was inspired by CIDOC CRM (Conceptual Reference Model) [2] ontology. Another part of the project is eChase portal which supports text and content-based queries and a browsing interface. This way the stored data are accessible by users. One of the successful attempts to query ontology is presented in the SPARQL-DL Engine [9] projects. It introduces an application which accepts SPARQL query and returns demanded results. The deficiency of this approach is the necessity to exactly specify the query by the user who has to be familiar with SPARQL syntax.

4 Possible Solutions

The first necessary step is data processing. The way how it is done depends on concrete data sources. In case of structured or partially structured data, it is possible to automate the data processing. In case of unstructured text, it is very difficult to process it automatically and so it is common to process the text manually. It is necessary to create the data representation which can be worked with in next steps. First possibility is to use one of standard metadata schemes for cultural heritage domain, for instance, DC, MARC [3], EAD [7] or VRA [1]. Metadata in these schemas describe and identify objects, they enable access to these objects, their usage and management. In spite of possibility to be understandable by people who understand their relation to described object this relation is not obvious by computer processing. Metadata schemes, however, do not allow expressing the rich semantics. The ontology is much more suitable for this. It works at more abstract level by trying to conceptualize the domain. It does not offer the specific elements for object description. Instead, it defines basic concepts from domain and relations between them. And the most importantly, in difference to metadata schemes it offers the constructions for expressing

the meaning of data. To clarify the difference between metadata scheme and ontology we adduce a simple example: we need to express that a specific architect is the author of the certain palace building. For instance, in DC schema we assign a value containing architect's name to DC.creator attribute. On the contrary, in CIDOC CRM we use entities and properties to express general information about the creation of palace building meaning that Actor (architect) participated in a Creation Event which produced a Physical Man-Made Thing (palace). This way we make the knowledge concerning palace creation explicit and understandable to computer which was not possible using metadata scheme.

As we mentioned before, our goal is to enable the deductive information retrieval. Based on this demand we consider ontology to be the most suitable for achieving our goal.

In the cultural heritage domain the formal ontology CIDOC CRM is a standard. It enables integration, mediation and exchange of information from this area. CRM creates a structure of basic domain information in the form of semantic network which connects the facts in user understandable manner. It focuses on temporal activities. The presence of other entities means that they take part in these events and activities. It is also necessary to represent the ontology to be able to work with data it contains. Suitable standard for this is XML based RDF. This ontology representation is in the next step useable as a source for deductive retrieval of information which was not directly accessible before. This course follows also our solution introduced in the next chapter.

5 Data Processing and Filling in the Ontology

To demonstrate our solution we use two data sources. The first source was granted to us by The Monuments Board of the Slovak Republic. It contains the information about historical landmark properties. We used web as the second data source. We focused on data from relevant historical portals concerning events connected with historical landmarks. To shorten the whole process for now we processed the sample of data manually. From first source we extracted data concerning enlistment of historical landmarks to cadastre of properties and their architectural style and from the web we used data about reconstructions, fires and other destructions of landmarks. It was necessary to fill this data in CIDOC CRM ontology. First we created the mapping between the data and ontology entities and then we created connections between entities matching their properties.

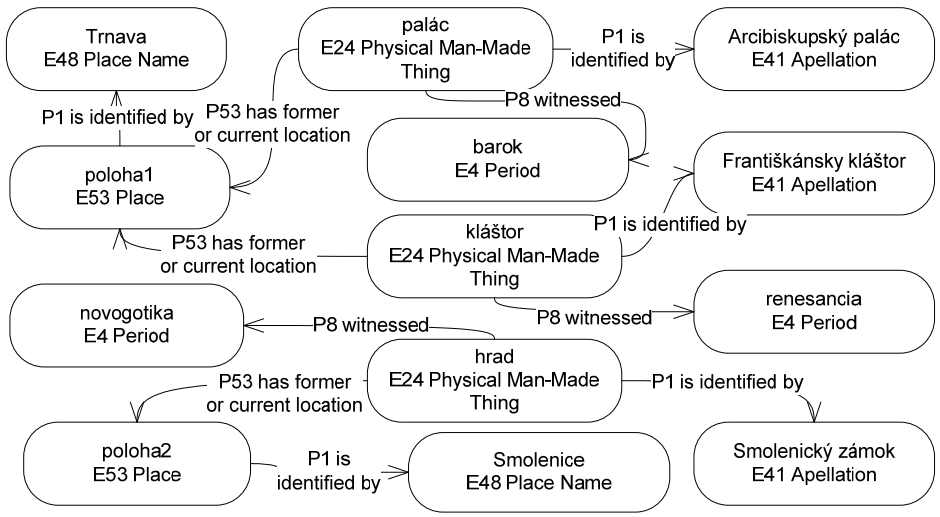

Figure 1. Ontological network for the first data source.

Figure 1 represents the part of ontology containing data extracted from first data source. We can see the representation of three historical landmarks which are through appropriate properties connected to information which describe their location and architectural style.

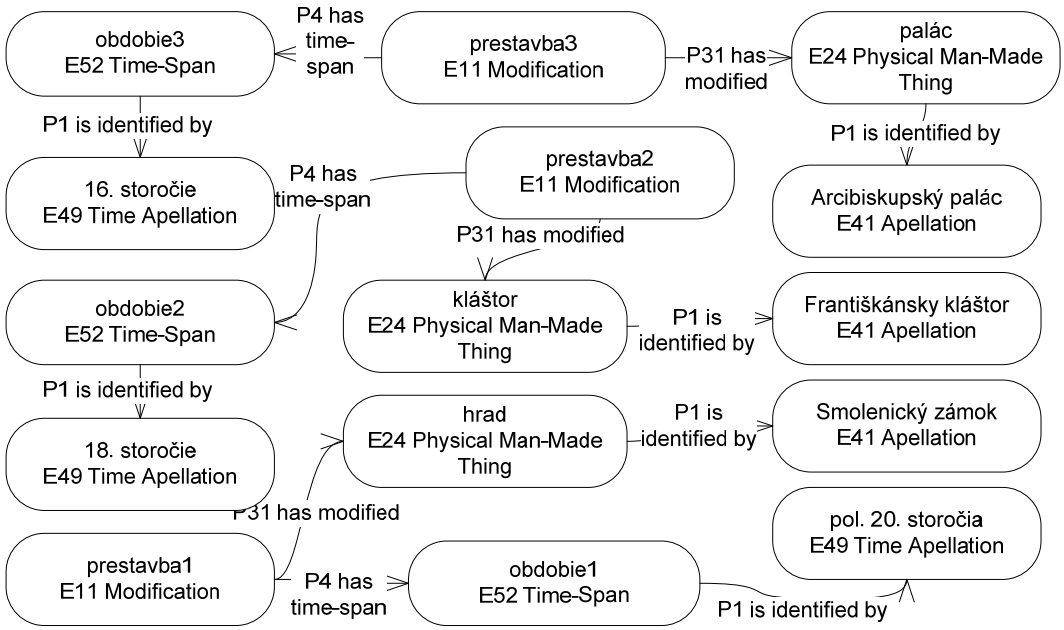

Figure 2. Ontological network for the second data source.

Figure 2 represents the part of created ontology filled with data from the web. We can see there the connection of landmarks and events of their reconstructions. These events are also defined in time.

Filling in the ontology was carried out manually using Protege 4.1 tool which offered also the RDF output. This ontology representation was further used by the system enabling more intelligent search for new useful information.

6 More Intelligent Information Retrieval

We created a simple web application based on JSP technology. Its role is to accept the search parameters and return the correct answer. The system formulates the search query based on input parameters. It is realized on the basis of deductive information retrieval. The queries executed in ontology are formulated in SPARQL language designed specifically for this purpose. The system ensures correct transformation of user demands to query language. Queries for each input parameter are constructed and executed in automated and unified manner. The conjunction of results of all partial requests is the answer for initial request. All this is possible because all the data are integrated in CIDOC ontology and connected according their meaning.

The process of deductive information retrieval can be explained by example from the beginning of the paper. We search for all the historical landmark properties in Trnava cadastre reconstructed from the beginning of 18th century. System executes the query for all the landmarks in Trnava cadastre. The results from previous visualization of ontological network are Arcibiskupský palác and Františkánsky kláštor. After that system executes the query for all the landmarks reconstructed from the beginning of 18th century. The results from our visualized part of ontological network are Františkánsky kláštor and Smolenický zámok. The conjunction of two

result sets is Františkánsky kláštor. From our ontology visualization, only this result fulfils the given criteria. This result is visualized in Figure 3.

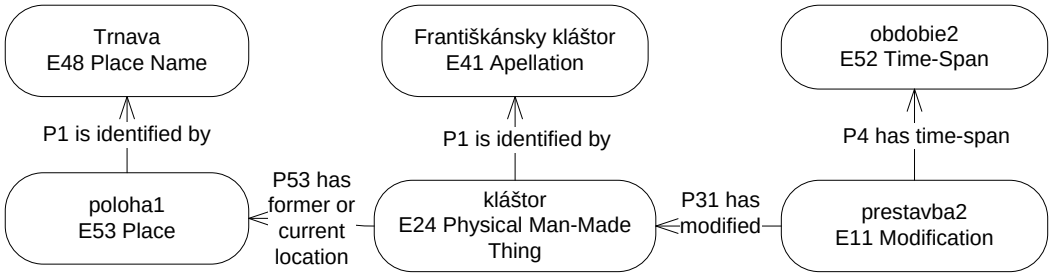

Figure 3. Ontological network for the search result.

It is obvious that it is possible to narrow the search request by adding more parameters. We could search for all the landmarks from Trnava cadastre reconstructed from the beginning of the 18th century which were built in the renaissance style. Another possible request is to find all the fires which damaged landmarks in Smolenice cadastre in 17th century. These and many other requests can be answered in the same way as we described.

7 Conclusion

The developed system was exposed to informal user test. These users evaluated system as interesting with potential for further development. We are currently working on partial automation of filling in the ontology and automation of creating RDF ontology representation. The work conducted until now has resulted in system allowing more intelligent search for new useful information which were initially not available. When comparing to other projects mentioned in the paper, our solution achieves this also by deductive information retrieval from ontology containing data from different sources. Our goal is, furthermore, to offer the user the possibility to express the search request in explicit way by choosing the search parameters he wants to use and setting them to desired values. In this way we are able to offer the maximal possible amount of results which satisfy the user's demands.

Acknowledgement: This work was partially supported by the Slovak Research and Development Agency under the contract No. APVV-0208-10.

References

[1] Caplan, P.: *International Metadata Initiatives: Lessons in Bibliographic Control.* Center for Library Automation, Florida, (2002). [Online; accessed February 20, 2012]. Available at: http://arizona.openrepository.com/arizona/html/10150/106353/caplan_paper.html

[2] Crofts, E.N., Doerr, M., Gill, T., Stead, S., Stiff, M.: *Definition of the CIDOC Conceptual Reference Model, Version 5.0.4.* (2011). [Online; accessed February 20, 2012]. Available at: http://www.cidoc-crm.org/docs/cidoc_crm_version_5.0.4.pdf

[3] Furrie, B.: *Understanding MARC Bibliographic: Machine-Readable Cataloging. Cataloging Distribution Service*. Library of Congress, (2009). [Online; accessed February 20, 2012]. Available at: http://www.loc.gov/marc/umb/

[4] Gatenby, P.: *Reaching new audiences: the People Australia and Picture Australia projects at the National Library of Australia*. World Library and Information Congress 2007,

Durban, (2007). [Online; accessed February 20, 2012]. Available at: http://ifla.queenslibrary.org/IV/ifla73/papers/147-Gatenby-en.pdf

[5] Hillmann, D.I., Sutton, S. A., Phipps, J., Laundry, R.: A metadata registry from vocabularies up: the NSDL registry project. In: *Proceedings of the 2006 international conference on Dublin Core and Metadata Applications: metadata for knowledge and learning* (DCMI '06). Dublin Core Metadata Initiative, (2006), pp. 65–75. [Online; accessed February 20, 2012]. Available at: http://arxiv.org/ftp/cs/papers/0605/0605111.pdf

[6] Kakali, C., Lourdi, I., Stasinopoulou, T., Bountouri, L., Papatheodorou, C., Doerr, M., Gergatsoulis, M.: Integrating Dublin Core metadata for cultural heritage collections using ontologies. In: *Proc. of the 2007 international conference on Dublin Core and Metadata Applications: application profiles: theory and practice (DCMI '07).* Dublin Core Metadata Initiative, (2007), pp. 128-139. [Online; accessed February 20, 2012]. Available at: http://www.ionio.gr/~papatheodor/papers/16-118-1-CE_final.pdf

[7] Pitti, D.V.: Encoded Archival Description An Introduction and Overview. In: *D-Lib Magazine*, (1999), vol. 5, no. 11. [Online; accessed February 20, 2012]. Available at: http://www.dlib.org/dlib/november99/11pitti.html

[8] Sinclair, P., Lewis, P., Martinez, K., Addis, M., Pillinger, A., Prideaux, D.: eCHASE: Exploiting Cultural Heritage using the Semantic Web. In: *4th International Semantic Web Conference, ISWC 2005*. Galway, (2005). [Online; accessed February 20, 2012]. Available at: http://eprints.ecs.soton.ac.uk/11535/1/echase.pdf

[9] Tzoganis, G., Koutsomitropoulos, D., Papatheodorou, S., P.: Querying Ontologies: Retrieving Knowledge from Semantic Web Documents. University of Patras, (2009). [Online; accessed March 16, 2012]. Available at: http://www.hpclab.ceid.upatras.gr /viografika/kotsomit/pubs/eureka09.pdf

Adaptation of Web Contents Browsed in Mobile Devices

Ján SIVUĽKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
sivulka@gmail.com

Abstract. In this paper we analyze the available means and methods of processing and presentation of the information on the web such as the adaptation of content and user interface aimed at web browsing by means of mobile devices. We have designed and implemented a prototype of an application to find a solution which would make the web browsing by a mobile device easier and better arranged. We point out some innovative ways how to display the relevant content to the user in an appropriate form with respect to the restrictions resulting from the use of mobile phones.

1 Introduction

Recent years have witnessed rapid development in the field of web technologies and the internet has become the most popular means of communication of these days. The web space is oversaturated with myriad of information, so that it is often a problem for the user to look up the desired content. When it comes to user satisfaction, complexity and effectiveness of the system, visual design of the user interface, as well as the content presented are the deciding factors [1]. The user expects that he will be provided with the right content at the right time in the right way. Offering valuable content alone is no longer enough – it has become inevitable to apply innovative ways of promoting and presenting it as well.

This trend has also been adopted by mobile technologies and mobile devices which are becoming even more popular than the computers themselves. This is due to the fact that we carry our mobile device always with us, it is small, handy and very helpful by a number of activities such as shopping (you can scan a barcode and compare the product prices) navigation, acquiring up-to-date information (departures of trains and buses) etc. However, web applications have failed to keep up with the dramatically increased usage of the smart phones and adopt their content to the mobile devices only to a small extent. As a result, if we use our mobile device for browsing pages which have not been adopted for such purpose, it might be rather difficult for us to find the desired information or to achieve the desired result.

* Master degree study programme in field: Software Engineering
Supervisor: Tomáš Kuzár, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 69–74.

In our research we try to improve the access to the information by reducing the content or, in some cases, generating some of the interface elements (menu reduction on sub-pages, navigation improvement etc.).

2 Related work

The number of people using mobile devices has recently reached 3 billions which is approximately half of the world's population. Even though mobile devices were originally intended for telephoning alone, gradually, their functionality has grown and nowadays they are able to compete with the desktop computers to a considerable extent.

Most of the web pages have been created with the purpose of being displayed on a desktop computer, as a result of which the users of the mobile web encounter numerous problems when browsing the web (e.g. ever enlarging window, lacking page arrangement, overall complexity etc.). Owing to these complications, the user usually has to make much greater effort to find the information that he is looking for when using a mobile device than it is the case of a desktop computer. There have been several researches which tried to solve this problem in the way that heuristic methods [2, 3, 4] and predefined rules were applied to parse the original page content and thus gain the headers of the paragraphs which were converted into a list of references to the individual paragraphs and these were displayed to the user. Some researchers even tried to improving resource management for applications on mobile devices [5].

When looking for a suitable way how to make information better accessible on mobile devices, adaptation of visualization techniques, such as zooming in or focusing on some specific parts of a web page, has also been applied [6]. This issue has been dealt with by Boonlit Adipat, Dongsong Zhang, and Lin Zhou, who invented a new method of adaptation of web pages for mobile devices. In their research they defined three ways of adaptation of data visualization (highlighting of the key words, tree display, hierarchical summarization of the text) [7].

Students of the Hong Kong University of Science and Technology have presented another way of transformation of web content for the purpose of mobile devices. In their research they invented a method which divides the transformed web page into several sub-pages which are made to fit the dimensions of a mobile device. The user can see the original web page in a modified way – it is divided into separate blocks on which he can click and view the selected part of the transformed web page [8].

The web service Skweezer[1] has also been concerned with the issue of page optimization for mobile devices. This service enables adaptation of the viewed page for mobile devices in the way that the styles defined on the page are removed and a new style is defined for references (green color together with underlining). The same way of transformation is applied to all pages.

Another web service which converts the web pages for mobile viewing is Google Mobiliser[2] from the world renowned company Google. The user can view the pages with or without images, moreover, large web pages are divided into several sub-pages. Unlike the preceding example this transformation method preserves some of the styles of the converted page (color and highlighting of the text). This service makes it also possible to view the picture of the original page version which includes icons with numbers referring to sub-pages into which the page was divided by an algorithm. The user may view one of the respective sub-pages at a time.

All of the various methods of turning a regular web page into a mobile friendly one that we have outlined above focus predominantly on the displaying of the data regardless of the original version of the web page. As a result, it could happen that all the web pages would share the same form. In this respect, these methods could be further developed, so that the page visitors would be able to view the data in their proper form instead of their predefined stripped-down version. In

[1] The service is available at http://www.skweezer.com/
[2] The service is available at http://www.google.sk/gwt/n/

other words, the visual image of the original web page would be reflected in its mobile friendly version. Making the mobile friendly version of a web page as close as possible to its original is quite desirable as it improves the trustworthiness of the web page as well as the impression of page browsing which contributes to the fulfilment of the user's expectations (in case he knows the original version of the page).

3 Concept of Smartfonizer

The aim of this paper is to present a method of making a web page mobile friendly which would enable the user of a mobile device to browse the internet pages and get to the information presented on them without any difficulties. Moreover, the user should not even feel the difference between browsing a page on a desktop computer and on a mobile device. We shall prove the effectiveness of the proposed solution by means of a designed prototype under the title "*Smartfonizer*".

The prototype will represent a native application for Android, now the fastest-growing platform from the Google company. The native application will be applied for an easier use of the prototype and also for its other benefits (e.g. effects by browsing the individual pages, possibility to start the app via desktop icon etc.) We created the app in the JAVA language which is used by the Android platform.

3.1 Mobilizing process

The optimization process begins by inserting the URL address which the user wants to be displayed. First of all, we verify whether there is such a web page at all. If there is such a web page, we retrieve its HTML code. Then we select references from the code to the files representing the rules for properties and formatting of the individual page components. These files end in "*.css*". However, in order to avoid searching through all the files including those which define jQuery or MooTools, we skip the references which include the names mentioned. Then we analyze and change the acquired files in the way described below.

When we already have properly defined rules for the appearance and formatting of the page at our disposal, we make the necessary changes also in the HTML document which we load in a DOM document for easier data manipulation. After parsing, analysis, extraction and modification of the needed data are finished, we add the acquired data to our data which define the additional information necessary for generation of the mobile version of the page. All the necessary operations having been performed, we can show the user the mobile friendly version of the desired web page. This process is repeated every time a reference to some other domain than the one currently displayed is activated. A simple visualization of the process is depicted by the picture below (see Figure 1Figure 1).

Figure 1. Mobilizing process.

3.2 Page analysis

The input parameter will be the URL address which is unique and which is the source from which the user wants to retrieve information. When pages are browsed in a web browser, after entering the desired address a request is sent, the necessary data are processed and, as a result, a web page represented by a HTML is displayed. The HTML includes the definition of the page style (CSS) and possibly also of other page properties (title, description, author etc.), and information on what styles are used by the page and what data the page includes (titles, lists etc.).

3.3 Styles analysis

When creating a mobile friendly version of a page we create our own headers and footers which we attach to the retrieved body of the page. In order to preserve the style of the original page, we need to display the same colour in the background as was in the original page. For this purpose we use the analysis of the files defining style, references to which can be found in the original page. From these files we retrieve information on the colours used and choose the one with the highest saturation which, at the same time, does not exceed 91%. Another important colour parameter is brightness which has to be from 30% to 80%. Such colour is bright enough for the page title to be legible in white and also to enliven the mobile friendly page version.

3.4 Page transformation

Having retrieved all the necessary data and having carried out the analyses we get to the next stage of the adaptation process which is the transformation of the existing HTML document. When turning the page into its mobile friendly version we will predominantly focus on the information presented by the page but we will also take into consideration the styles used. In order to simplify the access to the information and to improve the display on a mobile device we will make the following changes in the original HTML document:

1. We will remove the tag “head” together with its descendants.
2. We will remove the JavaScript from the page.
3. We will eliminate the values of the attribute “style” by the individual elements (in this way the styles for the individual elements will not be defined elsewhere as in the files determined for this purpose and, at the same time, we will have control over them – the styles which we will additionally define will really show).
4. We will change the relative paths to the image sources for absolute ones (e.g. we will change the relative path “/img/sample.jpg” for “http://www.nameofthedomain.sk/img/sample.jpg”), in order to show them to the user on the page.
5. We will adapt the size of the pictures for mobile devices by defining their maximum width under consideration of the actual display.
6. We will create the page menu (a more detailed description can be found below).
7. We will change the relative paths of the references into absolute ones.
8. We will remove the tag “footer” together with its descendants.
9. We will eliminate the values of the attributes “style”, “height” and “width”.
10. We will replace the tags “table”, “tr” and “td” by “div”. I will replace the tag “th” by “h2”.
11. We will remove the tags “object”, “form” and “iframe”.
12. Finally, we will create a page logo.

When optimizing the page we focus on a user friendly environment and display of the texts in a legible form. At the same time, we take into consideration the context of the use of a mobile device (one-handed control, use during walk, in a queue or in a tram etc.). We will try to make the user interface simpler, we will not take into consideration the use of the mouse

pointer (e. g. the attributes "hover"). Instead, we will concentrate on the use of a thumb (bigger size than mouse). For illustration we show the page optimization in the picture below (see Figure 2).

Figure 2. Example of optimized mobile page www.fiit.stuba.sk.

3.4.1 Menu creation

The menu of the mobile friendly page version will be displayed in a different way than the other references on the page. We will regard as menu the items "*ul*" and "*li*" which will be descendants of the element with a defined attribute "*class*" with a value including the text "*menu*". By "*li*" items we will remove the originally defined value of the attributes „class" and "*id*" and then we will create a new parent (element "*div*"), whose "*id*" we will change so that it will correspond with the pre-defined menu style which was determined beforehand in an own file defining the rules for visualization. Such file will be included in the head of the resulting mobile friendly version of the page. For this element we will also define an action (JavaScript) which will enable the activation of a specific menu item by clicking on any part of its surface. The menu on the sup-pages will be reduced by those menu items which occurred on the main page in order to make the contents of the sub-page that are displayed to the user better arranged.

3.4.2 Header and footer creation

From the source code of the page we will retrieve the tag including the attribute "*class*" with a value including the text "*logo*". If there is a HTML code and its descendants, we will also retrieve them. Then we will shift this code from the place of its occurrence into a pre-defined head. If there is no such a tag, the name of the domain of the displayed page in the form of "*nameofthedomain.sk*" (or .com etc.) will be displayed instead of the logo. The header and footer of the mobile friendly page will have the background color retrieved by the page analysis and, at the same time, they will include a back button, top and bottom navigation buttons. The bottom of the page includes the domain name of the current page and a link to non-optimized original page. Samples of the created headers and footers can be seen in the picture below (see Figure 3).

Figure 3. Headers and footers of smartphonized page.

4 Conclusions and future plans

In the paper we analyzed the current state of information accessibility in the field of mobile devices. We pointed out the existing solutions as well as some questions from this field that have not been answered yet.

We designed a method which adapts the browsed internet pages to the restrictions of the mobile devices in order to display to the user the relevant content in an appropriate form. As far as the page transformation is concerned, we placed emphasis on preserving the original character of the page as well as on such adaptation and presentation of the content which respect the context of use of the mobile phone.

The method could be further developed in the field of interaction – e.g. the page content could be reduced by an input which the user could also activate by voice. It is also necessary to reduce the time of transformation of already viewed pages for instance by using cashing.

We also tested the solution by means of an experiment. The participants of the experiment were asked to solve some tasks by using the designed app and to answer some questions in a questionnaire relating to the use of the app. The aim of the experiment was to get a feedback with regard to the use of the designed prototype. As the number of respondents was rather small and they constituted only a small specimen, we decided not to present the results of the experiment in this paper (we plan to carry out the experiment with more respondents in the future). However, the results of the experiment show, that the accessibility of the information in the field of the mobile web was improved, although there are still many improvements that could be made.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/1221/12.

References

[1] Liu, J., Wong, C.K., Hui, K.K.: An Adaptive User Interface Based On Personalized Learning, *IEEE Intelligent Systems*, Vol. 18, No. 2, (2003), pp. 52–57.

[2] Kenteris, M., Gavalas D., Economou, D.: An innovative mobile electronic tourist guide application, *Personal and Ubiquitous Computing*, Vol. 13, No. 2, (2009), pp. 103–118.

[3] Lim, H.A.M., et al: Optimization of LRT Route for Mobile Web Application Engine, Soft Computing and Pattern Recognition. In: *International Conference of Soft Computing and Pattern Recognition (SOCPAR 09)*, (2009), pp. 642–646.

[4] Chang, W., Tan, Q.: Augmented Reality System Design and Scenario Study for Location-Based Adaptive Mobile Learning, In: *Proceedings of the 2010 13th IEEE International Conference on Computational Science and Engineering*, IEEE, (2010), pp. 20–27.

[5] Li, D., Anand, M.: MaJaB: Improving resource management for web-based applications on mobile devices. In: *Proceedings of the 7th international conference on Mobile systems, applications, and services (MobiSys '09)*. ACM, New York, NY, USA, (2009), pp. 95–108.

[6] Baudisch, P., Xie, X., Wang, C., Ma, W.: Collapse-to-Zoom: Viewing Web Pages on Small Screen Devices by Interactively Removing Irrelevant Content. In: *Proceedings of the 17th annual ACM symposium on User interface software and technology*, ACM Press, Santa Fe, (2004), pp. 91–94.

[7] Adipat, B., Zhang, D., Zhou, L.: Adapting Content Presentation for Mobile Web Browsing, *Communications in Computer and Information Science*, Springer, Berlin, Heidelberg, Vol. 54, (2010), pp. 293–303.

[8] Xiao, X., Luo, Q., Hong, D., Fu, H., Xie, X., Ma, W.: Browsing on small displays by transforming Web pages into hierarchically structured subpages, ACM Transactions on the Web (TWEB), Vol. 3(1), (2009), pp. 1–36.

Topic Extraction in Text Documents Based on Word Position Analyses

Tomáš KUČEČKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kucecka@fiit.stuba.sk

Abstract. Topic extraction from text documents is an important object of research these years. It can be used, for instance, in an information retrieval to group similar results together returned by a web browser or to group articles with similar topics in different systems. In this paper we propose a new approach to topic identification. It is based on analysing word positions in paragraphs of a text document. This approach is therefore structure oriented and shows how much about a document can be told from its structure. We think that through this approach we are able to better cluster the text documents as it introduces similarity on different levels (local and global topics, hierarchies). We carried out first experiments and present the results in this article. Based on these results we derive first conclusions about the performance of the proposed method.

1 Introduction

Assigning a text document to a category based on its content (topic) has been an important part of a research these years. In this problem area we can talk about text categorisation or text clustering. Note the difference between these two terms. In case of categorisation a text document is categorised into a predefined set of categories, commonly called classes. This problem belongs to supervised learning tasks. Clustering, on the other hand, groups similar documents together without any information given about the categories the documents belong to. It is an unsupervised learning task.

In information retrieval these two approaches are commonly used to group similar text documents together so the user can easily and comfortably get to relevant data. For instance, we can group text documents returned by a web browser or, in case of a conference system, group papers from different authors by their topic.

In this article we propose our own method to document clustering. We focus only on text documents written in natural language. The key feature of our method is the word extraction process based on analysing document structure, more specifically analysing word positions in this structure. The extracted words by our method are those that are most important for the given document. Next we convert a text document on a set of regions. Each region represents a global or

* Doctoral degree study programme in field: Artificial Intelligence
Supervisor: Assoc. Professor Daniela Chudá, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

a local topic and is associated with different words extracted by our method. Thereby we follow the idea that a text document can belong to more than one category, where different categories are represented by different regions.

This paper is organized as follows. Section 2 describes related work in the field of keyword extraction and text clustering. Section 3 describes the preprocessing phase of our algorithm and section 4 introduces our algorithm to clustering textual documents based on analysing word positions. In section 5 we show results of carried out experiments with our approach. Section 6 concludes this paper and proposes future work on this topic and our method.

2 Related work

Lots of research has already been carried out in the area of topic identification in textual documents written in natural language. In the introduction section we mentioned text categorisation and document clustering and pointed out the difference between these two approaches. As our method deals with keyword extraction and clustering therefore in this section we focus on related work in this field of area.

The most common way to keyword extraction is the usage of *tf-idf* weighting. In article [5] authors propose a new *tf-idf-ci* model to compute weighting of the term. Another group of methods is based on probability approaches. In article [7] authors extract keywords from text based on comparing the probability distributions.

To cluster the text documents in a given corpus, simple clustering methods like k-means, bisecting k-means or hierarchical clustering can be used. However all of these approaches suffer from several problems like high dimensionality, large size of data or absent cluster description which are common problems in the field of document clustering. Better approaches to document clustering are based on frequent sets. In article [1] two algorithms for clustering are presented that use frequent itemsets.

The first algorithm FTC (Frequent Term-based Clustering) assigns each document with a frequent term set. The frequent term sets are most commonly obtained with *Apriori* [3] algorithm used for mining association rules. At every step of FTC algorithm one frequent term set with best score is picked up to form a cluster of documents assigned to it. FTC algorithm creates non-overlapping clusters. The second algorithm HFTC (Hierarchical Frequent Term-based Clustering) creates overlapping clusters for which it uses the FTC algorithm. Better results than FTC and HFTC in clustering text documents achieves FIHC (Frequent Itemset Based Hierarchical Clustering) algorithm [2]. Again it uses *Apriori* algorithm to find frequent itemsets of terms. Each one of these frequent itemsets creates a cluster to which documents containing the itemset belong.

In article [4] authors improved the existing FIHC algorithm by introducing frequent word sequences. The main difference is that FIHC algorithm uses the vector space model in its process but the word sequences carry information about word positions. They proposed two approaches. The first approach CFWS (Clustering based on Frequent Word Sequences) works with frequent word sequences.

The second approach CFWMS (Clustering based on Frequent Word Meaning Sequences) is an improvement to CFWS. It uses WordNet[1] to convert word sequences to word meaning sequences. In [4] authors compared the individual approaches to document clustering and the overall results showed that CFWS performed better than FIHC and bisecting k-means algorithm. FIHC and bisecting k-means algorithm had similar performance but FIHC automatically provides description (labels) for created clusters whereas bisecting k-means does not.

[1] http://wordnet.princeton.edu/

3 Text preprocessing

Before our method can be applied on a text document, we have to preprocess its text in order to remove irrelevant parts. Without these preprocessing our method will not perform well on a given set of text documents. For now we use the following preprocessing steps.

- *filtering* – removes diacritic and non-letters from text document and replaces multiple spaces with one.
- *stop-words removal* – stop words are the most common words appearing in natural text and are specific for individual languages. They have none or little meaning and therefore can be safely removed. For instance, stop words in English language are *'a'*, *'the'* and *'or'*.
- *lemmatization* – process of determining a lemma of a given word so the words with the same meaning have the same lemma. Lemmatization can only be done with morphology dictionary.

Besides these three steps we have also experimented with another preprocessing technique – *synonym replacement* which replaces all synonyms of one word with the same form. Unfortunately integrating this step into a preprocessing phase has worsened our results.

4 Our method

The proposed method for similar topic detection among text documents is based on analysing word positions. The key idea of that is to detect important words in a text document and whether these words are important for the whole document or only for some part of it. From now we would refer to set of important words for some text document as *"keywords"*.

We suppose that a text document does not have to contain only one topic but several topics can be found in it. Most commonly the document deals with one main topic (global topic) but in its different parts (local topics) an author can discuss different problems that reflect the main topic. A good example of our understanding how topics are spread in a textual document illustrates the following example. A dissertation thesis on topic *"Identifying Plagiarism in Textual Documents"* contains global keywords *"text"*, *"similarity"*, *"method"* and *"document"*. These four keywords define global topic. In its different parts an author can describe various approaches to similarity detection like *"longest common subsequence"* or *"probabilistic models"*. These two parts are local topics and different set of keywords is used to describe each of them.

Supposing this we proposed a method for such topic detection. This method can be described by the following four steps. All of these steps are explained in more detail later in this section.

1. *content chunking* – we divide the document into paragraphs, sentences and words and rate the words using the *tf-idf* weighting [5]. Generally we can refer to this step as part of the preprocessing process.
2. *keyword extraction from text* – this extraction is based on two methods – word occurrence in paragraphs and word rating. The word rating is obtained from the previous step. These two extractions are independent which means that one set of keywords is extracted based on the word positions and the other set depends on the word rating.
3. *global and local topic identification* – the extracted keywords from the text can belong to global or a local topic of a text document. This belonging is based on positions of the keywords in text document.
4. *topic clustering* – the extracted topics are grouped together into clusters based on the overlap of their keywords.

Figure 1 shows the overall architecture of our system. Individual components of this system represent the above four steps. The flows between components represent data that one component provides to the next one. As can be seen in the figure, the input to the system is an unprocessed

text document. Chunking and keyword extraction is handled by the *Content Loader* and *Keyword Extractor* component. The found keywords are passed to the *Topic Extraction* component which extracts the local and global topics from the text document. The *Clusterer* then groups the similar documents based on their local and global topics and the found pairs form the output of the system.

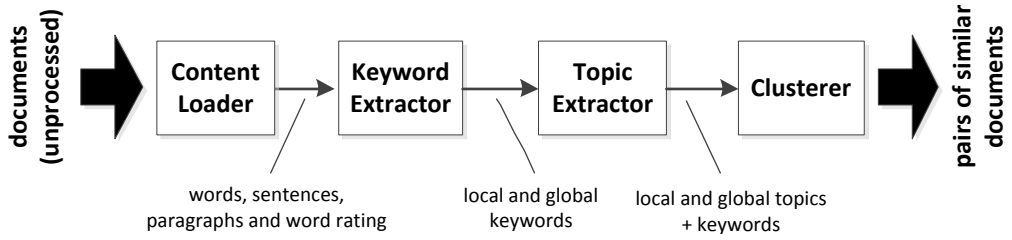

Figure 1. Architecture of the proposed system. The rectangles represent individual components of the system, arrows data flow. The input to the system are unprocessed documents from the corpus, the output represent identified pairs of documents with similar topic.

4.1 Individual steps

Now we take a closer look at the individual components of the proposed system – we explain three from the above four steps in more detail. We skip the first step which is the simplest one. In the following text we use the term *"paragraph identifier"*. This term represents a number reflecting the position of a paragraph in a given textual document. For instance, a paragraph with a paragraph identifier equal 3 means that it is a fourth paragraph in a textual document (we index the paragraphs from number 0). We use phrase *"word position at paragraph level"* in a meaning that we distinguish word position in a text document using only paragraph identifiers.

Step two involves keyword extraction from document's content. This extraction is based on word's positions at paragraph level. We consider some word *w* as a keyword if it satisfies the following four conditions:

- it is found in at least 5% of all paragraphs in a given textual document.
- it is found in at least 5 sentences in a given textual document.
- its *tf-idf* value greater than 8. The *tf-idf* weighting enables us to distinguish important words from words frequently used by authors with no (or little) meaning. For instance, words like *"very"* or *"much"* usually have little meaning in case of English language.
- it is found at least in one paragraph group with length greater than 2.

Paragraph groups are defined for some word *w* in a given text document *d*. They are created based on the word's positions at paragraph level in document *d*. For instance, let us have word *w* with positions at paragraph level given by the ordered set {7, 10, 13, 17, 23, 35, 37, 38, 39, 40} (meaning that *w* occurs in the 8^{th}, 11^{th}, 14^{th}, etc. paragraph). From this set we create a set of paragraph groups based on the closeness of individual paragraphs to each other. Two paragraphs are close (belong to the same group) if they satisfy the following equation:

$$\min(\log_2(P), 4) \leq dis(p1, p2) \tag{1}$$

where *P* is the total number of paragraphs in document *d* and *dis(p1, p2)* is the distance between paragraphs *p1* and *p2* (the paragraphs for which we estimate the closeness). The distance is calculated as the absolute value of subtraction of their paragraph identifiers. In our example with ordered set we would get the following set of two paragraph groups {{7, 10, 13, 17, 23}, {35, 37, 38, 39, 40}}. It is clear that the calculated distance between paragraphs given by their identifiers

23 and 35 does not satisfy the equation (1). Therefore, we divided the paragraphs into two groups. The length of paragraph group is given by the count of identifiers it contains. For instance, length of paragraph group {7, 10, 13, 17, 23} is 5.

At step three we divide obtained keyword set on global and local keywords based on the identified paragraph groups. The keyword is global if its paragraph groups cover more than 50% of all paragraphs, otherwise the keyword is local. Paragraph group coverage is calculated from paragraph groups and it cannot be mislead with paragraph group length. Coverage is the number of paragraphs that are contained in a paragraph group, for example coverage for word *w* in document *d* from our previous example is 23. We get this value by simple calculation (23-7+1) + (40-35+1), where numbers 23 and 7 are the borders of the first paragraph group and 35 and 40 of the second one.

After dividing the keywords into global or local, the local topic identification follows. In this step we identify individual local topics based on the identified paragraph groups. Two words *w1* and *w2* form a local topic if their paragraph groups are close enough. The closeness is calculated by the following equation:

$$\frac{\sum_i \frac{G1 \cap G2}{G1 \cup G2}}{i} \geq 0.75 \tag{2}$$

where *G1* and *G2* are the paragraph groups for which we estimate the closeness and *i* is the number of paragraph groups for word *w1* and also for word *w2*. Therefore, the two words *w1* and *w2* must have same number of paragraph groups (parameter *i*) before they are tested by equation (2) if they satisfy the condition for local topic. Note that topic identification is not done in case of global keywords as document can have only one global topic therefore all global keywords automatically form this topic.

Figure 2 shows a sample of a textual document written in Slovak language. The document contains 6 paragraphs total. The rectangles in the figure represent found keywords. If we look at keyword 1, we see that it is present in almost all paragraphs of a textual document. All of these paragraphs are close together so they all form one paragraph group. This group covers more than 50% of all paragraphs therefore keyword 1 belongs to the global keyword set. Keywords 2 and 3 are present only in the top 3 paragraphs each one forming on paragraph group {0, 1, 2}. Because these paragraph groups cover exactly 50% of all paragraphs keywords 2 and 3 are local.

In final step 4 we cluster the text documents based on the identified local and global topics. The clustering is performed by finding the overlap between topics of different types (local, global). The parameter *n* in the following lines represents the number of documents in corpus.

1. *local to local comparison* – all found local topics from all text documents are compared mutually except for the topics from the same document. Together *(t.(t-1) / 2).n* document comparisons are done where *t* is the average number of local topics on one document (note that one document can have several local topics).
2. *global to local comparison* – all found global topics from all text documents are compared to all local topics. Together *n.t* document comparisons are done where *t* is the number of found local topics.
3. *global to global comparison* – all found global topics from all text documents are compared mutually. Together *n.(n-1) / 2* document comparisons are done.

The distance between individual topics (local from local, local from global or global from global) is calculated based on the keyword overlap between the topics. We set the threshold to 0.5 which means the two topics must have at least 50% overlap between their keyword sets to be considered similar. The two documents are similar if they share at least one similar topic of any type.

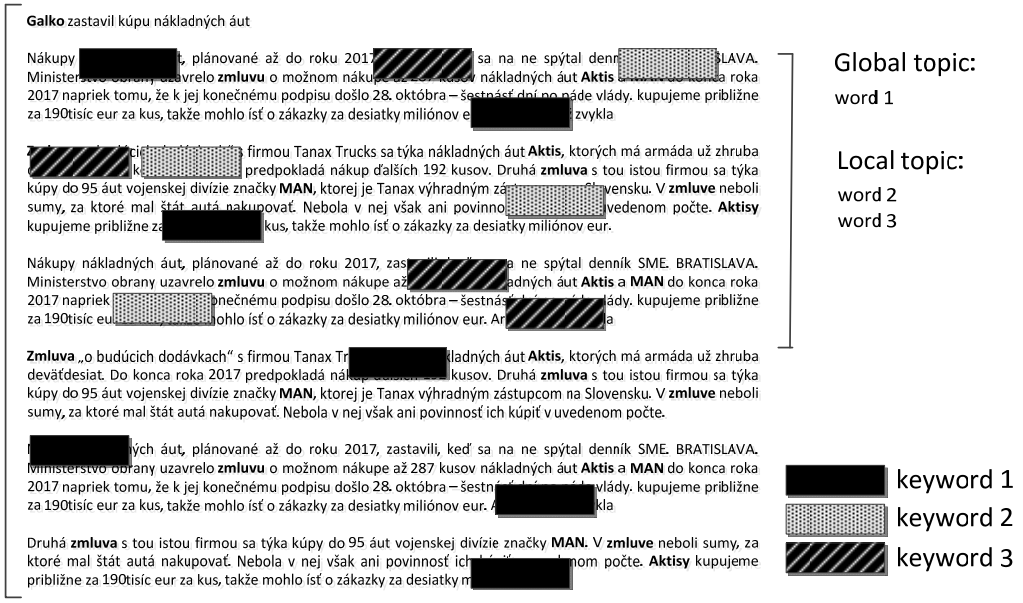

Figure 2. Global and local topic identification based on keyword's positions in a document's content. The rectangles represent keywords. The lines at the sides of the text illustrate the global and local topics.

5 Experiments

In this section we give results of our approach to topic identification over a corpus of textual documents. In our experiments we used system PlaDeS [6] – a system for detecting plagiarism in textual documents written in Slovak language.

The main objective of our experiments is to tell which documents should be checked on similarity with system PlaDeS. We suppose that only documents having at least one common topic (local or global) should be compared with 3-gram method implemented in system PlaDeS. For instance, it is highly improbable that two different documents that contain different topics (for instance *"sport"* and *"math"*) are similar in any way. Therefore we obtain two lists of document pairs. First list contains unordered pairs *(x, y)* returned by our method where *x* and *y* are text documents from the given corpus. All returned pairs *(x, y)* share at least one common topic. The second list contains ordered triples *(x, y, p)* where *x* and *y* are again text documents from the given corpus and *p* is the found similarity between *x* and *y* by system PlaDeS. PlaDeS determines the similarity based on the portion of identical 3-grams between two texts.

We compare the two lists in the following way. We restrict the records in the second list on different values of parameter *p*. This parameter has to be greater that a given constant *c*. We compare the two lists to find out which records from the first list are missing in the second one being restricted by condition $p \geq c$. The point here is that only documents with similar topic can have higher values of *p*.

We carried out the experiments on the corpus of 243 student term papers written in Slovak language. Average length of one document in this corpus was about 2300 words. The results of performed experiments are shown in figure 3. The vertical axis represents the portion of returned similar document pairs by our method when compared to the PlaDeS output restricted by condition $p \geq c$. The different values of parameter *c* are on the horizontal axis (numbers 1 to 20 meaning percentage range from 1% to 20% increasing by 1%).

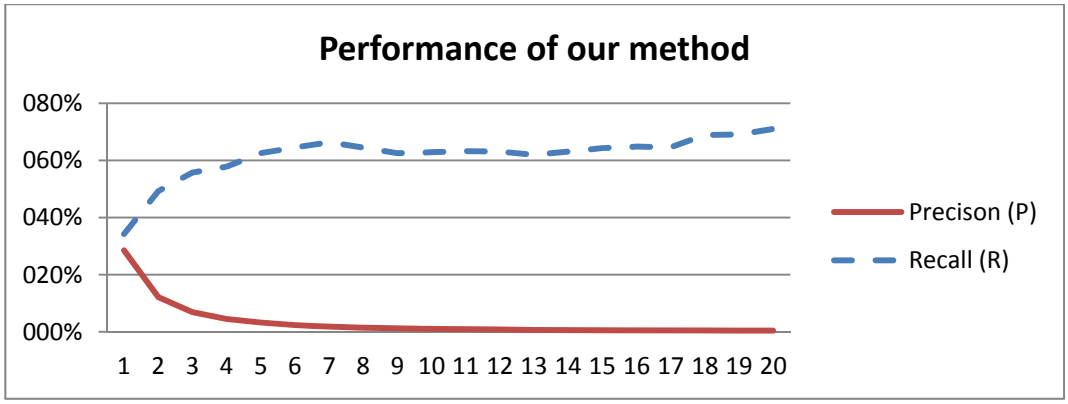

Figure 3. Performance of our method measured by calculating precision and recall for different values of parameter c. The horizontal axis represents different values of parameter c, the vertical axis the percentage (portion) of identified pairs compared to the output of PlaDeS.

As can be seen from this figure, the recall of our system increases with the increasing value of parameter *c* (horizontal axis). This is a predictable behaviour as two documents can have a small portion of similar 3-grams even if they do not share any topic. Therefore, for the lower values of *c* the topics of two different documents can differ but still some portion of 3-grams will be shared. Overall the recall of our system looks promising for future experiments. Its average value for $c \geq 6$ closes to 70%. On the other hand, the precision is very poor which is caused by the high number of returned similar documents. The total number of returned unordered document pairs by our method was 6 223 whereas the number of relevant documents at $c=6$ was 352.

Nevertheless from the look of dimensionality reduction the results look quite well. Because the returned document pairs by our method are unordered we have to assume that 12 446 comparisons have to be done (6 223 x 2) in order to get approximately 65% of results returned by PlaDeS. The PlaDeS originally did 59 049 comparisons. This means that if we send our output (12 446 pairs) to PlaDeS as a list of ordered pairs on comparison, we would have to perform only 24.5% of original comparisons.

6 Conclusion

We proposed a new method to topic recognition in text documents written in natural language. This method is based on analysing word positions in text document to identify global and local topics where each topic is characterised by its own set of keywords. Topic clustering is than done by measuring the overlap of keywords in individual keyword sets. The main contribution of our work can be seen in the local topic identification. Local topics are in our opinion frequent especially in longer documents and we suggest that their recognition enhances the clustering performance.

The performance of our method was evaluated on 243 student term papers written in Slovak language. First we tried to identify similar document pairs with our method based on topic similarity. Then we identified similar document pairs using the system PlaDeS which implements 3-gram comparison technique. We compared the obtained results and found out that our method achieves average recall 65% on condition that we assume similarity border higher than 5%. On the other hand the precision of our method is extremely poor which was expected as from 59 049 document pairs about 352 were relevant. From the view of dimensionality reduction in order to get approximately 65% of results returned by PlaDeS we would have to perform only 24.5% of the original comparisons (when compared to PlaDeS).

In our opinion the yet achieved results show that the suggested approach to similarity detection based on the local and global topics appears promising. Therefore we will continue with further experiments in this field. For now the carried experiments showed the weaknesses of our method with which we now have to cope.

6.1 Future work

Primarily we would like to improve the precision of our method in order that it can be used to reduce the input set (perform dimension reduction) for similarity detection systems like PlaDeS. This would be possible if most of the found similarities would be present in the reduced set of similar document pairs. For now the experiments showed that only 65% of the original similarities would be detected. Therefore our next goal is to increase this number by altering the key algorithms after which would follow the system parameter tuning.

Besides this, our next aim is to implement topic hierarchy identification. This would enable us to detect associations between topics. For instance, assume that a dissertation thesis on topic *"Identifying Plagiarism in Textual Documents"* contains global keywords *"text"*, *"similarity"*, *"method"* and *"document"* and local keywords *"pLSA"*, *"LDA"* and *"probability"*. Now we have another article with global topic *"pLSA"*, *"probability"*, *"text"* and *"document"*. By analysing the keywords in found topics we would like to identify hierarchy levels. From our example, on the zero level would be keywords *"text"* and *"document"* and on the first level keywords *"pLSA"* and *"probability"*. This would mean that keywords *"pLSA"* and *"probability"* are some kind of concretisation of topic represented by keywords *"text"* and *"document"*. Evidently this example is very simplified and the real situation is much more complicated.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0971/11.

References

[1] Beil, F., Ester, M., Xu, X.: Frequent Term-Based Text Clustering. In: Proceedings of the eighth ACM SIGKDD international conference on Knowledge discovery and data mining, (2002), pp. 436–442.

[2] Fung, M. C. B., Wang, K., Ester, M.: Hierarchical Document Clustering Using Frequent Itemsets. In: Proceedings of the third SIAM International Conference on Data Mining, (2003), Vol. 3, pp. 59–70.

[3] Agrawal, R., Srikant, R.: Fast Algorithms for Mining Association Rules, In: Proceedings of the 20th International Conference on Very Large Data, (1994).

[4] Li, Y., Chung, M. S., Holt, D. J.: Text document clustering based on frequent word meaning sequences. Data & Knowledge Engineering, (2008), Vol. 64, pp. 481–404.

[5] Zhanguo, M., Jing, F., Liang, Ch., Xiangyi, H., Yanqin, S.: An Improved Approach to Terms Weighting in Text Classification, In: International Conference on Computer and Management (CAMAN), (2011), pp. 1–4.

[6] Chudá, D., Kučečka, T.: PlaDes – Effective Way to Plagiarism Detection of Student Assignments Written in Natural Language. In: Proceedings of the International Conference on E-learning and the Knowledge Society (E-learning´11), Bucharest, (2011), pp. 47–52.

[7] Wartena, C., Slakhorst, W., Wibbels, M., Gantner, Z., Freudenthaler, Ch., Newell, Ch., Lars, S.T.: Keyword-Based TV Program Recommendation. In: Intelligent Techniques for Web Personalization & Recommender Systems (ITWP'11), (2011), Vol. 756, pp. 15–21.

Search in Source Code Based on Identifying Popular Fragments

Eduard KURIC*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kuric@fiit.stuba.sk

Abstract. When programmers write new code, they are often interested in finding definitions of functions, existing, working fragments with the same or similar functionality, and reusing as much of that code as possible. Short fragments that are often returned by search engines as results to user queries do not give enough information to help programmers determine how to reuse them. Understanding code and determining how to use it, is a manual and time-consuming process. In general, programmers want to find initial points such as relevant functions. They want easily understand how the functions are used and see the sequence of function invocations in order to understand how concepts are implemented. Our main goal is to enable programmers to find relevant functions to query terms and their usages. In our approach, identifying popular fragments is inspired by PageRank algorithm, where the "popularity" of a function is determined by how many functions call it. We designed a model based on the vector space model, by which we are able to establish relevance among facts, which content contains terms that match programmer's queries. The result is a sorted list of relevant functions that reflects the associations between concepts in the functions and a programmer's query.

A paper based in part on this paper was published in Proc. of 39th Int. Conf. on Current Trends in Theory and Practice of Computer Science (SOFSEM'13), LNCS, Springer, 408-419.

* Doctoral degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Exploiting of Motivation and Player-Specific Expertises in Image Annotation

Jakub ŠIMKO*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
jsimko@fiit.stuba.sk

Abstract. Among human-oriented approaches to multimedia annotation, the crowdsourcing-based games with a purpose (GWAP) have proven to be able to provide a scalable way of harnessing human labor to produce quality metadata for resources of the general domain. However, if we want to employ their principles in specific domains, such as one's personal multimedia, we need to overcome the issue of extremely small number of competent potential players, which hinders the use of classic crowdsourcing principle of redundancy-based task result filtering. In this paper, we extend an existing image annotation GWAP – the PexAce. It exploits the additional motivation of players working over their own images and is enhanced by several algorithms for tag extraction for small number of players. We show that our approach is able to yield valid image annotations, specific to the context of the resource owner and examine its performance with different types of annotated images and tags.

A paper based in part on this paper was published in
Proc. of the 8^{th} Int. Conf. on Semantic Systems (I-SEMANTICS'12),
ACM, New York, NY, USA, 88-93.

* Doctoral study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Context Inference Using Correlation in Behaviour

Dušan ZELENÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
zelenik@fiit.stuba.sk

Abstract. Context-aware computing received a significant amount of attention last years. The paper addresses some of the challenges in context acquisition. It is focused on a method for inference of unavailable contextual information such as dwelling time or emotions. The method for context inference is based on observed behaviour of individual and groups of similar users whose contextual information is available (through explicit feedback or more advanced devices). We discuss the role of user behaviour and its significant impact on the interest and needs. In experiments we demonstrate this impact with real news readers.

A paper based in part on this paper was accepted for publication in Proc. of 7^{th} Int. Workshop on Semantic and Social Media Adaptation and Personalization (SMAP'12), IEEE Computer Society Press.

* Doctoral study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Web Science and Technologies

Enhancing Web Surfing Experience in Conditions of Slow and Intermittent Internet Connection

Ľuboš DEMOVIČ, Martin KONÔPKA, Marek LÁNI
Matúš TOMLEIN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
icup2012@gmail.com

Abstract. Despite of the advancements in information and telecommunication technologies, slow and intermittent Internet connection is still a serious issue in many places of the World and is most visible in developing countries. At the same time, Internet with its most popular service – the Web, became one of the very important parts of our everyday lives as more and more of human activity is taking place online. We believe that providing access to information on the Web is crucial for young people in developing countries to get the required skills and acquire experience in order to finally achieve significant progress in solving problems of their countries. In this paper, we propose a concept of software solution called OwNet which makes the Web surfing experience less frustrating even in the case of slow and intermittent Internet connection. OwNet is based on using a local proxy server, acting as an intelligent bridge between the client's browser application and the Internet, communicating with other clients and services in order to provide the best surfing experience. Although this concept is not bound to the quality of available connection, we mainly target the current situation in developing countries. The paper presents the overall concept and details on methods used for intelligent caching and prefetching of web content.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 25-29.

* Bachelor study programme in field: Informatics
Supervisor: Dr. Michal Barla, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 109–114.

Social Web Search

Martin GREGOR*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
greczsky@gmail.com

Abstract. Web search nowadays provides results that do not always satisfy user requirements. Our mission is to supervise user's exploration of the Web and forecast user queries in time of document browsing. We propose method which analyses user activity on the Web, get all keywords from browsed documents via Alchemy API and presents a list of recommended queries. Our method selects several keywords with highest incidence from user's social network and several keywords with lowest incidence from user's model. The new proposed queries are created from this keywords. Evaluation is based on comparing real desired queries of users and proposed queries from our method.

1 Introduction

New information is created on the Web every day. With this progress it is more and more difficult to find out correct answers to our search queries. Keane et al. [7] show that over one hundred million queries are run every day and almost everyone clicks on the first result. These results do not exactly fit to user's needs. It is widely accepted that imprecision of web search is problem of modern internet. The idea of fast and accurate searching on the web impressed many scientists and even companies operating in Web environment.

We primarily focus on users of web search machines. They are consumers of information from all over the world with different needs. Typical user wants to finish a project. Often he cannot find information about problem like *drupal 6 newsletter and smtp support not working* even though the solution to the problem was found by his colleague recently, but the colleague don't know the source of solution. The user spent a few hours by mining the web search results. There is also a problem regarding how the search results are sorted. The ranking functions use various signals, popularity of the resource (e.g. PageRank) being one of the most influential. If the user is not interested in the particular meaning of the search query, there is usually little help from the search engine besides query reformulation. One example is information about the *Bee* wifi socket. The results for this query consist mostly of information on insects, and the required information may be buried deep in the search results page stack.

---

* Bachelor study programme in field: Informatics
Supervisor: Tomáš Kramár, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 115–120.

Our method predicts search queries based on the documents seen by a user and recommends the best relevant queries from all users in his social search network. In general it returns the most used queries with results relevant to opened document.

Many partial solutions to these problems exist. We propose a new approach which we evaluate on proxy server rabbit. We focus on query prediction based on the inferred needs during reading of document. Our method is described in Section 3. In Section 2 we describe related work. Section 4 consists of information about mining web search activity. The next Section include information about search query construction. We conclude with evaluation and summary of the results.

2 Related work

Analysis of user behaviour is important to understand user needs after reading document. User's behaviour study in [6] shows that the search query is more general as the underlying real information need. Also rare interest evoke more queries and take more time to search for relevant information. The correlation between number of results and number of queries proves that rare results are best. We draw inspiration in rare queries. Our method selects rare metadata from the user model which are also present in browsed document.

One of the efforts to predict search query is described in [10]. They support query recommendation from most trusted user in social network or search stack. Search stack looks like social network. It stores information about user's search actions and activities. Search stack represents relations between individual queries and results. Usage of network or stack is an important attribute. Not only an increase of number of users in network improves result provided by the method but increase of usage inside the network is important too. Also stack should consist of trusted users. An untrustworthy user decreases accuracy of stack.

A method proposed by Bhattacharyya et al. [2] creates social search networks. It is based on the idea that people with similar interest associate together. Their method enriches metadata from user's models with other words form their special data structure called forest. One forest is similar to a cluster of words in one category. Distance between two words in forest determines relation between two users. There is a problem when a single word is in multiple forests, because that implies that it has multiple meanings. This word can negatively influence evaluation of relation between two users in the network.

One of the solutions, proposed in [8] is to implement an approach to social web search on proxy server. Their method traces and stores important information of user's activity on the web in user's model. The metadata provide information about topic of document. User models are grouped in social networks of similar users. A new search session builds up new social search network which consist of top ranked social networks to user actual interest. User's activity is tracked by JavaScript which is inserted to each browsed document. The user model consists of user unique id, visited url, time of visit, extracted metadata and checksum computed from time and visited url. The document is translated to English via google translate. Metadata are extracted from translated text via Alchemy API. Their method enriches user query by metadata from new social search network.

There are other possibilities to supervise social web search. A method in [4] creates one profile for whole community. It stores results from web search selected by users. Indexed results are ranked according to their usage. One problem is recognition between incorrect and correct results.

An extraction of all user queries after document browsing is one of possible approaches [5]. Described method ranks stored queries according to relevance to current search query. In consequence it predicts top ranked query. Search queries can be divided to groups like site search query, name search query and browsing of web. Problem is that 71% of all queries are not search queries.

3 Search query prediction

An important part of our proposed method is capturing of user interest. User interest is a source of significant information about his needs, areas of interest and so on. Our method predicts results according to amount of information about user which is described in this Section. These information are gained from user activity on the Web. The performance of our method depends on size and quality of user search activity.

This activity is captured from the Web browsing by tracking JavaScript. Tracking JavaScript is inserted to every browsed document via proxy server and asynchronous sends important input data to our method. Input data consist of visited URL, time, unique user id, time spend by browsing and control checksum. Control checksum is computed from visited url and time of access to page. As in [3] we store these important data in user model. Each user model is stored in a database. These user models group to social networks based on the available, lexically similar keywords. One social network is consist of models with common interests. Model contains this extracted keywords from document too.

Our proposed method predicts user search query by comparing keywords stored in the user model or social network and keywords extracted from document via Alchemy API. Search query prediction starts when the document is opened for browsing. Our method is realized in few steps:

1. keyword extraction from browsed document via Alchemy API,
2. comparing extracted keywords with keywords stored in the user model,
3. selection of keywords with lowest incidence in the user model, which are similar to extracted keywords from the browsed document,
4. comparing extracted keywords from browsed document to keywords stored in user's social network,
5. selection of keywords with highest incidence in user's social network, which are similar to extracted ones,
6. formation of queries from keywords.

Firstly keywords are extracted from browsed document by Alchemy API. Our method needs url of browsed document as input variable. We select several highly rated keywords returned by the API.

Secondly our method compares each keyword retrieved from browsed document with each keyword stored in user's profile. In consequence it selects the keywords with lowest incidence in user's model, which are lexically similar to high rated keywords from document. Similarity is computed in database with *LIKE* or *fulltext search* in selection database query.

Next step is selection of keywords from browsed document which are similar to keywords with highest incidence in user social networks. Similarity of keywords is defined as same lexical structure of keywords. This one is also managed via database.

The final result consists of a list of pairs from the social network and a list of pairs from the user model. Both are ordered by size of relevant documents from Wikipedia API.

The final step is creation of hyper link to each of these selected metadata and consecutive presentation to the user.

The final problem is query construction and presentation to user. The method constructs simple links to Google search with selected keyword pair in predefined pattern like

```
https://www.google.com/search?client=ubuntu&channel=fs&q=our+proposed+query
&ie=utf-8&oe=utf-8}
```

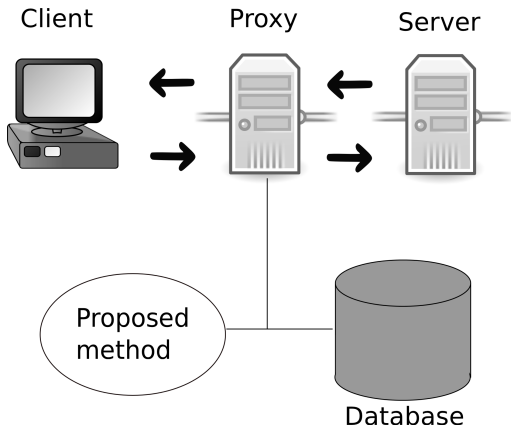

Figure 1. A communication between server and client flows through proxy server which controls and inserts method's data.

Possible improvement is enrichment of query by topic of document or another applicable keyword from Wikipedia result. If the results of our method will not satisfied our requirements, we will have to proposed more precise selection of keywords from browsed document and user model.

The next step is constructing simple popup block in html, css and JavaScript. This bundle of code has to be inserted to every opened document. This embedding is done via proxy server. The most important part is presentation in correct time and in correct document. Naturally the presentation is simple and well suited to user needs similarly to [1]. Correct time depends on time spent reading the document. We choose two minutes of reading the document. The time is measured when user reads document, moves by cursor, scrolling down the page or another actions during browsing. It is possible to have opened more than one tab in browser or to have the browser hidden or overlapped by another window. In this cases the time is stopped [9]. User activity is recorded by a tracking JavaScript. The correct document problem means displaying recommend search queries on suitable pages. We cannot recommend queries on Google search page for example. Our method displays this block in top right corner of browsed document.

4 Evaluation

Proposed method is limited to documents in English language. Also it cannot show any proposed queries on Google search page. Another limit is count of metadata extractions per day. Alchemy API can work up only 30 000 document per day for student registration.

We implemented our method on a proxy server PeWeProxy [8]. It means that the user has to browse the Web via our proxy server to use our query prediction. This proxy server embeds the output of the proposed method to every visited page. The output from our method consists of tracking JavaScript and source code of predicted queries. The main flow of engagement of our method is described in Figure 1. A communication between server and client flows through proxy server which controls and inserts method's data. Server is a place where the document is publicized. Client is a user's internet browser. The proxy server is also connected to database where our method stores user profiles.

Effectiveness of suggested method is evaluated by comparing accuracy of created query with the real user need. The test is designed as follows:

– We manually build a network of users with similar interests; each one of them has been browsing via our proxy server for two weeks and we have collected enough data about his interests.

- We select a human judge from this network.
- We randomly select 20 documents seen by the judge and ask the judge to carefully read them, and for each document suggest queries, that he would likely issue after reading the document.
- We run our method on the clickstreams of the judge and for each judged document generate a set of recommended queries.
- Finally, we compare the queries manually selected by the judge and automatically suggested by our method – if there exists a semantic overlap, i.e., there are queries that are semantically similar, we count that as success of our method.

Similarity of queries means equivalent meaning of queries. Also it means equivalent results returned from web search.

5 Conclusion

Our goal is to make the web search easier and more accurate. Main problem is inaccuracy of results returned via web search engines where the correct results are often deeply buried in a list of results from web search. We propose to use user models and social networks build from search activity on the web to predict user's search queries. Our solution of query prediction is based on extracting and comparing of metadata gained from browsed document via Alchemy API to metadata stored in user model. We propose only existing queries which existence is proved via semantic Wikipedia database. The final list of proposed queries is inserted to document via proxy server in form of links to direct search. This list consists of pairs of keywords from user model and from user's social networks. The list is shown only after 2 minutes of activity on the document. Activity is measured via tracking JavaScript. It means that user has to read document, move cursor or scroll down the page. Our proposed method is limited only to document in English language.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0675/11.

References

[1] Ali, H., Scholer, F., Thom, J.A., Wu, M.: User interaction with novel web search interfaces. In: *Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7*. OZCHI '09, New York, NY, USA, ACM, 2009, pp. 301–304.

[2] Bhattacharyya, P., Garg, A., Wu, S.F.: Social Network Model Based on Keyword Categorization. *2009 International Conference on Advances in Social Network Analysis and Mining*, 2009, pp. 170–175.

[3] Bilenko, M., White, R.W.: Mining the search trails of surfing crowds: identifying relevant websites from user activity. In: *Proceedings of the 17th international conference on World Wide Web*. WWW '08, New York, NY, USA, ACM, 2008, pp. 51–60.

[4] Boydell, O., Smyth, B.: Capturing community search expertise for personalized web search using snippet-indexes. In: *Proceedings of the 15th ACM international conference on Information and knowledge management*. CIKM '06, New York, NY, USA, ACM, 2006, pp. 277–286.

[5] Cheng, Z., Gao, B., Liu, T.Y.: Actively predicting diverse search intent from user browsing behaviors. In: *Proceedings of the 19th international conference on World wide web*. WWW '10, New York, NY, USA, ACM, 2010, pp. 221–230.

[6] Downey, D., Dumais, S., Liebling, D., Horvitz, E.: Understanding the relationship between searchers' queries and information goals. In: *Proceedings of the 17th ACM conference on Information and knowledge management*. CIKM '08, New York, NY, USA, ACM, 2008, pp. 449–458.

[7] Keane, M.T., O'Brien, M., Smyth, B.: Are people biased in their use of search engines? *Commun. ACM*, 2008, vol. 51, no. 2, pp. 49–52.

[8] Kramár, T.: Towards Contextual Search: Social Networks, Short Contexts and Multiple Personas. In Konstan, J., Conejo, R., Marzo, J., Oliver, N., eds.: *User Modeling, Adaption and Personalization*. Volume 6787 of *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg, 2011, pp. 434–437.

[9] Kramár, T., Barla, M., Bieliková, M.: Modeling of user on the open web. In: *In proceedings 2011*, VŠB-Technical University of Ostrava, 2011, pp. 66–77, in Slovak.

[10] McNally, K., O'Mahony, M.P., Smyth, B., Coyle, M., Briggs, P.: Social and collaborative web search: an evaluation study. In: *Proceedings of the 16th international conference on Intelligent user interfaces*. IUI '11, New York, NY, USA, ACM, 2011, pp. 387–390.

Keyword Extraction Based on Implicit Feedback

Jakub KŘÍŽ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
jacob.kriz@gmail.com

Abstract. To improve the results from search engines and make them more personalized for the user, we need to find out about the interests of a particular user. Many of the search personalization methods analyse documents visited by the user and from these documents infer the user's interests. However, this approach is not accurate, because the user is rarely interested in the whole document; he might be interested in parts of the document only or the document does not have to interest him at all. In this article we analyse the user's activity on a web site, called implicit feedback. This feedback is represented by the user's behaviour in the Web browser: time spent browsing, mouse cursor movement, clicking, scrolling etc. Our method is then able to more accurately extract keywords from the documents by putting more weight on the keywords the user is more interested in and disregarding those which did not interest him. We extract keywords directly from the text and also by using traditional methods enhanced by the implicit feedback.

Amended version published in Information Sciences and Technologies
Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 43-46.

* Bachelor study programme in field: Informatics
Supervisor: Tomáš Kramár, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 121–126.

Using Social Media to Facilitate Face-to-Face Meetings

Jaroslav MICHALCO*, Martin LÍŠKA†

*Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia

†Comenius University in Bratislava
Faculty of Philosophy
Gondova 2, 814 99 Bratislava, Slovakia
michalcojaroslav@gmail.com, liska.ffuk@gmail.com

Abstract. Everyone, who has organized an event, has faced a problem like this – one invites fifty friends to an event and only four of them attend the event. In addition, many of the invited friends even do not respond to the invitation. The intention of this paper is to devise an effective support for organizing face-to-face meetings (or other events) of people who are somehow networked within a social network. This application can help the organizer of an event determine how many people would attend the event and predict the likelihood of each user's attendance. Moreover, this application can also help the invited guest to know which of his friends might attend the same event. The likelihood of user's attendance at a specified event is affected by various factors, which had been determined by a survey and will be used in calculating the probability of user's attendance.

A paper based in part on this paper was accepted for publication in Studies in Informatics and Control.

* Bachelor study programme in field: Informatics
Supervisor: Professor Pavol Návrat, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

† Master study programme in field: Sociology, Faculty of Philosophy, Comenius University in Bratislava

Tag Recommendation System

Martin PLANK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
plank09@student.fiit.stuba.sk

Abstract. Collaborative tagging is popular information management approach in various information systems. Despite tagging is easy and flexible, tag recommendation systems can even simplify this process and solve some drawbacks of the collaborative tagging systems. In this paper, we present hybrid tag recommendation system proposed for Stack Overflow[1] – internet forum for programmers. We proposed and evaluated method for analyzing the content of the posts by means of Wikipedia Miner toolkit[2] for tapping the semantics encoded within Wikipedia, the free encyclopaedia.

A paper based in part on this paper was submitted to a peer reviewed scientific journal.

* Bachelor degree study programme in field: Informatics
Supervisor: Tomáš Kuzár, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

1 http://stackoverflow.com/

2 http://wikipedia-miner.cms.waikato.ac.nz/

Feedback Acquisition in Web-Based Learning

Andrea ŠTEŇOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
andrea.stenova@gmail.com

Abstract. For efficient web-based learning, we need information on how students interact with system, which materials they find hard to learn or insufficiently explained, and which on the other hand they like. We can achieve this by feedback acquisition. Most of the time, students are not willing to provide the feedback or they do it only when they are very satisfied or not satisfied at all. In this paper, we introduce the method of feedback acquisition, which motivates students to evaluate system more, offers different rating forms of distinct parts of the system and provides transformation of ratings on various rating scales.

1 Introduction

User's interests and opinions can be determined by user feedback acquisition. Thanks to which, it is possible to review, improve, recommend and personalize webpage content. When acquiring information directly from a user, we can use explicit feedback methods such as questionnaires. In case of implicit feedback we gather information by user observation and derive user's characteristics in pursuance of observation results. Both approaches can be combined since each of them has specific deficiencies even though they complement each other. Overall, user feedback is context-sensitive. Inappropriate explicit feedback might bother web page user, however, lack of explicit feedback and irreplaceable information we receive from it is a great issue that should not be ignored. There is always sufficient amount of information from implicit feedback available, but accuracy of the information might be lower.

In this paper we introduce feedback acquisition method from web page users based on evaluation of objects in the system. When evaluating objects we use different scales, which we customize for certain object and user preferences. We concentrate on incorporating a feedback into the system, with focus on educational system ALEF [6]. ALEF is Adaptive LEarning Framework, which is being developed on Faculty of Informatics and Information Technology of Slovak University of Technology in Bratislava. The results from rating in education system of this type can be used for improvements in efficiency of user education process by recommending good articles and reviewing bad ones.

* Bachelor study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 139–144.

2 Related Works

Several works have focused on explicit feedback. Explicit feedback can be categorized as a general feedback (the user rates or comments the whole system or its information space, we ask general questions) or feedback associated with an object in the information space (mostly presented as rating of this object). Both types of feedback can be realized either as synchronous or asynchronous feedback. Presentation of synchronous feedback depends on a display of particular object, which is being evaluated. Display of asynchronous feedback is not directly dependent on user interaction with the system. The time, when the feedback is shown to user, is not defined by viewing particular page and can be further customized. This type of feedback can be displayed to user during his work in the system, although when he is reading documents, feedback acquisition might cause more distraction than in the first case. During asynchronous feedback collection we can ask user general questions about system or questions focused on some objects in system. Asynchronous feedback can be also used to confirm our experiments. For example in [5], the author used asynchronous feedback to confirm information obtained via implicit feedback.

Most present-day works deal with explicit feedback by discussing rating of objects. It was found out that the rating can give very inaccurate results of users' preferences [4]. One reason is problem known as J-shaped distribution, which shows that most reviews on the Internet are overwhelmingly positive. There are some negative ratings, but hardly any average ratings have been found. Users provide feedback when they are really satisfied or dissatisfied, but they are not motivated enough to give average ratings.

To rate acquisition we use rating scale, the widget to express user's preferences on selected range. It has been shown, that not only different users prefer using different scales for their ratings [1], but also rating scale itself affects user's rating [2,3]. The way rating scales are perceived by user is called rating personality. Thus, the results from ratings of a user on different scales may not capture actual meaning of ratings, transformed by the mathematical normalized distribution. Users give higher ratings on binary scales and scales without neutral point [2]. Correlation of results between different scales is still strong, but least accurate on binary scale. When designing system with different rating scales, we should be aware of these issues and take them into account.

In ALEF there are different objects, which are displayed to users and can be rated by them. Our method of feedback acquisition is aimed on these objects, with stronger focus on differences between them. The biggest difference, that affects the design of obtaining feedback, is range of object. Objects for rating in ALEF are of two types [6]:

- Learning Objects

  Explanation Educational text.

  Exercise Student is asked to solve exercise alone, or with help of the system, eventually system displays the sample solution.

  Question Question with short answer or multiple choice answer.

- Annotations

  Comment Commentary of user to text of learning object.

  External source Link to document out of ALEF.

  Issue report Mistake in learning object reported by user.

  Tag Keyword from text added by user.

3 Rating as a form of explicit feedback acquisition

In this paper we focus on synchronous explicit feedback in educational system ALEF, while for users' information collection we use rating of objects in system. During design process of the method for obtaining ratings from users, we aimed mostly on identifying differences between objects, which implies the need of different rating scales. User rating process consists of these steps:

1. display of rating scale in object,
2. user rating and logging,
3. object evaluation.

For rating we use rating scale, which has characteristics such as range, visual representation in the system and presence or absence of neutral value. Selection of scale depends on domain, size (texts or contents) of object, in which it is displayed and of users' preferences. As we focus on the learning framework ALEF, we should adapt selection and design of scale to this system. For ALEF we designed these scales in Figure 1:

Like it/like it not This scale has range two and is visualized by pictures of plus and minus, it does not contain neutral value, which forces user to decide about his preferences.

Emoticons Scale with range three, which in addition to options like it and like it not contains also neutral value, it is visualized by emoticons.

Stars This scale has five options of rating, which allows user to express their preferences accurately.

As we mentioned earlier, there are two types of objects in ALEF suitable for explicit feedback – learning objects and annotations. Annotations are usually short texts and a smaller range is sufficient for their rating. Therefore we choose the rating range of objects to 2. User can express his opinions about these short objects, whether he likes it or not. Learning objects have larger text and a range of content, so the feedback obtained by them should be more accurate. Therefore, in these objects we will use range of 3 and more objects.

When designing and getting feedback in other systems, we can use other rating scales. For example, the product evaluation in an e-shop we will need a wider range of ratings than 5, to allow users to express their preferences in a better way. On the other hand, for example in social networks scale with only one option can be used, where users only represent their positive preferences.

Besides type of scale we need to know other rating parameters – where and when it will be displayed. While solving this problem, we need to consider logical continuity of student's actions during learning. For example, when viewing Explanation type of a learning object, namely educational text, we want the student to read the text first and rate it afterward. Rating scale appears below the text. Except for reading, the student does not provide any other activities, therefore the form with rating scale is displayed as soon as the rated object is loaded. However, when student answers an object of Question type or solves Exercise type object, rating display along with object loading can be distracting. In this case we want to achieve a state when student first answers the question or solves the exercise. Therefore, the rating is shown after completion of these actions. Since answering the question and exercise solving is done below the object, rating is displayed below this object, too.

For objects of type Annotation we also do not always show the evaluation, but only when the student reads it. As the comments and reported errors are only shown after moving the cursor over them, the rating will show along with the object. Location of rating for such a small object does not play such a big role, as it is visible above and below the object. In external sources we can also detect when the user has read, or at least has viewed them, so we will show the feedback when the user clicks on the link. We will display rating scale next to the link and the user will be able to use it

Figure 1. Rating scales.

and rate when he is back in ALEF from external site. Tags from text are still visible, so there is the opportunity to evaluate these objects. As with external sources, we show a range for evaluation next to the specific tag.

If we add another type of object for which we would like to obtain users' rating, it is required to specify following parameters – which scale and which range should be shown with the object, where the rating should be shown in the object and whether its showing was affected by some event.

After user's rating, we record rating value, object, that was rated, and also rating scale, on which the user rated. As system administrator can change the scale, which is displayed it specific objects, it may happen, that one object will have ratings on different scales. As we do not want to throw away previous ratings, with change of rating scale, we have to recalculate them. However, it causes the problem with transformation of these ratings. The transformation may not be easy, in our method we use mathematical normalization.

After feedback acquisition we have to evaluate the results, to decide which objects in system are good and bad. This evaluation is computing from users' rating and we also normalize these ratings.

In our method, we use mathematical normal distribution. All users' ratings are converted into the interval $\langle 0, 1 \rangle$. For scale with only two values (like it/like it not), transformation of results is simple. Value "like it" represents 1 and "like it not" value 0. When we add neutral value in scale of emoticons, we have to compute only value for neutral value. We map it to the value 0.5. Problem is with scales with bigger range. We know how to map extreme and neutral values, to compute transformation of other values we use normal distribution with parameters $\mu = 0.5$ and $\sigma = 0.2$. Input and output values for this function are from interval $\langle 0, 1 \rangle$. On the input are values in percent (for example for scale stars and rating 2, the input is 0.25), on the output we get transformed result from rating.

4 Evaluation

The goal of our experiment was to compare results from user's ratings on different scales and find out, if the results correspond with transformation using mathematical normal distribution. We also asked users, which scale they prefer the most and the least, when they rate on the Internet and how we can motivate them to rate more. For the experiment we have designed 5 different rating scales:

Like Users rate only if they like the object.

Like it / like it not Users show they preferences by liking or hating of object, on this scale there is no neutral value, so users were forced to choose their preference.

Emoticons (range of 3) Users can choose also neutral value.

Stars (range of 5)

Percent Greater range to show user's real preferences.

Each of used scales has different range (from 1 when using the "like" scale, to 100 when using "percent"), different visual representation and they differ also in presence or absence of neutral value.

Our experiment consisted of 11 users rating independently 14 randomly chosen pictures with each of selected scales. To prevent computing results between scales by users, users were asked to rate all pictures on one scale at a time. Pictures and selected scales were displayed to each user and user's ratings of these pictures were recorded. We have collected 770 ratings. We have normalized these values to interval $\langle 0, 1 \rangle$ and we have looked for correlation between user's ratings on various scales. The experiment also showed that results from the "stars" scale and the "percent" scale

Table 1. Users ratings of pictures in percent.

	like	like it/like it not	emoticons	stars	percent
1	72.73	81.82	81.82	77.27	75,27
2	45.45	72.73	54.55	56.82	55.91
3	54.55	63.64	72.73	65.91	62.73
4	27.27	45.45	54.55	45.45	49.09
5	63.64	90.91	68.18	52.27	58.27
6	63.64	90.91	77.27	65.91	66.82
7	72.73	81.82	81.82	75.00	70.91
8	54.55	72.73	54.55	50.00	57.73
9	45.45	45.45	59.09	40.91	44.55
10	54.55	54.55	59.09	52.27	49.09
11	45.45	63.64	68.18	59.09	60.45
12	36.36	36.36	36.36	34.09	38.18
13	45.45	45.45	50.00	31.82	43.45
14	18.18	36.36	27.27	29.55	28.91

correlate the most. The average difference between ratings on these scales was only 1.79%. Scale "like" has showed the lowest values. 69.64% of results were lower than results on other scales. As we can see in Table 1, 9 of 14 rated pictures achieved lowest average ratings on scale "like". On the other hand, "like it/like it not" scale and "emoticons" scale has reached higher values according to other scales. The "like it/like it not" scale in 71.42% and "emoticon" scale in 67.86% of results. As shown in Table 1, these scales had highest average ratings in 13 of 14 rated pictures. These numbers has confirmed previous results. User's scales affect user's ratings and a binary scale gives higher results.

When transforming results from various scales, we want to know how different these values are. In ALEF we use scales "like it/like it not", emoticons and stars, so we compared transformation between these scales. Average difference between results after transformation between "stars" and "emoticons" was 7.44%, between "like it/like it not" and "emoticons" 9.02% and difference between "like it/like it not" and "stars" was 10.78%.

The results have shown, that despite the fact the differences between results are not negligible, in ALEF they do not bother us so much. Computed values are less than half of difference between two ratings on one scale, so this inaccuracy should not affect our final results in large degree. Taking these results into account, we consider mathematical normal distribution of results as adequate.

Users were also asked about their choice of favourite scale. Most users prefer the "star scale" (7), then "emoticons" and "percents" scale (both 2 users). They like "star" scale, because it can depict their needs in rating the best. User's opinions about least favourite scale varied more. The least favourite scale was "like it/like it not" scale (5 users), than "percent" (4 users) and "like" scale (2 users). Users did not like their limitation in range, and unnecessarily huge range when choosing

"percent" scale. When they were asked to choose which scale they like better between "like it/like it not" and "emoticons", all of them choose the latter one.

Next we asked users, when they usually rate on the Internet. We confirmed the expected hypothesis, 8 of 11 asked users rate only when they are very satisfied or dissatisfied. Because of that, we wondered what would motivate them to rate more, also objects, they would rate. We focused this question on rating in learning system ALEF. Users would be motivated by some extra points in school (8 users), by helping somebody to verify their experiments (10 users), competition (2 users) and improvement of learning text (1 user).

5 Conclusions

We proposed a method of explicit synchronous feedback acquisition. It is based on students' ratings in system. When we want to collect quality feedback, we have to adapt our method to domain, its objects and users. We designed 3 ratings scales for ALEF educational system and theirs parameters – time and position of appearing. We proposed a method of results normalization and in the experiment we verified its use for system ALEF. We discovered users' preferences about rating scales and discussed several options of users' motivation.

The proposed method was evaluated in the educational system ALEF, but it is designed for usage in other domains as well, after some customizing. Size of objects affects range of rating scale and typical user of domain influences visual representation of scale.

In future work we will focus on asynchronous feedback method, design of questions and other feedback parameters. We also may consider the use of collected feedback. The information about objects' quality may be used to delete or improve bad objects and to recommend objects with the best results. Furthermore, we could personalize the content and also method of feedback thanks to identified user preferences.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0675/11.

References

[1] Amatriain, X., Pujol, J.M., Oliver, N.: I Like It... I Like It Not: Evaluating User Ratings Noise in Recommender Systems. In: *Proceedings of the 17th International Conference on User Modeling, Adaptation, and Personalization: formerly UM and AH*. UMAP '09, Berlin, Heidelberg, Springer-Verlag, 2009, pp. 247–258.

[2] Cena, F., Vernero, F., Gena, C.: Towards a customization of rating scales in adaptive systems. In: *Proceedings of the 18th international conference on User Modeling, Adaptation, and Personalization*. UMAP'10, Berlin, Heidelberg, Springer-Verlag, 2010, pp. 369–374.

[3] Gena, C., Brogi, R., Cena, F., Vernero, F.: The impact of rating scales on user's rating behavior. In: *Proceedings of the 19th international conference on User modeling, adaption, and personalization*. UMAP'11, Berlin, Heidelberg, Springer-Verlag, 2011, pp. 123–134.

[4] Hu, N., Zhang, J., Pavlou, P.A.: Overcoming the J-shaped distribution of product reviews. *Commun. ACM*, 2009, vol. 52, no. 10, pp. 144–147.

[5] Labaj, M.: Web-Based Learning Support based on Implicit Feedback. *Information Sciences and Technologies Bulletin of the ACM Slovakia*, 2011, vol. 3, no. 2, pp. 76–78.

[6] Šimko, M., Barla, M., Bieliková, M.: ALEF: A Framework for Adaptive Web-Based Learning 2.0. In Reynolds, N., Turcsányi-Szabó, M., eds.: *Key Competencies in the Knowledge Society*. Volume 324 of *IFIP Advances in Information and Communication Technology*. Springer Boston, Berlin, Heidelberg, 2010, pp. 367–378.

Discovering Keyword Relations

Peter KAJAN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
peto.kajan@gmail.com

Abstract. There are many approaches of revealing keyword relations in the area of Social web often based on user's explicit actions such as tagging. In our approach we experiment with user's implicit action like Web browsing. We introduce a method of revealing keyword relation based on the analysis of the records of visited pages described by these keywords. We focus on finding connections from the dynamics of the Web usage such as the user's click-streams. Revealed relations further enriched by Linked Data network are formed into ontology which can be applied in the area of personalized Web (personalized search, navigation, recommendation).

A paper based in part on this paper was submitted to a peer reviewed scientific journal.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Michal Barla, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Trend-Aware User Modelling with Location-Aware Trends

Marcel KANTA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kanta07@student.fiit.stuba.sk

Abstract. Microblogs are part of modern society. As there is much real-time social information in there, microblogs are ideal candidates to be used as a source for various scientific, but also real-life enhancing use cases, such as trend detection, news recommendation and user modelling. In this paper we focus on trend-aware user model with location-aware trends. This model can be used to improve user's recommendations of news, however, it is a general model. It can be a part of other information system. We focused on location aspect of the model and we created a model and its validation process.

A paper based in part on this paper was accepted for publication in Proc. of 7th Int. Workshop on Semantic and Social Media Adaptation and Personalization (SMAP'12), IEEE Computer Society Press.

* Master degree study programme in field: Software Engineering
Supervisor: Marián Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Emotion Classification of Microblogs Based on Appraisal Theory

Peter KORENEK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
pkorenek@gmail.com

Abstract. From immemorial there is a desire of people and companies that sell goods or provide services to know what people think about their products. In this paper we present a novel method for emotional classification of text that allows recognizing opinions in microblogs that are connected to particular target or entity. This method differs from other approaches by using the Appraisal theory, which we utilize in linguistic, semantic and syntactic analysis of microblog texts. This theory also allows us to describe in more detail the type of emotional relationship between the user and entities he writes about in his microblogs.

A paper based in part on this paper was submitted to a peer reviewed scientific journal.

* Master degree study programme in field: Software Engineering
Supervisor: Marián Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 157–162.

Acquiring Web Site Metadata by Heterogeneous Information Sources Processing

Milan LUČANSKÝ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
lucansky.milan@gmail.com

Abstract. In this paper we focus on mining relevant information from web pages. Unlike plain text documents web pages contain another source of potentially relevant information – mark-up and visual information encoded in style sheets. We present an approach to keyword extraction that enhances Automatic Term Recognition (ATR) algorithms intended for processing plain text documents with an analysis of HTML tags with semantic potential and text formatting CSS properties. In our previous work we have demonstrated significant improvement (up to 30 %) of keywords relevancy, using only naive method of keywords weight improvement by processing limited set of HTML tags. In this paper we refine the method to get even better results.

A paper based in part on this paper was published in Proc. of 39th Int. Conf. on Current Trends in Theory and Practice of Computer Science (SOFSEM'13), LNCS, Springer, 445-456.

* Master degree study programme in field: Information Systems
Supervisor: Marián Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Identifying Hidden Topics and Their Relations over Time in News Corpus

Martin MOLNÁR*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
teo.martin@gmail.sk

Abstract. This paper describes our work on identifying hidden topics and their relations over time. Our method is based on splitting whole corpus to smaller pieces, bordered by defined time slice, which we train separately using LDA topic model. We infer document-topic distribution for each new added document using previous LDA model and compare with previous articles to find similar articles. We also build graph of related topics over multiple models. We use metric based on comparing common words of compared topic pairs for computing topic similarity score. Each edge in resulting graph is labeled by shared words, which describe transitions between related topics. Resulting graph of related topics over time can be used for recommending new articles based on their common topics.

1 Introduction

There are a huge amount of unstructured text documents on the web these days. In such a huge text corpora is not easy to find relevant documents or information contained in these documents. It is important to detect and analyze connections between documents for better understanding whole text corpora. If we find hidden topics in documents, we can better understand these documents. Hidden topics are distributed across whole document and across whole corpus as well. We can find this latent topic structure by using topic models. Statistical topic model LDA [1] can be used to accomplish task of finding hidden topics. LDA can model text corpora by assigning topic probability to each word in each document. Identified topics can be represented by top most probably words.

LDA model is a generative model, which means that trained model can be used for obtain document topics distribution on new documents [3]. If we would like to identify topics on new document, we can perform statistical inference to obtain document topics distribution.

One problem with LDA model is that there is fixed set of learned topics. We can infer topic distribution for new documents but we cannot identify new topics in new documents without retraining model. Retraining whole model is not suitable because LDA generative process is based on statistical significance of words in corpus. If we perform LDA training on some document set

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Peter Lacko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

and retrain model with some new documents, we can lose some topics because of new added documents.

We propose our method by dividing incoming text document to defined time slice and use classical LDA to train model with documents from each time slice separately. We evaluate our solution on newspaper articles. For each article we find similar articles from different time slice. Inferred document-topic distribution for new article we use to compute similarity score between articles.

We also build graph of related topics over time. We can use resulted graph of related topics for retrieval content similar news articles and for recommending new articles based on their common topics proportions as well.

2 Related work

We mentioned in previous chapter that classical LDA model is not suitable for finding relations among topics.

There are several modifications of LDA, which can capture relations between topics [2, 4, 5, 6]. These models belong to Bayesian hierarchical topic models. Advantage of this type of models is that we can obtain hierarchical latent structure of related topics for whole corpus [2]. Disadvantage is that we need whole corpus for training phase. We cannot train hierarchical models incrementally by adding new documents to training set. We would like to find topics in dynamic data such as news articles, so we cannot use hierarchical model for incoming news articles because we would like to identify new topics and connect them with previous identified topics.

There is another modification of LDA model. Dynamic Topic Model(DTM) [8] was used to capture evolving of topics over time in scientific journal *Science*. DTM was used to capture evolutions of scientific ideas in analyzed time range. Disadvantage of this model is that DTM can capture only changes of word distributions within the topics and assumes the set of topics stays constant throughout the corpus, so it does not model how topics appear and disappear over time.

Another approach of identifying related topics is about constructing topic chains through time [9]. Topic chains are constructed by comparing their topic-word probability distributions. This approach is similar to our method in case of building graph of related topic through time by measuring similarities between topics learned by different LDA models within different time slices. Difference is in way of computing similarity between topics. We cannot use KL divergence to compute similarity score between two topics in two different topic models because compared topic-word distributions are not same size. Size of the topic-word distribution is defined as size of the vocabulary used to train LDA model. Each trained LDA model has its own vocabulary. This vocabulary contains words from documents belonging to time slice.

3 Extract topics from stream text corpora

We propose our method for stream text corpora. News articles are natural choice for stream text data because they are incoming in relatively short intervals. Each time is article arriving, we add it to defined time slot. If time slot is full, new time slot is created and we start training LDA model with documents from last time slot.

3.1 LDA

Topics are extracted using statistical topic model LDA. LDA is a probabilistic generative topic model for modeling text documents as a mixture of topics. LDA define two probability distributions. Topic-word distribution represents probability of word in given topic. This distribution represents words in vocabulary and their probabilities. Topic-word distribution can be used to measure similarity between topics with same vocabulary [10]. Second distribution is

document-topic distribution, which represents probability of document in given topic. Both distributions sum to one.

3.2 LDA inference

We can infer topic document-topic distribution for new documents using statistical inference, because LDA is fully generative model for new unseen data [1]. We infer document-topic distribution for each new added document using previous LDA model, trained in previous time slice. Obtained document-topic distribution from previous LDA model for new document is used for computing similarity between new document and documents, which were used to training previous LDA model. This process continues for all previous LDA model within defined time slice window.

Inferred document-topic distribution is fully probabilistic distribution, so we can use it to compute similarity between documents in one time slice to documents in another time slice using JS divergence. The whole process is described in Figure 1.

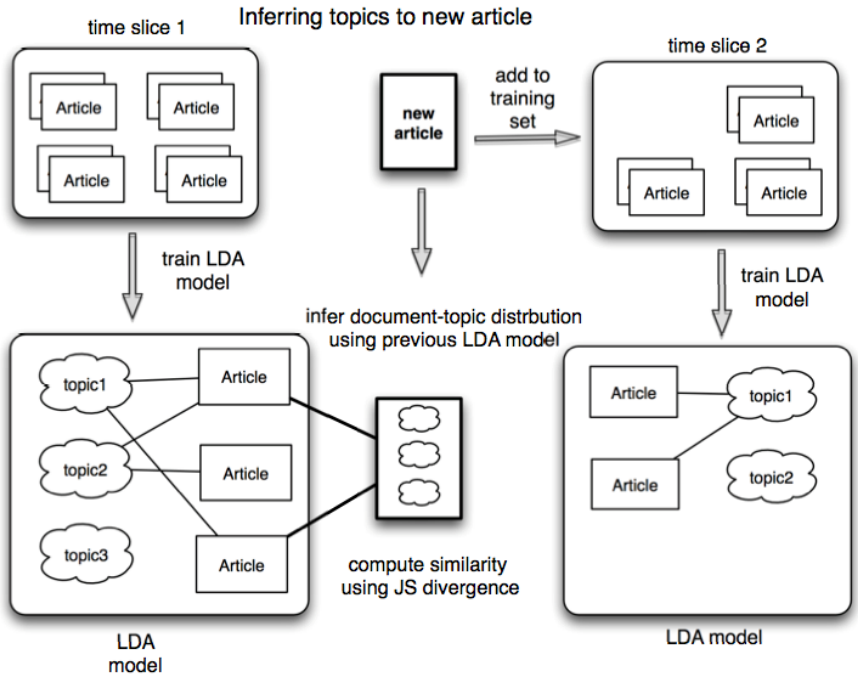

Figure 1. Inference document-topic distribution for new article. Obtained document-topic distribution is used for computing similarity between new document and previous documents.

3.3 Topics similarity

Building graph of related topics is based on computing topic similarity score between pairs of topics in different time slices within defined time slice window. Several metrics can be used to measure similarity between pairs of topics [9]. We cannot use probabilistic metrics such as KL divergence or JS divergence [7] to compute similarity between pairs of topics in different time slices because these word-topic distributions come from various LDA models and thus we cannot compare these distributions in probabilistic way. We perform another metric to compute similarity score between two topics. For each topic pair, we obtain common words. Final similarity score is computed as a sum of weights of each common word. Process of computing topic similarity is described in Figure 2.

3.4 Constructing graph of related topics

We build graph of related topics from past to future. We start in the defined beginning and incrementally build graph over time.

Constructing graph of related topics is based on computing similarity score between each topic in one time slice and others topics in next time slice within given time slice window. Resulting graph is build follows:

1. For each time slice compare topics with next time slice within time slice window
2. For each topic in current time slice compute similarity score for topics in next time slice
3. Order similarity score for current topic and choose the most similar topics
4. For each selected topics create edge between selected topic and current topic
5. Label each edge with topics common words to define transition between these two topics

The resulting graph consists of connected nodes and labeled edges. Each level of graph represents time slice. Each node in graph is labeled by top most probably words for given topic. Each edge between two topics is labeled by their common words. These words represent similarity between topics and can be used for interpretation of topics similarity.

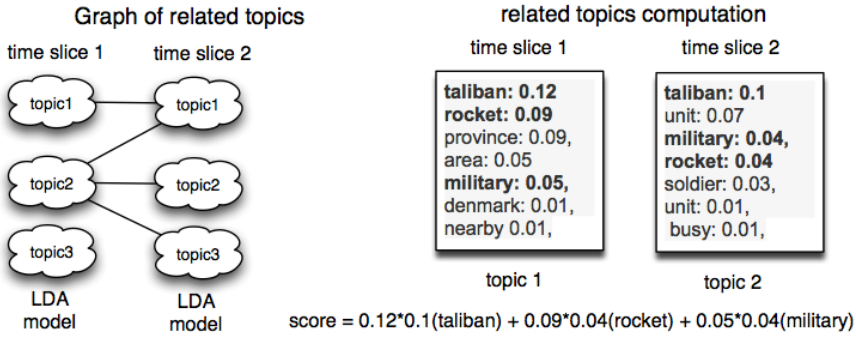

Figure 2. Constructing graph of related topics. Similarity score between topics is computed as a sum of weights of each common word.

4 Evaluation

We performed our experiments on news articles from Slovak news portal *sme.sk*. We analyzed 3 000 news articles. We sort this dataset by published date and divide in 10 time slice. Each time slice had 300 articles. Vocabulary had in average 20 000 unique words in each time slice.
For better results we employed standard natural language preprocessing such as lemmatization and stop words removal.

Parameters of LDA model are number of topics K and priors hyper parameters α, β. We set number of topics K according to best local model likelihood. For each trained model we train LDA using various number of topics from 40 to 300 and choose K according to best model likelihood value. Priors hyper parameters of model was set to $\alpha = \frac{50}{K}$, $\beta = 0.001$ according to previous works [3].

For each article we found similar articles in different time slice. The most similar article was selected and evaluated if article content is similar or not. We tested 100 article pairs. We found 20 incorrect cases, where identified similar article was not similar. The success rate was 80 %. Example of content similar articles is in Figure 3.

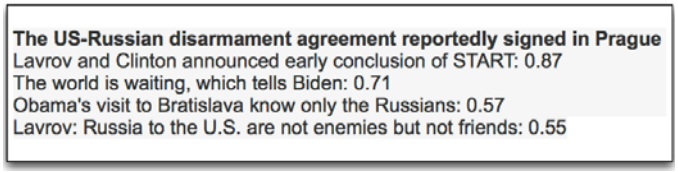

Figure 3. Example of similar articles to article The US-Russian disarmament agreement reportedly signed in Prague. Similar articles are about Russian and American relationship.

We built graph of all topics over time. Resulting graph is too large to visualize. Number of edges depends on time slice window size. Topic about *police* and *criminality* and their related topics are illustrated in Figure 4.

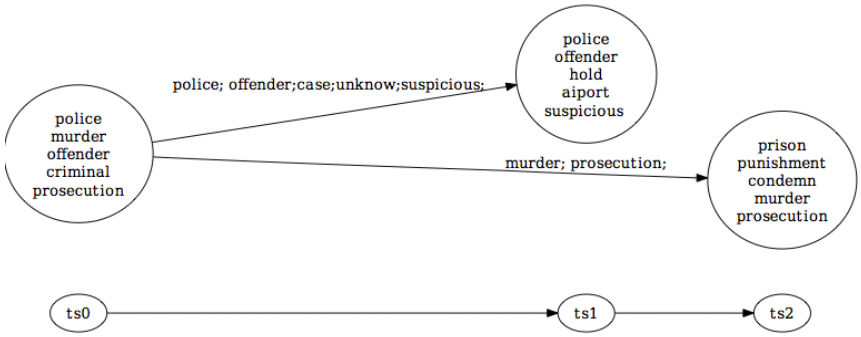

Figure 4. Example of topic chain about criminality.

Transitions between topics are represented as set of words, which are common for both topics. These transitions define semantic similarity between these topics.

By analyzed resulting graph we found some topic connections more interpretable and some less. Less interpretable connections are because of connected topic consists of more general words and this type of connection is less interpretable and should be removed from graph. On the other hand there are some very good interpretable topic relations.

We evaluated connections between 50 topics. Evaluation task was defined as number of correctly identified connections compared to all connections. Correctly identified connection was for example *murder, prosecution*, on the other hand incorrectly identified connection was labeled for example with words *according, must*. From 50 connections were 20 connections meaningless. Computed success rate was 60 %. Lots of meaningless connections were because we were not using any strategy to identify meaningless topics. Topics with too many assigned words or too fewer words are probably meaningless [11] and should be removed.

5 Conclusion

We proposed method for identifying topic relations over time. We evaluated our method on news articles, which were natural choice for stream and time based data.

We divided incoming news articles into time slots and trained documents in each time slot separately. We computed topic similarity score between pairs of topics in different time slices within defined time slice window. We used metric based on comparing common words of compared topic pairs for computing topic similarity score. We built graph of related topics over time using these topics similarities. This graph can be used for recommending new articles based on their common topics proportions. Each edge in resulting graph is labeled by shared words,

which can be used for describing transitions between related topics. There are lots of meaningless connections in resulting graph. These connections are because of there are lots of meaningless topics. These meaningless topics consist of words, which are too general or irrational. Removing these meaningless Topics should improve identified connections.

For each article we found similar articles in different time slice. We used statistical inference to obtain document-topic distribution for article in different time slice. We computed similarity score between articles and selected the top most similar articles. We compared document-topic distributions in probabilistic way using Jensen Shannon divergence. We evaluated 100 randomly selected articles and found 20 articles were not similar. Removing meaningless topics should also impact this result.

References

[1] Blei, D., Ng, A., Jordan, M.: Latent Dirichlet allocation. *Journal of Machine Learning Research*, 3, (2003), 993–1022.

[2] Blei, D., Griffiths, T., Jordan, M., Tenenbaum, J.: Hierarchical topic models and the nested Chinese restau- rant process. *In Advances in neural information processing systems*, 16, (2004).

[3] Heinrich, G.: Parameter estimation for text analysis, Technical report, Fraunhofer IGD, (2009).

[4] Blei, D., Lafferty, J.: Correlated topic models. *In Advances in neural information processing systems,* 18, (2006).

[5] Li, W., McCallum, A.: Pachinko allocation: DAG-structured mixture models of topic correlations. *International Conference on Machine Learning (ICML)*, (2006).

[6] Mimno, D., Li, W., McCallum, A.: Mixtures of Hierarchical Topics with Pachinko Allocation. *International Conference on Machine Learning (ICML)*, Corvallis, OR, (2007).

[7] Lin, J.: Divergence measures based on Shannon entropy. *IEEE Transactions on Information Theory*, 37(14), (1991), 145–151.

[8] Blei, D., Lafferty, J.: Dynamic topic models. *Proceedings of the 23rd International Conference on Machine Learning*, (2006)

[9] Kim, K., Oh, A.: Topic Chains for Understanding a News Corpus. *12th International Conference on Intelligent Text Processing and Computational Linguistics (CICLing)*. (2011)

[10] Steyvers, M., Griffiths, T.: Probabilistic topic models. *In T. Landauer, D. McNamara, S. Dennis, and W. Kintsch (eds), Latent Semantic Analysis: A Road to Meaning. Laurence Erlbaum,* (2006).

[11] AlSumait L., Barbará D., Gentle J., Domeniconi C. Topic Significance Ranking of LDA Generative Models. ECML, (2009).

Decentralised User Modelling and Personalisation

Márius ŠAJGALÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
sajgalik@stuba.sk

Abstract. Since Web browser is nowadays the main work tool for the user to browse the Web, new opportunities in realisation of decentralised personalisation arise, directly on the client device – in a Web browser. In this paper we analyse existing possibilities in the area of decentralised user modelling and personalisation not just in the browser and describe a new way of realisation via designed-by-us distributed multi-agent collaborative personalisation platform, which is built as the browser extension. The proposed solution consists of two main parts – decentralised user interests modelling (global and local in the various domains) and decentralised collaborative personalisation of web pages.

A paper based in part on this paper was published in Proc. of 7th Workshop on Intelligent and Knowledge Oriented Technologies (WIKT'12), STU Press, Bratislava, 63-66.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Michal Barla, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Encouragement of Collaborative Learning Based on Dynamic Groups

Ivan SRBA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
srba07@student.fiit.stuba.sk

Abstract. We propose a method for creating different types of study groups with aim to support effective collaboration. We concentrate on small groups which solve short-term well defined problems. The method is able to apply many types of students' characteristics as inputs, e.g. interests, knowledge, but also their collaborative characteristics. Our method takes as the base the Group Technology approach. Students in created groups are able to communicate and collaborate with several collaborative tools in a collaborative platform. We designed a collaborative platform called PopCorm which allows us to automatically observe dynamic aspects of the created groups, especially how students collaborate to achieve their goals. The results of this observation provide a feedback to the method for creating groups.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 62-64.
A paper based in part on this paper was published in Proc. of 7th European Conf. on Technology Enhanced Learning (EC-TEL'12), LNCS, Vol. 7563, Springer, Berlin, 432-437.

* Master degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Modeling a Tutor for E-Learning Support

Peter SVORADA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
psvorada@gmail.com

Abstract. E-learning web systems allow students to educate themselves for example by studying materials, solving tests or doing exercises. It is proved that students can learn more if they are included in the learning process and this process is adapted to the needs of individual student. Likewise it is known that student advances faster in the learning process if he is led by someone who acts more like a friendly tutor than a leading authority. In this paper we describe our model of a tutor used to support e-learning process in the domain of basic procedural programming based on peer tutoring. In this model we use computer tutor to support peer tutoring by giving advice to peer tutor via chat messages. The most distinctive and main ability of our tutor is to notify peer tutor that students are working on a solution that seems to be different than any other known correct solution, hence probably wrong. For this we created a method based on code clone detection which is capable of calculating similarity between two pieces of code from which one is only in the process of creation.

1 Introduction

While analysing the field of e-learning support for possible room for improvement we reached the issue of peer tutoring. Peer tutoring is a process where one student supports another in the learning process consisting mostly of diversity of different tasks belonging to the certain domain (mathematics, physics, programming etc.) It has been proven [2, 4], that students involved in such a process (both tutor and tutee) show greater progress compared to process where they study alone.

However peer tutoring provides challenges for the pedagogue to give it a form when this process will not bear too much risk. Students are not educated teachers, sometimes they do not understand the problem very well and can reach dead ends or get repetitively wrong results. This can lead to frustration, demotivation [3]. We can't afford that as motivation is one of two key aspects of effective learning environment [5].

In the existing research [6] two methods to support peer tutoring were compared. In the first method, the student was provided with learning material and non-interactive support in the field of simple mathematical tasks. The second method was to give peer tutor a support from PC tutor. This PC tutor provided peer tutor with initial hints for the given task, could give some more hints if requested and told peer tutor that they are attempting to submit a wrong result.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Jozef Tvarožek, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Surprisingly, these two methods (interactive and non-interactive one) showed similar results and thus including PC tutor did not provide mucho of an improvement.

In our model we try to broaden the ability of PC tutor by adding additional functionality, to see how it will affect the actual learning process. We considered several ideas but in the end we decided to propose a model of PC tutor capable of telling students that they are working on "a wrong" solution (solution that does not resemble any known correct solution) while they are still working on it.

2 Tutor model

In order to implement tutor capable of recommending reconsideration of the way the task is solved first of all it is required to propose an automated method that is able to provide such a functionality. To propose a method like this we need to clearly specify a domain in which our tutor should work. In our case it is a domain of basic procedural programming and this fact will be referenced on several places in this paper. First thing that we have to take into notice in this domain is that solving a task in the domain of procedural programming is not necessarily a process consisting of steps that can be provided to our model of a tutor so that he can check them during the learning process (like it would be possible with for example some simpler mathematical solutions) Because of this we decided that our method will use comparison of source code that is in the process of writing and source codes that had been determined to be correct solutions to calculate similarity between these parts of code. Using this similarity we are capable to tell students whether they are working on solution that does not bear resemblance to known correct solutions, hence is mostly probably wrong considering that a reasonably sized dataset is collected before the tutoring session.

2.1 Calculating similarity between solutions

There are several different methods used to determine similarity between two pieces of code. While creating our method we used the method of Baxter et al. [1] For comparing abstract syntax trees for its bases. As basis of our method we used the formula used in [1] to calculate similarity between two parts of abstract syntax trees. We have proposed a novel formula and process. The reason for this is mainly based on fact that the original method and our method are both used in different situations. While the original method is used to compare two unknown, complete pieces of code our method is used to compare pieces of code that we suppose should solve the same task and code we compare does not have to be necessarily complete.

The exact process that we use to determine whether the currently written solution is similar to some of the known correct solutions can be divided into several parts:

1. Code pre-processing
2. Creation of abstract syntax tree
3. Determining the similar nodes in abstract syntax trees
4. Calculating of similarity
5. Method application

In the following text we look on these steps in a little more detail.

2.1.1 Code pre-processing

In the code pre-processing part of our method we remove all the commentaries from the code. In our case commentaries bear no importance when it comes to calculating similarity between two pieces of code. Includes of libraries are removed from the code as well as some students tend to use the same package of includes in all of their solutions, comparing these parts of code could lead to some irregularities in our results.

2.1.2 Creation of abstract syntax tree

Abstract syntax tree is created from pre-processed code. There are several known ways to represent the nodes in this type of tree. In our method we use nine different types of nodes.

1. Method declaration
2. Method call
3. Output
4. Cycle
5. Condition
6. Switch
7. Variable
8. Constant
9. Operation

2.1.3 Determining the similar nodes in abstract syntax trees

Abstract syntax tree created from currently written solution is then compared with abstract syntax trees which are created from known correct solutions of given task. The comparison is done like this:

1. A node in one sub-tree is taken and we look for the similar node in equivalent sub-tree of known solution
2. If two similar nodes are found (the nodes belong into same category) their sub-trees are then being compared in similar way
3. All nodes that were left without similar pair are labelled as different.

2.1.4 Calculating of similarity

Bases of our formula to calculate similarity between two abstract syntax trees can be found in already mentioned method [1]. This method used formula that looked like this (Figure 1):

$$P = 2 * S / (2 * S + L + R) \tag{1}$$

where P is the calculated similarity between two abstract syntax trees. S stands for number of similar nodes in both trees, L and R stand for number of different nodes in respective trees.

However this formula proved to be insufficient for our problem. If we take an example of code that is just being written, its similarity to the already finished code will be always pretty low because it is missing high number of nodes that are included in correct solution. This is not a result of fact that we are holding two different solutions to the same problem, it just means that the solution that is being currently worked on, is not finished.

To get around calculating low similarities of unfinished and finished code we altered formula (Figure 1) a little to get a new formula (Figure 2)

$$P = 2 * S / (2 * S + L + R * (N(L) / N(R)) \tag{2}$$

where P is again the calculated similarity between two abstract syntax trees and S stands for number of similar nodes in both trees. The difference is that L is number of different nodes in the tree that was created from currently written solution while R is number of different nodes in the tree that was created from known correct solution. In addition we have here a ration of number of nodes in the tree created from currently written code (N(L)) and number of nodes in the tree created from known correct solution (N(R)) By multiplying number of different nodes in the tree that was created from known correct solution with this ratio we lower the importance of this number more when the difference in length of two pieces of code is bigger and vice versa.

As you will be able to see in the next part of this article, the formula (Figure 2) proved to be insufficient as well. Its main application problem can be seen when used with solutions that are really short and one of the compared pieces of code is still not finished. In that case we got high similarity of currently written solution with solutions coming from different tasks and it became hard to determine the level of similarity which we could consider as a level where we could say that two pieces of code are similar. For this reason we altered the formula for the final time.

$$P = 2 * S / (2 * S + L * (N(R) / N(L)) + R * (N(L) / N(R)) \quad (3)$$

As it can be seen (Figure 3) we added additional ratio of number of nodes in the tree created from known solution and number of nodes in the tree created from solution that is being worked on. This ratio multiplies the number of different nodes in the tree created from unfinished solution and thus effectively penalises differences (the lesser number of nodes we have written is penalised for differences more than the higher number)

2.1.5 Method application

This method does not tell students that they are working on a wrong solution. It can only determine that the solution they work on is similar to some known correct solution. This, however, can provide increased guidance toward a good/better solution. That is why our tutor does not stop students when the level of similarity is low, it just recommends more deeply correctness of their solution simply because it does not come close to any solution known thus far. Novel solutions that students submit only improve the dataset we can work with.

Determining the level of similarity that can be used as a definitive sign to distinguish correct solutions from wrong solutions remains a challenge. As it can be seen in the next part of the article, different tasks give us different results when it comes to determining the threshold when we can safely say that the two solutions are similar.

Table 1. Results of proposed method using formula from Figure 2.

	p11	p12	p13	p14	p15	p21	p22	p23	p24	p25	p31	p32	p33	p34	p35
p11	x	0,81	0,63	0,81	0,87	0,52	0,52	0,52	0,52	0,63	0,7	0,76	0,76	0,53	0,58
p12	0,93	X	0,67	0,93	0,93	0,86	0,86	0,86	0,86	0,86	0,93	0,93	0,93	0,93	0,67
p13	0,78	0,7	X	0,7	0,78	0,38	0,38	0,38	0,38	0,7	0,53	0,78	0,78	0,53	0,36
p14	0,93	0,94	0,67	x	0,94	0,86	0,86	0,86	0,86	0,86	0,93	0,93	0,93	0,93	0,93
p15	0,94	0,9	0,61	0,875	X	0,63	0,63	0,63	0,63	0,8	0,857	0,94	0,94	0,875	0,875
p21	0,9	0,9	0,8	0,9	0,9	x	0,9	0,9	0,9	1	0,9	0,9	0,9	0,9	0,9
p22	0,9	0,9	0,8	0,9	0,9	0,9	x	0,9	0,9	1	0,9	0,9	0,9	0,9	0,9
p23	0,9	0,9	0,8	0,9	0,9	0,9	0,9	x	0,9	1	0,9	0,9	0,9	0,9	0,9
p24	0,9	0,9	0,8	0,9	0,9	0,9	0,9	0,9	x	1	0,9	0,9	0,9	0,9	0,9
p25	0,9	0,9	0,8	0,9	0,9	0,9	0,9	0,9	0,9	x	0,9	0,9	0,9	0,9	0,9
p31	0,9	0,9	0,8	0,9	0,9	0,9	0,9	0,9	0,9	0,9	x	1	1	1	1
p32	0,53	0,53	0,67	0,53	0,53	0,5	0,5	0,5	0,5	0,55	0,78	x	0,97	0,96	0,56
p33	0,53	0,53	0,67	0,53	0,53	0,5	0,5	0,5	0,5	0,55	0,78	0,97	X	0,96	0,56
p34	0,9	0,9	0,8	0,9	0,9	0,9	0,9	0,9	0,9	0,9	1	1	1	x	1
p35	0,9	0,9	0,8	0,9	0,9	0,9	0,9	0,9	0,9	0,9	1	1	1	1	x

2.2 Results

In the Table 1 we see results that our method gave us when we used the formula as it could be seen on Figure 2 earlier in the article. We can see five different solutions for three different tasks compared to each other. The solutions that are currently written (with approximately 50% finish rate) are written in the rows of table, while the solutions that are finished are written in the columns. The problem with this formula, we described earlier can be seen with the solutions p21-p25. While we can determine the level of similarity that can tell us that we are working on similar/different solution when looking at longer tasks p1 and p3, it is impossible for task p2 as it is too short and with the given formula the solution solving this task was similar to pretty much anything. That is why we changed the formula into its final form as seen on Figure 3. The results we have got using this formula can be seen on the following table.

Table 2. Results of proposed method using formula from Figure 3.

	p11	p12	p13	p14	p15	p21	p22	p23	p24	p25	p31	p32	p33	p34	p35
p21	0,77	0,71	0,57	0.83	0.83	x	0,91	0,91	0,91	0,91	0,77	0,83	0,77	0,91	0,83
p22	0,77	0,71	0,57	0.83	0.83	0,91	x	0,91	0,91	0,91	0,77	0,83	0,77	0,91	0,83
p23	0,77	0,71	0,57	0.83	0.83	0,91	0,91	x	0,91	0,91	0,77	0,83	0,77	0,91	0,83
p24	0,77	0,71	0,57	0.83	0.83	0,91	0,91	0,91	X	0,91	0,77	0,83	0,77	0,91	0,83
p25	0,77	0,71	0,57	0.83	0.83	0,91	0,91	0,91	0,91	x	0,77	0,83	0,77	0,91	0,83

In this table (Table 2) we included only comparison of currently written (approximately 50% finish rate) solutions for the same task 2 as in Table 1 but the results are different. We can say that when the similarity we get between two solutions is 0.91 or higher the two solutions are similar and most likely solve the problem given in the task 2.

3 Conclusions

In this paper we proposed a model of tutor capable of calculating similarity between two solutions from which one is only being written and use this similarity to recommend reconsideration of correctness of such solution if the calculated similarity is too low. This kind of tutor can be used both in one-on-one tutoring and peer tutoring scenarios.

We have yet to decide how the level of probability for certain tasks will be determined. Once we solve this problem we plan to proceed with testing of our method in actual learning environment to determine its effect and actual usefulness. We created a prototype which implements model of our tutor. Students will use this application to work together on tasks from domain of simple procedural programming. Our goal is to prove that our model of tutor uses a method that makes solving of problems easier and faster and that the proposed model supports the learning process in a way that makes it more effective than a learning process without interactive support.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0675/11.

References

[1] Baxter, I., Yahin, A., Moura, L., Sant Anna, M.: *Clone Detection Using Abstract Syntax Trees.* In: Proceedings of the 14th International Conference on Software Maintenance (ICSM'98), Bethesda, Maryland, (1998), pp. 368–377.

[2] Fantuzzo, J. W., Riggio, R. E., Connelly, S., Dimeff, L. A.: *Effects of reciprocal peer tutoring on academic achievement and psychological adjustment: A component analysis.* Journal of Educational Psychology, 81(2), (1989), pp. 173–177.

[3] Medway, F., Baron, R.: *Locus of control and tutors' instructional style. Contemporary Educational Psychology*, 2, (1977), pp. 298–310.

[4] Roscoe, R. D., Chi, M.: *Understanding tutor learning: Knowledge-building and knowledge-telling in peer tutors' explanations and questions, Review of Educational Research.* 77(4), (2007), pp. 534–574.

[5] Tvarožek, J.: *Bootstrapping a Socially Intelligent Tutoring Strategy*. Information Sciences and Technologies Bulletin of the ACM Slovakia, (2011), Vol. 3, No. 1, pp. 33–41.

[6] Walker, E., Rummel, N., Koedinger, K. R.: *Integrating collaboration and intelligent tutoring data in the evaluation of a reciprocal peer tutoring environment. Research and Practice in Technology Enhanced Learning*, 4(3), (2009), pp. 221–251.

Acquiring Metadata about Web Content Based on Microblog Analysis

Tomáš UHERČÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
uhercik07@student.fiit.stuba.sk

Abstract. Semantic Web, which is understandable by machines, needs metadata. There are several possible sources of metadata about Internet resources. In this paper we deal with keyword represented metadata about URLs acquired from microblog Twitter. We present the method which considers ranking of authors to gain metadata of higher quality. We compute the ranking of keywords from their text relevance in tweets and rankings of their authors. Finally we combine the results with only content based methods to measure the benefits of enriching the keyword set by our method.

A paper based in part on this paper was published in Proc. of 39th Int. Conf. on Current Trends in Theory and Practice of Computer Science (SOFSEM'13), LNCS, Springer, 457-468.

* Master degree study programme in field: Software Engineering
Supervisor: Marián Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Visualization of User Model in Educational Domain

Maroš UNČÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xuncik@is.stuba.sk

Abstract. Nowadays, web-based educational systems offer still more and richer content, enable communication and collaboration among users. The rise in use of these systems causes information overload, which together with a need to improve learning is related with a success of adaptive e-learning systems. The performance of such personalized systems is derived from an important element – a user model, which is used for personalization to minimize error rates and learning time. In our work, we allow students access their user model. We have proposed an innovative method for user model visualization, which allows users direct and explicit feedback to enrich the user model. We report a small qualitative evaluation of the proposed method, which indicates that users apperceived the visualization of user model positive.

1 Introduction

The trend of using web-based educational systems is progressively growing and opportunities that the Web provides are huge. Nowadays, e-learning systems offer more and richer content, enable communication and collaboration among users. This evolution is related with information overflow, which cased increase of difficulty to find and classify certain information. The adaptive e-learning systems address the most crucial issues, which are related to this overflow: (1) adaptive systems present only information, which is appropriate and/or interesting for him/her at the moment, (2) help user to choose the way to proceed when viewing content, (3) prevent user from getting lost in the content and/or avoid to prevent him/her from forgetting the original objectives [1]. To allow such personalization web-based educational systems monitor characteristics of individual users, including modeling of their skills, knowledge and/or interests. The performance of such systems is derived from an important element – the user model, which is used to minimize error rates and learning time [2].

A lot of problems in the domain of user modeling were identified. Combinations of several different inputs entering the user modeling process or the use of information about user beyond the adaptive system to enrich the user model are just two of them. Another challenge, the scrutability, concerning the visibility of the user model to users, is also closely related. In most of the systems,

* Master degree study programme in field: Computer Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 199–204.

the user cannot directly access the user model and cannot provide explicit feedback about him/her, which could be otherwise taken into account.

The method described in this paper enables users to see a system believes about them, it makes the user model visible to students and allows to the system and the student a mutual interference. The main idea is to let students select the information which they are interested in themselves. User related information is described in term of user model, and visualization shows this information and information relevant to this information. We believe that visualization is not just another feature for users of an adaptive system, but a tool to help interference between the systems believes and reality. This opens further possibilities in the use of visualization for qualitative evaluation of the user model, which is currently difficult task [3].

This paper is structured as follows. In Section 2 we describe the related work in field of visualization of the user models. The proposed method for visualization is shown in Section 3. We describe a usability study on the visualization in Section 4, which is followed by discussion and conclusions in Section 5.

2 Related work

One of the first thoughts about a visualization of user model are appeared in intelligent tutoring system that used a user model. In [7], Self suggested some practical guidelines and changes in philosophical approach to user modeling, which may help in building more effective student models. The main idea is to tell and show students what system needs to know, thus the information for building user model should be provided more or less direct. Such opened user model increases the motivation of students and supports self-reflection.

The system SIV, Scrutable Inference Viewer [4], can visualize large user models. It was designed expressly to give users an overview of their model and it tries to determine what the system models about user as true, what it models as false and how the beliefs are related. The system SIV has an ability to visualize general user models in a vertical segment as a graph. The visualization enables the user to adjust the visualization. Thus, users can determine the boundary between the classification of components, which are related to he user as true (displayed as green) or false (red). The hue of the color indicates a degree of certainty. We consider the idea of using colors interesting, but there is a problem of overcoloring, if we try to distinguish among elements with large scale of colors [10].

In [6], Mitrovic et al. introduced an e-learning system aimed at university-level students for learning SQL, SQL-Tutor. The system contains set of problems and the ideal solutions to them. SQL-Tutor models knowledge of students and visualizes information about model. The authors decide to compress the student model into a simple structure that resembles the structure of the SELECT statement. This structure is represented with six terms, which are shown as six skillometers. Skillometers show to the students the user model. Each skillometer represents the coverage (the percentage of constraints that the student has used) and correctness (the percentage of all relevant constraints that the student has used correctly) of related term.

In [5], Mabbott et al. proposed a study where students are allowed to view an open learner model in several formats by a system for learning C programming, called Flexi OLM. Flexi OLM provides several presentations of the user model: *hierarchy*, in form of a grouping of related concepts, *lectures*, in form of topics, which are organized the same as in the related course, *concept map*, which showing relationships between the topics and *prerequisites*, which showing possible sequences for studying topics. In all presentations, the system uses same color scale to indicate the level of knowledge. White color is used for very limited understanding, yellow for somewhat limited, yellow/green for moderate and bright green for excellent understanding. Red color is used to indicate the topics with possible misconceptions. It is interesting, that the study shown that learners were most comfortable with little direct control and relatively comfortable with a small amount of control, but not comfortable with full direct control (e.g. editing).

Referenced visualization approaches allows users and teachers to better understand user modeling process, they provides an overview of the whole model and enables users to understand the dependencies that affect user's knowledge. It is interesting, that just very few systems allow the user to manipulate the user model directly. In most cases, systems just show to the user her current knowledge or interest estimation. This can motivate her only indirectly, through encouraged of self-reflection. The user has not usually any direct tools to correct her knowledge, for example in case that system models the user knowledge incorrect. Such systems often present only the current knowledge of the user and do not explain how user gained such level.

3 User model visualization

To visualize the user model we design an overlay user model based on light weight representation [9]. In the proposed user model, built above the domain model, we use domain-independent (e.g. age) and domain-dependent characteristics (knowledge and interests). The domain-dependent characteristics characterize a user in relation to concepts of the domain model. The value of the domain-dependent characteristics is represented by a three-dimensional vector [*level*, *confidence*, *source*]. The level of the characteristic is in fact its value. It takes real values from the closed interval <0, 1>, where 1.0 denotes the maximum value. Each characteristic is associated with the confidence which expresses probability that the user really has given value. Each characteristic is determined by a source, which can be either a tool or a method.

Characteristics of knowledge and interests are directly changed by the behavior of the user, based on recorded activity in the educational system. To determine these characteristics, we can use several sources. The problem is that every single characteristic has more probability-value pairs from different sources. For practical reasons we need only one value-confidence pair, which characterize the relation between user and concept. Therefore, each pair must be appropriately combined. To this purpose we designed method for combination more inputs, which enter the user model.

Our main aim is to create a visualization of the user model of educational system, which allows us to interfere between believes modeled by the system and what thinks user. Visualization is in that way a tool to evaluate user model. We assume three main features:

- to show the student what is the system believes about her,
- to provide an insight into a user model and to show its time changes,
- to allow students to give explicit feedback.

We decided to visualize the user's knowledge as a graph (Figure 1). Vertices in the graph represent domain relevant terms and links among them represent relationships represented in the domain model. Each term has connections to other term if there is relationship between them. Such visualization is sufficiently comprehensive, but easy to understand, to show the relationships between concepts and to show a way they interact. We use two main relationships:

- prerequisity (it is presented as solid oriented narrow),
- relatedness (it is presented as dashed non-oriented line).

Another important aspect is the color scale we used in the graph. We use levels of green, red and white color. The green color is used to label the terms that user has understood. The brighter color indicates the level of user knowledge about the term. The red color shows the term with some sort of defect in the learning process. For example, if the user has not understood the term, the hue of red color is stronger. If the user has not visited the term yet, we do not have any information about the level of knowledge for this term, we use the white color.

The basic overview shows all relevant domain terms and all relations among them. The user may select a particular terms, which is she interested in. In this case, the selected term is highlighted in yellow and visualization shows dependent and associated term to selected terms.

The user can add more details with a decreasing of a slider in the left. The closest visualization shows only prerequisites and related concepts of the first level.

An important part of visualization is an explanation for the user, which is represented by a natural language form of pop-up window, which appears while pointing to the concept (Figure 2). The explanation gives basic information about knowledge achieved by user. If the user wants to know more specific details, she can use the "I want to learn more" option, which allows seeing more detailed time changes. The explanation is generated on the basis of information, we have logged about a user. Thus, we can determine which learning objects the user was working with. We use the weight of the relation concept-to-learning-object from a domain model to show to the user only relevant learning objects related to chosen concept.

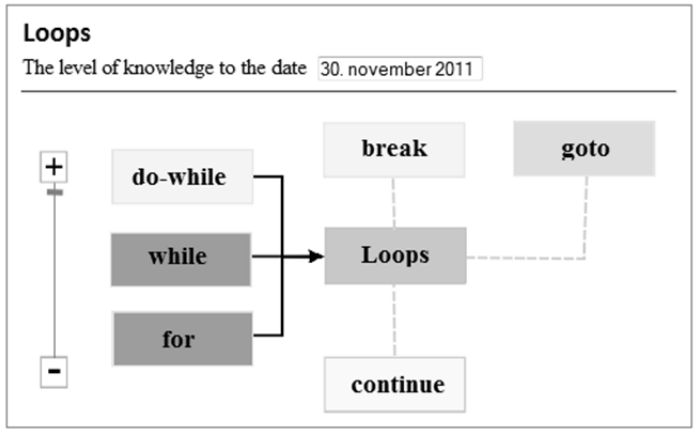

Figure 1. Visualization of user model.

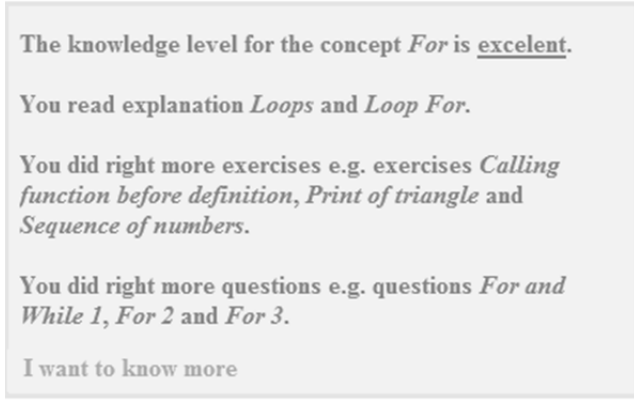

Figure 2. Explanation window.

4 Evaluation

We experimented with the visualization. The participants were five university students, who are not studying in field of informatics, but they had some experience with computers. Each student had to explore the same example of the visualization of a user model. The example was taken from domain of English course. We show the example of visualization to students and a scenario of evaluation was following:

1. We provided to participants the example of visualization and following explanation:

   Imagine an electronic e-learning system for learning English. In such system there is a component, which shows your overall knowledge. Example of such a component is shown in the following figure below. Imagine that it is your overall knowledge. Please answer the following questions.
2. We asked Question 1 and Question 2.
3. After users provided responses to the Question 1 and Question 2, we explained idea of visualization. We explained them the color scale and dependencies among components. After that, we asked the Question 3.

The questions were as follows:

1. Look around the figure and comment whether you think the components on figure denotes.
2. What represent the colors in the figure?
3. What do you think of the idea to show people information about their overall knowledge?

The Question 1 indicates that participant could find out how to interpret the component of proposed visualization. All participants spent a few minutes before they answered the question. It is interesting that all participants explored the visualization right, but just participants 2 and 4 were aware of relationship among components. All users noted that interface was familiar and easy.

The Question 2 question required the participants to understand the color scale used in visualization. This indicates the participant's ability to interpret the visualization. Participant 2 was only one, who fully did not understand the color scale and did not try to interpret the colors.

After users answered the Question 1 and Question 2, we explained to the participants the visualization and we asked them Question 3. Responses to Question 3 are summarized in Table 1. The Question 3 concern on general idea of the visualization and query participants to explicitly provide information about their experience of interface. Only participant 3 mentioned the need for more explanation, because visualization was for him confusing.

Table 1. Responses to Question 3.

User	Response for Question 3
1	*It is good approach because it allows students to see related information to their progress in learning. It would be easier for them to find, what should they learn or learn again.*
2	*I like it. I like the idea that system shows my progress in learning. This helps me to find the gaps in my knowledge.*
3	*It is a little bit confusing. This visualization needs more explanation.*
4	*I like the idea. It will be great if I could select topics which I am interesting in.*
5	*It is a good idea. People see what they have already learnt and what should they learn. I like the colors scale.*

This experiment suggested that the participants considered the visualization of user model interesting. They appreciated the general principle of the visualization, and understood the proposed visualization. In addition, although a Participant 3 made negative comments about aspects of the interface, others appeared to be able to figure out the main purpose of such visualization without explanation and they appeared to be able to use it effectively in real conditions.

5 Conclusions and future work

In this paper we have described our method for visualization of a user model, which we believe, can allow a user to gain a global overview of a user model, to get a clearer overview of dependencies in the user model and to adjust the sensitivity of the own user model. We proposed innovative visualization approach to help interference between the systems believes and reality. Proposed method allows to users providing direct and explicit feedback from user point of view, which can enrich the user model.

The qualitative evaluation we have described is rather limited. The experiment has been designed to be short and to be easily understood by users. The main purpose of experiment was to verify clarity, readability, attraction for users and positive experience of visualization. Our evaluation indicates the promise of the approach. It also indicates that the participants in our study could understand the visualization and use the visualization of user model.

Although the proposed method is at the moment used in the domain of programming, method is not limited for this domain. The method can be used in any adaptive educational system, which models users and provides user model. An example of such system could be a system for learning foreign languages, or system for learning SQL. Neither the domain of e-learning is limitation. The method for visualization can be used generally in any adaptive system, e.g. adaptive system for recommendation.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0675/11.

References

[1] Brusilovsky, P., Millán, E.: The Adaptive Web, User Models for Adaptive Hypermedia and Adaptive Educational Systems, LNCS 4321, Springer, (2003), pp. 3–53.

[2] Brusilovsky, P.: Methods and Techniques of Adaptive Hypermedia. User Model. User-Adaptation Interaction, (1996), 6(2-3):87–129.

[3] Gena, C.: Evaluation methodologies and user involvement in user modeling and adaptive systems. In: *Simposium on HumanComputer Interaction HCITALY,* (2003), pp. 74–78.

[4] Kay, J., Lum, A.: Exploiting Readily Available Web Data for Scrutable Student Models, In: *Proc of 12th International Conference on Artificial Intelligence in Education*, IOS Press, Amsterdam. (2005), pp. 338–345.

[5] Mabbott, A., Bull, S.: Student Preferences for Editing, Persuading and Negotiating the Open Learner Model, Intelligent Tutoring Systems, Springer, Berlin, (2006), pp. 481–490.

[6] Mitrovic, A., Martin, B.: Evaluating the Effects of Open Student Models on Learning, In: *Proc. of 2nd International Conference on Adaptive Hypermedia and Adaptive Web-based Systems*, Springer-Verlag, Berlin, Heidelberg, (2002), pp. 296–305.

[7] Self, J.: Bypassing the intractable problem of student modelling: Invited paper. In: *Proc. of the 1st International Conf. on Intelligent Tutoring Systems*, Montreal, (1988), pp. 18–24.

[8] Šimko M., Barla M. and Bieliková M.: ALEF: A Framework for Adaptive Web-based Learning 2.0. In: *Key Competencies in the Knowledge Society at World Computer Congress 2010*, Brisbane, Australia, (2010), pp. 367–378.

[9] Šimko, M., Bieliková, M.: User Modeling Based on Emergent Domain Semantics. In*: LNCS 6075 User Modeling, Adaptation, and Personalization*, Springer-Verlag Berlin Heidelberg, (2010), pp. 411–414.

[10] Uther, J., Kay, J.: VIUM, a Web-Based Visualion of Large User Models, Proceedings User Modeling, In*: Brusilovsky, P, Corbett, A. and de Rosis, F. (eds), Springer-Verlag in Lecture Notes in Artificial Intelligence (LNAI/LNCS)*, (2003), pp. 198–202.

Recognition of Semantically Related Articles in Wikipedia

Ivan VALENČÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
valencik@gmail.com

Abstract. Wikipedia has become the most used encyclopaedia in the world. The English edition itself has more than 3.8 million articles and there are together more than 280 language editions of Wikipedia. However there are big differences in their scope and detail. This difference is an opportunity to improve the content of the less detailed Wikipedias by information extracted from the big ones. In this paper we propose a method for recognition of semantically related articles based on connections between Wikipedia editions. We evaluate an implementation of this method using a MapReduce programming model and a HBase database system.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 65-68.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Peter Lacko, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 205–210.

Filtering Long Lists of Web Objects Using Automatically Generated Facets

Michal HOLUB*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
holub@fiit.stuba.sk

Abstract. Users searching the Web usually get a long list of results. This list may contain products from e-shops, advertisements of users or articles from digital libraries, etc. The websites often lack the possibility for filtering such lists based on various attributes of displayed web objects. In this paper we propose a method for automatic generation of facets which can be used for filtering the lists of results in digital libraries, thus reducing their length. In the experiments we show the suitability of the method for generating facets from data with certain characteristics.

1 Introduction

One of the main activities that users do on the Web is searching for information. This is done not only via search engines indexing a large part of the Web but also via search functionality within particular portal. All in all, the search yields a list of results from which the user has to choose what is he interested in. The results are formed by a list of hyper-links to other web pages or by a list of particular web objects matching the user's query. Because of the huge amount of information published on the Web the list of search results can get quite large. Therefore, users need some help navigating through it.

Keyword-based search engines like Google or Bing, which are used for searching for an appropriate website, sort the results according to their relevance to the query. They usually do not provide means for filtering the results other than by refining the query. The user cannot select other sorting criterion or filter the hyper-links according to the attributes of the target web pages.

On the other hand, a lot of web portals containing information about many entities of the same type provide their own search functionality. This is the case of e-shops, digital libraries, portals with users' advertisements, recipes, etc.

The specialized web portals provide functionality for filtering and sorting the search results, which varies depending on the type of the entities the portal contains. For example, an e-shop usually allows sorting the products by price or filtering them by their category. However, the filtering options are pre-configured by the portal's administrator and do not automatically adapt if the nature

* Doctoral study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 211–216.

of the entities change (e.g. new products are included in an e-shops offer). Also, the administrator might omit some filtering options the users may like, e.g. filtering the clothes according to their colour or filtering scientific articles in digital libraries according to their citation count.

In this paper we present a method for automatic generation of facets from web objects of the same type, which could be used for filtering the search results. Nowadays, faceted interfaces are widely used for exploration of collections of images or photos [4, 12, 15], but there are also approaches utilising facets for browsing textual data [1, 2]. Facets can also be used for filtering of personal data [13]. We generate the facets by analysing the textual representation of web objects, as well as their attributes.

Web objects are information units which integrate all related information about the same object extracted from web pages, typically people, papers, conferences or organizations [9]. Every web object has attributes and can be linked to other web objects via relationships.

This paper is organized as follows. In Section 2 we present related work in the field of faceted search and automatic generation of facets. In Section 3 we propose a method for the automatic generation of facets meant for filtering the objects. In Section 4 we describe the process of data gathering and preparation in order to generate the facets. Section 5 contains description of evaluation of the proposed method. Finally, Section 6 this paper with discussion.

2 Related Work

Facets are labels which introduce an alternative categorisation of the objects in the information space [6]. They allow the users to reduce the information space they need to browse by selecting restrictions based on which the objects are filtered out [11].

Wu et al. use facets for making aggregations over textual data which are the results of using a keyword-based search engine. The facets are dynamic and adapt to the underlying data [14].

Dakka and Ipeirotis automatically extract facets from documents by identifying important phrases in the text [2]. They also use WordNet and Wikipedia to expand these phrases with so called *context* phrases in order to better describe the target set of documents [1].

WordNet is also used by Stoica et al. to create faceted hierarchies that help with browsing textual data [10]. Their algorithm Castanet finds synsets in WordNet which match the content of the target data and use them for creating the hierarchy of facets.

Automatic construction of facets for data on the Semantic Web is discussed in [5]. The authors use RDF data and utilize various relationships between entities for creating the facets, e.g. for a particular class they only show facets which are common to all of its subclasses.

Facetedpedia, a faceted retrieval system for navigating the articles in Wikipedia, was proposed by Li et al. [7]. For the generation of facets article categories and hyper-links between articles are used. The authors also propose a method for ranking of the facets based on the way the users navigate through the articles.

Facetedpedia assumes the taxonomy of categories as an input to the process of facets generation. However, there are many cases when we do not have such taxonomy. As Web 2.0 applications emerge user generated content as tags becomes more common. The tags can also be used for generation of facets [8]. The authors use the tags (keywords) of items from sites like `del.icio.us` to automatically group search results.

Finding of query facets (or so called query dimensions) is dealt with in [3]. Query dimensions reflect the query from different perspectives or aspects. The authors give an example on the query “watches” which can yield facets as “brands”, “colors” or “styles”. They derive these facets by analysing the Top-K search results provided for a particular query. This approach is domain independent and does not require any initial knowledge or hierarchy.

When generating facets we can come to a problem when we have too many of them. In this case we need to select the most appropriate ones. This can be done according to explicit ratings of items, that the users provide [6, 12]. This leads to personalized faceted interface which adapts to its users.

3 Automatic Generation of Facets

We generate facets in order to filter the lists of web objects based on the common values of their attributes. We consider textual representation of a web object and we generate the facets for the selected attribute (e.g. the title of the object). This process is composed of two steps:

1. Use information extraction to generate candidate facets represented by keywords.

2. Determine the meaningful facets based on how they would divide the data space.

In the first step we process the data using methods common in the domain of information retrieval. We tokenize the values of the selected textual attribute of each web object in the list. Then we remove the stop words using dictionary and perform stemming. Previous two steps are language dependent (we experimented with data in English language). Afterwards, for each term we count the number of web objects which contain this term as the value of a particular attribute.

If we consider the web object to be a document this measure is equivalent to document frequency. One could argue that we should have used tf-idf metric. However, tf-idf promotes a term when it occurs only in few documents in the collection. If we based the filters on a rare term (with high tf-idf) the filter would have only small effect.

In the second step we compare the number of web objects containing a particular term against the total number of all web objects in the filtered list. In order to filter the list effectively we do not want this ratio to be very high, which would mean that the term occurs in many web objects. Thus, using it would not filter out significant amount of results. The same is valid for very low ratios meaning that the term occurs only in few web objects.

Based on the data we had experimented with, we set the ratio to be a value between 0.1 and 0.5. In any list of web objects this would cover from 10 % up to 50 % of the items. Decreasing the lower bound would allow very specific terms to become facets, which causes two difficulties. First, there would be too many terms and therefore too many facets. Second, they would not filter out a significant portion of the list so the effect for the user would be very low. On the other hand, raising the upper bound would allow very common terms to become facets. As these terms occur in absolute majority of objects their usage as facets would not be of much help.

4 Data Gathering and Processing

In our research we focus on the domain of digital libraries. Therefore, we are interested in:

- scientific papers,
- authors of the papers,
- publications, namely proceedings, journals and books, and
- events, which can be conferences or workshops.

Currently, we gather data from ACM Digital Library[1] and CEUR Workshop Proceedings[2] portals. We use a focused web crawler for downloading web pages from these portals, which we later parse and process in order to extract metadata about the mentioned entities.

[1] http://dl.acm.org/

[2] http://ceur-ws.org/

Table 1. Numbers of entities extracted from two different portals in our dataset.

source	papers	people	publications
ACM Digital Library	3794	8243	35
CEUR-WS portal	3314	7725	271

Table 2. Facets generated for publication titles.

term	occurrences	facet – algorithm	facet – expert
proceedings	95 %	no	no
workshop	79 %	no	yes
international	39 %	yes	yes
web	19 %	yes	yes
semantic	15 %	yes	yes
conference	11 %	yes	yes
systems	10 %	yes	no
information	8 %	no	no

ACM publishes every paper with a unique numeric ID, which also appears in the URL of the web page with the paper. We use this principle for systematic crawling of the portal and download the freely available metadata about the papers.

CEUR publishes proceedings from various workshops which are usually held in conjunction with a larger conference (proceedings from which frequently appears in ACM DL). One web page within the portal contains proceedings from a single workshop identified by a numeric ID. Again, this enables us to systematically crawl the portal.

Our focused web crawler downloads the HTML files which need to be processed. For this purpose we created an extractor which uses parser to obtain attributes and metadata of the objects located within the web page. We store the extracted data in a relational database.

5 Evaluation

We experimented with data that come from the domain of digital libraries, as described in the previous section. We used these data to generate the facets which were evaluated by the domain expert. The numbers of entities of various types contained in our dataset are indicated in Table 1. First, we conducted our experiment with data of 306 publications (i.e. proceedings, journals and books). We chose the title of the publication as the attribute for which we were creating the facets. Table 2 summarizes top 8 facet candidates with the highest number of occurrences which our algorithm generated (for clarity they are not stemmed). For each term we can see in what portion of web objects it occurred. We can also see if it was confirmed to be a facet by our algorithm and by the domain expert. As we can see the precision on this data was 75 %. The results would be better with more diverse dataset. Our dataset contained a much more publications from workshops than it did from conferences. Therefore, the facet "workshop" was disqualified by our algorithm, although the expert considered it to be relevant.

Next, we used dataset containing 7108 papers, which is around 20 times more than publications. The results are summarized in Table 3. In this case the precision of our algorithm was very low, only 25 %. This was due to the nature of the data. Paper titles are much more diverse than publication titles which are created from smaller set of terms. This experiment showed that our method is not

Table 3. Facets generated for paper titles.

term	occurrences	facet – algorithm	facet – expert
based	11 %	yes	no
data	10 %	yes	no
using	8 %	no	no
semantic	8 %	no	yes
web	8 %	no	yes
ontology	5 %	no	yes
systems	5 %	no	no
model	4 %	no	yes

appropriate to be used with such a diverse dataset. We also tried to generate bigrams of terms; however, this did not cause much difference. The only bigram in the publications dataset with sufficient occurrences to be among the top facets was "international workshop" which is a pair of words already present in the original results. In the papers dataset there was no bigram in the top places.

Bigrams would be useful when creating labels for the facets for the presentation to the end user. This way some terms would give more sense (e.g. facet "international" would be more comprehensible when labelled as "international workshop").

6 Discussion and conclusion

In this paper we have presented a method based on information retrieval principles which can be used to generate facets in order to filter long lists containing web objects. It can be used to group web objects based on the values of the selected attribute.

The method is suitable for usage with data which can be clustered into few clusters. Examples are filtering publications according to their type (e.g. journal or book) or scope (e.g. local or international), products according to their type (e.g. CD, DVD or book), flats in advertisements according to the number of their rooms, reconstruction status (e.g. original state, partially or fully reconstructed), clothes according to their gender suitability (e.g. kids, men's or women's), etc.

We used free text from which we generated the facets. This in some way naïve approach could be further improved by working with semantic data in the form of RDF triplets. This will allow us to generate facets according to the types of the web objects or their attributes. We could also utilise the relationships where objects could also be facets themselves (e.g. filtering all subclasses of a class).

So far we have only done an off-line evaluation by assessing the relevancy of generated facets with regards to the target domain. In the future work we would like to conduct a user study in which we will let users to filter and further explore the search results within a digital library using facets we generate.

Acknowledgement: This work was partially supported by the grants No. VEGA1/0971/11 and APVV-0208-10.

References

[1] Dakka, W., Ipeirotis, P.: Automatic Extraction of Useful Facet Hierarchies from Text Databases. In: *ICDE '08: Proceedings of the 2008 IEEE 24th International Conference on Data Engineering*, IEEE Computer Society, 2008, pp. 466–475.

[2] Dakka, W., Ipeirotis, P.G., Wood, K.R.: Automatic Construction of Multifaceted Browsing Interfaces. In: *Proceedings of the 14th ACM International Conference on Information and Knowledge Management*. CIKM '05, New York, NY, USA, ACM Press, 2005, pp. 768–775.

[3] Dou, Z., Hu, S., Luo, Y., Song, R., Wen, J.R.: Finding Dimensions for Queries. In: *Proceedings of the 20th ACM International Conference on Information and Knowledge Management*. CIKM '11, New York, NY, USA, ACM Press, 2011, pp. 1311–1320.

[4] Hare, J.S., Lewis, P.H., Enser, P.G.B., Sandom, C.J.: Semantic Facets: An In-depth Analysis of a Semantic Image Retrieval System. In: *Proceedings of the 6th ACM International Conference on Image and Video Retrieval*. CIVR '07, New York, NY, USA, ACM Press, 2007, pp. 250–257.

[5] Hildebrand, M., van Ossenbruggen, J., Hardman, L.: /facet: A Browser for Heterogeneous Semantic Web Repositories. In Cruz, I., Decker, S., Allemang, D., Preist, C., Schwabe, D., Mika, P., Uschold, M., Aroyo, L., eds.: *The Semantic Web - ISWC 2006*. Volume 4273 of *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg, 2006, pp. 272–285.

[6] Koren, J., Zhang, Y., Liu, X.: Personalized Interactive Faceted Search. In: *Proceedings of the 17th International Conference on World Wide Web*. WWW '08, New York, NY, USA, ACM Press, 2008, pp. 477–486.

[7] Li, C., Yan, N., Roy, S.B., Lisham, L., Das, G.: Facetedpedia: Dynamic Generation of Query-dependent Faceted Interfaces for Wikipedia. In: *Proceedings of the 19th International Conference on World wide web*. WWW '10, New York, NY, USA, ACM Press, 2010, pp. 651–660.

[8] Liang, X., Xie, M., Lakshmanan, L.V.: Adding structure to top-k: from items to expansions. In: *Proceedings of the 20th ACM International Conference on Information and Knowledge Management*. CIKM '11, New York, NY, USA, ACM Press, 2011, pp. 1699–1708.

[9] Nie, Z., Ma, Y., Shi, S., Wen, J.R., Ma, W.Y.: Web Object Retrieval. In: *Proceedings of the 16th International Conference on World Wide Web*. WWW '07, New York, NY, USA, ACM Press, 2007, pp. 81–90.

[10] Stoica, E., Hearst, M.A.: Automating Creation of Hierarchical Faceted Metadata Structures. In: *Proceedings of the Human Language Technology Conference*, Association for Computational Linguistics, 2007, pp. 244–251.

[11] Tvarožek, M., Bieliková, M.: Adaptive Faceted Browser for Navigation in Open Information Spaces. In: *Proceedings of the 16th International Conference on World Wide Web*. WWW '07, New York, NY, USA, ACM Press, 2007, pp. 1311–1312.

[12] Tvarožek, M., Bieliková, M.: Factic: Personalized Exploratory Search in the Semantic Web. In Benatallah, B., Casati, F., Kappel, G., Rossi, G., eds.: *Web Engineering*. Volume 6189 of *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg, 2010, pp. 527–530.

[13] Weiland, M., Dachselt, R.: Facet Folders: Flexible Filter Hierarchies with Faceted Metadata. In: *CHI '08 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '08, New York, NY, USA, ACM Press, 2008, pp. 3735–3740.

[14] Wu, P., Sismanis, Y., Reinwald, B.: Towards Keyword-driven Analytical Processing. In: *Proceedings of the 2007 ACM SIGMOD International Conference on Management of Data*. SIGMOD '07, New York, NY, USA, ACM Press, 2007, pp. 617–628.

[15] Yee, K.P., Swearingen, K., Li, K., Hearst, M.: Faceted Metadata for Image Search and Browsing. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '03, New York, NY, USA, ACM Press, 2003, pp. 401–408.

Exploring Group Recommendation for Single-User Recommendation Tasks

Michal KOMPAN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kompan@fiit.stuba.sk

Abstract. More and more attention is paid to the personalized recommendation nowadays. However the group recommendation is designed for the group of users, it seems that group principles can be used for single-user recommendation. In this paper we propose an approach for the single user recommendation based on the principles of the group recommendation. We explore the best configuration for such an approach in order to the group size, strategy used for the aggregation of ratings within the groups or the number of similar users used for the recommendation. Experiments are performed over the standard MovieLens and SME.SK dataset and proposed approach is compared to the standard collaborative recommender. Obtained results support our hypothesis that proposed approach brings statistically significant improvement and thus can be used for the single-user recommendation.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 35-37.
A paper based in part on this paper was submitted to a peer reviewed scientific journal.

* Doctoral degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Analysing Temporal Dynamics in Search Intent

Tomáš KRAMÁR*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kramar@fiit.stuba.sk

Abstract. Understanding how searchers change their search goals over time is important for purposes of a personalized search. This knowledge is crucial for building a time-sensitive ranker, search intent prediction and multitude of other search related tasks. In this work, we analyse temporal search intent dynamics, using the publicly available AOL search engine clickthrough log. We show that there are searchers who completely switch context during weekend and off-business hours and search for semantically different information in these periods. We also show that there is a correlation between the context switching during weekend and context switching during off-business hours.

A paper based in part on this paper was accepted for publication in Proc. of Student Research Forum at the 39^{th} Int. Conf. on Current Trends in Theory and Practice of Computer Science (SOFSEM'12).

* Doctoral study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Tracking of Parallel Browsing Behaviour

Martin LABAJ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
labaj@fiit.stuba.sk

Abstract. Current web browsers support multiple means of parallel browsing. Users can open multiple new windows and tabs and switch between them at any time. Such behaviour is often invisible to web usage mining, as only page loads are tracked server-side. However, if we can capture such data from common users, we can track revisitations, paths through resources, etc. more accurately. In this paper we introduce a model for reconstruction of parallel browsing behaviour from client-side tracked data (page load/unload, fragmented time spent). With this model, we evaluate browsing behaviour of students in an adaptive learning system.

A paper based in part on this paper was accepted for publication in Proc. of 10th Int. Conf. on Emerging eLearning Technologies and Applications (ICETA'12), IEEE Computer Society Press.

* Doctoral degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Maintenance of Knowledge Tags in Heterogeneous Web Content: The Repository

Karol RÁSTOČNÝ*

Slovak University of Technology
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
rastocny@fiit.stuba.sk

Abstract. Knowledge tags provide new layer of light semantics over web content, in which computer systems and web users can share their knowledge about tagged content. To allow this type of collaboration, tags' data must be stored in form which is understandable for computer systems and provides flexible and fast access for these systems. The next issue is dynamic character of the Web, whose content changes in the time. These changes can leads to invalidation of knowledge tags, its parts or anchoring in tagged content. In this paper we present basic ideas of automatized knowledge tags maintenance and our approach for knowledge tags repository.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 59-61.
A paper based in part on this paper was published in Proc. of Int. Conf. on Conceptual Modelling Workshops (ER'12), Lecture Notes in Computer Science, Vol. 7518, Springer, Berlin, 327-336.

* Doctoral degree study programme in field: Software Engineering
Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Beehive Metaphor Inspired Web Crawler

Štefan SABO*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
sabo@fiit.stuba.sk

Abstract. In this paper we present a web crawler based upon the Beehive Metaphor model. This crawler uses the general perception of a swarm to asses the fitness of currently visited web sites and to decide on which page to visit next. We present this as an alternative to decision process based on link analysis. Next we discuss the strengths and weaknesses of this approach and compare the performance of presented crawler to a simple random crawler. Finally, we conclude by outlining the possibilities of further development by coupling the presented approach with methods of machine learning and link analysis.

1 Introduction

Web crawlers provide the means of navigating the virtual space of World Wide Web and collect information from web pages tailored to human users. Depending on the goal of a web crawler, different strategies can be utilized to move between web pages. In this paper we concentrate on focused crawlers, that aim to visit only the pages relevant to a certain topic [1]. To achieve this goal, the crawler needs to be able to predict the content and relevance of web pages that are being linked to from a given, already visited web page.

There are a number of approaches to address this task. Modern crawlers [2] evaluate a web page before visiting it by analysing the link leading to the page, together with its surrounding text and context. Thus the crawler is able to predict the fitness of a given page and decide, which page to visit next. When analysing outgoing links from a web page, the crawler is able to evaluate the anchor text associated with a link, the surrounding text and the URL of the link itself. This information can be fed to evolution algorithms, neural networks, or other means of machine learning. However, the scope of information, that we can discern about a page not yet visited is limited by the form and information contained within a link to the page.

We have adopted a different approach of deciding the next page, inspired by the natural behaviour of honey bees. The proposed agents rely on swarm intelligence, instead of precise analysis of a single source, to decide the optimal sources to forage. Every agent evaluates its source individually, without considering its surroundings. Depending on the fitness of the source, the agent can recruit other agents for the same source and thus the best sources are searched more thoroughly than the less

* Doctoral study programme in field: Software Engineering
Supervisor: Professor Pavol Návrat, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 249–254.

fit ones. In This way, we can direct the crawler towards the more promising regions of the web, provided that the sources are not distributed randomly and two pages connected by a link share some of their qualities, relevant with regards to the fitness function of the crawler.

2 Beehive Metaphor

The behaviour of the proposed crawler is modelled in accordance with Beehive Metaphor model [3]. Beehive Metaphor is a simplified model based on the behaviour of common honey bee worker when foraging for food. It describes the roles that agents in a multi agent system can assume, along with conditions and probabilities of assuming the roles.

2.1 Overview of the model

Beehive Metaphor utilizes a single type of bee that is able to assume three roles – foraging, dancing and observing. A foraging bee gathers food from a given source, until it decides to switch to dancing or observing. If a foraging bee considers its source to be fit enough to be propagated, the bee can interrupt its foraging for a given period of time to recruit other bees for its source. On the other hand, when the source is not fit enough, the bee can decide to abort the foraging and observe other bees, currently propagating their sources. While observing, the bee attempts to find a new suitable source for it to forage. If it fails to do so in a given time, it adopts a new random source, not necessarily propagated by the dancing bees.

2.2 Dynamics of the model

The probability of a single bee switching from one role to another depends stochastically on the fitness F_s of a source s, that the bee is currently visiting. The probability $P(L_s)$ of a bee leaving the source and thus switching from foraging to observing is expressed as $P(L_s) = 1 - F_s$. If a bee has decided to stay on its source, probability of it being $P(S_s) = F_s$, it further decides to propagate the source with probability $P(D_s|S_s) = F_s$ given that the bee has already decided not to leave the source. The total probability of deciding to dance for a source s is then $P(D_s) = F_s^2$. Alternatively, if the bee had decided not to leave the source, but not to dance for it either, it continues to forage from the source further, with the probability of $P(F_s|S_s) = 1 - F_s$ giving us the total probability of continued foraging $P(F_s) = F_s(1 - F_s)$.

The sources rated as the ones with highest fitness will inspire the highest rate of propagation and in turn attract more bees that have decided to abandon their sources. This leads to highest concentrations of bees foraging from the best sources. Depending on the task requirements, the affinity of the bees towards the best source can be influenced by the *Maximum Dance Time* [4] parameter of the model. Increasing of the MDT parameter increases the affinity of the bees towards the best sources and vice-versa. The drawback of increased MDT is the slower rate of exploration, as the bees focus on exploration of already established sources with highest fitness, instead of finding the new sources that have not yet been evaluated.

3 BM crawler

In comparison to an approach utilizing link analysis for navigating the web, the proposed Beehive Metaphor crawler analyses only the current page, being foraged by the agent. This approach enables us to evaluate fitness of a page more accurately, as its full content is already available for us to analyse. Also, we can consider additional attributes of a page when evaluating its fitness, such as its meta information, time-stamp, or size. As a result, the presented crawler can perform searches based on a broader range of queries when compared to a traditional focused crawler [2, 5].

However, although the method of evaluating the whole page instead of just outbound links enables us to give a more detailed calculation of page fitness, it does not say anything about the fitness of the surrounding pages. It is implied, that the pages connected together by a hyperlink will share some of the attributes. This limits the use of the proposed BM crawler to a domain of web pages, that are interlinked together on the basis of a mutual relevance. A domain of news portals, where articles on similar subjects are interlinked, may be an example of such a domain.

3.1 Greedy strategy

The strategy of BM crawler resembles a greedy approach, where the best pages are automatically preferred. The difference is in the swarm aspect of the BM crawler. While the general attention of the swarm is directed towards the best sources, some number of the agents will continue roaming and look for a new best source. If a new best source is found, the agents will gradually transfer to the new best source, as shown in [4]. This allows the crawler to avoid the local maximums and traps, that would otherwise inhibit its performance, would it be a simple greedy crawler.

Other aspect, that distinguishes BM crawler from a simple greedy crawler is the possibility of dynamic scaling and adjusting of its parameters. The overall behaviour of swarm, measured in dancing rate, foraging rate and rate of source abandoning, gives us a feedback on swarm performance, that enables us to dynamically adjust the evaluation function. This adjustment would allow us to dynamically fine-tune the range of fitness, assigned to the sources, so that the agents are able to differentiate between the sources more effectively in the event that many sources share similar fitness values. While not yet comprehensively tested, this technique remains as a prospective possibility of further enhancing the proposed crawler.

4 Experiments

To evaluate the performance of the proposed crawler, a testing framework was implemented, along with a reference crawler for comparison with the BM crawler. Two experiments had been carried out, one evaluating the ability of designing the best source and one to determine the final distribution of agents amongst the individual sources.

4.1 Testing framework

The testing framework consists of index, parser and repository containing link structure and meta data of parsed pages. The framework consists of an index, a parser, a link repository and a crawler. The overall architecture of the testing framework is illustrated by Figure 1.

The index was implemented using Lucene library and stores full-text versions of pages. It is used to perform full-text searches and to evaluate similarity between queries and pages for the purpose of simple topic detection. The parser was implemented using Jericho library and is used to extract full-text, title, timestamp and links from a raw page. The information gathered by the parser are used to build index and establish the link structure amongst the pages. The link repository is used as an internal representation of the crawled portion of the Web. It stored the information about the individual pages, along with the link structure and meta information about the individual pages. The crawler module was implemented as replaceable, so that different crawler representations could have been used during the experiments. It operates over the link repository by following the link structure contained within. When the crawler follows a link to a page that is not yet available, it feeds the link to the parser, which in turn makes a request to the respective web server, parses the response and sends update notices to link repository and index.

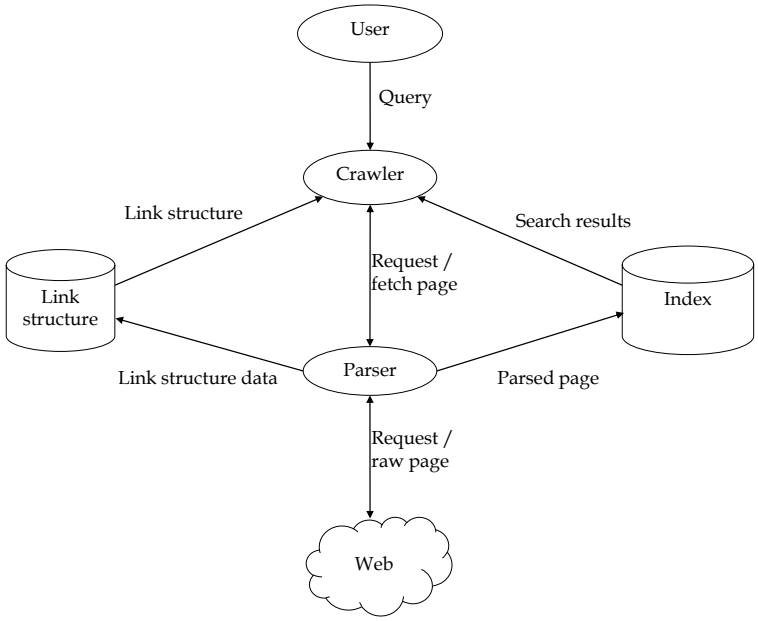

Figure 1. Architecture of testing framework.

4.2 Search for the top source

To evaluate the performance of the BM crawler, when searching for the best page matching a query, an experiment was performed, that compared the BM crawler to a simple random crawler, used as a reference. The objective was to determine, whether the additional effort, that the individual BM agents invest into propagation and observation will bring an improvement over the crawler that uses all its resources to crawl and download pages.

The experiment took place on the `http://www.reuters.com` domain and the goal of both crawlers was to find the latest article on the topic of *European debt crisis*. For the sake of objectivity, the crawlers were limited only to follow the links to articles within the selected domain, so that they would not stray away from the designated web space, which could potentially be an issue for the random crawler. The best article was manually identified in advance. Subsequently we let both crawlers start and measured the time it took the first agent to find the best article. The measurement was performed ten times with twenty agents per each crawler type. In addition, the parameters of BM crawler had been set as follows: $MDT = 4, OT = 2$, with the parameter names in accordance with [4]. The results of the experiment are shown in Table 1.

Table 1. Time needed to find the best page.

Crawler	$\overline{t}[ms]$	$\overline{d}(t)$
BM crawler	1456.8	248.8
Reference crawler	4213.4	172.5

We can see, that BM crawler reached the best source in a considerably shorter amount of time, than the random crawler. From this we conclude, that the ability of the crawler to consider the quality of the pages it has already crawled improves its performance enough to outweigh the costs associated with such an approach. This however applies only in the environment where the relevant pages are linked together appropriately, a condition that we consider to be met by a news portal.

4.3 Final distribution

The objective of the second experiment was to provide a more detailed look on how the distribution of the agents looks at the end of the search. For this experiment only the BM crawler was used, as the random crawler does not take into account the fitness of the individual sources. The measurement was performed on the `http://www.reuters.com` domain and the parameters were set as follows: $bees = 100, MDT = 4, OT = 2$ with the parameter names in accordance with [4].

The goal of the crawler was to retrieve the latest possible source dealing with the topic of the *Iranian nuclear program* and the search was limited to 100 iterations for every agent. The results of the search are illustrated by Figure 2. The sources have been ordered by their fitness and the ordering does not reflect the order in which they had been found. We can see, that the best sources have gathered the most agents in the end, with the exception of the source with fitness of 0.95. After inspection of the results, the reason of this was found to be the fact, that this source had been discovered only shortly before the end of the search and did not manage to attract many agents in time.

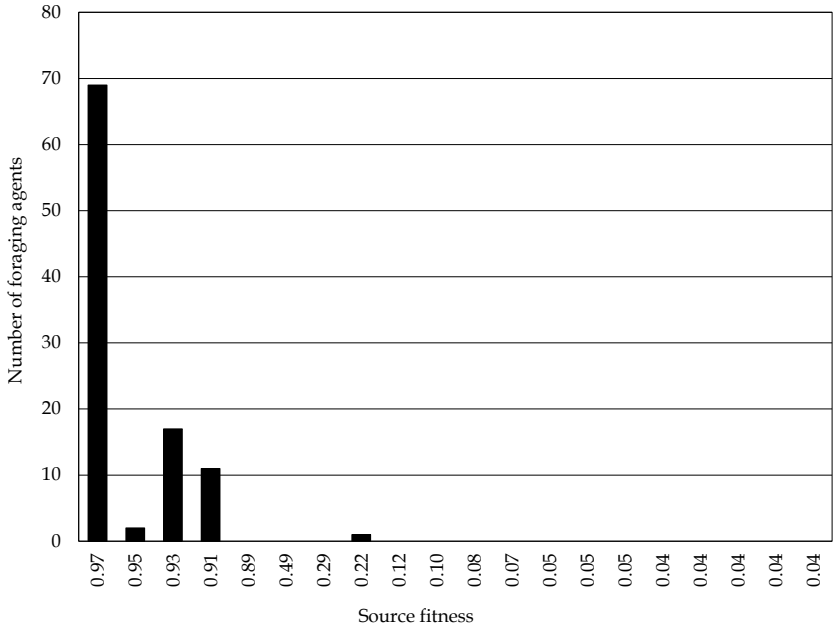

Figure 2. Final distribution of agents amongst the sources.

The notable drop in the fitness after first five sources is attributed to the fact, that one of the criteria included in the fitness evaluation was the relevance to a selected topic and while the first five sources were relevant to the topic of *Iranian nuclear program*, the others were not. The finer differences in fitness are caused by distribution of the articles over time and by occurrence of searched keywords in pages not related to the selected topic, which slightly raised the fitness of the sources.

5 Conclusion

When trying to find the optimal path through the web space, a classic focused web crawler tries to analyse the outgoing links from a page and evaluate the target pages accordingly, to decide its next step. We propose an alternative approach, that relies on a more in-depth analysis of the current page, allowing us to take into account a wider range of aspects when evaluating a page. The choice of

the link to be followed is then random, without any analysis. When coupled with a swarm intelligence modelled according to the Beehive Metaphor model, we get a different type of web crawler, one that does not rely on machine learning methods, but exploits the character of web environment, where two interlinked pages may share certain degree of mutual relevance, or common attributes. This crawler, however, may not be used in an environment, that does not provide such an advantage.

Furthermore, the proposed mechanism of page evaluation is less rigorous than the one used by advanced link analysing web crawlers and as such can not be directly compared in terms of performance. However, it is our hope that these two approaches can be combined to supplement each other and provide a more advanced type of nature inspired focused crawler. This also would be the direction of our future work in this field, along with the development of dynamic auto-adjustment of model parameters, including the evaluation function of single agents, that would be adjustable according to the overall quality of sources.

Acknowledgement: This work was partially supported by the Slovak Research and Development Agency under the contract No. APVV-0208-10.

References

[1] Chakrabarti, S., van den Berg, M., Dom, B.: Focused crawling: a new approach to topic-specific Web resource discovery. *Computer Networks*, 1999, vol. 31, no. 11–16, pp. 1623–1640.

[2] Menczer, F., Pant, G., Srinivasan, P., Ruiz, M.E.: Evaluating topic-driven web crawlers. In: *Proceedings of the 24th annual international ACM SIGIR conference on Research and development in information retrieval*. SIGIR '01, New York, NY, USA, ACM, 2001, pp. 241–249.

[3] Navrat, P.: Bee Hive Metaphor for Web Search. *Communication and Cognition-Artificial Intelligence*, 2006, vol. 23, no. 1-4, pp. 15–20.

[4] Navrat, P., Kovacik, M.: Web Search Engine as a Bee Hive. In: *Proceedings of the 2006 IEEE/WIC/ACM International Conference on Web Intelligence*. WI '06, Washington, DC, USA, IEEE Computer Society, 2006, pp. 694–701.

[5] Pant, G., Srinivasan, P.: Learning to crawl: Comparing classification schemes. *ACM Trans. Inf. Syst.*, 2005, vol. 23, pp. 430–462.

Software Engineering and Computer Science

Aspect-Oriented Solution for Mutual Exclusion in Embedded Systems

Alojz GOMOLA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
alojz.gomola@gmail.com

Abstract. Embedded systems are developed for wide range of applications. The best known applications are industrial process control and banking solutions. Fault tolerance is the crucial requirement in long-term embedded systems. This paper presents solution for mutual exclusion in embedded systems. The usual mutual exclusion solution using semaphores is a crosscutting concern. Semaphores are difficult to maintain in code and their failure rate is high. We propose new aspect-oriented solution for mutual exclusion. Our solution utilizes aspect-oriented approach, is usable in other systems and designed to be robust against program changes, and it provides a solution to aspect fragility problem.

This paper was accepted but not presented at the conference.

* Master degree study programme in field: Software Engineering

Preprocessor for Aspect-Oriented Programming in Haskell

Miroslav HRUŠKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xhruskam3@is.stuba.sk

Abstract. Incorporation of aspect-oriented techniques into purely functional languages is specific due to the nature of pure functions. Such functions are permitted to interact with environment only within clearly specified bounds. This situation has in several cases unpleasant consequence – for example the well-known logging aspect is more difficult to weave into existing code in comparison with other non-pure languages. We briefly introduce the EffectiveAdvice approach and propose syntactic preprocessor scheme for enhancement of its practical usability. Its preliminary implementation for Glasgow Haskell Compiler indicated its potential for solution of several tasks. Limitations are summarized and discussed at the end of the paper.

1 Introduction

Aspect-oriented programming in Haskell is an open research problem, with only few approaches [4–6] currently present in literature. These approaches share very little similarities are very dissimilar with different ways of components composition and varying level of complexity.

We focus on EffectiveAdvice [4] approach because of its theoretical simplicity and ability to work with effectual advices, which is an important factor for practical application in functional languages with pure functions.

In Section 2 we present the basics of EffectiveAdvice along with a few examples. Based on these observations we propose a translation scheme in section 3 which enables us to do basic asymmetric AspectJ-like programming. We show few results of such translation scheme in section 4. In section 5 we discuss other related approaches. The paper ends with conclusion and discussion of limitations.

2 EffectiveAdvice

EffectiveAdvice presents a simple theory for composition of components in Haskell. These components must preserve additional structure to fit the theory. It is important to note that such additional

* Master study programme in field: Software Engineering
Supervisor: Dr. Ján Lang, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

structure is derivable and therefore the process of composition can be automated, which is pointed out by this paper.

2.1 Theory

The theory of EffectiveAdvice is based on the concept of *open recursion*. Open recursion is a *"property of a component in which, recursive references are left open, so that the recursive behaviour can be extended later"* [4]. The implementation of this property can be easily done in Haskell; we are interested in functions as components.

Suppose that recursive function f references itself in its definition; then this reference has to be parametrized by another function g with the same type of parameters f has. So, whenever the original function f references itself, this reference is replaced with the reference to g. The openness property is represented as:

$$\textbf{type}\ \text{Open}\ \text{s} = \text{s} \rightarrow \text{s}$$

This says that for any s, if it should be open, it needs something with the same structure as s and then it is able to return some s back. Example for factorial function:

$$\begin{array}{ll} fac_0 :: \textbf{Int} \rightarrow \textbf{Int} & fac_1 :: \textbf{Open}\ (\textbf{Int} \rightarrow \textbf{Int}) \\ fac_0\ 0 = 1 & fac_1\ \text{proceed}\ 0 = 1 \\ fac_0\ \text{n} = \text{n} * fac_0\ (\text{n} - 1) & fac_1\ \text{proceed n} = \text{n} * \text{proceed}\ (\text{n} - 1) \end{array}$$

To make ordinary function fac_0 open, it is necessary to redefine it (as shown in fac_1) and add an extra argument $proceed$ for fac_1 recursive reference.

To call fac_1, it is necessary to provide another function of type **Int** $\rightarrow$ **Int** as an argument and then a value to get a result. Sure, we can use fac_0, but then we will have two conceptually equivalent functions. The trivial case with open recursion is to apply the same function as recursive reference. This is the same as if we did not "split" the function at all. Suppose we want to call fac_1 with argument n. We can not do this by calling

$$\underbrace{fac_1}_{f}\underbrace{fac_1}_{g} n$$

where f is a base function and g is a recursive reference. It is because the g function has to be of type **Int** $\rightarrow$ **Int**, but it is of type **Open** (**Int** $\rightarrow$ **Int**); it needs another function of type **Int** $\rightarrow$ **Int**. But if we keep inserting the function fac_1 infinitely many times, then certainly it will become as our previous function. And this is exactly what the process of weaving does; it recursively closes the component. The definition of *weave* is as follows:

$$\text{weave}\ \text{a} = \text{a}\ (\text{weave}\ \text{a})$$

To obtain regular fac_0 we can set $fac_0 =$ weave fac_1. Another important operation is the advice composition operator ($\oplus$). Its definition can be found in [4]. But to get an idea what it does, we illustrate how call to base function fac_1 advised by advice adv_1 would look like:

$$adv_1(fac_1(adv_1(fac_1(adv_1(fac_1 \ldots) \ldots)\ n$$

Advice adv_1 refers to fac_1 in *proceed*, which in turn refers to adv_1 and so on. Then we can create the advised function as

$$\text{facAOP} = \text{weave}\ (adv_1 \oplus fac_1)$$

2.2 Logging Example

We now provide practical example – we add well-known aspect of logging to functions. Recall that there is a significant difference between pure and effectual code in pure functional language. If we choose to log to a console, or to a file, the function must somehow interact with them. This interaction is captured by the notion of monad, in case of logging it is `IO` monad. Observe the differences between standard and effectual version of the same function:

```
facM :: Monad m => Int -> m Int       fac0 :: Int -> Int
facM 0 = return 1                     fac0 0 = 1
facM n = do l <- facM (n - 1)         fac0 n = n * fac0 (n - 1)
            return (n * l)
```

The `facM` function is rewritten in monadic style. The function `facM` does not *really* need to operate in a monad, but it must be rewritten into this form to be combined with advices, which will operate in other monads.

The process of *automatic lifting* of pure functions to monadic computations is called *monadification* [2]. The tool [3] capable of monadification is named HaRe.[1] The logging aspect can be captured as:

```
advLogIO :: (MonadIO m, Show a) => Open (a -> m a)
advLogIO proceed x = do (liftIO . putStrLn) ("enters with " ++ show x)
                        y <- proceed x
                        (liftIO . putStrLn) ("leaves with " ++ show y)
                        return y
```

Now we can weave the advice with base function:

```
facLogIO = weave (advLogIO +++ facM)
```

Compare the resulting types of monadified `facM` and advised `facLogIO`:

```
facM     ::   Monad m => Int -> m Int
facLogIO :: MonadIO m => Int -> m Int
```

The `facLogIO` is capable to work in monad, which is able to access the `IO`, while `facM` is more general and it is able to work in any monad.

2.3 Memoization and State Monad

Another example is incorporating of state into computation. We will use slightly generalized example from [4].

```
memo :: (Ord a, MonadState (Map a b) m) => Open (a -> m b)
memo proceed x =
  do m <- get
     if member x m then return (m ! x)
                   else do y <- proceed x
                           m' <- get
                           put (insert x y m')
                           return y
```

[1] HaRe is an abbreviation of Haskell Refactorer.

We are working in monad capable of holding associative map (`Map a b`) and with a functions of type `a -> m b`. When the advice gets the control flow, it checks if it already contains result for given value. If not, then it proceeds with the computation, and stores its result for later use. We can apply memoization to naive implementation of fibonnaci function `fib` in this manner:

```
fastfib  n = (runStateT (weave (memo +++ fib) n) empty) >>= (return . fst)
```

It is more complex, but it reveals the nature of ordinary monads. Functions, which operate in a monad, are considered as encapsulated computations and therefore must be explicitly ran (`runStateT`). In case of `IO` monad, this is implicit, because we expose the `IO`, when the program starts. The program inherits the access to the console – it gets the access to the `IO` from the environment which ran that computation.

In case of state monad, we also need to explicitly provide the initial state (`empty`). Situation is even more complicated, because the outcome of such computation is not only the result, but associated resulting state as well; this information is stored as a tuple and we must discard the second part (hence the `>>= (return . fst)`). Explicit run of computations with specified initial state and output processing is general enough for all monads.

3 Translation Scheme

We propose preprocessing scheme, which turns the concepts from previous section into asymmetrical aspect-oriented technique similar to basic subset of AspectJ. If advices obey explicit syntactical structure, they can be weaved into base functions. Let advice be defined as a combination of these standard Haskell functions:

```
_adv_NAME_pointcut :: String              _adv_NAME :: Open ...
_adv_NAME_pointcut = "*"                  _adv_NAME proceed ... =
```

where `NAME` is the name of a specific advice. The first function defines pointcut using regular expression. The second function is advice in form of open recursion, which will be applied to affected functions. Then the preprocessing scheme for Haskell module is as follows:

1. Monadify the functions in module.
2. Import EffectiveAdvice as a theoretical base.
3. Rename every function f with suffix s so its name is fs.
4. Tansform every function fs to have a property of open recursion:
   a. Change fs type annotation from x to $Open(x)$.
   b. In pattern matching of fs add parameter with name y (we used it as *proceed*) which will stand for recursive reference.
   c. Change every fs reference to itself into a reference to y.
5. For every function fs with arguments $x_0, x_1, \ldots x_l$ affected by advices $(a_0, a_1, \ldots a_k)$:
   a. Define its weaving core as $fs_{core} = (weave(a_0 \oplus a_1 \oplus \ldots \oplus a_k \oplus fs)x_0x_1 \ldots x_l)$.
   b. For each a_i augment the $fs_{core} = ((a_{i_{\mathbf{run}}}(fs_{core})a_{i_{\mathbf{params}}})a_{i_{\mathbf{return}}})$.
   c. Create function $f\ x_0x_1 \ldots x_l = fs_{core}$.

Table 1. Monad-specific units to run a computation and process its output.

Monad	$a_{i_{\mathbf{run}}}$	$a_{i_{\mathbf{params}}}$	$a_{i_{\mathbf{return}}}$
IO			
Reader	`runReaderT`	environment	
Writer	`runWriterT`		`>>= (return . fst)`
State	`runStateT`	initial state	`>>= (return . fst)`

Note. The step $5b$ may look too complicated, but in case of `IO` monad, $a_{i_{\mathbf{run}}}$, $a_{i_{\mathbf{params}}}$ and $a_{i_{\mathbf{return}}}$ are empty strings. Other cases are covered in Table 1.

In case we use non-standard monads, the translation scheme has to be able to gather additional necessary information. With reference to previous table, there is need for information on how to `run` the computation with `params` and how to process the resulting information after `return`. While the `run` and `return` are specific to monad, the `params` depends on the advice. Therefore in case of non-standard monad it is necessary to add `_adv_NAME_params` function to advice definition.

4 Results

With preliminary implementation of preprocessor we were able to obliviously advise functions with multiple advices. As an example, here is a commented list of functions:[2]

```
-- simple, non-augmented version of fibonnaci
fib  n = weave (fib_) n

-- fibonnaci with trace function, for debugging purposes
fib n = weave (_adv_deb +++ fib_) n

-- fibonnaci with memoization
fib n = (runStateT (weave (_adv_memo +++ fib_) n) empty) >>= (return . fst)

-- fibonnaci with inherited environment and memoization
fib n = (runReaderT ((runStateT
               (weave (adv_read +++ adv_memo +++ fib_) n)
         empty) >>= (return . fst)) (fromList [(0, -1), (1, -1)]))
```

Note that when the preprocessor is not present, the code still compiles and works, but without additional functionality.

5 Related Work

AOP Haskell [5] approach extends Haskell syntax with aspect-oriented structures and supports AspectJ-like "around" advice. Composition of advices with functions is done on type level during the process of type class resolution. The paper considers two implementation schemes, one based on type class system in GHC and another on experimental one. The major drawback of this approach is the lack of support for effectful advices, which results in its limited utility.

EffectiveAdvice is more recent approach which is able to work with effectful advices, as the name of the library suggests. The paper [4] inspired by Open Modules [1] defines the structure of composable components that serve as a base for aspect-oriented programming. The paper also

[2] Note the function suffix s equals to underscore ("_").

elaborates on classification of data and control flow interference patterns with applications to the EffectiveAdvice. The library offers the means to do effectful aspect-oriented programming with explicit denotation of composable components and their composition.

AspectAG [6] is an advanced attribute grammar framework with composition operation, usable for aspect-oriented programming. The library uses a lot of modern extensions to Haskell 98 standard, heterogeneous collections and a great amount of type-level programming. With all these extensions, the attribute grammar system was implemented as combinator library without need for preprocessing, which is helpful for debugging purposes. AspectAG is a complex library and presents symmetrical means of aspects composition.

6 Conclusion

Results have shown that proposed preprocessing scheme can serve as a basic enhancement of existing aspect-oriented technique in Haskell. Preprocessor was implemented with the use of `Language.Haskell` library. The code is parsed into AST and then re-generated after necessary transformations are performed. There are also several limitations where the proposed scheme (and the underlying EffectiveAdvice theory) is insufficient.

At first the monadic functions must be written in type class style. This means that functions like `abc :: a -> IO a` must be written as `MonadIO m => a -> m a`. This does not present a substantial obstacle. In case we use standard monads they are combined using monad transformers library. In case we use own monads, it is necessary to define the monad transformation behaviour.

The second limitation is that the advice is only able to advise functions with the same number (and structure) of parameters as the advice has. This is because of realization of components composition in EffectiveAdvice. Both advice and base function must have the same structure to fit composition requirements. Thus it is not possible, e.g. to log arguments for functions of various arities with one advice. There is need for generation of multiple advices with arities corresponding to base functions, but this also requires universal system for variable-arity advice definition.

The third limitation comes due to the preprocessor focus on each module separately. Such approach will be insufficient for bigger projects with multiple interdependent modules. However, the major limitation is the second one, which significantly reduces the utility of overall solution and thus it serves as an objective of future work.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/1221/12.

References

[1] Aldrich, J.: Open Modules: Modular Reasoning About Advice. In Black, A., ed.: *ECOOP 2005 – Object-Oriented Programming*. Volume 3586 of *LNCS*. Springer, 2005, pp. 734–734.

[2] Erwig, M., Ren, D.: Monadification of functional programs. *Sci. Comput. Program.*, 2004, vol. 52, pp. 101–129.

[3] The Haskell Refactorer. `http://www.cs.kent.ac.uk/projects/refactor-fp/hare.html`, 2010.

[4] Oliveira, B.C.d.S., Schrijvers, T., Cook, W.R.: EffectiveAdvice: disciplined advice with explicit effects. In: *Proceedings of the 9th International Conference on Aspect-Oriented Software Development*. AOSD '10, New York, NY, USA, ACM, 2010, pp. 109–120.

[5] Sulzmann, M., Wang, M.: Aspect-oriented programming with type classes. In: *Proceedings of the 6th workshop on Foundations of aspect-oriented languages*. FOAL '07, New York, NY, USA, ACM, 2007, pp. 65–74.

[6] Viera, M., Swierstra, S.D., Swierstra, W.: Attribute grammars fly first-class: how to do aspect oriented programming in Haskell. *SIGPLAN Not.*, 2009, vol. 44, pp. 245–256.

Modelling Aspect-Oriented Design Patterns

Matej LIPTÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xliptakm@gmail.com

Abstract. There are several intrinsic aspect-oriented design patterns identified, but they are not as analysed and designed as the design patterns in the object-oriented paradigm. For only some of them, graphic models were created and these models do not reflect the real aspect-oriented nature. In this report, an approach for modelling aspect-oriented design patterns was proposed. As an example pattern, the Director pattern was selected. The approach is a combination of more views to modelling software. Theme approach was applied to express the main meaning of the pattern and a role graph was added to express role multiplicity. In addition to these two types of diagrams, a feature model was needed to capture pattern variability.

1 Introduction

Generally, a pattern describes a core of a solution to a problem in a specific context. The solution needs to be bound to the context, but general enough to solve different problems with same type [1]. This definition may be applied in various domains.

One of the domains is software engineering. In software engineering, there are several types of patterns: analytical, architectonic, design, specialized business patterns and idioms. In this report, we will only explore the design patterns – the patterns used in designing particular software components.

There were introduced several intrinsic aspect-oriented design patterns [5,9]. The patterns were described and for some of them models were given too. However, these models are not satisfying, because they do not reflect behaviour of classes. Besides, they are rather a graphically expressed source code than modelled behaviour or structure of a software module.

In this report, modelling intrinsic aspect-oriented design patterns will be explored and discussed on the *Director* pattern. Modelling a pattern sometimes requires more than one modelling technique, so we will look at combining these techniques to provide a general view of patterns. The *Director* pattern was chosen as an example pattern. This pattern does not define behaviour of classes, so the models will not contain any behavioural views.

In Section 2 we will look at existing aspect-oriented pattern – *Director*. In Section 3, base model of the *Director* is provided. In Section 4, role multiplicity in design patterns is expressed.

---

* Master study programme in field: Software Engineering
Supervisor: Assoc. Professor Valentino Vranić, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 269–274.

Section 5 captures pattern variability and discusses impact of configuring the pattern features on its base model. Section 6 is about work related to the report. In last Section, the report is concluded and possibilities of the future work are described.

2 Director: Invoking an Example

In aspect-oriented paradigm, there are two types of design patterns: those taken from the object-oriented paradigm and expressed in aspect-oriented way and those that are specific for the aspect-oriented paradigm. The second type is called intrinsic design patterns and this report will only work with this type of patterns. *Director* is one of the intrinsic aspect-oriented design patterns and can be used when new relationships need to be set between classes. Bálik and Vranić described the pattern in Coplien's form:

Problem Additional roles have to be defined in application.

Forces The application has to be extended with additional roles, but the original class hierarchy in the source code has to remain free from these roles.

Solution Introduce the additional roles as types and enforce their implementation by the corresponding types externally.

Resulting Context The type hierarchy preserved in the source code, but extended with new roles in execution.

However, Bálik and Vranić did not provide us with a model of the pattern. This pattern was introduced by Miles, along with the graphic model of the pattern [9], but Miles used keywords from the AspectJ to express behaviour and structure of the pattern in this model. Therefore, model introduced by Miles is not general for aspect-oriented paradigm, but dependant on the AspectJ.

This report explores the *Director* pattern and uses it as a working example to show views of modelling design patterns.

3 Base Models of aspect-oriented Patterns

Theme is a modelling approach made especially for the aspect-oriented paradigm [3]. Its purpose is to capture the cooperation of aspects. Theme supports not just the design process, it supports the analysis process as well – with Theme/Doc. Theme/UML supports the design phase – it uses a class diagram (for a theme structure) in conjunction with a sequence diagram representing the behaviour of a theme. The sequence diagrams are based on UML, but to be able to express what is happening within the pointcuts, notation had to be modified.

The Theme approach supports both symmetric and asymmetric way of designing system modules. In this section, we will look at the symmetric way of modelling used on the *Director* pattern (Figure 1). In the model we can see two themes *Business* theme and *Director* theme. *Business* theme denotes a theme, in which a business logic can be designed. *Director* theme represents the theme, which manages the roles in the application. It defines an interface *Role*, which may contain an operation and then it defines that a class *Owner* will implement this Role. These two themes are merged together. Classes *Owner* and *BusinessClass* represent the same concept, so these two classes will be merged together. Other classes will be simply added to the resulting composition. In the resultant composition the *BusinessClass* will implement the *Role* – it becomes the owner of the role.

This way, we can model the two themes separately. In *Business* theme we can focus on business logic and in *Director* theme we can focus on the role behaviour, which will be established between the business classes. Therefore, this approach supports well the symmetric way of modelling in

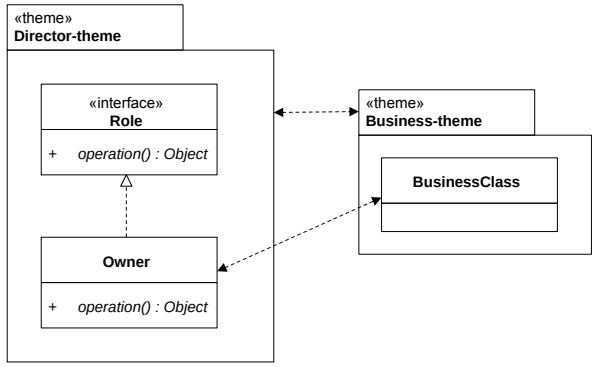

Figure 1. Director modelled using the Theme approach.

aspect-oriented paradigm. Asymmetric realization of the model for the *Director* pattern would look like in Figure 1, but the *Director* theme would be a cross-cutting theme parametrized with the class Owner. *Business* theme would be bound to the *Director* theme via the *BusinessClass*, which would be merged to the *Owner* class.

In Section 2, we mentioned that the *Director* pattern introduces additional roles no matter how many roles there are. In Theme/UML, we do not have possibilities to express that there may be multiple roles, so in Figure 1 just a base model of the *Director* pattern was provided.

4 Expressing Role Multiplicity in Patterns

The *Director* pattern introduces additional roles to the application. In Section 3, we mentioned that it does not matter, how many of them there are. Therefore, we need to express multiplicity of roles. Marko had explored pattern instantiation and for constraints and role multiplicity had used a role graph [7].

Dependencies in the role graph are directed edges and each endpoint is characterized by multiplicity constraint. If there are dependencies in both directions between any two roles, then there is only one edge between them without arrows, denoting it as a bidirectional dependency. In Figure 2, we can see a role graph for the *Director* pattern. There is a *Caller*, which represents a context accessing multiple *Roles*, which are interfaces. The *Caller* may have multiple operations. The *Role* interface may be implemented by multiple *Owners*, but one *Owner* can only implement one *Role*. *Role* may have multiple operations and so can *Owner* of the *Role*.

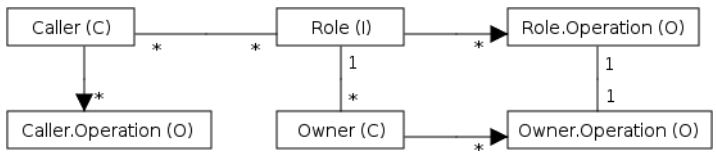

Figure 2. Model of the role multiplicity for the Director pattern.

Expressing the role multiplicity, we can see the *Director* pattern may have multiple *Roles*, which may be implemented by multiple *Owners*. With the feature model, *Director* expression is not only limited to one *Role* as it was depicted in Figure 1.

5 Capturing Pattern Variability with Feature Modelling

Models provided above were examples of patterns. There are some variabilities in the models and to provide general view of the pattern, we need to express possibilities of pattern features. Feature modelling is a technique for capturing commonalities and variabilities in system families and product lines [4]. In this section, we will look at the variabilities in the *Director* pattern.

Feature models tend to be of two types. Models of the first type contain only those characteristics, that are variable and may change in the design. In the second type, all main features of the designed module, on which we need to get focused, are expressed. Whether they are variable, or permanent. In this section, we will look at feature models of the first type – with only the variable characteristics.

In the model of the *Director* pattern in Figure 1, some characteristics of the pattern were not expressed. One of them is that behaviour of a role defined by the operation method may be introduced as a new behaviour for the class and it will be added to the *BusinessClass*. In this case, the method implementation is defined by the *Director* theme. Another case is when the *BusinessClass* already contains such behaviour (operation implementation is defined in *Business* theme) and the *Director* theme only introduces the relationship and provides information about methods with which the role can be accessed.

Another characteristic of the pattern is the specification scope of the Role interfaces. Interfaces may be specified as global, or as nested in the aspect, which will introduce the relationship between the business class and the role interface. Theme/UML does not provide possibilities to express aspects, so it could not be expressed in Figure 1. These characteristics are depicted in a feature model (Figure 3).

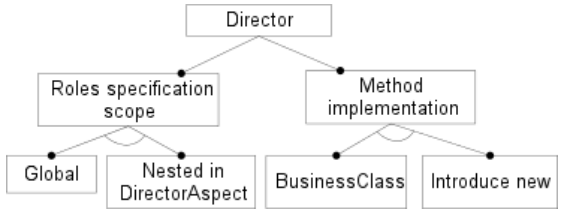

Figure 3. Feature model for Director.

Such model could be used in configuring features of the pattern. Each feature represents a characteristic in the pattern model. In the beginning, there would be a diagram of the pattern filled with all listed features. As for the *Method implementation* feature, the method would be placed in both the *BusinessClass* and the *Owner* (in that case, the *Director* theme introduces this method as a new method in the application). Configuring the feature model, we would get various instances of the pattern.

Choosing the *Introduce new* from the two features *BusinessClass* and *Introduce new* under the *Method implementation*, if the operation method was new and was not defined in the *BusinessClass*, the *Director* theme would introduce it alongside the method implementation and the model of the pattern would look like in Figure 1.

Choosing the *BusinessClass* feature, if the operation method was already defined and its implementation provided in the *BusinessClass*, the *Director* theme would not need to define the method implementation and the model of the pattern would look like in Figure 4. As we can see, configuring the feature model, we can change other models of the pattern and get its specific instance. Therefore, particular models of the pattern are closely tied together.

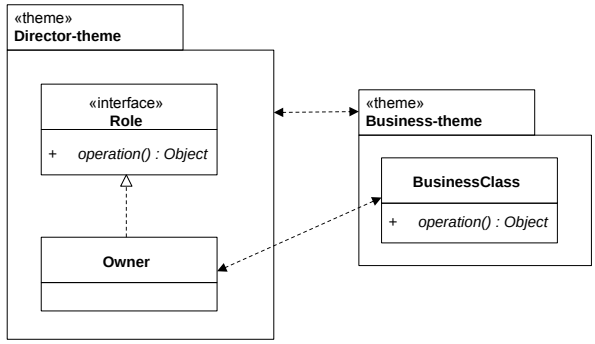

Figure 4. Director modelled using the Theme approach.

6 Related Work

Several works were about aspect-oriented design patterns. However, many of them did not provide a graphic model [5] [10] and those that did, provided graphic models modelled in the object-oriented way [9]. This report tried to analyse modelling approaches that express specific features of aspect-oriented paradigm. Theme approach was selected to be applied on modelling the *Director* design pattern. It was aimed to model the pattern in a general way for aspect-oriented paradigm and avoid creating a model dependant on a programming language.

Some works explored intrinsic aspect-oriented patterns too. Bálik and Vranić analyzed patterns and their symmetric implementation and expressed the patterns in Coplien's form [2]. To generally express a pattern, roles multiplicity was needed to be captured. Marko was exploring pattern instantiation and for constraints and role multiplicity used a role graph [7].

Variability of the pattern was captured with a feature model. Majtás used feature models to capture patterns variants in his report [6]. Menkyna and Vranić used feature modelling for multi-paradigm design to facilitate easier aspect-oriented change realization by enabling direct change manipulation [8]. In this report, feature modelling was used to capture various possibilities of the patterns behaviour.

7 Conclusions and Future Work

In this report, intrinsic aspect-oriented design pattern *Director* was analysed in detail. Existing models of the pattern appeared not general enough and dependant on concrete programming language instead of providing a general expression of the pattern nature.

There are several approaches to modelling aspect-oriented software in a way, in which actions specific for aspect-oriented paradigm are captured. In this report, modelling approach Theme was used to model the *Director* pattern in Section 3. This model is independent of any aspect-oriented programming language, so it is general in sense of being able to be implemented in various aspect-oriented programming languages. The model is just an example model of the pattern, because some features of the pattern could not be expressed using the Theme approach. Since *Director* pattern does not define number of roles that are introduced in the application, generalization in multiplicity of the roles was needed. This was provided by a role graph in Section 4.

Patterns sometimes contain features that are not important for the nature of the pattern, but still can not be avoided in a model. Moreover, sometimes it was not possible to express some features in base models using the Theme approach. Therefore, in Section 5, feature model was used to express the variable features of the pattern and possible impact on pattern models, configuring the feature model, was discussed. Using various techniques in modelling the patterns we can see that if only the Theme approach was used, we could not get as general view of the patterns as we get using also

role graphs and feature models. Combining these techniques, we get a new approach for modelling design patterns, which could be used not only in aspect-oriented paradigm, but in other paradigms as well.

The *Director* pattern was chosen as an example pattern for this report. This pattern does not define behaviour of classes and their methods. Therefore, no behavioural views were provided in the models. However, the *Director* pattern expresses well how a structure of software components could be changed in aspect-oriented paradigm. Other intrinsic aspect-oriented design patterns should be explored to show behavioural views in the models.

In the future, configuring feature models could be analysed in more detail, other intrinsic aspect-oriented design patterns could be explored and a domain study could be provided to show usage of the patterns in the implementation.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/1221/12.

References

[1] Alexander, C.: *A Pattern Language: Towns, Buildings, Construction*. Oxford University Press, 1977.

[2] Bálik, J., Vranić, V.: Sustaining Composability of Aspect-Oriented Design Patterns in Their Symmetric Implementation. In: *2nd International Workshop on Empirical Evaluation of Software Composition Techniques, ESCOT 2011*, Lancaster, UK, July 2011.

[3] Clarke, S., Baniassad, E.: *Aspect-Oriented Analysis and Design: The Theme Approach*. Addison-Wesley, 2005.

[4] Czarnecki, K., Helsen, S., Eisenecker, U.: Staged Configuration Through Specialization and Multi-Level Configuration of Feature Models. *Software Process: Improvement and Practice*, 2005, vol. 10, pp. 143–169.

[5] Laddad, R.: *AspectJ in Action*. O'Reilly, 2010.

[6] Majtás, L.: *Príspevok k tvorbe a rozpoznávaniu inštancií návrhových vzorov*. PhD thesis, Slovak University of Technology in Bratislava, Slovakia, 2011.

[7] Marko, V.: Template Based, Designer Driven Design Pattern Instantiation Support. In: *Advances in Databases and Information Systems*. Volume 3255 of *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg, 2004, pp. 144–158.

[8] Menkyna, R., Vranić, V.: Aspect-Oriented Change Realization Based on Multi-Paradigm Design with Feature Modeling. In: *4th IFIP TC2 Central and East European Conference on Software Engineering Techniques, CEE-SET 2009*.

[9] Miles, R.: *AspectJ Cookbook*. Manning, 2004.

[10] Noble, J., Schmidmeier, A., Pearce, D.J., Black, A.P.: Patterns of Aspect-Oriented Design. In: *Proceedings of European Conference on Pattern Languages of Programs*, Irsee, Germany, Hillside Europe, 2007, pp. 769–796.

Extending the Method of Schedule Shortening for Schedule Simulation

Jaroslav PROKOP*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
prokop06@fiit.stuba.sk

Abstract. This work focuses on schedule shortening method based on minimal graph cut and possibilities of improving schedule simulation by using already obtained data of actual schedule and this method. Besides analyzing existing methods that can be used for schedule progress estimation, we also deal with the problem of insufficient data quantity during beginning phase of a project and schedule realization. We propose extensions of existing methods to reach better schedule progress estimation in terms of tasks and schedule duration. We have introduced grouping of tasks based on contractors. Benefits of these extensions come from the possibility of schedule duration estimation without the need of complex parameters examination.

1 Introduction

Currently there are several methods of schedule duration and cost estimation. Methods of duration estimation are however problematic to use in practice. Reason for this problem is the complex parameters, which are difficult to estimate for every task in a schedule. For example, we need to estimate minimal and maximal task duration, probability density of task duration based on normal distribution and similarly. These parameters are different for every task but can be similar for similar tasks. Task similarity results from contractor (resource) and nature of the task.

In practice, usually the problems of one contractor result in problems with majority of his tasks. Problems can be limited to a certain area of his tasks as for example implementation task in IT or technological task in construction project.

Purpose of this work is to estimate duration of large schedule and to find potentially critical tasks, which can shift schedule deadline. Another aspect of this work is schedule shortening after duration estimation.

2 Related Work

The schedule duration estimation or simulation is described in widely used methods such as *Schedule Performance Index* (*SPI*) [2] and *Monte Carlo* method [4]. Although *SPI* is index based

* Master degree study programme in field: Software engineering
Supervisor: Dr. Marián Lekavý, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

method and *Monte Carlo* is probabilistic method, they both lead to duration estimation of schedule and its elementary tasks. There are also "*what if*" decisions methods [2], but these are not suitable for large projects in practice because number of possibilities of schedule progression. There are principally three types of estimation:

- Index based estimation
- Probability estimation
- "What if" estimation

In case of schedule shortening based on cost, there are methods such as COST/CPM [3] (*COST/Critical path method*) and schedule shortening based on *minimal graph cut* [6]. Principle of these methods is the same, to find cheapest solution to shorten a schedule to reach deadline. Solution is based on shortening individual tasks.

From the point of view of simulation and estimation, there are only several tools. Primavera [8] is the most sophisticated but it doesn't offer possibility of simulation during schedule realization and is not free. There are any other tools used in practice to solve such problem in general schedule. Generally, simulation is used before schedule and project execution to find potential bottlenecks of financial and human resources [8] but without any focus on data obtained from realization. Of course, these data can be put into simulation only by project managers and other relevant people, but they don't because of the lack of time and the lack of reliable experiences and estimations.

3 Schedule Duration Estimation

As we described in previous section, schedule estimation can be probability or index based. These two methods can bring different results. In probabilistic methods it is necessary to declare probability density distribution and result is then probability distribution of tasks and schedule duration [7]. Problem with probability is that we need exact parameters of density distribution or enough data to create such distribution. We will discuss amount of data needed later. Advantage of probabilistic result is that we can calculate probability of any duration result. Another disadvantage of probabilistic methods related to amount of data is that it is more suitable for larger schedules. This is advantage of index based methods. They do not need any specific amount of data or number of finished tasks.

3.1 SPI Method Extending

Schedule performance index is very easy to use method in terms of needed parameters and data. Index is calculated from finished tasks [2]. Index is quotient of sum of real duration d_i and sum of scheduled duration s_i of task i (see Formula 1 [2]).

$$SPI = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} s_i} \tag{1}$$

Considering large project problems, there can be these two major situations:

- Individual contractor has specific problems with his tasks
- Problems with certain area (*Group*) of tasks

These situations can lead to potentially big variance of SPI estimation, especially if lagged tasks are not on critical path. It may also occur opposite situation when almost all contractors are working on time or in advance and only few of them are producing time lags. If these time lags lay

on critical path, it is obvious that project deadline is in danger. In default SPI, these lags are compensated by other tasks, although they are not located in critical path or in important groups of tasks. We solved this problem by extending *SPI* method by dividing tasks between contractors or groups. Despite this division of tasks, we will count *SPI* (see Formula 1 [2]) and also our extended SPI (see Formula 2). In Formula 2, d_i^t represents real task duration where task belongs to group *t*, s_i^t represents scheduled duration of task *i* where task belongs to group *t.*

$$SPI_t = \frac{\sum_{i=1}^{n} d_i{}^t}{\sum_{i=1}^{n} s_i{}^t} \tag{2}$$

In our extended *SPI*, we are counting *SPI* for every single group of tasks. This group is based on contractor or on specified group of task. Task durations are calculated and assigned separately for every group:

- SPI_t (see Figure 2) for every task of group *t* with at least one finished task
- *SPI* (see Figure 1) for every task of group without finished task

This separation leads to elimination of variation in not important tasks.

3.2 Monte Carlo Density Duration Estimation

Monte Carlo method [4] needs probability distribution of every task's duration. This can be defined as parameters for normal or other distribution [9]. Optimistic, optimal and pessimistic duration [4] are often used as parameters for input distribution. Another option which we are using to create distribution is to calculate distribution of finished tasks of individual contractor or defined group of tasks.

Similarly to previous section of SPI extending, groups of tasks are created based on individual contractors. Distribution is calculated for each group separately and also for the whole schedule. This is due to lack of data in groups which were not realized yet.

We count probability distribution *p* of selected group of *n* finished tasks as kernel estimator (see Formula 7) with normal kernel *K* [4], [9] (see Formula 6). *x* represents task's lag of duration. Width *u* of kernel estimator is counted as *normal distribution approximation* [9] (see Formula 5) where σ represents variance of input data [4] (durations of tasks) and μ is mean of input data (see Formula 3, 4 [4]).

$$\mu = \frac{1}{n}\left(x_1 + x_2 + \ldots + x_n\right) \tag{3}$$

$$\hat{\sigma} = \sqrt{\frac{1}{n}\left[\left(x_1 - \mu\right)^2 + \left(x_2 - \mu\right)^2 + \ldots + \left(x_n - \mu\right)^2\right]} \tag{4}$$

$$h = \left(\frac{4\hat{\sigma}^5}{3n}\right)^{\frac{1}{5}} \tag{5}$$

$$K(u) = \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{u^2}{2}\right] \tag{6}$$

$$\hat{p}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x^i}{h}\right) \tag{7}$$

After calculations, we have these results:

- Distribution of every defined group of tasks with at least one finished task
- Distribution of the whole schedule

In this step it is crucial to define minimum number of finished tasks for group generally. If there are not enough finished tasks in individual group yet, we will use distribution for the whole schedule. Otherwise we will use distribution of corresponding group. Distribution has to be assigned to every task in every group.

During the simulation we are generating random numbers of every task's duration based on its distribution [5]. Generating of duration iterates through the whole schedule. After one generation of durations for the schedule is completed, critical path is calculated. Obtained schedule length is stored as an input for creating schedule duration distribution. We repeat this process of generating and calculating for as many times as needed to obtain accuracy. Usually there are 500-1000 iterations [1] of the schedule's duration generation for one simulation.

3.3 Results of SPI and Probability Distribution

We have applied our extended SPI and probability density distribution to real schedule. Size of the schedule is over 1200 tasks, contains 25 contractors. We took into account every week update of schedule. It was technological construction project containing building, construction, technological and testing tasks. Groups are based on technological aspect of tasks.

In the following example, we included only contractors with more than 25 finished tasks in 40th week schedule actualization and one example group of technological tasks (see Table 1 and Table 2). Other tasks have been assigned to global SPI and probability density distribution.

Table 1. Column names of Table 2.

	Column name
A	Number of finished tasks in 40th week
B	Number of all tasks
C	Kernel estimator width of 40th week schedule (see Formula 7)
D	Kernel estimator width of finished schedule (see Formula 7)
E	Mean of 40th week schedule (see Formula 3)
F	Mean of finished schedule, 75th week (see Formula 3)
G	SPI of 40th week schedule (see Formula 2)
H	SPI of finished schedule, 75th week (see Formula 2)

Table 2. Results of kernel estimation and SPI.

Group	A	B	C	D	E	F	G	H
Contractor1	178	189	347	400	79	77	1.102	1.080
Contractor 2	60	240	99	85	103	73	1.452	1.362
Contractor 3	28	94	61	289	34	74	1.175	1.538
GroupB	70	214	87	134	102	100	1.354	1.238

As it is obvious from columns *G* and *H* (see Table 1 and Table 2), project was lagging. Lag of selected contractors was generally bigger in the middle of the project realization than in the end.

When comparing column *E* with column *G* and column *F* with column *H*, it is clear that tendencies of growth of distribution mean and of SPI are similar.

Kernel density estimation is counted as percentage lag of duration of tasks (see Figure 1, 2).

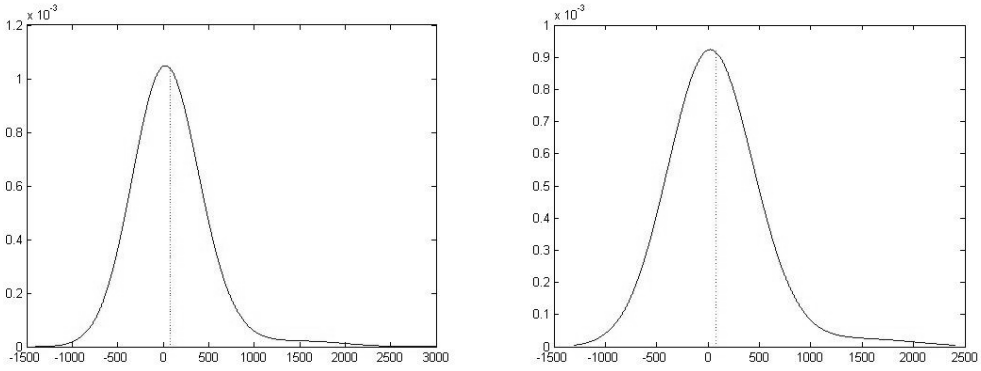

Figure 1. Contractor1 density distribution in 40th (left Figure) week and in final state (right Figure).

Kernel estimation of *Contractor1* (see Figure 1) shows that tasks of these contractor are rather lagging (*mean>0*). There are several tasks with very big lag and therefore graph is shifted on the right side of *x* axis.

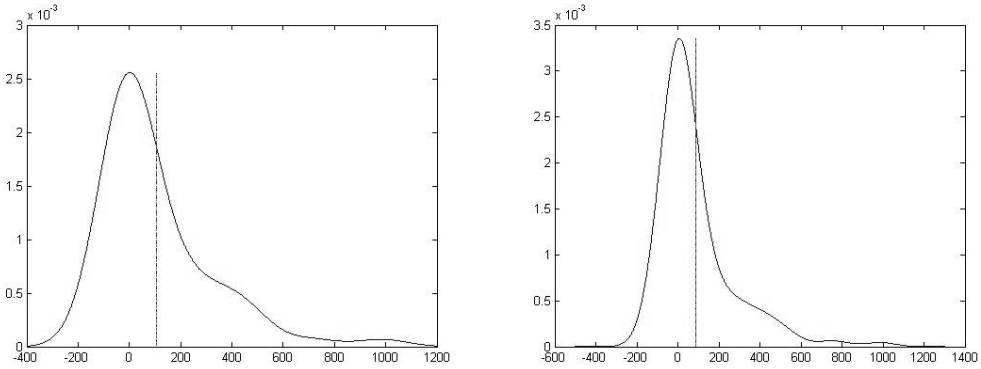

Figure 2. Contractor2 density distribution in 40th (left Figure) week and in final state (right Figure).

Kernel estimation of *Contractor2* (see Figure 2) shows that tasks are lagging and also there are several shifts on the right site of the graph. This is caused by individual problematic contractor and project management behavior on this specific project. In ideal case, the kernel estimation distribution with normal kernel is similar to normal distribution. In this case it is not. It is obvious that tasks have been divided into several groups by importance (management action). Tasks with low importance had very big lag over 200%. Tasks with higher importance had smaller lag about 20%. This percentage of lag of important tasks can be counted only if non critical tasks are excluded from the calculation.

3.4 Evaluation Price for Shortening

Price per time unit of the shortening can be determined by percentage of duration lag of the task. One of the possible strategies is to set higher price for tasks with lower lags and lower price for

tasks with higher price. We will get all critical tasks that are shifting project schedule potentially. Time lags are obtained from schedule simulation or SPI calculation.

4 Evaluation and Conclusions

We verify correctness of proposed extensions of methods via calculation realized on real schedule. We compared three aspects of results:

- *SPI* index
- Distribution based on kernel normal estimation
- Practical experience from schedule and project realization

Comparison shows that *SPI* and distribution shows that they both have similar tendency to lag or overtake when used in same group of tasks. Our results show that progression of individual contractors was problematic. It is evident from variances of distributions and big *SPI* and mean of distributions. These results are consistent with real result of schedule.

Proposed method extensions were made in order to simplify using of these methods in practice. It is clear that methods which need many parameters to be estimated are very difficult to use. *SPI* and *Monte Carlo* estimation methods can be used in practice with ours extends. Input parameters are calculated from obtained data of previous schedule actualization. However it is necessary to divide tasks into groups based on contributors or other aspects that are common for specific area of tasks.

Acknowledgement: This work was partially supported by the Science and Technology Assistance Agency under the contract No. APVV-0233-10.

References

[1] Araúzo, J.A., Pajares, J., Lopez – Paredes, A.: *Simulating the dynamic scheduling of project portfolios.* Simulation Modeling Practice and Theory, (2010), Vol. 18, pp. 1428–1441.

[2] Chatzoglou, P., Macaulay, L.: *A review of existing models for project planning and estimation and the need for a new approach.* International Journal of Project Management, (1996), Vol. 14, pp. 173–183.

[3] Fiala, P.: *Project management – models, methods, analysis.* Professional Publishing, Praha, (2004), ISBN 808641924.

[4] Hendrickson, Ch.: *Project Management for Construction.* Prentice Hall, (1989), ISBN 0137312660.

[5] Hormann, W., Leydold, J.: *Automatic random variate generation for simulation input.* In: Proceedings of the 2000 Winter Simulation Conference, (2000).

[6] Lekavý, M., Návrat, P.: *Extension of Rescheduling Based on Minimal Graph Cut.* Springer Berlin / Heidelberg, (2008), ISBN 9783540775652.

[7] Malcolm, D. G., Rosenbloom, J. H., Clark, C. E., Fazar, W.: *Applications of a Technique for R and D Program Evaluation.* Operations Research, (1959), Vol. 7, No. 5, pp. 646–669.

[8] Oracle, *Primavera project management application.* [Online; accessed January 20, 2012]. Available at: http://www.oracle.com/us/products/applications/primavera/index.html

[9] Silverman, B.W.: *Density Estimation for Statistics and Data Analysis.* Chapman & Hall, London, (1998), ISBN 0412246201.

Appropriate State Evaluation in the Battleship Game Strategy

Ladislav CLEMENTIS*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
clementis@fiit.stuba.sk

Abstract. Board game called Battleship can be divided into three main tasks. One of these tasks is effective destruction of enemy ship after first hit. From the point of view of optimization problems we can imagine our current view of enemy battlefield as a current problem space instance. If we imagine a player shooting the enemy battlefield, it is an action. Our goal is to choose the unrevealed part of enemy battlefield wisely, to increase probability of a hit. This task can by supported by pattern matching approach. This work is focused closely on hit probability strategy model of the Battleship game.

1 Introduction

The Battleship game can be apparently divided into three basic tasks. The first task is to initially deploy our ships in the battlefield. The second task is to initially hit some of hidden enemy ships in unrevealed territory of the enemy battlefield. The third task is to sink damaged enemy ship by its complete destruction. Each of these three tasks should have some strategy if we want to increase the probability of our victory.

In this work we focus on the third task, to effectively destroy the whole enemy ship, which is already damaged – its part is already hit. Our view of enemy battlefield is our current state. This state includes unrevealed territory of enemy battlefield and partially destroyed enemy ship (and maybe already destroyed ships, which is irrelevant for now). Player shoots into unrevealed enemy territory. The shot, be it a hit or a miss, results in revealing part of enemy battlefield. This new view of enemy battlefield where newly revealed part is incorporated in is our new state. Set of possible actions that includes all possible next shot positions we can imagine as a wide multiple decision tree. Almost each action could lead us to both of resulting state options. Our goal is to pick next hit position wisely to increase our successful shot (or hit) probability.

As a first step we have to filter the set of available positions so we get the set of possible next shot positions, remaining only those which can possibly contain unrevealed part of already damaged ship. Second step for us is to evaluate possible positions from remaining set, based on

* Doctoral study programme in field: Applied Informatics
Supervisor: Professor Vladimír Kvasnička, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 281–287.

some technique. Note that we can have some deterministic or also some stochastic approach to this technique. As a remaining step we have to somehow pick one of evaluated positions. Next in this work we discuss some alternatives of evaluated positions picking techniques and probability based evaluation technique model.

2 Simple Problem Space Definition

To make our example more readable and more understandable, let us define the very simple example of the enemy battlefield. Let it be the square area – a matrix with size of seven times seven positions. Let our enemy have two ships (for us randomly or unknown way but with respect to the Battleship game rules) deployed in his battlefield. Let each of his two ships be same size of one times three positions.

The simplest case of partially destroyed ship which gives us minimal information is one successful hit in middle of unrevealed enemy battlefield. In our case we can achieve this state by shooting the enemy battlefield randomly until we hit a part of enemy ship. After some time of shooting randomly – sooner or later – the enemy ship is hit by our shot. This is our initial state. Now we can begin to discuss our next steps.

3 Initial Current State Evaluation

According to enemy battlefield definition specified in section 2, let us have initial problem space shown in Figure 1, but with no first successful hit attempt done.

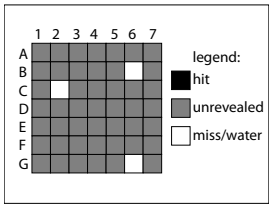

Figure 1. State of battlefield after three unsuccessful shots.

As shown in Figure 1, after random shooting at position B6, C2 and G6 we still have not hit any of two enemy ships. So we shall keep shooting (randomly in our simplified case). Note that soon as we finally hit first part of enemy ship there are theoretically six possible location options of damaged ship shown in Figure 2. Let us call them *Oa, Ob, Oc, Od, Oe* and *Of*. First three of them – *Oa, Ob* and *Oc* – are horizontally oriented and other three remaining options – *Od, Oe* and *Of* – are vertically oriented.

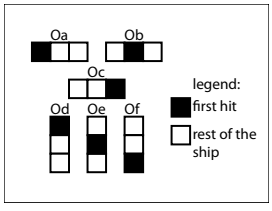

Figure 2. All real possible ship positions after first successful hit.

The first successful hit by shot aimed at position D4 is shown in Figure 3. It is obvious (because of two unrevealed positions in each possible direction of D4) that we know nothing about ship's orientation and just that ship covers position D4. So the hit position and ship's orientation can be any of options previously shown in Figure 2.

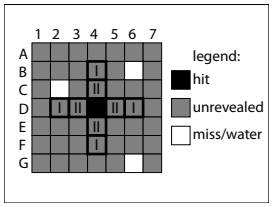

Figure 3. State of battlefield after first successful hit to D4.

The area in the battlefield that completely covers damaged ship is marked by bold lines as shown in Figure 3. Each position in this area has a number of flag marks placed in it. This number gives us covering rate for each position. For example B4 position has one flag mark because there is only one possible ship location option – Of that covers initial hit (D4) position and B4 position. Otherwise C4 has two flag marks because this position is covered by two ship location options – *Oe* and *Of*.

As each of six ship location options (corresponding to our initial hit position D4) have the same probability to be in this case, we can use number of flag marks to evaluate probability that specific position is covered by ship initially hit by D4. Probability for each position to be covered by our damaged ship is counted as a number of flag marks for that position divided by the sum of all flags in the area. Table 1 shows us non zero covering probabilities of possible positions which may be covered by ship (initially hit by D4).

Table 1. Next non zero hit probabilities after first successful hit to D4.

Square to shoot	Number of flag marks	Hit probability	Covering probability
B4	1	1/6	1/12
C4	2	1/3	1/6
D2	1	1/6	1/12
D3	2	1/3	1/6
D5	2	1/3	1/6
D6	1	1/6	1/12
E4	2	1/3	1/6
F4	1	1/6	1/12
$\sum$	12	2	1

From covering probabilities we can calculate hit probabilities for every possible position by multiplying it by number of remaining (unrevealed) parts of damaged ship. Values of hit probabilities are also shown in Table 1.Note that sum of all hit probabilities is two. That happens because we are looking for two remaining parts of already damaged ship.

4 The Simple Decision Process in Use

As is shown in Table 1, most probable positions for successful hit are C4, D3, D5 and E4. We can also use some of stochastic approaches to choose position to shoot at in this state. For example roulette technique. In our simple case we choose one of most probable positions randomly. We

choose D3. But shooting at position D3 was unfortunately unsuccessful. Our state as it changed is shown in Figure 4.

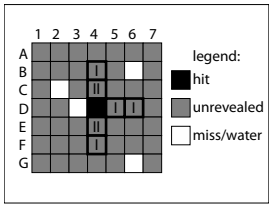

Figure 4. State of battlefield after unsuccessful shot to D3.

Now we can see that not only position D3 is marked as impossible position for next shooting but also D2. It is obvious that current state is not matching ship location options *Ob* and *Oc*. Only matching ship location options for our current state are *Oa, Od, Oe* and *Of*.

Another change that occurred is the number of flag marks for position D5. Position D5 was previously covered by ship location options *Oa* and *Ob*. Now both of positions D5 and D6 are covered by ship location option *Oa* only. Hit probabilities have changed as is shown in Table 2.

Table 2. Next non zero hit probabilities after unsuccessful shot to D3.

Square to shoot	Number of flag marks	Hit probability	Covering probability
B4	1	1/4	1/8
C4	2	1/2	1/4
D5	1	1/4	1/8
D6	1	1/4	1/8
E4	2	1/2	1/4
F4	1	1/4	1/8
$\sum$	8	2	1

Now we choose one of two positions with highest hit probability – C4 or E4. For example, we choose C4. Hit! Our current state is shown in Figure 5.

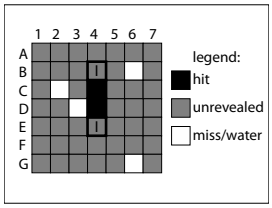

Figure 5. State of battlefield after second successful hit to C4.

Our research has shown that eight of ten asked respondents would rather shoot at position D5. We think it is because their vision of fast ship destruction if shooting to position D5 would be successful (hit position D6 would be obviously successful in that case), what matches ship location *Oa*. But not in this case.

Shooting to position C4 or E4 is more probable to be successful. Now we can see that our state has rapidly changed. There is only one unrevealed part of ship and only two possible positions where it can be hidden. Remaining possible ship location options are *Oe* and *Of*, corresponding with first

hit position. Ship location options *Oa* and *Od* are now no longer considered. New hit probabilities have changed as shown in Table 3.

Table 3. Next non zero hit probabilities after successful hit to C4.

Square to shoot	Number of flag marks	Hit probability	Covering probability
B4	1	1/2	1/2
E4	1	1/2	1/2
$\sum$	2	1	1

Now we can see that hit and covering probabilities have the same values because only one unrevealed ship part remaining. Position B4 is covered by ship location option *Of* and position E4 is covered by ship location option *Oe*. Next shot will be successful (or not) with probability 1/2 even if we choose to shoot at position B4 or E4. However now we can say for sure that we need two shots at the most to destroy the first ship. We were lucky, as we had chosen B4. Our next state is shown in Figure 6.

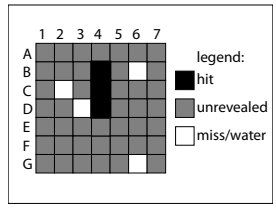

Figure 6. State of battlefield after third lucky successful hit to B4.

Now we can make some clearing because there are positions in the battlefield of which we are certain they do not contain part of the second ship (according to the Battleship game rules). Of course without shooting them away. Clearing is shown in Figure 7. Now every one unrevealed position in the battlefield can be hiding the second enemy ship.

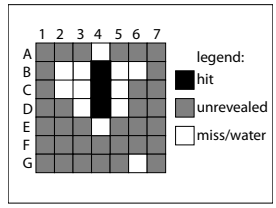

Figure 7. State of battlefield after clearing without need to shoot.

5 The Simple Decision Process With Advanced Boundaries

For showing us another model situation, our next pseudo-random shot was surprisingly successful. We hit a part of second enemy ship deployed in battlefield. Shot was aimed at position F1. Our current state is shown in Figure 8. We have done same ship location option matching. According to ship location matching we have done same flag mark placement, covering probabilities and hit probabilities for all next possible shot positions.

Table 4 shows us hit and covering probabilities after initial hit to the next ship. Only position covered by more than one ship location option is E1 – it is covered by *Oe* and *Of* ship location options.

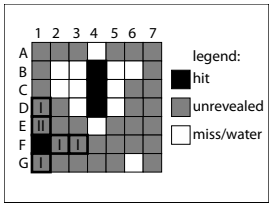

Figure 8. State of battlefield after successful hit to the next ship on F1.

Table 4. Next non zero hit probabilities after successful hit to next ship on F1.

Square to shoot	Number of flag marks	Hit probability	Covering probability
D1	1	1/3	1/6
E1	2	2/3	1/3
F2	1	1/3	1/6
F3	1	1/3	1/6
G1	1	1/3	1/6
$\sum$	6	2	1

Now we choose position E1. But luck is not on our side this time. Miss! Although position E1 had the highest probability of holding next ship part, it did not. The point of this probability model is to reasonably increase hit rate in decision process of destroying a single ship. The attempt itself was not bad. It also helped us to reveal positions of two remaining parts of the second ship as it is shown in Figure 9. The current state matches only *Oa* ship location option.

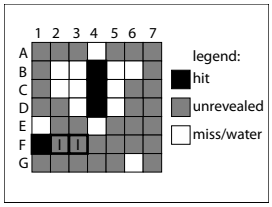

Figure 9. State of battlefield after unsuccessful shot to E1.

Table 5 shows us that both positions F2 and F3 have the same hit probability of value 1 because it is certain that each one of them is containing remaining part of the second ship. We can choose position F2 or F3 in any order to hit them one by one with 100% success rate it this state.

As soon as there is no other ship hidden under unrevealed enemy battlefield territory we have won. There is no need to do clearing again at all, however clearing can by useful while dealing with first task – search for next ship to get initial hit while some positions, where ship can not be at all, could appear. The good question now is whether our opponent finished destroying our fleet faster than we finished destroying his two ships.

6 Conclusions

State evaluation or state-action evaluation like this example of probability decision model is essential by attempting evaluating decision process. Evaluating action value upon current state should be based

Table 5. Next non zero hit probabilities after unsuccessful shot to E1.

Square to shoot	Number of flag marks	Hit probability	Covering probability
F2	1	1	1/2
F3	1	1	1/2
$\sum$	2	2	1

on some model if we want to guarantee statistically better results. Especially if we know only current state, possible actions and basic rules, but not always which state we get if we attempt an action.

We can talk about if-then-else rule based system where rule is used when satisfying input conditions with some probability which could be learned. Other example system in which rules are not so visible is neural network [2, 4] which could be learned by our probability model. Input can sometimes obviously lead us to some result which is rarely but with non zero probability possible in all types of systems like these. Other mentionable system is Learning Classifier System (LCS) [1] introduced by John Holland as a combination of genetic algorithm and rule-based system.

There are situations (based on partially visible problem space) in which we can not make right decision with 100% guaranteed success but our goal is to achieve statistically better results as was shown in our example. Imagine much bigger battlefield with many ships of many types and different counts are deployed. Our example was trivial but good to explain our thoughts. Further readings on complex decision making and its impacts can be found in [3]. Our probability model of more complex Battleship game definitions remains based on the same idea.

Acknowledgement: This work was partially supported by the VEGA (Slovak Scientific Grant Agency) of the Ministry of Education of the Slovak Republic (ME SR) and of Slovak Academy of Sciences (SAS) under the contract No. VEGA-1/0554/12 and No. VEGA-1/0553/1.

References

[1] Holland, J.H.: *Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control and Artificial Intelligence*. MIT Press, Cambridge, MA, USA, 1992.

[2] Kriesel, D.: *A Brief Introduction to Neural Networks, Zeta version*, 2007, available at http://www.dkriesel.com.

[3] Qudrat-Ullah, H., Spector, J., Davidsen, P.: *Complex decision making: theory and practice*. Understanding complex systems. Springer, 2008.

[4] Smith, M.: *Neural Networks for Statistical Modeling*. 1st edn. Thomson Learning, 1993.

An Approach to Partial Formalization of SOA Design Patterns Using Production Rules

Roman ŠELMECI*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
selmeci@fiit.stuba.sk

Abstract. Service oriented architecture (SOA) is nowadays one of the dominant styles for creating new information systems with many benefits such as standardized service contract, service reusability, service statelessness etc. Design patterns have been also identified in SOA by T. Erl. SOA design patterns are represented in form which is suitable for humans, but not for computers. In this paper we present our approach to partial representation of SOA design patterns using production rules.

A paper based in part on this paper was published in Proc. of the Federated Conf. on Computer Science and Information Systems (FEDCSIS'12), IEEE, Piscataway, 1381-1384.

* Doctoral degree study programme in field: Software Engineering
Supervisor: Assoc. Professor Viera Rozinajová, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

Computer Systems, Computer Networks and Security

NetLogo – an Alternative Way of Simulating Mobile Ad Hoc Networks

Miroslav BABIŠ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
mirroloid@gmail.com

Abstract. The characteristics of mobile ad hoc network result in necessity of using the simulation for verification of newly proposed concepts in mobile ad hoc networks. Traditional network simulators are oriented towards low level simulation, which leads to various difficulties when these simulators are used for simulation of high level aspects of mobile ad hoc networks. This paper proposes the use of multi-agent programming language NetLogo for simulating high level aspects of mobile ad hoc networks. Applicability of this tool is demonstrated by simulating and evaluating security criteria of various public key infrastructure approaches in mobile ad hoc network in NetLogo.

A paper based in part on this paper was published in Proc. of 5th Joint IFIP Wireless and Mobile Networking Conf. (WMNC'12), IEEE, Piscataway, 122-125.

* Master degree study programme in field: Computer Engineering
Supervisor: Peter Magula, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

A New Electronic Presentation System for Design and Test

Matej HLATKÝ, Valter MARTINEK*

Slovak University of Technology
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
matej.hlatky@gmail.com, martinek@freevision.sk

Abstract. Today there are many different types of electronic presentation systems that make education more attractive for students and more comfortable for lecturers. Current technologies include Tablet PCs with new input – touch-screen display with stylus. This allows teachers and students modify the educational materials, but students are still not active in the education process. In addition, the presentation systems are implemented more generally and the lecturer has to prepare all materials and pictures before his/her presentation. This paper presents a new interactive electronic educational system that uses Tablet PC, primarily targeted for design and test topics. This system allows integration of interactive work with students based on real-time textual and graphical anonymous polls. Students can also make their own remarks and save the new modified presentation. The developed presentation system was evaluated and shows very good and useful feedback from students.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 32-34.

* Master degree study programme in field: Computer Engineering
Supervisor: Assoc. Professor Elena Gramatová, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

Application of GPS Device as a Tourist Guide

Martin JÁNOŠ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
tinomar@gmail.com

Abstract. In this paper we describe the application of tourist guide for usage in a GPS device. A GPS device in automobile traffic creates navigation system and belongs among telematic applications. Telematic applications combine the features of telecommunications and informatics systems. In these devices many types of specific software services run, e.g. MOD (Media on demand). The MOD product deals with multimedia content viewing during the vehicle driving. MOD can be extended with new properties which includes route scheduling, classification of points of interest from cultural, leisure, whether a user defined aspects. Main goal of this research is to provide an analysis in this area and propose the solution for usage telematics applications and GPS technology in real life.

1 Introduction

Living in this age of growing automotive and technology bears us many possibilities of their usage. They are very helpful for orientation in known or unknown area. But this is not the only activity that these technologies do. The navigation from point A to point B is not enough, of course. The passengers often want to entertain during transport. Moreover they can improve their knowledge of passing area. And this is one of the many challenges to make the journey more interesting. This is according to nowadays´ trends making systems multifunctional.

More telecommunications and informatics systems, known as telematics, are being integrated into the vehicles in a rapid manner. An automotive telematics platform consists of five key components: location device, communication device, entertainment device, vehicle interface and user interface. The location device, which includes the GPS (Global positioning system) as the key element, is crucial in providing the position for all location-based services, which include: roadside assistance, airbag deployment notification, routing assistance, convenience services, emergency assistance, stolen vehicle tracking, remote door unlocking, and remote vehicle diagnostics [1].

Generally, a MOD system allows the user to request video or music and have it played back without interruptions and after little or no delay. MOD means that the content starts playing back from the beginning or from some specified point as opposed to joining a transmission in progress. Typical MOD server traffic is usually placed on vehicle's board as in case of Funtoro company which delivers appropriate devices creating MOD connection in cars, buses and trains. The MOD

* Master degree study programme in field: Computer Engineering
Supervisor: Peter Pištek, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

server's interfaces communicate with external entities via various I/O ports, e.g. SD, USB, AV IN/OUT, VGA, IR, RS232, RJ45 LAN Port, GPS SMA Port and many optional such as WiFi or Bluetooth [2].

This solution should be capable to process geospatial data, show it to user, notify nearby POI and increase the cultural awareness.

2 Map display formats

For digital computer use, there are basically two display formats used for maps. These are bitmap maps and vector maps. Each of these map forms can be augmented with a POI database as well. Because of downloading data from Google Maps[1] for off-line usage is restricted, OpenStreetMap[2] project is the better solution.

2.1 Bitmap images

Bitmaps, also known as raster images, can certainly be used as maps. We can use a drawing of a map or we could even use an actual photograph as a map. Computer processes these images as pictures, only user interprets them as a map. There may be roads indicated on the map, or buildings, or water, or any number of other things but the computer simply knows about the image color of individual pixels and nothing about how we are interpreting it. This is one of the big limitations in using bitmaps as maps. The big advantage of raster image maps is that we can generally get maps from anywhere in the world if we are willing to scan them in ourselves. We also have full control of the detail [3].

2.2 Vector images

Unlike the case of bitmap drawings there are no standard formats for mapping databases that are used by the mapping vendors. Each one has an internal form that in proprietary and thus one database is designed to only work with one program. For this reason we will generally only use the database that was supplied with the program user bought. Some vendors change the format from year to year so we can only use maps supplied by that version of the program. Some programs can use multiple databases but usually only from the same vendor. In a few cases we may find that the form of the database is documented or just stored as easily interpreted text and we can alter or create our own database entries. Unfortunately because of the size and complications of the database, even when documented, most users would find this to be a formidable task. Even a vendor can change format within the database. For example the database format on the PC may be different from the structure of the information data downloaded into the GPS device. The program performs a translation during the download [3].

3 POI

A point of interest or POI is a feature on a map that occupies a particular point, as opposed to linear features like roads or areas of landscape. A point of interest is not necessary very *interesting*, so, for example, post boxes are relatively interesting / uninteresting, depending on context and your subjective opinion. The term POI is actually quite imprecise, but is widely recognised by users of satellite navigation systems who are often presented with options to show or hide points of interest. Some example of types of POI:

- Churches, schools, town halls, distinctive buildings, tourist attractions
- Post offices, shops, postboxes, telephone boxes, speed cameras

[1] http://maps.google.com/
[2] http://www.openstreetmap.org/

- Pubs (pub names are useful when navigating by map)
- Car parks and lay-bys (and whether free or not)

OpenStreetMap has an element type of POI: node which has geographic coordinates. Nodes are certainly used to represent POIs, but the concepts are not placed directly across the map. For example nodes are also used as part of ways to represent linear features. All standalone nodes (nodes that are *not* part of a way) as representing points of interest can be regarded; however, a point of interest can actually be part of the way, for instance, a railway level crossing.

We will need to look at the tags of nodes to see what type of POI is being represented, and perhaps we can regard any node which has tags applied to it, as POI. Most nodes which are just part of way, do not have tags applied to them (tags are applied to the way), but a node for a railway crossing *will* have a tag: *railway=crossing*. This is still not all, because features which we might think of as POIs are in some cases (and increasingly more frequently with the availability of more high resolution imagery) drawn as areas. Data users might try to simplify areas down to a centroid point. Some devices (satnavs, GPS units, SmartPhone apps) will support display of POIs provided you can load them in the required format [4]. Example of a node element structure is shown below.

```
<node id="25496583" lat="51.5173639" lon="-0.140043" version="1"
changeset="203496" user="80n" uid="1238" visible="true"
timestamp="2007-01-28T11:40:26Z">
    <tag k="highway" v="traffic_signals"/>
</node>
```

4 Related work

There are many similar systems which use GPS device for the purpose of determining the device's current location on Earth. We can divide these systems to various categories: commercial or noncommercial, map storage is on board (off-line) or we need Internet connection to browse map's content.

The OpenstreetMap Wiki page[3] shows us comparison of many projects run on Windows Mobile or Android devices. These projects are capable in tracking, navigating, displaying map in vector or bitmap form, making track, monitoring, supporting of many languages, storing map data on-board or off-board (downloaded from Internet), map rotation, 3D mode of view, navigating to certain point, finding location, finding nearby POIs, voice or graphical navigating along predefined or calculated route. Many transports as car, bike, even foot, are supported in routing. Additional features includes turning restrictions, navigation with voice keep on road, showing current track, opening existing track, making altitude diagram, sending current position via SMS, uploading current position and data logging. We found among them free and proprietary licenses.

Among commercial solutions belong products from vendors of navigation hardware as Garmin[4], TomTom[5] and iGO[6]. POIs (in the Garmin devices) are usually stored in the same file with map data. BMW makes its own navigation system which except mentioned features can optimize planned route or avoid traffic congestion and right then navigate to the appropriate detour [5].

[3] http://wiki.openstreetmap.org/wiki/Software/Mobile/
[4] http://garmin.com/
[5] http://www.tomtom.com/
[6] http://igomyway.com/

5 Proposed System architecture

Our solution consists of several components such as embedded system device, GPS antenna and monitor with touch screen. The basic hardware architecture is shown in the Figure 1, while the Figure 2 describes the data flow of the whole system running on the device. In this place is important to notice that the monitor fulfils two task as display unit an as a interface for sending commands from user. The network connection is rather a option because map is stored onboard and we must establish connection only for the purpose of downloading new tiles. This feature makes application also capable to work in areas without connection.

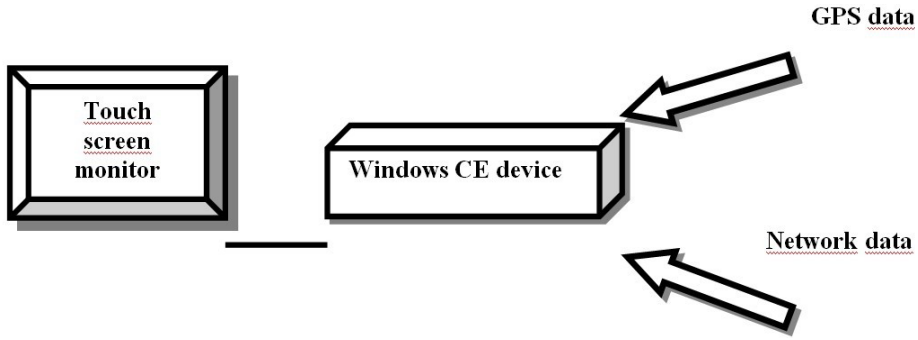

Figure 1. Hardware architecture.

5.1 Embedded system application

The embedded system application is built on BV-105 infotainment box with Samsung 6410 processor. This platform is using Windows CE 6.0 operating system. Because of this we decided for Microsoft Visual Studio 2008 as development environment. This environment offers many useful tools for application debugging, device connection, file viewing, registers editing.

This solution uses GPS Port serves for getting location information, while via LAN port we can download map data. The obtained GPS data are analyzed and in binary form for the purpose of obtaining position parameters as latitude, longitude, heading and so on.

A touch screen display is connected to the device. Its main purpose is to show current location on map, route statistics and to provide application control by graphical element, e.g. buttons. The graphical user interface in current time consists of map and settings windows. The map consists of many pieces called tiles, small images with dimension 256x256 pixels. Tiles are downloaded from selected tile storage server and stored on board for later usage. This could be very helpful for hiking, family excursions or trips in final stage of this project.

The user will be able to start and stop GPS and network communication, manually scrolling map to achieve desired location and zooming the map. The main requirements of the user interface are intuitiveness, effectiveness and usability.

Figure 2 shows how data flow through several layers. Using layers makes data flow more comprehensible. Physical layer contains serial and network interface and we work here with binary “raw” data. These data are received from either GPS antenna connected to device via serial interface. Then they are loaded and sent to logical layer in the form of NMEA sentence [6]. This sentence is an ordinary string containing desired location data to be parsed. In the Processing stage we parse string and thereby obtain location data as latitude or longitude. Others functions of Logical layer monitors a cursor position by manual map scrolling and loading map tiles from appropriate storage file to create the whole map. Presentation layer serves for displaying results from NMEA data parsing on the map, these are sent to monitor in form map, text and icons (POI). Work with POIs included their sorting according to many categories as culture, social life and free-time activities or sport. So after this we can select to display only what we want. For POI

storage was chosen file format used by OpenStreetMap project for simple reasons such as easy to read, widespread usage and future changes. This layer also provides display of current track allowing us to easy recognize what places we have invited already.

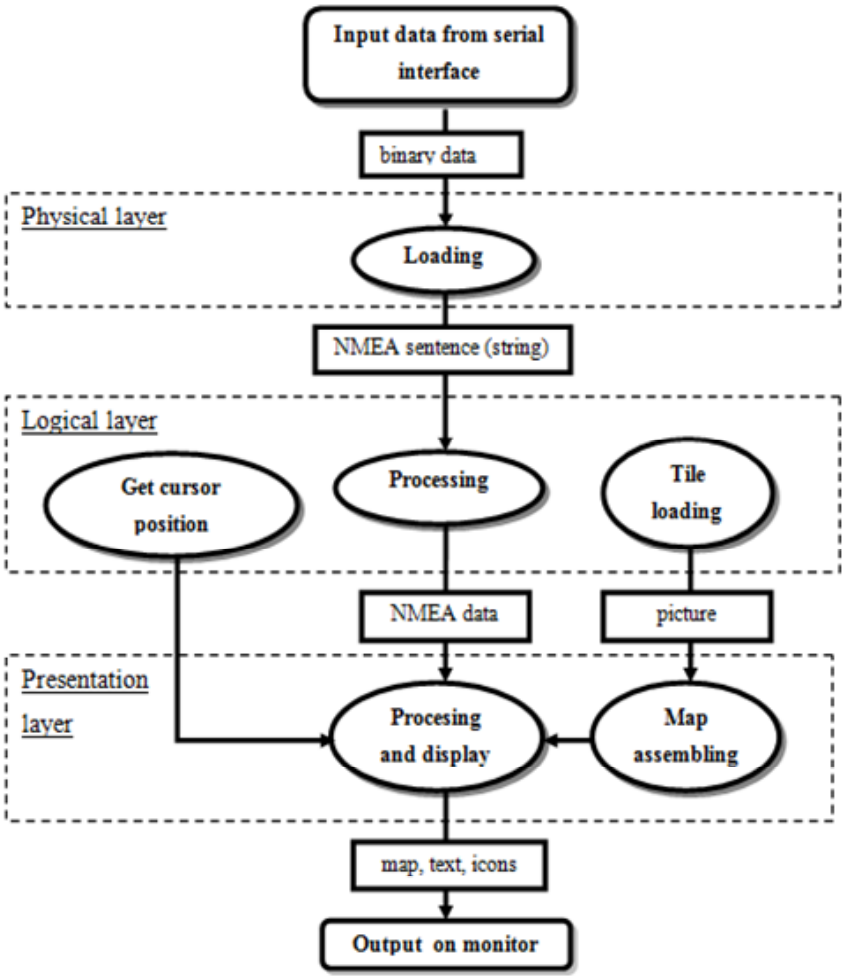

Figure 2. Data flow diagram.

6 Conclusion

At the beginning of this paper we introduced and explained the term “telematics applications” as a connection between informatics and telecommunications. They are closely related to GPS technology which allows collection of location information. Abbreviation MOD means media on demand. This product provides streaming of audio or video data in cars, buses, planes or trains. It can be extended by adding new features as abovementioned location services. Embedded on appropriate devices creates a whole telematics application architecture. We focused on displaying of current map position and work with so called POIs (points of interest) and route tracking. Maps can be obtained from many ways: either prerendered (predrawed) from Internet or from file with specific format stored in device directory. Commercial solutions use mainly second options, whilst non-commercial or free project display data on-line. Offline map browsing is possible too by

downloading map divided to many pictures called tiles. We also mentioned some existing solutions related to this work from car navigation sphere. After comparing licensed and free products we concluded that there are only a few differences. In the other words free application reach very similar quality compared to their professional alternatives. Commercial vendors often implemented their applications on their own hardware in contrast to open source which are not devoted to certain device or platform using existing map format. Both have various features. We focused on map displaying possibilities and work with POIs. This analysis was really helpful by determining what operations should be able to do. Other important aspect, without which we cannot imagine further progress, was overview of file format where POIs and tracking data can be stored. A device which has been running MOD product contains many types of interfaces including serial port for GPS antenna connection and network interface for map tile downloading. The storage for useful data is also various supported. We can select SD card with high capacity and access time and USB flash disk.

Main goal of this work is to help users know their country better by noticing it when they are driving around interest object from cultural-knowledge aspect. Similar solutions for these devices offer only on-line map browsing, off-line option (if is present) is not fully supported. This makes our system more robust and more independent to Internet connection. We believe that our proposed solution has very good capability to accomplish established functionalities.

6.1 Future work

In the present time we managed to get and process location data from GPS antenna. To the final version we need to add POI management, categorisation and notification, route tracking and displaying. There is a possibility to migrate on another platform, for example Android. After successful creation of final version, our solution can be implemented on road excursion trains where are specific requests for departure signalling to the next stop. Signalling can be executed in form of voice record playing or showing letter with information about certain location. With a few changes is possible to mount it on mass traffic. There are some improvements to be done in the future including routing optimization, voice guide.

Acknowledgement: This work was partially supported by the Slovak Science Grant Agency (VEGA 1/1008/12 “Optimization of low-power design of digital and mixed integrated systems“) and the Young researchers support program on STU: Embedded system's usage in automotive industry.

References

[1] Aloi, N. Daniel: A Methodology for the Evaluation of a GPS Receiver Performance in Telematics Applications, *IEEE Transactions on Instrumentation and Measurement*, (2007), Vol. 56, No. 1, pp. 11–24.

[2] FUNTORO Inc.: BV-105 Infotainment Box Specification Version: V0.1, 5F., No. 99, lide St., Jhonghe City Taipei Country, Taiwan(R.O.C), (2009), p. 12.

[3] DePriest, D.: Map Display Formats [Online; accessed March 17, 2012]. Available at: http://www.gpsinformation.org/dale/mapdisplay.htm

[4] OpenStreetMap: Points of interest [Online; accessed March 17, 2012]. Available at: http://wiki.openstreetmap.org/wiki/Points_of_interest

[5] Cecil, D: BMW 300 nav user guide, 2011 [Online; accessed March 17, 2012]. Available at: http://www.e38.org/BMW-03_00-Nav-system-manual-en.pdf

[6] EL-Rabbany, A.: Introduction to GPS: The Global Positioning System Second Edition. Boston: Artech House Publishers, (2006) ISBN 1596930160, s. 194.

Variometer with GPS Logger

František KUDLAČÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
frantisek.kudlacak@gmail.sk

Abstract. Variometer is a device that informs user about his/her vertical velocity. It is particularly useful in paragliding, hang gliding and other air sports. The device has to inform user about vertical velocity by sound. Ground position of user is important too, because of complex functions (e.g., computing flying range, altitude above ground) and after-flight evaluation. This paper deals with the hardware design of such device and software implementation of its special functions. Tracklog from GPS logger can be transferred to computer in a common format.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 47-50.

* Master degree study programme in field: Computer Engineering
Supervisor: Mária Pohronská, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 317–322.

Digital Circuit Design and Simulation System Using Gesture Recognition

Jakub POLÁK, Tomáš MASARYK, Michal BEHÚŇ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{polak.ja, tomas.tmasaryk, michal.behun}@gmail.com

Abstract. In recent years, tablet PC type computers have reported a big boom, that we considered in the system design, which would enable to use their properties in the educational process. In this paper the digital system design and real-time simulation system is described. The system utilizes basic properties and advantages of the HP Tablet PC platform. It allows to design the combinational or sequential digital circuit using standard library of combinational and sequential elements. These elements may be selected not just from the corresponding library, but also by means of the panel for handwritten gestures recognition using stylus and touch-screen technology. The recognition may be customized creating the user-defined gestures that can then be recognized in addition to the default gestures already embedded in the system. Furthermore, the designed digital circuit can be simulated using an external simulator Icarus Verilog. The user can set logic values to the input buttons and the simulation results indicate the output LEDs. The program offers standard functions like storing and opening the designed circuit, exporting the schema into the PNG format as well as advanced function like displaying Verilog description of the designed circuit. The system is optimized for Windows 7/XP and thanks to its easy and user friendly GUI it has a potential to become a useful educational tool in courses devoted to digital circuits design.

1 Introduction

Digital circuits design methods are considered a fundamental knowledge in informatics and computer science study programs [1–3]. At the Faculty of Informatics and Information Technologies, Slovak University of Technology in Bratislava, logic circuits represent an important part of two introductory courses of the bachelor study programs. In courses devoted to logic circuits design it is especially important to have a possibility to verify the designs and to experiment with their versions. Since the laboratory time is limited it is important to minimize the time that the students spend on learning

* Master study programme in field: Computer Engineering
Supervisor: Dr. Katarína Jelemenská, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 323–328.

how to verify their designs. For this reason a simple and intuitive simulator seems to be the ideal choice for the verification purpose.

Tablet PC technology is the mobile technology, which the main characteristic is receiving the input data using stylus and touch-screen technology. This is a more natural way of communicating with the computer than using the keyboard, thus increasing efficiency in the design process. Therefore, it is especially suitable for use in tools to support educational process. Many applications devoted to logic gates simulation and verification are available, including freeware, shareware, and commercial solutions. The selected logic circuits simulators have been revised in [4]. The most useful simulators provide a graphical toolbox interface enabling repeated placement of the selected component [1, 5] or using the drag and drop technique [6–8] for composing the logic circuit. Some of them offer improved features like custom wire paths [5], truth tables/Karnaugh maps display, automated wire path calculation [4, 5] or export to HDL [4]. However, we were not able to find a logic circuits simulator that would support the touch-screen input. This was the main motivation for designing a new tool for designing the combinational and sequential circuits using the basic elements – logic gates and flip-flops. The system should also allow a real-time simulation of the designed circuit for verification purposes and export to HDL model. Because of using it on tablet PC type computers, the whole system should be intuitively controllable using stylus.

The paper is organized as follows. The main aspects of the system design together with some useful functions are described in Section 2. In Section 3 the principal results and the first experience in using the proposed digital circuit design system are summarized. The final section concludes the paper and suggests some possibilities for further system development.

2 System design

To design the logic circuit simulator that will bring the most of the potential advantages, various kinds of requirements have been collected, analyzed and the final requirements have been specified. Based on these requirements the software system was designed and implemented, enabling the user to compose combinational and sequential digital circuits and consequently to simulate them.

2.1 Gestures recognition

The simulator was designed to support touch-screen input so it can be controlled using suitably chosen predefined or user-defined gestures sketched on the touch-screen display. This makes the user interface very natural and intuitive. All the standard available combinational and sequential logic components are included in the system and for each of them a gesture is available. Gestures for combinational parts are produced by a uniform rule. The first number represents the number of logic gate inputs. In the case of a gate with negated output the letter "N" follows the number of inputs. The last character of gesture is a character clearly identifying the gate type. The gestures for sequential component are inspired by their labels (e.g. JK, D, T etc.). However, the program allows to create custom gestures for components as well, while the original gestures still remain present in the system. In case the program can unambiguously identify the drawn gesture, the component is selected automatically. Otherwise the program offers a choice of several similar alternative gestures that were previously recognized.

Gesture recognition is implemented in element inkcanvas. It is a specific extension of the traditional canvas element, designed to work with graphic elements. After drawing a gesture the method is started to evaluate possible alternatives of the entered text. The recognition is implemented in English, since it is the most used language version of the Windows operating system. Based on the ranking of the recognized words only those gestures are evaluated that have a sense of our program (sequential, combinational, input, and output elements). The following libraries of Microsoft SDK were used for this purpose: `IACore.dll`, `IALoader.dll`, `IAWinFx.dll`. In spite of the gestures recognition support, a user can still adopt the traditional way of control using mouse and keyboard shortcuts.

2.2 Circuit components representation

Each element of the designed circuit is represented by the interdependent data and graphical structure. The data structure contains the element parameters (such as ID, number of inputs, behavior, label etc.). The graphical structure base (see Figure 1) consists of the main container (StackPanel) including a grid. The grid background is the PNG drawing of the element. The grid of given element is designed in order to gain an appropriate arrangement of the fixing pins. The pins are objects embedded into the grid and their thickness is designed in order to simply select the wires by stylus. Figure 2 illustrates the selected and highlighted pin together with its number displayed. New components can be created only by extending existing classes in source code.

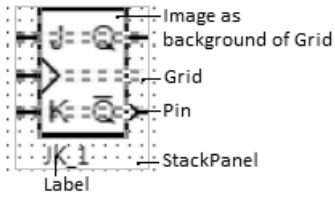

Figure 1. Graphic structure of the object.

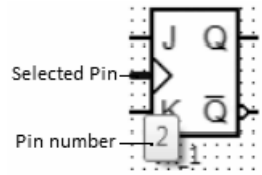

Figure 2. Selected pin.

2.3 Circuit simulation

To implement the circuit simulation an external simulator Icarus Verilog (http://iverilog.icarus.com/) was used. Icarus Verilog supports all released versions of Verilog language including the newest version IEEE 1364-2001. It is released under GNU/GPL licence. The greatest advantage of this tool is support of the third-party extensions (plugins). Simulation is flexible, almost as if performed in a real time. The simulation is not controlled using traditional VLI and PLI Verilog interface. Integration of these interfaces can be complicated. The simulator is therefore directly controlled by commands entered at the operating system command line. The advantage is that the simulator is separated from the application and it is not integrated into the system itself.

Real-time simulation can be divided into four steps: generating of Verilog code for designed circuit, compilation of this code, repeated simulation run based on the input variables changes, end of simulation process.

Code generating

Verilog code generating for the designed circuit is implemented in several steps. First of all the secondary modules are defined. These are input-output module and flip-flops modules. The next step is generating of basic module and the whole circuit entity. Inputs and outputs of this circuit are generated along with default output in case of unconnected output of some logic gate in the circuit. The internal signals between components are generated afterwards. The next step is generating the entities of all logic components for whole circuit and their mapping to these components. If there is an unconnected input signal in the component, its value is set to the default value. This is done because of the compilation process requirements. When the code of the whole circuit is generated the circuit testbench is added in the next step. The testbench contains input variables to which the circuit will be sensitive. In the last step the commands are generated that will capture the circuit and inner signals responses based on the changes of input variables. This code is stored on hard drive and used during the compilation process. It is actually the Verilog model of the circuit that can be later reviewed in external editor.

Code compilation

The Verilog code is compiled using Icarus Verilog compiler (http://iverilog.icarus.com/). The output of this compilation is saved to the file and is ready for further circuit simulation. The first simulation starts automatically in case the compilation was successful. The actual values of input buttons are used for this simulation. In case of compilation errors, the warning message is displayed.

Circuit simulation

For simulation purpose the actual values of circuit input buttons are used. The simulation output is captured and the values of all the LED diodes and wires colors are set based on this output. The simulation runs again whenever a value of any input button is changed. The change causes the separate thread to be invoked that is automatically sorted into the queue. This ensures that all the changes in the circuit are simulated in exact order in which they were forged. The simulation will stop in case of simulation mode exit or when some simulation error occurred. In that case the warning message is displayed and simulation ends immediately.

2.4 Graphic user interface design

The graphic user interface (see Figure 3) was designed to utilize the advantages of tablet PCs for the intuitive system control. Based on the final requirements the working canvas (1) was designed with 4000x4000 px dimension, which is the largest section of the user interface. The left and right menus can be hidden using buttons (2) to enlarge the canvas visibility for designing larger and more complex digital circuits. The right menu contains the panel (3) for handwritten gestures recognition where the user can enter the gesture to select the required component. As an alternative to the component selection there is the component library available in the left hand side menu (7) enabling to select a component using the mouse. In the library the user can switch among the combinational, sequential and I/O components (9) and for the combinational components to switch between the basic logic gates and multiple-input gates (8). If the gesture recognition is ambiguous, the listbox (4) in the right hand side menu will appear to offer recognized gestures alternatives. The right hand side menu also contains the selected component preview (5) and its parameters (6), where the user can modify component properties (if possible). The well arranged main menu (11) offers standard functions for circuit design and simulation control. It is adjusted to simple and intuitive stylus control.

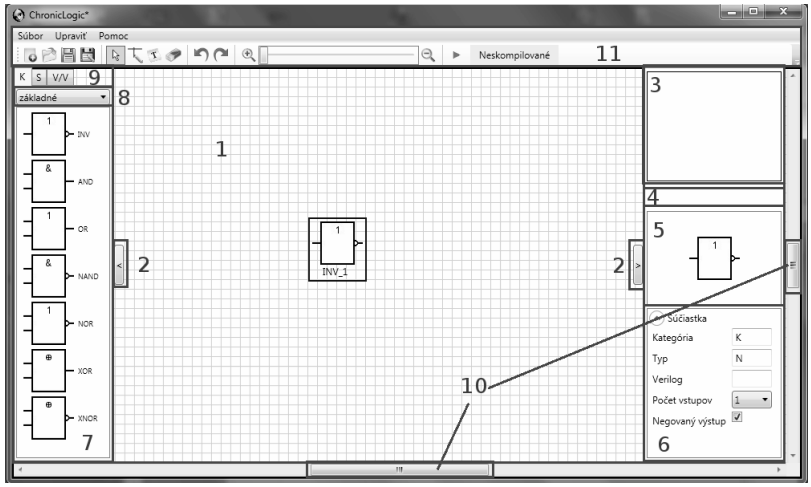

Figure 3. Graphic user interface design.

2.5 Standard functions

– Opening and saving of the designed schema in XML format

The elements saving is realized as objects serialization to the XML format. Not all the objects can be serialized, so before saving the schema it is necessary to modify such elements for serialization purpose. The new objects (that can be serialized) are created based on these objects, containing just the attributes necessary for the original objects re-creation. All the objects are then saved to the list of all objects and written to the XML file.

– Circuit export into PNG image

The circuit export is done in two steps. In the first step the coordinates of the border objects appearing on the canvas are obtained. At the beginning of this process the variables min(x) and min(y) are set to 4000 and max(x) and max(y) are set to 0. The left corner coordinates of each object in the canvas is compared to the stored border coordinates. If the object coordinates are greater than the maximum stored, the maximum value is replaced. To x coordinate the width of the object is added and to the y coordinate the height of this object is added. If the coordinates of the objects are less than the minimum stored, the minimum value is replaced. This will provide the canvas size for exporting. In the second step all objects on the canvas are added to the temporary canvas. The difference is in location of all objects. The objects are added to the temporary canvas from the upper left corner. After this step the size of exported image is set based on dimensions get in the first step. In the last step the selected part of temporary canvas is converted to PNG format and saved to the image file.

– Interactive help with education videos

The components available in the program allow to simulate any logic function. To draw the scheme the components are inserted to the canvas first and then interconnected using wires. The objects on the canvas can be modified in four modes: adding components to the canvas, adding wires to the canvas, erasing objects, and adding labels. In each of these modes the characteristic features of the other modes are disabled.

– Adding components to the canvas

A component can be selected either directly or through gesture recognition function. The basic properties of the selected components are displayed in the property grid. The components are on the canvas represented as bitmap images. The component position is determined by clicking on canvas with stylus or mouse. The mode can be exited either pressing the right button, or changing the mode.

– Adding wires to the canvas

The wires on the canvas are represented by lines, or a set of perpendicular lines. The breaking points calculation is based on comparing current x and y coordinates of both wire ends. The wires branching is created by means of nodes.

– Erasing objects

Primary are objects deleted from canvas with back side of the stylus. Deleting with the mouse is available in a special mode. After removing the common part of many wires is removed only the last drawn wire in the common area.

3 Results and experience

During the testing phase the functionality of all parts of the application have been verified. The main part of the tests was focused on the verification of the simulation accuracy and endurance testing. The first endurance test was based on the application performance testing in the situation when about 250 gates and about 70 wires were placed on the canvas. The time necessary for saving the schema of more than two hundred inverters was less than half a second. The schema opening time of the in the same case was less than a second. The second endurance test was based on the performance testing of the application in case the huge number of wires and wire breaks is used in the schema. The performance results were visibly slower than in the first endurance test. The schema opening and closing times were nearly three seconds.

4 Conclusion

The software system was designed and implemented allowing to simulate any combinational or sequential circuit using available logic gates and flip-flops. The system consists of the graphical tool used for creating schemas and external simulator Icarus Verilog for their real-time simulation. In simulation mode the simulation results are interactively displayed directly in the simulated circuit by means of output LEDs.

The system was tested using a set of combinational and sequential circuits. A useful extension could be an auto-route feature, the ability to import a hardware description language model of the schema, or an integrated tool for creating new components.

Acknowledgement: This work was partially supported by Slovak Cultural and Educational Grant Agency (KEGA 022STU-4/2012 “MEDU – technical courses mobile laboratory”) and the Slovak Science Grant Agency (VEGA 1/1008/12 “Optimization of low-power design of digital and mixed integrated systems“).

References

[1] Burch C. Logisim: a graphical system for logic circuit design and simulation. In: Journal on Educational Resources in Computing (JERIC), 2 (1), 5-16; 2002.

[2] Boluda JC, Peiro MA, Torres MA, Girones R, Palero RJ. An active methodology for teaching electronic systems design. In: IEEE Transactions on Education, 49 (3), 355–9; 2006.

[3] Donzellini G, Ponta D. From gates to embedded systems: a bottomup approach to digital design. In: MSE09 Proceedings, p. 61-4. Printing House; 2009.

[4] Jelemenská K, Siebert M, Macko D, Čičák P. Logic circuit design verification support tool – FitBoard. In: Procedia - Social and Behavioral Sciences, 28, p. 305–310, 2011.

[5] Burch C. Logisim 2.7.1 webpage. Retrieved May 10th, 2011, from http://ozark.hendrix.edu/ burch/logisim/.

[6] Arase, K. Simcir the circuit simulator, Version 1.2.1. Retrieved May 10th, 2011, from http://www.d-project.com/simcir/

[7] Temmerman, K. The Logic Lab. Retrieved May 10th, 2011, from http://www.neuroproductions.be/experiments/the-logic-lab/

[8] Tynjala, J. (2010). Logicly. Retrieved May 10th, 2011, from http://logic.ly/

A Security Threat to IP Devices in Mobile Cellular Networks

Martin NAGY*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
martinko.nagy@gmail.com

Abstract. Mobile networks based on GSM/GPRS/UMTS and lately LTE standards are slowly becoming a regular part of our lives. We use our brand new smartphones daily, don't even bothering, whether these devices and applications are properly secured. In the past, the security research in this area was limited mainly to mobile malware and radio protocol stack. In this paper we focus on vulnerabilities that result from bad network configuration and implementation of intermediary devices. These security threats are not just theoretical, but they were found in one commercial network. We propose a simple solution on mobile operator and user handset side.

A paper based in part on this paper was published in Proc. of the 35th Int. Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO'12), Croatian Society for Information and Communication Technology, Electronics and Microelectronics, 780-783.

* Master degree study programme in field: Computer Engineering
Supervisor: Assoc. Professor Margaréta Kotočová, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

Control-Flow Checking Using Software Signatures

Hana SEVERÍNOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
hana.severinova@gmail.com

Abstract. Correct execution of a program source code is an essential part of the modern information systems. Due to various external causes, the process execution can fail and lead to unpredictable consequences. Proposed solution detects control-flow errors caused by a faulty execution of jump instructions, by the means of program execution controlling technique based on inserting software signatures to a source code. In this paper we briefly introduce the reader to our solution dealing with a process' control-flow checking and we evaluate its applicability.

1 Introduction

Execution of a program source code is one of the fundamentals of each information system. There are some situations, when it can become faulty, either permanently or only as a one-time experience. One of the possible failure sources is a radiation, which can cause transient hardware failures leading to an incorrect program execution. In the area of information technologies, a correct execution of computer programs is considered a matter of course and any fault is considered inadmissible. Faulty program execution can cause many problems, especially with programs those are performing mathematical tasks, or those used for controlling or regulating various machines. Failure of such program, for example of an aero-navigation system, can lead to disastrous consequences.

Due to its key role in the software field, the reliability of a program execution should be among the main interests of each software-developing organization. Therefore the detection of failures plays an important role in securing the process reliability. Our solution deals with detecting control-flow errors with the aim on an incorrect execution of jump instructions, which is an enormous risk in the majority of software systems.

Almost every program code contains branch instructions or function calls, which are translated into jump instructions in the low-level programming languages. According to [1, 2], more than 70% of all transient faults lead to control-flow errors, which are basically an incorrectly executed jump instructions. Detection of this type of errors is called control-flow checking and it can be done either by hardware or software means. Hardware control-flow checking requires

* Master degree study programme in field: Computer Engineering
Supervisor: Jaroslav Abaffy, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

a special hardware device called Watchdog processor, which is checking the control-flow of a program executed by a separated processor. Software solutions are usually based on a technique that uses special signatures those are being inserted into the source code in the time of compilation, or before. Based on these signatures and a checking function it is decided in the run-time whether the execution is faulty or not. Two of the most popular software control-flow checking algorithms are CFCSS and ECCA; most of the other software algorithms are based on these two. While CFCSS is an implementation using a low-level language and is using xor (an exclusive or) as its validating function, ECCA is a high level implementation using prime numbers and modulo as a part its checking function. Our solution is trying to merge the advantages of both of these algorithms into a new, more effective one.

2 Proposed algorithm

In this paper we introduce the reader to the proposed algorithm designed to detect illegal execution of jump instructions.

2.1 Control-flow graph concept

In order for the reader to understand the notions used in this paper, we briefly describe the concept of a control-flow graph, which we refer to in our solution.

Control-flow graph

Control-flow graph is a representation of all of the logical paths of the program execution. It is represented by a directed graph where the vertices represent basic blocks and edges represent possible transfer of control-flow from one basic block to another. [3]

Basic block

A basic block is a straight-line sequence of code with only one entry point and only one exit. [3]

Edge

Edges represent possible control-flow transfers from the end of some basic block A to the head of another basic block B. We say that A is a predecessor of B, and B is a successor of A. [3]

2.2 Creating the control-flow graph

In order to insert control-flow checking signatures into the program source code, the control-flow graph has to be created first, as shown in Figure 1.

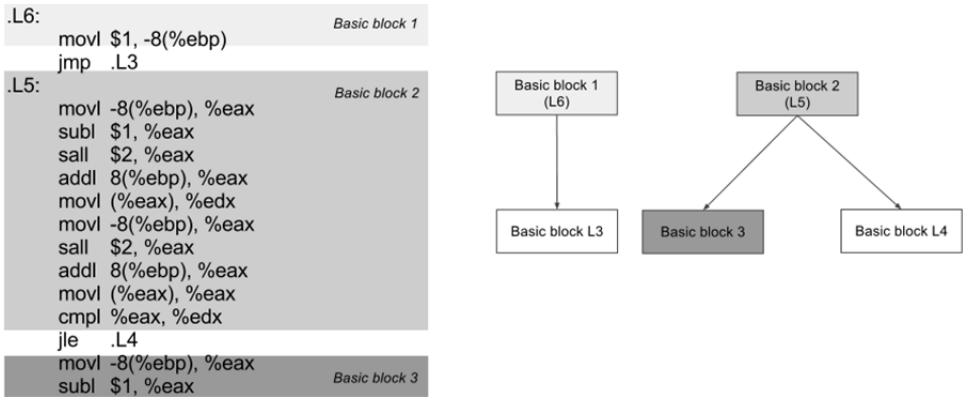

Figure 1. Example of a control-flow graph creation.

As a part of our solution we developed a program that parses a program source code (currently is supported x86 assembler files with AT&T syntax). Based on a regular expression driven parsing it searches for entry and exit points of functions, jump instructions and function calls. It identifies all of the basic blocks and edges between them and finally builds an internal representation of the program control-flow graph.

2.3 Assigning signatures

The proposed algorithm assigns two types of signatures to the identified basic blocks – ID and PREV. In the first step of the signature assignment are basic blocks divided into two groups as follows:

- First group contains each basic block, which has exactly zero or one predecessor.
- Second group contains every basic block, which has more than one predecessor.

Based on these two groups we can divide all of the identified basic blocks into two main categories, which we will solely for the purpose of this document call Category A and Category B. The basic blocks are assigned to these two categories according to the following rules:

- Category A contains all of the predecessors of the blocks from the first group. On the Figure 2 and Figure 3 are blocks from this category marked with a lighter shade of grey.
- Category B contains all of the predecessors of the blocks from the second group. On the Figure 2 and Figure 3 are blocks from this category marked with a darker shade of grey.
- If a basic block B, according to the rules above, belongs to both Category A and B, it will be assigned to Category B.

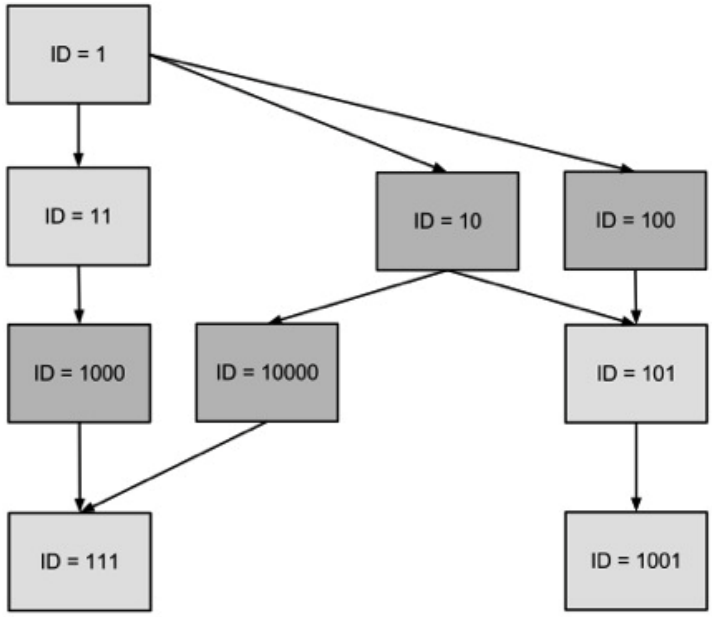

Figure 2. Assigning ID to each basic block.

Second step is to assign ID to each basic block, as can be seen on the Figure 2. The ID is a unique identifier of the block, and is used to determine the correctness of the execution of the jump instructions. The rules used for ID assignment are designed for each ID to be unique and are as follows:

- Each basic block from Category A is assigned an ID that is odd, beginning with 1 and ascending.
- Each basic block from Category B is assigned an ID that is a power of 2, starting with 2 and ascending.

The last step is assigning the PREV signature for each of the basic blocks, as can be seen on the Figure 3. PREV holds the information about the legal jumps to the block to which it is assigned. PREV is a result of performing a logical OR operation on the IDs of all of its predecessors.

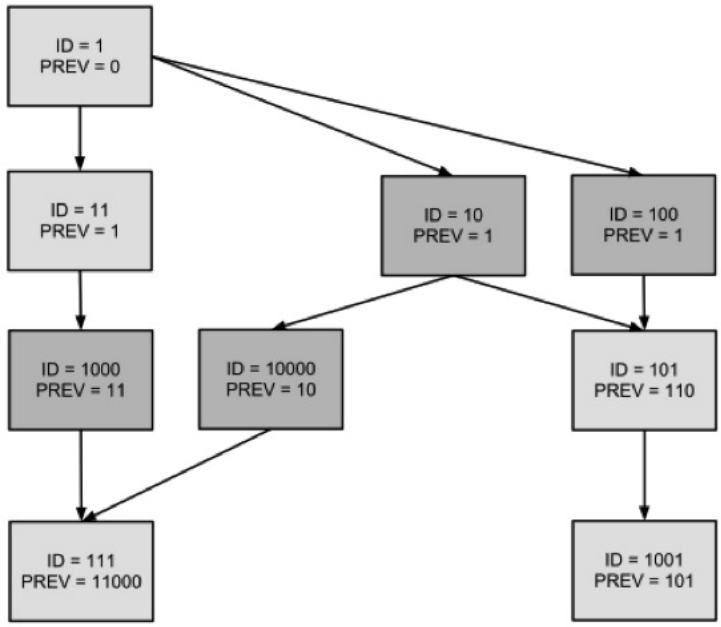

Figure 3. Assigning PREV to each basic block.

We created categories A and B in order to decrease the memory demands of the algorithm, since our solution is primarily based on assigning powers of 2 as IDs. Since the basic blocks marked as Category A blocks are the only single predecessor to all of their successors, there is no need to store more than one predecessor in their successor's PREV signature. Therefore, to decrease the number of bits required, they are assigned odd numbers as an ID.

2.4 Signature checking algorithm

The proposed control-flow checking algorithm is based on performing bitwise operations, due to their high efficiency and low calculating demands on the processor. The checking takes place at the beginning of each basic block. The algorithm consists of a few basic steps:

1. The variable LAST contains the ID of the last basic block that was executed. When entering a basic block, the correctness of the control-flow is checked as follows:
   a. If the value of the current block's PREV variable is odd, we compare PREV and LAST. If they are not equal, the jump was illegal.
   b. If the value of the current block's PREV variable is even, a logical and is performed on the LAST and PREV values. If the result is equal to 0, the jump was illegal.
2. The variable LAST is set to the ID of the current block.

In the case of detected incorrect execution of the program, the execution is stopped and an error is announced.

2.5 Inserting checking blocks

Blocks checking the correctness of the program execution are inserted into the original program's source code after creation of the control-flow graph and assignment of the signatures to the identified basic blocks.

A control-flow checking blocks are situated at the beginning of each basic block. There is also a checking block right after each function call used for validation of the function returning point.

3 Conclusion

In this section we briefly evaluate the described solution.

3.1 Comparison to existing algorithms

The proposed algorithm was designed with an aim on combining the advantages of the two existing ones – CFCSS and ECCA. Table 1 shows the comparison of the proposed algorithm to CFCSS and ECCA.

Table 1. Comparison of the proposed algorithm to the existing ones.

Algorithm	Advantages	Disadvantages
CFCSS	Fast (uses bitwise operation xor)	Cannot detect aliasing
ECCA	Can detect aliasing	Slow (uses modulo)
Proposed algorithm	Fast (uses bitwise operations) Can detect aliasing	High memory demand when storing IDs

In comparison to the most used algorithms CFCSS and ECCA is the proposed algorithm fast and can detect aliasing, but has higher memory demands for storing the IDs of basic blocks from Category B.

3.2 Overhead

The source code overhead and computing overhead depends on the exact implementation of the algorithm. The algorithm can be changed so, that for example only each second jump is checked, in order to reduce the computing and source code overhead. Therefore we do not evaluate the overhead.

3.3 Effectiveness

The described solution can detect majority of possible control-flow errors. Likewise the majority of other control-flow checking algorithms it cannot detect illegal jumps inside of a basic block. It can, however, detect all of the others illegal jumps inside of a function and between functions.

3.4 Future extensions

We plan on developing a more efficient concept of storing the ID and PREV. Current concept uses a 32 bit integer for storing the ID and PREV values, in the future we plan to enhance the solution so, that it will be able to store more values with a lower memory demand, using a coding scheme or other means.

We also intend to implement the proposed algorithm as a plugin to the GNU Compilers Collection. In the process of compilation of a source code, GCC creates its own control-flow graph representation of the program that is being compiled. GCC plugin has an access to GCC's internals, which can be used for insertion of the signatures and checking blocks directly into the intermediate pseudo code maintained by GCC during compilation, which would give us a fair amount of flexibility through various architectures and programming languages.

4 References

[1] Borkar, S.: Designing Reliable Systems from Unreliable Components: the Challenge of Transistor Variability and Degradation. In: IEEE Micro, Vol. 25, (2005), pp. 10–16.

[2] Mahmmood, A., McCluskey, E.J.: Concurrent Error Detection Using Watchdog Processors – A Survey. In: *IEEE Transactions on Computers*, Vol. 37, No. 2, (1988), pp. 160–174.

[3] Stallman, R. M., GCC Developer Comunity: *GNU Compiler Collection Internals.* Free Software Foundation, Inc., (2010).

[4] Oh, N., Shirvani, P. P., McCluskey, E. J.: Control-Flow Checking by Software Signatures. In: *IEEE Transactions on Reliabilit*y, Vol. 51, No. 1, (2002), pp. 111–122.

Consistency in the Identity Management

Katarína VALALIKOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
k.valalikova@gmail.com

Abstract. Identity management solutions are integrative solutions that automate processes associated with the users and theirs life-cycle. The results of the identity management solutions can be thought of as (loosely coupled) distributed systems. Many of the end resources managed by the identity management systems do not support transactions or other traditional consistency mechanisms therefore there is a considerable risk of inconsistencies. In this paper we introduce the mechanism which will be able to minimize the formation of inconsistencies and if they ever happen, this mechanism will be trying to resolve them and bring the system back to the consistent state.

1 Introduction

Identity management can be defined as a convergence of technologies and business processes [8]. It is integrative solution that usually consists of different systems and techniques. The main goal of identity management is to handle a lot of identities and their life-cycle including creation, usage, updating and revocation of the identity [1]. Identities have different roles and different permissions to access specified resources. There is a need to have different identities to work with the same system, or to have the same identity to work with different systems [8].

It is important to solve the inconsistency problems for many reasons. For example, the identity management solution interacts with various systems and information about user's identity is stored in more than one database. Without any reliable consistency mechanism the databases may diverge and it may not be clear which data record should be used. Another reason why it is needed to solve the problem with inconsistencies may be security. The identity management solutions are security-sensitive systems because they manage accesses to other systems. Consistency of security policy is important for maintaining good security level and also for being able to monitor overall security of the organization. For instance, potential attacker can intentionally cause inconsistency and escape the "security police".

The paper is organized as follows. The section 2 gives the brief view on the related work in the area of the transaction mechanisms. Next section, section 3, deals with the problems which must be solved for ensuring consistency in the identity management and also in this section the

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Radovan Semančík, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 341–346.

consistency mechanism is introduced. The section 4 evaluates the proposed mechanism and in the section 5 is the conclusion summarizing the proposed mechanism and the future work.

2 Related work

Consistency in the database systems is guaranteed by transactions described using ACID properties (Atomicity, Consistency, Isolation, Durability) [9]. Transactions in the distributed systems are often realized using two-phase commit protocol that is responsible for coordination of all participants in the transaction and for decision if the transaction will be committed or rolled back. Before all transaction are either committed or aborted, the data in the database are locked to enforce concurrency control [10]. The paper [4] describes an approach where a long running transaction called *saga* is divided into shorter sub-transactions where each sub-transaction has its own compensation mechanism. If transaction fails, compensation mechanism is called to undo this transaction. Success of the all sub-transactions implies success of the whole transaction.

According to CAP theorem [3, 5] it is impossible to guarantee consistency, availability and partition tolerance at the same time in distributed systems. The paper [5] provides a proof of the theorem using asynchronous network model. With respect to the CAP theorem author in the [7] introduces approach called BASE (Basically available, Soft state and Eventual consistent system) where he suggests to establish persistence message queue and to divide the database tables across functional groups (table for users, transactions, messages, etc.). Each message is peeked from the queue and processed. If operation is successful, the message is removed from the queue, otherwise it is re-tried [7]. The eventual consistency is also provided by the Simple Storage Service (S3) introduced by Amazon [2].

However, many of the end resources managed by the identity management do not support transactions. Therefore the standard transactions, two-phase commit protocol or other traditional consistency mechanism are not suitable for ensuring consistency in the identity management and the other mechanism must be found. In addition, many of the operations in the identity management can take a long time so there cannot be used the standard lock and log mechanism. There is also problem with the Sagas. The author in [6] explains that Sagas fail to cover all cases where compensation is needed. Following these facts, the best approach to ensure the consistency in the identity management seems to be the concept of eventual consistency. Therefore we decide to use this model to design the mechanism.

3 Consistency mechanism for non-transactional systems

The goal of this paper is to find an appropriate way to solve the consistency issues in identity management systems. The identity management system must be able to recover from unexpected errors and to continue to work without limiting the users. It is unacceptable to allow identity management to be in the inconsistent state for a long time because this could result to the malfunction of the system.

Identity management systems provide automation of the processes related to the users and their life-cycle in the enterprise, from hiring new employee through changing his position to firing employees. Each employee usually has multiple accounts in the various systems to be able to perform his work properly. Therefore, there are a lot of external resources which need to communicate with the identity management systems. External resources contain information about the employees and their access rights, one employee should have accounts in the different resources and may also have more than one account in the same resource.

Accounts are created in different ways, e.g. using central identity management system, by synchronization of changes on external resources, or by adding the user to the role which defines that an account should be created, etc. Unexpected situations and errors may happen during the user management processes, e.g. the account may not be created, exceptions may be thrown, etc.

Ultimately, this may lead to the inconsistency of the record. According to the way the inconsistencies originate we can divide them into the following categories:

- Resource failures – this group describes failures that happened on the external resource by propagating changes that were made by end user using identity manager. For example, adding account through the identity management to the external resource which is not reachable.
- Synchronization failures – this group describes failures that happened by synchronization. Changes on the external resource was detected and propagated to other external resources and also to the identity manager but some crash occurred.
- Dependencies – this group describes inconsistencies that should happened by creating account that may have dependencies to other accounts. For example, creation of the account in the application depending on the account in the operation system.
- Groups – this group describes failures that happened when some operation with the group was made. For example, creation of account and adding it to the group are in the LDAP two different operations.
- Role Assignment – this group describes inconsistencies that occurred while working with roles. For example, the role is defined to have four different accounts, but only two of them are successfully created and the question is what to do with such a role.

3.1 Proposed mechanism

Proposed solution follows the model of the eventual consistency which means that the system does not guarantee that data will be consistent all the time. Instead, the temporary inconsistencies are allowed and the attention is made for the mechanism which solves the inconsistencies and eventually brings the data to the consistent state.

The main reason why we decided to use the weak consistency model results from the CAP theorem, because for such systems like identity management solutions are, it is required to guarantee high availability and so you can read and write to the system all the time. Every request to the system must have appropriate response even if failures occurs (e.g. one of the node is down). It does not matter if the operation was successful, but it must be terminated and the result returned to the user. Even, if a message sent from one node to another is lost, the system must continue to operate. Mechanism proposed in this paper is based on the three base concepts:

- CAP theorem, where the availability and partition-tolerance is chosen and the consistency is weakened.
- Relative change model – this means that in the case when the object was changed, we do not assume absolute state of the object (all its attributes) before the change and after the change, but we only use the attributes that have been really changed.
- Compensations for the unsuccessful operations. Each operation can end successfully or unsuccessfully. If the operation ends with an error, we first decide if this error is processable. If yes, then the compensation mechanism is called to resolve the problem, otherwise we can do nothing.

The mechanism is proposed to minimize the formation of the inconsistencies and if they ever happened, it should reasonably react and bring the system to the consistent state. The mechanism was designed with respect to the one of the identified groups of problems – resource failures. It consists of two parts. The first part tries to handle the unexpected error that occurred and the second part, called reconciliation, is used to compare the state of the object stored in the repository and in the end resource.

It has to be known if the error that occurred is processable or not in the first part. If the error is processable, there are specified compensation mechanisms as the reaction to the error. Each

error has its own compensation mechanism. The simple example of the compensation mechanism is, when we try to add the account to the end resource which is actually unreachable. In this case, we want to add this account later, but without the need of the user's assistance. Therefore the whole account object including all of its attributes is stored to the IDM system database and it is also marked as unsuccessfully added object to be able to process it later by reconciliation.

The more complex example can be a scenario, when we need to process the error immediately. This is a group of errors that we know either process immediately and eliminate the error state or we cannot do anything and the error must be repaired by the user, e.g. adding account that actually exist on the resource shown in Figure 1.

If the error is not processable it means, that we do not know how to implement the compensation to the error. Such an error can be also considered as fatal, and then the user help is needed for its reparation. As the example we can mention the issue where no definition for the required attribute was specified. The attribute was not specified, and the objects cannot be added to the end resource.

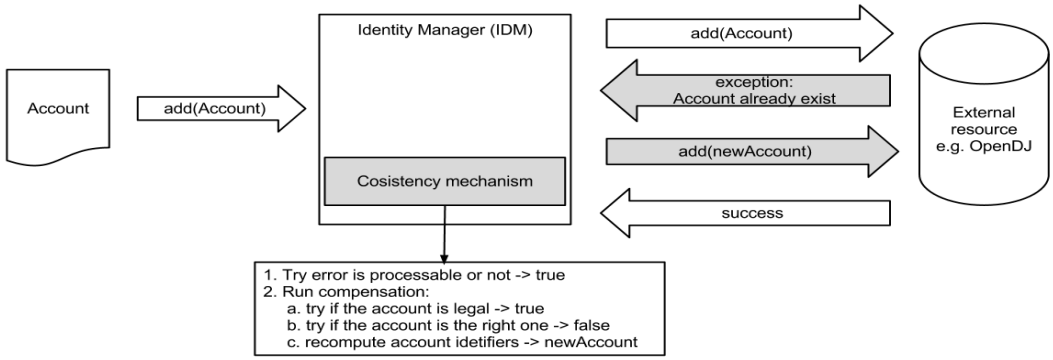

Figure 1. The first part of the mechanism (compensation for the situation where the account already exist on the resource).

Now, when the first step is done, it is needed to specify the policies for reconciliation process according to which the unsuccessful created accounts will be picked from the repository. This brings the idea that storing only account attributes is not enough. If there is no additional information to such account, it is quite impossible to declare it as unsuccessfully handled and it can be considerably difficult to find it by the reconciliation process and process it to resolve the inconsistency. Therefore, it is needed to expand the account object with some additional information which provides the detailed view about what and why went wrong. These are:

- all the account attributes when operation fails (e.g. creation of the account failed because of the end resource is unreachable and we want to try to add this account again later without he user's assistance),
- description of properties changed (e.g. the account was modified, but there was some error which avoided for applying the changes),
- some information about the operation and the type of error which occurred (e.g. the name of the operation, the status, is the operation was successful or not, the error which occurred),
- the number of the attempts made for re-try of operation.

Now, the account in the repository contains also information about operations and theirs results. The reconciliation process is used to scan the repository for the failed accounts and to try to run the failed operation again. The scanning is done with filter on the failed accounts and the number of attempts made for re-trying of operation. Found accounts are processed using additional

attributes that describe the operation and its inputs to run again. We use the number of attempts because it makes no sense to retry the operation endlessly.

The reconciliation process ends either successfully or it can also fail. It will be implemented in the way to not limit the end user for his activity. After defined number of attempts it will not be interesting in the solving the inconsistencies. Figure 2 illustrates the reconciliation process.

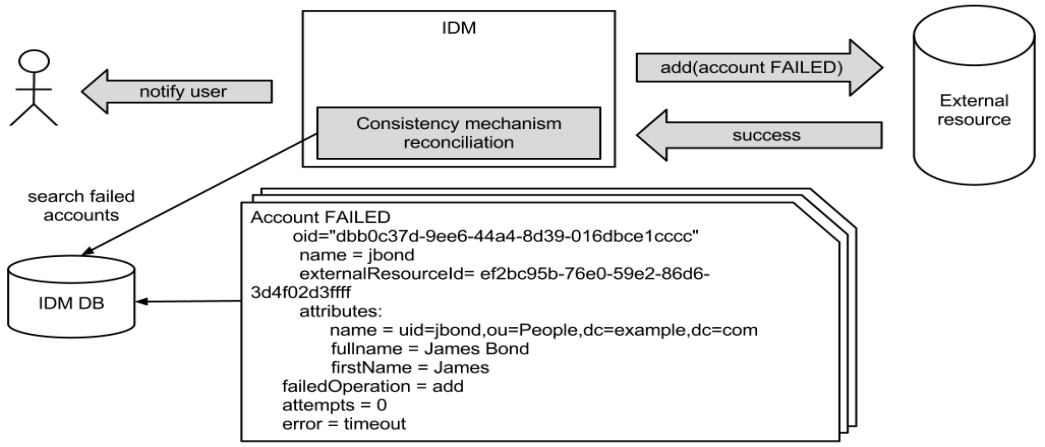

Figure 2. Reconciliation process.

4 Evaluations and Achievements

The theoretical proposal of the consistency mechanism was practically proven. The proof of concept was made on the existing identity management solution called midPoint[1]. MidPoint is open-source identity management solution and the main reason to choose it was the fact, that we are members of the development team so we have the practical experiences with the system.

The mechanism implementation consists of all parts proposed in the paper. There were identified concrete situations which can lead to the inconsistencies. To each situation we first decided if it is possible to solve the resulting problem and then we divided the situation into the processable and unprocessable errors. Each processable error has its compensation mechanism written according to its nature. If the compensation mechanism is not enough to resolve the issue, there is also implementation for the reconciliation process.

The implementation was tested manually by simulating the identified situations. We observed that this mechanism was able to properly recognize the situation and reasonably react to it. Where the compensation mechanism was not enough, the reconciliation process was used to additionally eliminate the inconsistencies in the system. The tests made on the prototype implementation are shown in the Table 1.

5 Conclusions

In this paper we introduced the mechanism for ensuring the consistency in the systems where the transactions are not supported. We proposed the mechanism with respect to the known mechanisms that was also analysed in the introduction of this paper. The mechanism is based on the relative change model, model of compensations and the CAP theorem according to which distributed systems cannot satisfy the consistency, availability and partition tolerance at the same time. Therefore we decided to weak the consistency and guarantee only the eventual consistency.

[1] http://evolveum.com/midpoint.php

It means, we do not guarantee that after every operation the data are consistent. Instead, we allow temporary inconsistencies and we try to solve them and eventually bring the system to the consistent state. The implementation was made on the existing identity management system called midPoint. The future work can be concentrated on the other identified group of problems stated in the paper.

Table 1. Tests provided on the prototype implementation of the consistency mechanism.

Situation	Error	Reaction
Add, Modify, Delete account	Connection problem	Account was saved to the repository. Reconciliation process finds this account and tries again to add it.
Add account	Already exist on the external resource	If the found account belongs to the specified user, the account was linked to the user, otherwise new account identifiers were generated. If the found account was illegal, it was deleted.
Modify account	Not found on the resource	If the account should exist, it was created and the modifications were applied, otherwise the modifications were discarded.
Delete account	Not found on the resource	The result of this reaction is that the account was deleted from the repository and it was also unlinked from the user.

References

[1] Bertino, E., Takahashi, K.: *Identity Management: Concepts, Techniques and Systems*. Artech House Publisher, Norwook MA, (2010).

[2] Brantner, B., et al.: Building a database on S3. *In Proceedings of the 2008 ACM SIGMOD, international conference on Management of data* (SIGMOD '08). ACM, New York, NY, USA, (2008), pp. 251–264.

[3] Brewer, E.: A certain freedom: thoughts on the CAP theorem. *In Proceeding of the 29th ACM SIGACT-SIGOPS symposium on Principles of distributed computing* (PODC '10). ACM, New York, NY, USA, (2010), pp. 335–335.

[4] Garcia-Molina, H., Salem, K.: Sagas. *In Proceedings of the 1987 ACM SIGMOD international conference on Management of data* (SIGMOD '87), (1987), pp. 249–259.

[5] Gilbert, D., Lynch, N.: *Brewer's conjecture and the feasibility of consistent, available, partition-tolerant web services*. SIGACT News 33, 2 (2002), pp. 51–59.

[6] Greenfield, P. et al.: Compensation is Not Enough. *In Proceedings of the 7th International Conference on Enterprise Distributed Object Computing* (EDOC '03). IEEE Computer Society, Washington, DC, USA, (2003), pp. 232–240.

[7] Pritchett, D.: BASE: *An Acid Alternative*. Queue 6, 3 (2008), pp. 48–55.

[8] Slone, S. and the open group identity management work area: *Identity Management*. (2004), pp. 1–109.

[9] Wang, T. et al.*: A survey on the history of transaction management: from flat to grid transactions.* Distributed Parallel Databases 23, 3 (2008), pp. 235–270.

[10] Wolfson, O.: *The overhead of locking (and commit) protocols in distributed databases*. ACM Trans. Database Systems 12, 3 (1987), pp. 453–471.

Information System Security Assessment Method Based on Security Mechanisms

Jakub BREIER*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
breier@fiit.stuba.sk

Abstract. Risk evaluation approaches in information technologies are based on subjective and qualitative methods of measurement and evaluation mainly. This paper proposes approach based on the Analytic Hierarchy Process technique that uses level of security mechanisms implementation as an input. By using the predefined weights of these mechanisms it will give us overall security score in five main security attributes – confidentiality, integrity, availability, authenticity and non-repudiability. The main purpose of this work is to bring an objectivity into the process of the risk assessment and to provide an adequate evaluation of implemented security controls. As a basis for our work the ISO/IEC 27002:2005 standard is used. This standard contains the database of control objectives to which the proposed security mechanisms are assigned.

1 Introduction

Information security risks pose a serious threat to organizations dependent on their information systems. Both known and unknown vulnerabilities can be exploited to compromise security attributes – confidentiality, integrity, availability, authenticity or non-repudiability of information used by organization. It is necessary that responsible leaders and managers understand their responsibilities and support the information security management so it could improve the protection of organization assets.

There are many documents describing risk assessment techniques, they usually propose theoretical approaches and provide generic guidances on choosing security controls. But they usually fall short on describing practical aspects and giving an objective discrete-scale evaluation. Risk managers and security professionals need formalized quantitative risk measures and metrics, so they can efficiently and correctly measure risks. The comprehensive risk management framework with risk metrics would improve the risk assessment by giving organizations and would enable easier decision making in information security management.

Our goal is to bring the objectivity into the process of the risk assessment and evaluation and to express the security score in an organization in five basic security attributes. We used the

* Doctoral study programme in field: Applied Informatics
Supervisor: Assoc. Professor Ladislav Hudec, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 347–354.

security mechanisms implementation score to measure the quality of implemented security controls and the Analytic Hierarchy Process technique to express the importance of particular mechanisms. Security controls are originated from the ISO/IEC 27002:2005 [6] standard and we propose security mechanisms for each control objective from this standard.

The rest of this paper is structured as follows. Section 2 provides an overview of a related work in the field of the security evaluation. Section 3 describes our approach for this problem and defines methods used in our work. Section 4 contains case study of our method and Section 5 concludes this paper and provides a motivation for further work.

2 Related work

There are several recent papers describing the security evaluation supported by some sort of metrics or proposing an evaluation model based on quantitative criteria.

In [9] Sarmah et al. constructed a formal model for organization security patterns. This paper uses Formal Concept Analysis (FCA) [7] method to generate the security pattern lattice that could be used as a hierarchy classification model for information security attributes and high-level security mechanisms. The work is based on Common Criteria for Information Technology Security Evaluation (CCITSE) [5], which serves as a database for trusted elements used in the model. However the proposed model does not concern about security evaluation, it only discusses the way how the information security elements should be organized.

In [2] Ekelhart et al. propose a security ontology for organizing knowledge on threats, safeguards, and assets. This work constructs classification for each of these groups and creates a method for quantitative risk analysis, using its own framework. The work does not use known standards or guidelines as an input for its evaluation model, so desired mechanisms and countermeasures have to be defined in the process of risk analysis.

The closest work, proposed by Cuihua et al. [1] uses the Analytic Hierarchy Process (AHP) and Grey Relational Analytic Process (GRAP) to combine qualitative evaluation with quantitative decision. First it uses the AHP technique to get the security elements weights and then it analyzes the evaluation data with GRAP. The paper is also based on CCITSE, but it does not clarify the process of assigning weights to elements from this standard.

There are further works using AHP as a main technique for the security evaluation [3, 11], however these do not follow some well-known standards in information security.

There is also a paper [10] criticizing the quantitative security evaluation approach stating that there is a lack of validation and comparison between these methods against empirical data.

3 Methods

The methods described in this section are used for security evaluation based on security mechanisms and metrics. This evaluation is based on the ISO/IEC 27002:2005 standard [6].

This section is divided into two subsections – 3.1 provides the overview of the proposed model and 3.2 describes the Analytic Hierarchy Process (AHP) technique and its usage for our problem.

3.1 Overview

Figure 1 illustrates the main idea of our model. We select appropriate security mechanisms for each control objective from the standard. One security mechanism can contribute to one or more control objectives and one control objective can be supported by one or more security mechanisms. These relations are weighted, so we can adjust the influence of each assignment. We can express this part

of a model with the weighted sum:

$$CO_i = \sum_{1}^{n} M_n \times W(M_n), \tag{1}$$

where M_n is the score of the security mechanism n and $W(M_n)$ is its weight. As we can see in Table 1, variable M_n can take six values in accordance to correctness of implementation and variable $W(M_n)$ can take values from interval [0;1]. For example, Cobit 4.1 [4] defines similar classification in its Maturity model for internal control, however there is no quantitative parameter – the status of internal control implementation is expressed in a verbal way.

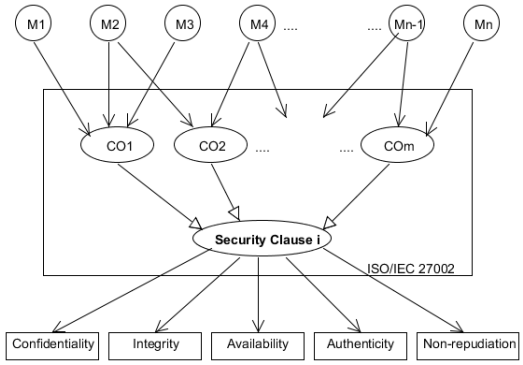

Figure 1: Security mechanisms $M_1 - M_n$ implement security controls desired by control objectives in standard in order to improve the overall score of information security attributes, depicted at the bottom.

Total sum of incoming weights to one control objective is 1. Following this proposal, each control objective is evaluated by one value from interval [0;1], which can tell us, how the organization successes in its implementation.

Table 1: Overall score of the security mechanisms implementation.

Level	Score	Description
0	0.0	Not implemented
1	0.2	Implemented with serious defects, not working properly
2	0.4	Implemented with serious limitations
3	0.6	Implemented with minor limitations
4	0.8	Implemented well, not tested in a real environment
5	1.0	Implemented well, tested and verified in a real environment

The other part of the picture depicts the relationship between control objectives and security clause. The standard does not tell us anything about the importance of particular control objectives for the security clause, however the importance cannot be distributed equally considering just particular security attribute. We will use the weighted sum to get the evaluation of security clauses:

$$SC_i = \sum_{1}^{n} CO_n \times W(CO_n), \tag{2}$$

where variable CO_n is the evaluation of the control objective n and variable $W(CO_n)$ is its weight.

The last part of the picture is about relationship between security clauses and security attributes. We have chosen the way of expressing the overall security score in an organization with standard security attributes, confidentiality, integrity, availability, authenticity and non-repudiation in order to maximize simplicity of the result. It improves readability of the final security report also for people who are not familiar with the ISO/IEC 27002 standard. The security clauses are listed below together with the abbreviations used later in the text:

1. Security policy (SP)
2. Organization of information security (OIS)
3. Asset management (AM)
4. Human resources security (HRS)
5. Physical and environmental security (PES)
6. Communications and operations management (COM)
7. Access control (AC)
8. Information systems acquisition, development and maintenance (ISADM)
9. Information security incident management (ISIM)
10. Business continuity management (BCM)
11. Compliance (CMP)

Each security clause affects each security attribute in some way. We have to add the weight of each relation to express how significantly does the security clause contribute to particular security attribute. We will use the following expression to evaluate the chosen security attribute:

$$SA_i = \sum_{1}^{n} SC_n \times W(SC_n), \tag{3}$$

where variable SC_n is the evaluation of the security clause n and variable $W(SC_n)$ is its weight.

3.2 Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) [8] is a technique of organizing and analyzing complex decisions. Decision factors are arranged in a hierarchic structure, split into overall goal, criteria, sub-criteria and alternatives in successive levels. We make the judgments upon the lowest level elements of the hierarchy in the form of paired comparisons. Following the hierarchical structure, we compare them on a single property, without concern about the other properties, which makes it easier to decide which one has an advantage over the other one. The comparison is based on verbal judgments (equal, moderately more, strongly more, very strongly more, extremely more), expressed in odd values from 1 to 9.

We construct a matrix A of these comparisons and multiply it by vector w of weights. The solution of $Aw = nw$ is the principal right eigenvector of A and is unique to within a multiplication constant:

$$\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_n \end{array} \begin{array}{c} \begin{array}{cccc} A_1 & A_2 & \dots & A_n \end{array} \\ \begin{pmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \vdots & \vdots & \vdots & \vdots \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{pmatrix} \end{array} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix}. \tag{4}$$

We normalize vector w by dividing its components by their sum. Then we compute the largest eigenvalue:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(Aw)_i}{nw_i}, \tag{5}$$

where $(Aw)_i$ represents the element i in vector (Aw).

The next step is computing the consistency index (CI):

$$CI = \frac{\lambda_{max} - n}{n - 1}. \tag{6}$$

If the consistency ratio (CR), which is the ratio of CI to an index from random matrix, is significantly small (about 10%), we accept the estimation of w. Otherwise we have to improve the consistency.

The last step is obtaining the final ranking of the elements of the lowest (alternative) level. If the number of alternatives is n, the number of sub-criteria families in the middle level is m, $w = (w_1, w_2, \ldots, w_m)^T$ is the evaluation vector of all the criteria with respect to the goal level and $w_j = (w_{1j}, w_{2j}, \ldots, w_{mj})^T$ is the evaluation vector of all the alternatives with respect to family j, then the final ranking vector of alternatives is:

$$w_i = \sum_{j=1}^{n} w_j \times w_i j, \tag{7}$$

where $i = 1, 2, \ldots, n$.

This technique was previously used in several papers concerning risk assessment and security evaluation in information systems [1, 3, 11]. It can be used to analyze security decisions and to provide recommendations on investing into the right security controls.

In our work we use the AHP to determine weights of particular security mechanisms, so we can find out how do they contribute to security attributes. The model is split into the levels following the AHP technique. First, we define five overall goals – security attributes. Then we assign meaningful weights to security clauses and corresponding control objectives within each attribute. And finally, we assign weights to security mechanisms choosed for every control objective. AHP will give us the overall score of each security mechanism in the context of a security attribute, which will be further used as a parameter for security evaluation.

4 Case study

The proposed method is explained on a concrete example, which can provide an overview, how the evaluation model works. To save the space, we have chosen security attribute availability only to illustrate the evaluation.

The first parameter of the model – the availability matrix – contains the paired comparisons of security clauses. It denotes how do they contribute in ensuring availability of assets in an organization. For example, if the comparison between Asset management (AM) and Physical and environmental security (PES) is 3/1, it means that AM is three times more important than PES from the availability point of view. Numbers in the matrix are estimated from the detailed descriptions of the clauses from the ISO/IEC 27002 standard:

Availability	SP	OIS	AM	HRS	PES	COM	AC	$ISADM$	$ISIM$	BCM	CMP
SP	1/1	2/1	1/5	9/1	1/5	1/3	5/1	5/1	7/1	1/7	3/1
OIS	1/2	1/1	1/7	9/1	1/7	1/6	2/1	3/1	7/1	1/7	2/1
AM	5/1	7/1	1/1	9/1	3/1	2/1	7/1	7/1	9/1	2/1	5/1
HRS	1/9	1/9	1/9	1/1	1/9	1/7	1/3	1/2	1/2	1/9	1/7
PES	5/1	7/1	1/3	9/1	1/1	2/1	5/1	5/1	9/1	2/1	5/1
COM	3/1	6/1	1/2	7/1	1/2	1/1	5/1	5/1	7/1	1/2	5/1
AC	1/5	1/2	1/7	3/1	1/5	1/5	1/1	1/3	2/1	1/8	2/1
$ISADM$	1/5	1/3	1/7	2/1	1/5	1/5	3/1	1/1	7/1	1/6	4/1
$ISIM$	1/7	1/7	1/9	2/1	1/9	1/7	1/2	1/7	1/1	1/8	1/3
BCM	7/1	7/1	1/2	9/1	1/2	2/1	8/1	6/1	8/1	1/1	8/1
CMP	1/3	1/2	1/5	7/1	1/5	1/5	1/2	1/4	3/1	1/8	1/1

After three consistency approvals (squaring the matrix by itself) we get the final normalized weight vector for security clauses (numbers are rounded to three decimal places):

$$W_{ava}^{T} = \begin{array}{c} \begin{matrix} SP & OIS & AM & HRS & PES & COM & AC & ISADM & ISIM & BCM & CMP \end{matrix} \\ \begin{pmatrix} 0.077 & 0.052 & 0.236 & 0.012 & 0.185 & 0.128 & 0.026 & 0.043 & 0.020 & 0.192 & 0.029 \end{pmatrix} \end{array}$$

We can see that the most important clauses from the availability point of view are Asset management, Physical and environmental security, Business continuity management and Communications and operations management. Now we will define weights for control objectives of all the clauses concerning the availability attribute. In this paper we will choose just one clause as an example, the Asset management clause. The proposals of security mechanisms assignments to control objectives within the clause are listed in Table 2.

Table 2: Control objectives of the Asset management clause with corresponding security mechanisms

Control objective	**Security mechanism**	**ID**
Inventory of assets (IA)	Identification of all assets with their level of importance and information about the asset	M1
	Identification of ownership and information classification for each asset – with the level of protection	M2
	Ensuring the integrity of information – hashing	M3
	Ensuring the availability of information – backup, physical and environmental security, redundancy	M4
Ownership of assets (OA)	Implementation of access control policies (DAC, MAC, RBAC)	M5
	Implementation of non-repudiability mechanisms – operating system level, digital signatures	M6
	Implementation of accounting mechanisms – operating system level, authentication servers (TACACS, RADIUS), network logs	M7
	Implementation of authentication mechanisms – authentication servers (TACACS, RADIUS), tokens, biometrics, passwords	M8
Acceptable use of assets (AUA)	Identification of rules for usage of electronic devices and computer networks	M9
Classification guidelines (CG)	Determination of classification levels and implementation of confidentiality mechanisms – cryptography (securing data storages and data transmissions), steganography	M10
Information labeling and handling (ILH)	Definition of policies for labeling classified information – physical and electronic labels	M11

Below is the Asset management weight matrix with the corresponding weight vector:

$$\begin{array}{l} \text{Asset management} \\ IA \\ OA \\ AUA \\ CG \\ ILH \end{array} \begin{array}{c} \begin{matrix} IA & OA & AUA & CG & ILH \end{matrix} \\ \begin{pmatrix} 1/1 & 9/1 & 7/1 & 9/1 & 9/1 \\ 1/9 & 1/1 & 1/3 & 1/1 & 1/1 \\ 1/7 & 3/1 & 1/1 & 3/1 & 3/1 \\ 1/9 & 1/1 & 1/3 & 1/1 & 1/1 \\ 1/9 & 1/1 & 1/3 & 1/1 & 1/1 \end{pmatrix} \end{array}$$

$$W_{AM}^{T} = \begin{array}{c} \begin{matrix} IA & OA & AUA & CG & ILH \end{matrix} \\ \begin{pmatrix} 0.664 & 0.060 & 0.156 & 0.060 & 0.060 \end{pmatrix} \end{array}$$

Finally, we will propose weight matrices for control objectives. We have to construct only first two matrices (for IA and OA), since the other control objectives have only one security mechanism assigned, so their weight is 1.

$$\begin{array}{c} \text{IA} \\ M1 \\ M2 \\ M3 \\ M4 \end{array} \begin{array}{c} \begin{array}{cccc} M1 & M2 & M3 & M4 \end{array} \\ \begin{pmatrix} 1/1 & 1/1 & 4/1 & 1/7 \\ 1/1 & 1/1 & 4/1 & 1/7 \\ 1/4 & 1/4 & 1/1 & 1/9 \\ 7/1 & 7/1 & 9/1 & 1/1 \end{pmatrix} \end{array} \qquad \begin{array}{c} \text{OA} \\ M5 \\ M6 \\ M7 \\ M8 \end{array} \begin{array}{c} \begin{array}{cccc} M5 & M6 & M7 & M8 \end{array} \\ \begin{pmatrix} 1/1 & 9/1 & 3/1 & 3/1 \\ 1/9 & 1/1 & 1/7 & 1/7 \\ 1/3 & 7/1 & 1/1 & 1/1 \\ 1/3 & 7/1 & 1/1 & 1/1 \end{pmatrix} \end{array}$$

These are the corresponding weight vectors for the control objectives:

$$\begin{array}{c} W^T_{AM_{IA}} = \\ \end{array} \begin{array}{cccc} M1 & M2 & M3 & M4 \\ (0.129 & 0.129 & 0.045 & 0.697) \end{array} \qquad \begin{array}{c} W^T_{AM_{OA}} = \\ \end{array} \begin{array}{cccc} M5 & M6 & M7 & M8 \\ (0.531 & 0.039 & 0.215 & 0.215) \end{array}$$

After the last round of weight assignments, we can finally construct the evaluation model. The last step of the analytic hierarchy process is to multiply the weights on the alternative level – the security mechanisms level – with the corresponding levels above. Following this procedure, we will get the final weights, which can be used to express the importance of particular security mechanisms from the availability point of view. These weights are stated in Table 3.

Table 3: Final weights of the security mechanisms corresponding to Asset management clause.

Mechanism	Particular Weight	Final Weight
M1	$0.129 \times 0.664 \times 0.236$	0.020
M2	$0.129 \times 0.664 \times 0.236$	0.020
M3	$0.045 \times 0.664 \times 0.236$	0.007
M4	$0.697 \times 0.664 \times 0.236$	0.108
M5	$0.531 \times 0.060 \times 0.236$	0.008
M6	$0.039 \times 0.060 \times 0.236$	0.001
M7	$0.215 \times 0.060 \times 0.236$	0.003
M8	$0.215 \times 0.060 \times 0.236$	0.003
M9	$1.0 \times 0.156 \times 0.236$	0.037
M10	$1.0 \times 0.060 \times 0.236$	0.014
M11	$1.0 \times 0.060 \times 0.236$	0.014

We can see the difference between the most and the least important security mechanism from the Asset management clause in Figure 2. It is clear that we will not improve the availability significantly even with the highest score of the M6 mechanism, however with good implementation of M4 we can improve it by more than 46% within the clause and by more than 10% overall.

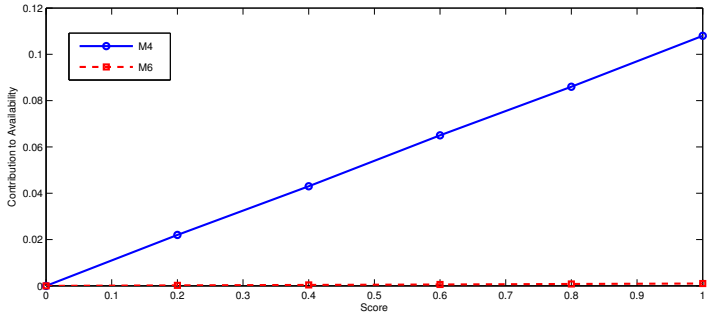

Figure 2: Difference between M4 and M6 mechanisms from the view of contribution to the availability. X-axis shows the mechanism's score and y-axis its contribution.

5 Conclusions

In this paper we proposed a way to evaluate the security in an organization using the implementation level of the security mechanisms. We used the ISO/IEC 27002:2005 standard as a database for security controls and we assigned security mechanisms to each control objective from this standard. The Analytic Hierarchy Process technique helped us to determine proper weights of suggested security mechanisms. These weights serve as parameters of security evaluation model which uses mechanisms' scores as input values.

For the evaluation based on our model can be easily constructed a software tool that will compute the security state in an organization. Security analyst will determine the score of security mechanisms and the model will give us meaningful values in security attributes.
In the future, we would like to automatize also the mechanisms' scores gathering. The model could be enhanced by extracting the useful information from the selected security metrics and use it to determine the value of the mechanisms' scores.

Acknowledgement: The paper was prepared with partial support of research grant VEGA 1/0722/12 entitled "Security in distributed computer systems and mobile computer networks".

References

[1] Cuihua, X., Jiajun, L.: An Information System Security Evaluation Model Based on AHP and GRAP. *2009 International Conference on Web Information Systems and Mining*, 2009, pp. 493–496.

[2] Ekelhart, A., Fenz, S., Klemen, M., Weippl, E.: Security Ontologies : Improving Quantitative Risk Analysis. *Risk Analysis*, 2007, pp. 1–7.

[3] Fu, S., Zhou, H.: The Information Security Risk Assessment based on AHP and Fuzzy Comprehensive Evaluation Sha Fu. *Finance and Economics*, 2011, pp. 2–6.

[4] Institute, I.G.: *Cobit 4.1*. ISA, 2007.

[5] ISO: *ISO/IEC Std. ISO 15408:2005, Common Criteria for Information Technology Security Evaluation*. ISO, 2005.

[6] ISO: *ISO/IEC Std. ISO 27002:2005, Information Technology - Security Techniques - Code of Practice for Information Security Management*. ISO, 2005.

[7] Priss, U.: Formal Concept Analysis in Information Science. *Annual Review of Information Science and Technology*, 1996, vol. 40, pp. 521–543.

[8] Saaty, T.L.: How to make a decision: The analytic hierarchy process. *European Journal of Operational Research*, 1990, vol. 48, no. 1, pp. 9–26.

[9] Sarmah, A., Hazarika, S.M., Sinha, S.K.: Security Pattern Lattice: A Formal Model to Organize Security Patterns. In: *Proceedings of the 2008 19th International Conference on Database and Expert Systems Application*, Washington, DC, USA, IEEE Computer Society, 2008, pp. 292–296.

[10] Verendel, V.: Quantified security is a weak hypothesis: a critical survey of results and assumptions. In: *Proceedings of the 2009 workshop on New security paradigms workshop*. NSPW '09, New York, NY, USA, ACM, 2009, pp. 37–50.

[11] Xinlan, Z., Zhifang, H., Guangfu, W., Xin, Z.: Information Security Risk Assessment Methodology Research: Group Decision Making and Analytic Hierarchy Process. *2010 Second World Congress on Software Engineering*, 2010, no. 2, pp. 157–160.

Wireless Remote Controller for Power Source Based on Embedded System

Peter JOMBÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xjombikp@fiit.stuba.sk

Abstract. AC power sockets are devices for removable connecting electrically operated devices to the power supply. Devices are powered from power sockets continuously throughout the time. In some cases, power sockets can be controlled with a switch. By connection embedded system, end switchable power socket will be create an intelligent remote control. This paper deals with the hardware design of such device and special functions software implementation. Prototype device was tested in real environment.

1 Introduction

Energy saving [1] is important today, but not all of existing electric devices are built on this principle. Common devices usually have some states as standby [2], sleep and power-off. Some devices have only common states. There are several ways to save more energy. If we consider the warranty integrity there is only one way. Disconnect device from the power. We can disconnect power plug or turn off power socket with switch. It is mechanical process and user must do it. The most efficient way is do it remotely. Common houses have many devices connected to power source as television, radio, DVD player, computer, wireless router and printer. By connecting more remote controllers together we can create control network. This network can control more types of devices, like lights [3], doors, ventilation. It is possible to use it from computer network such as internet.

This article deals with designing and realization of peripheral hardware, which allows users to remotely control power for devices on long distance. Device would be controlled via several inputs as switch, web interface and mobile device. Access to the system is ensured via access data.

This paper is divided into seven sections. The second section describes commercial solutions. The third section proceeds with draft of proposed solution. Sections four and five are dealing with the device's software and hardware design. The sixth section is oriented to results and analysis. The last section is oriented to the description of further work which will improve current design of device and the final conclusion of our work.

---

* Doctoral degree study programme in field: Applied Informatics
Supervisor: Assoc. Professor Tibor Krajčovič, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 355–360.

2 Available commercial solutions

Many companies offer remote controllers. Commercial solutions can be divided in two groups: end-user and professional [4]. End-user solutions contain basic control mechanism on/off and time set. Professional solutions contain network connect with network protocols. Inputs status can be send via email protocol or SMS gate. User authentication is secured by a username and password with 128-bit key. Commercial solutions contain system with one unit and only limited capability to expand existed functions or hardware parts.

3 Solution proposal

The solution provides full customize control for all remote input and output switches. Solution consists of two types of devices. Main unit works as central decision-making unit. It connects to computer network and provide decision algorithm. Extended units works as remote part of central unit. The network scheme is shown in the Figure 1. Extended units communicate only with main unit trough Bluetooth wireless network [5]. Extended unit send state data to main unit. Main unit process data and send new state to extended unit. Extended unit can send data if it is in range and have same access code to Bluetooth network as main unit. A central unit can be operated with seven extended units. This is huge advantage, because extended unit contains only necessary hardware for mechanical-digital conversion.

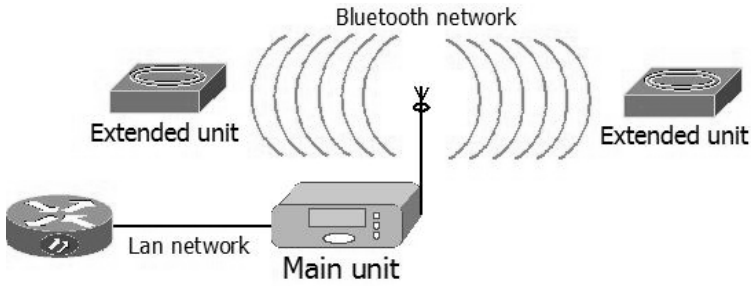

Figure 1. Network communication scheme.

Main unit is master unit for control. It contains I/O database, routing table, decision algorithm, web interface. I/O database contains states of all inputs and outputs from main and extended units. Information about input change is send to main unit and writes to I/O database. Database contains token. Token inform main unit about changes and call decision algorithm. Decision algorithm uses routing table to make decision over I/O database. Routing table is sets by user and contains links input-output and special links time-output for time control. After decision algorithm, main unit send new states of outputs to each affected extended unit. The main unit is set through the web interface. User can set many parameters such as time, states for outputs, routing table, type of extended unit. Web interface informs user about the current state of inputs and outputs. Main unit as an extension contains four switches and four power stocks.

Extended unit is fully customizable device. Each unit can contains up to 12 switches or stocks. Device can be powered by battery or power plug. Type of extended unit is set in main unit. After connecting new unit in network we must set parameters in main unit.

4 The enciphering device's software

The main goal in our project is put above on the design and implementation of controlling software, which would perform all actions described in previous section. First of all, the main unit

is embedded device and works as independent unit. This device can be configured via web interface. Device is powered by 12V AC power source. After the device initialization and time read from real-time clock connected extended units are initialized. Main unit send hello packet to Bluetooth network every few seconds to discovery new or missed units. All communication is handled by BT IO firmware inside Bluetooth modules. Main unit communicate with Bluetooth module trough UART bus. Control communication works on three basic messages: read request, status event, write request. Read request is send by main unit as request for status event. Status event is send by extended unit as state of all inputs and outputs belonging to unit. Write request is send by main unit as call for adjustment of outputs. After received status event by main unit is filled I/O database. I/O database contains links between input and output or time-value and output. If the database is changed, execute the Decision Algorithm. Decision algorithm has constant decision rules. Decision algorithm uses the routing table to change outputs. Decision algorithm solves problems as a multiple inputs controls one output according to internal rules. Embedded device and real-time clock communicates trough I2C bus. It's because embedded device do not have backup power source. We can take it as advantage, because controlled devices don't have back-up power and therefore unnecessary to control them. Communication works on messages: read, write.

All configurations can be done via web interface. In web interface user can set rules for remote control as connection between inputs and outputs, time change output, web interface change output. In web interface it must be set roles of extended units as remote control (like tv-remote) or power plug array. Figure 2 illustrates possibilities of web interface.

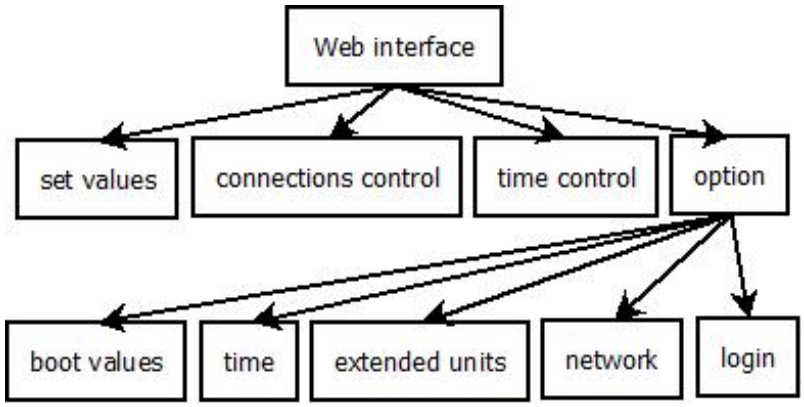

Figure 2. Web interface with possible options.

5 The enciphering device's hardware

At the embedded system selection we are focusing on the hardware that can fulfill all our requirements. System contains two parts.

5.1 Main unit

There must be enough hardware resources to connect wireless interface, real-time clock and enough inputs and outputsTo do so, we choose PIC18F6627. PIC18F6627 is 64-Pin, 1-Mbit, Enhanced Flash Microcontroller with 10-Bit A/D and nanoWatt Technology. For the realization of proposed design we are using development board form Motronix. The SBC65EC [6] is an embedded Single Board Computer with 98 KBytes Flash, 3936 Bytes SRAM and 64 Kbytes EEPROM, Ethernet, RS232, UART, I2C, Analog Inputs, Digital I/Os. SBC65EC [6] is programmed with bootloader. For network communication we use Bluetooth module

OEMSPA311[7] from connectBlue. OEMSPA311 can be loaded with special I/O firmware. For time control is used DS1307[8] serial real-time clock. As inputs are used switches and as outputs are used relays. Figure 3. illustrates the main unit circuit schematic diagram.

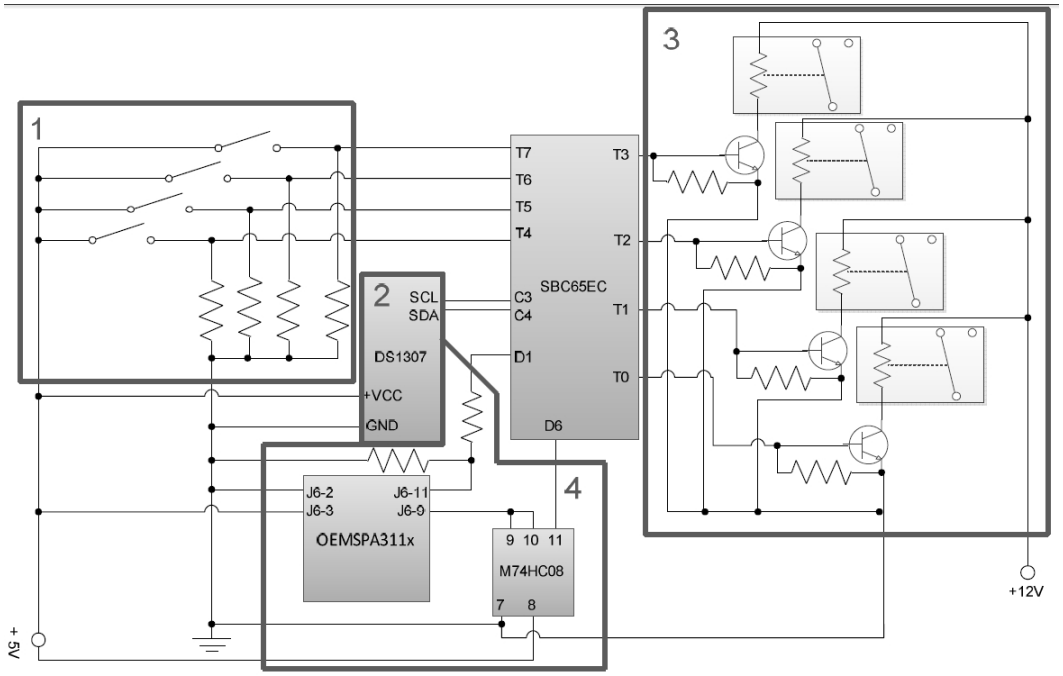

Figure 3. Main unit schematic diagram (1) switches (2) relays (3) real-time clock (4) Bluetooth module.

5.2 Extended unit

Extended unit was designed for any combination of input or output parts. Extended unit contains OEMSPA311[7] module with I/O firmware. Pins on chip work as input or output digital pins. As inputs and outputs hardware parts can be use same hardware parts as in main unit.

6 Result and analysis

The hardware testing is very important to ensure the components and circuits are in good condition. We use main unit and one extended unit. Extended unit works as remote control with four indicating LEDs. Via web interface we set four LEDs of extended unit as indicators for main unit plugs. Tested version of hardware is showed on Figure 4.

Each plug can handle 10 A. In tested circuit we connected common devices from house as computer, television, lamp, printer, speakers and notebook on power source trough remote controller. Energy consumption was measured with and without remote controller at the same conditions. Power source was switched off with remote controller while device don't was used. The result was the saving power consumption as shows Figure 5. Line A was without and B was with embedded system.

Tested version was used in real environment for long time. We analyzed outputs from real use and established the following conclusions: remote controller reduces energy consumption, increases safety and reduces the chance of damage to device from power source network as high power from thunder or equipment failure. The primary advantage is to increase user comfort.

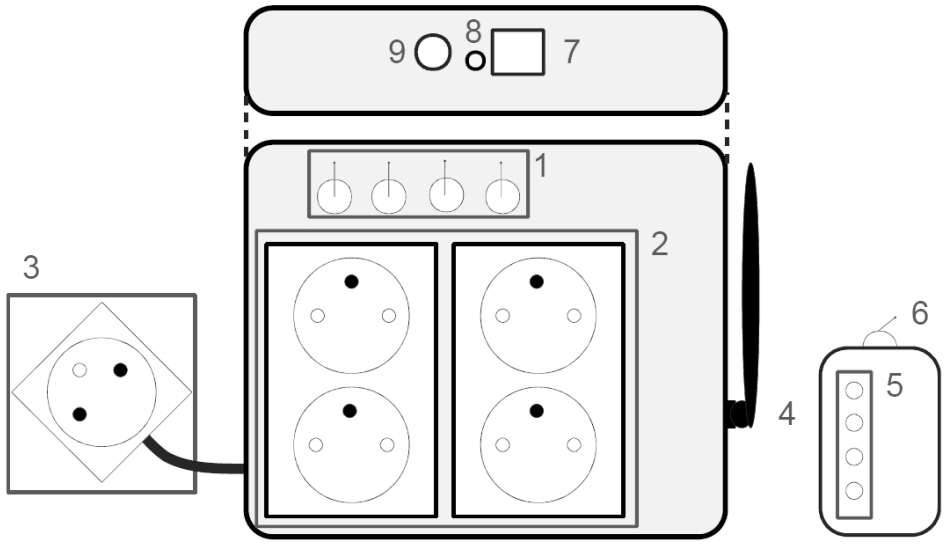

Figure 3. Tested version (1) switches (2) plugs (3) power source connector (4) BT antenna (5) LED indicators on extended unit (6) switch (7) network connector (8) power indicator (9) extern 12V power connector.

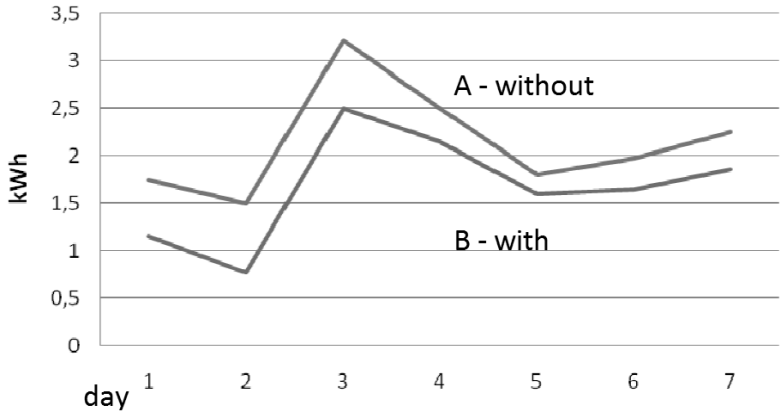

Figure 5. Energy consumption during 7 days.

7 Conclusions and further work

We designed solution for power saving and increasing safety. The solution comes with new view of wireless networks for remote control. The Solution is designed as portable for add new additional parts easily. It was designed with user friendly interface. In future we would like to use other type of wireless network and create communication between two and more main units. There is a possibility to improve decision algorithm with user defined options.

Acknowledgement: This work was supported by the Grant No. 1/1105/11 of the Slovak VEGA Grant Agency.

References

[1] He Chuan: "The Tactics of Urban Planning and Architectural Design on Urban Construction of Energy-saving and Environmental Affinity," *Energy and Environment Technology, 2009. ICEET '09. International Conference on* , Vol. 1, pp. 458–461.

[2] Clement, K., Pardon, I., Driesen, J.: "Standby Power Consumption in Belgium," *Electrical Power Quality and Utilisation, 2007. EPQU 2007. 9th International Conference* , pp. 1–4, 9–11.

[3] Jubadi, W. M., Zulkifli, N.: "Programmable infrared accessory light switch," *Intelligent and Advanced Systems, 2007. ICIAS 2007. International Conference,* pp. 1130–1134, 25–28.

[4] I/O Controller HWg-ER88a Datasheet [Online; accessed January 12, 2012]. Available at: http://www.hwg.cz/download/IO_Controller-ER88_SPEC_en.pdf

[5] Bhargava, A. S.; Gruenbacher, D. M.; , "Using piconet avoidance techniques to reduce interference in Bluetooth networks," *Consumer Communications and Networking Conference, 2004. CCNC 2004. First IEEE*, pp. 65–70.

[6] Modtronix Engineering: SBC65EC Datasheet [Online; accessed November 11, 2011]. Available at: http://www.modtronix.com/products/sbc65ec/sbc65ecr3.pdf

[7] OEM Serial Port Adapter™ cB-0901 Electrical & Mechanical Datasheet [Online; accessed December 12, 2011]. Available at: http://www.spezial.cz/pdf/em_ds_oemspa_311_331.pdf

[8] MAXIM: DS1307, I2C Real-Time Clock Datasheet [Online; accessed December 4, 2011]. Available at: http://datasheets.maxim-ic.com/en/ds/DS1307.pdf

Repair Analysis for Embedded Memories Using Block-Based Redundancy Architecture

Štefan KRIŠTOFÍK*

Slovak University of Technology
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kristofik@fiit.stuba.sk

Abstract. Capacity and density of embedded memories have rapidly increased therefore they have higher probability of faults. As a result, yield of system-on-a-chip designs with embedded memories drops. Built-in self-repair is widely used to improve manufacturing yield by replacing faulty memory cells with redundant elements. Most approaches perform reconfiguration on the row/column level. Block-based redundancy architectures divide memory and redundancies into blocks, performing reconfiguration on the block level and offering more efficient usage of the redundant elements. However, existing block-based approaches implement simple redundancy analysis algorithms which lead to non optimal repair rates. This paper proposes a new approach for block-based redundancy architectures, improving repair rates of previous approaches by utilizing a fast hybrid redundancy algorithm with low area overhead and optimal repair rate.

1 Introduction

The density of modern system-on-a-chip (SoC) designs is growing rapidly, so is the capacity and density of memories embedded within them. As a consequence, embedded memories have higher probability of faults and their manufacturing yield drops. Since embedded memories are occupying the majority of nowadays SoCs area (90 % according to [1]), they are the main source of faults in SoCs and they also dominate the overall SoC yield.

To improve reliability and manufacturing yield, the most widely used approach is to add some redundancy to the memories. Faulty memory cells are replaced by redundant elements. In the case of SoC, memory testing and repair are provided in the chip itself (built-in self-repair, BISR), because it is more cost effective than using external test equipment.

The BISR approach has three main functions. First, memories are tested for various types of faults by built-in self-test (BIST). Based on the fault information provided by BIST, memories are analyzed by the redundancy analysis (RA) algorithms which generate repair solutions for memories. Repair solutions consist of information on which redundant elements are to be addressed instead of every single faulty cell. Execution of RA algorithms is controlled by built-in repair analysis (BIRA). Repair solutions provided by BIRA are applied to memories by address

* Doctoral degree study programme in field: Applied Informatics
Supervisor: Assoc. Professor Elena Gramatová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 361–368.

reconfiguration (AR) which ensures that respective redundant elements are addressed instead of faulty memory cells.

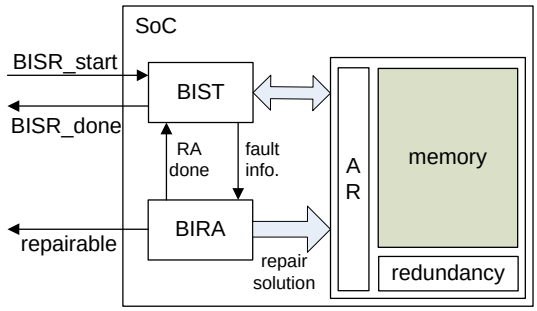

Figure 1. Built-in self-repair architecture.

Figure 1 shows the BISR architecture and its three main blocks: BIST, BIRA and RA. BISR function is started by activating *BISR_start* signal. When BISR function is finished, *BISR_done* signal is activated. If memory can be repaired, *repairable* signal is active. In case memory is un-repairable, *repairable* signal is not active. This may be due to insufficient number of redundant elements when fault density is high or due to usage of RA algorithm with non-optimal repair rate.

Physical defects in memories are caused by physical damage in the structure which causes a faulty behaviour of memories. These defects can be caused by various mechanical or environmental influences. As the process technology improves, many new types of faults in memories continue to emerge [2]. Memory test algorithms implemented within the BIST block have to be able to adapt to the trends in memory fault classification and detect and localize as many types of faults as possible. Fault information gathered by test algorithm is passed to BIRA.

Memories are regular structures therefore deterministic test algorithms (TA) are more suitable for them than pseudo-random TA. March TA [3] is the most used type of deterministic TA in memories. They have linear time complexity with respect to the number of memory cells. Moreover, they are regular and symmetric and offer high fault coverage (the ability of TA to detect and localize most known types of faults). The basic idea of march TA is to perform number of sequences, called march elements, of read and write operations to each memory cell. Fault coverage of these algorithms depends on the number and ordering of operations in each sequence as well as on the number of total memory operations.

An example of a simple march TA is MATS+ [3]. It consists of three march elements. First element has one write operation. Both second and third elements perform two operations, one read and one write operation. All operations are performed on each memory cell with varying logic values of '0' or '1'. Since it performs 5 basic memory operations on each cell, time complexity of MATS+ is 5.N. The number of total memory cells is denoted as N. MATS+ can detect only some basic types of faults and therefore has low fault coverage.

There are two basic concepts of BIST architectures – BIST based on finite state machine and BIST based on micro-codes. The former usually generates one TA, but is also able to generate a small number of TAs at the cost of rapidly growing complexity. The latter has much more flexibility and is able to implement any TA. Typical BIST architecture [4] comprises test address and test data generators and control block to execute and control BIST operations. Some of the most important criteria for evaluating BIST architectures are area overhead, fault coverage, flexibility and at-speed testing.

Fault information from BIST is processed in BIRA. This information is provided in the form of fault locations in the memory. Three main features of BIRA are area overhead, repair rate and analysis speed [5]. Smaller area overhead reduces chip production cost. Low repair rate impacts

yield negatively and speed affects the cost of repair. Repair rate represents the ability of an RA algorithm to find a repair solution for the memory and is defined as follows:

$$repair\ rate = \frac{good\ memories\ after\ BIRA}{\#\ of\ total\ memories}$$

The number of total memories includes both repairable and un-repairable memories. Un-repairable memories can be produced by various factors [5] and this may negatively influence the repair rate of RA algorithms that are evaluated using this value. Normalized repair rate was introduced in [5] and is defined as follows:

$$normalized\ repair\ rate = \frac{good\ memories\ after\ BIRA}{\#\ of\ repairable\ memories}$$

It is not dependent on the aforementioned factors, and therefore is more appropriate to evaluate the RA algorithms. Optimal repair rate is achieved when the normalized repair rate is 100 % [5]. Ideal BIRA has optimal repair rate with zero area overhead and analysis time. Finding a repair solution is NP-complete problem [3] and various BIRA approaches have been proposed that have tried to balance these three main factors [4-7]. Some general observations on how to obtain optimal repair rate with BIRA are listed in [5].

To be able to analyze fault information, BIRA needs to store it in some way. Approaches that utilize fault bitmaps of various sizes to store fault information have been shown to have negative impact on repair rate since some fault information is often omitted. Better repair rates were achieved by using of storage registers and content-addressable memories (CAM) [5-7].

Two important tasks of BIRA are fault collection (from BIST) and redundancy analysis of redundant elements. Both tasks are performed by RA algorithm. Based on the time of execution of these two tasks, we distinguish three types of RA algorithms [5]. Figure 2 shows a comparison of RA algorithms. Static RA algorithms perform RA after all fault information has been collected and stored in fault bitmap. This results in increased time it takes the algorithm to finish (slower analysis speed) and high area overhead. Static RA algorithms are neither suitable nor used in built-in solutions. Dynamic RA algorithms perform RA in parallel with fault collection. When BIST is finished, RA is also finished. Time to finish is shorter and area overhead is lower than in static RA algorithms, but repair rates are not optimal. Hybrid RA algorithms perform RA concurrently with fault collection, but after BIST finishes, RA continues for some time. Using hybrid RA algorithms, optimal repair rates can be achieved at the cost of slight increase in time and area overhead compared do dynamic RA algorithms.

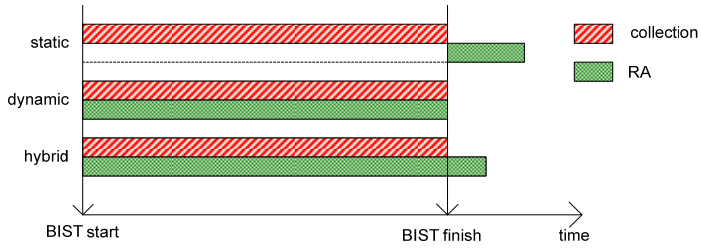

Figure 2. Classification of RA algorithms.

The types of redundant elements used in memories can be classified into four types as shown in Figure 3 on memories of size 8x8. Faulty cells are denoted by the "X" symbol. Redundant elements are represented as solid lines at the sides of memories and repair solutions are denoted by strike-through lines in memory arrays. 1-D redundancy architectures incorporate only one type of redundant elements (rows or columns) into memories. Figure 3 (a) shows an example where only

redundant columns are used. While this approach is easy to implement, RA algorithms are simple and area overhead is low, it suffers from non-optimal repair rates in larger memories. 2-D redundancy architectures are the most widely used and most BIRA approaches are based on it. Both redundant rows and columns are added to the memory as shown in Figure 3 (b). With 2-D redundancy, optimal repair rates can be achieved at the cost of enlarging area overhead needed to implement more complex RA algorithms. Local and global block-based redundancy architectures were proposed recently. They are based on divided word line (DWL) and divided bit line (DBL) architectures [6, 7]. Memory and redundancies are divided into number of blocks (divided blocks) and reconfiguration is performed on the block level instead of row/column level as in 1-D and 2-D redundancy architectures. For example, memories are divided into 4 blocks and redundancies are divided into 2 blocks, in Figure 3 (c) and (d). If local blocks are used, blocks of redundancies are restricted to be used only in their respective memory blocks [6]. Global blocks can be used in any memory block therefore providing better repair rates than local blocks [7].

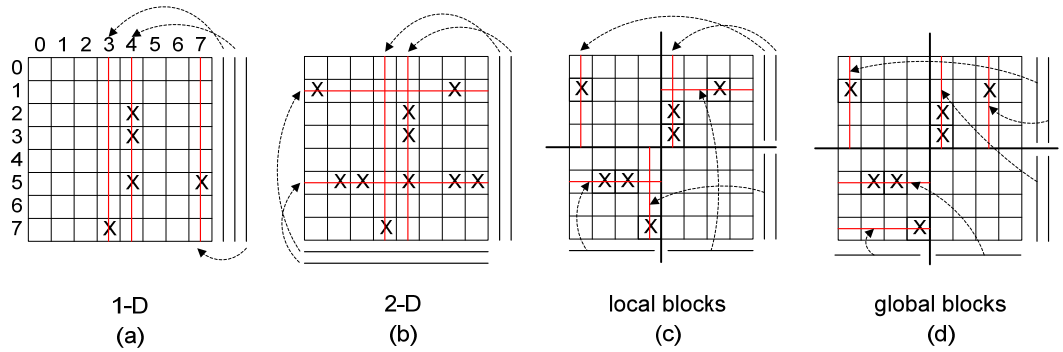

Figure 3. Redundancy architectures.

Among various RA algorithms for 2-D redundancy architectures, selected fail count comparison (SFCC) showed the best performance in matters of repair rate, area overhead and analysis speed [5]. SFCC is a hybrid RA algorithm that builds a fault line-based searching tree that searches through repair solution space faster than previous approaches based on cell-based searching trees thus improving analysis speed. Its fault storing structure is based on CAMs and it focuses on reducing storage requirements by discarding some overlapping fault addresses. Among a few known RA algorithms for block-based architectures, modified essential spare pivoting (MESP) showed the highest but not optimal repair rate [7]. MESP is based on essential spare pivoting (ESP) algorithm [3], which focuses on low area overhead and fast analysis speed, but cannot guarantee optimal repair rates in 2-D architecture. It is a dynamic RA algorithm that builds a repair solutions based on identification of pivots (first faults found in a row or column in divided blocks) often omitting some fault information which leads to non-optimal repair rates.

RA algorithms used in known block-based redundancy architectures achieved non-optimal repair rates [6], [7]. In this paper, we propose a block-based redundancy architecture with global redundancy, which uses modified SFCC (MSFCC) algorithm based on SFCC to improve repair rates of previous block-based approaches. Table 1 clarifies the idea proposed in this paper.

2 Proposed built-in repair analysis approach

We use global block-based redundancy architecture as in MESP and classification of memory faults based on SFCC. Single fault does not share either row or column address with any other fault in the divided memory block. Sparse fault shares its row (column) address with at least one other fault in the divided memory block, but not more than C (R) faults, respectively. C and R

denotes the number of available redundant column and row blocks in the memory, respectively. Must-repair fault shares its row (column) address with more than C (R) faults in the divided memory block.

Table 1. Idea of proposed approach.

redundancy architecture → / RA algorithm ↓	2-D	block-based
ESP	low repair rate low area overhead	-
MESP	presumably same as ESP	non-optimal repair rate low area overhead
SFCC	optimal repair rate higher area overhead	-
MSFCC	presumably same as SFCC	proposed

Proposed approach is based on SFCC. It uses a group of CAMs for storing fault information. When fault information collection is finished, all faults are classified into three types. Must-repair faults are repaired first using respective available redundant elements. After must-repair faults have been repaired, remaining redundant elements are used to repair sparse faults by utilizing an auxiliary buffer structure. After sparse faults have been repaired, remaining single faults are repaired using remaining redundant elements randomly.

Proposed fault collection structure is based on SFCC and is shown in Figure 4. Information on must-repair faults is stored in MR/MC CAMs in Figure 4 (a). Information on faults that are found first in their respective row or column (i.e. pivots or parents) is stored in PA CAMs in Figure 4 (b). Information on faults that share row or column address with parent faults (named child faults) is stored in CH CAMs in Figure 4 (c). Maximum number of must-repair CAMs for rows (MR) and columns (MC) is R and C, respectively. Maximum number of parent CAMs is R + C. Maximum number of child CAMs is R.(C – 1) + C.(R – 1). Fault collection is finished when BIST is finished.

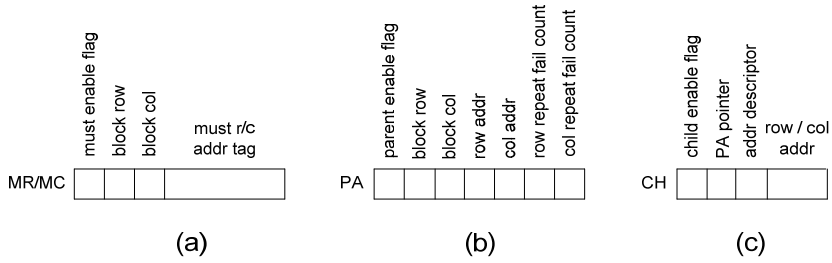

Figure 4. Fault collection structure of MSFCC.

In Figure 4, all enable flags are set to 1 if corresponding CAM is used to store fault information, otherwise it is 0. Block row and block col fields denote the divided block row and column address in which the fault is localized, respectively. The idea of how these values are derived is shown in Figure 5 (b), which depicts the same type of memory as shown in Figure 3 (d). Must r/c addr tag identifies the row or column address of the must-repair faults stored either in MR or MC CAMs, respectively. Row addr and col addr fields denote the row and column address of parent faults in divided blocks, respectively. Row repeat fail count and col repeat fail count fields store the number of how many child faults share the same row or column address with their parent faults, respectively. PA pointer points to a respective PA CAM in which the parent fault information is

stored. Addr descriptor is set to 0 if the child fault shares the column address with its parent fault, otherwise it is 1. Row / col addr field denotes the row address of child fault if add descriptor is 0, otherwise it denotes the column address.

Proposed approach uses auxiliary buffer structure based on sparse faulty line buffer [5] and is shown in Figure 5 (a). Maximum number of lines in auxiliary buffer (denoted as L) is 2.(R + C) if R + C is even, otherwise 2.(R + C – 1) + 1. In Figure 5(a), enable flag, block row and block col fields have the same purpose as in Figure 4. R/C flag is set to 1 if the sparse faults share the same column address, otherwise it is 0. R/C sparse addr field denotes the row or column address of the sparse faults if R/C flag is 0 and 1, respectively. Line fault count field stores the information on how many sparse faults are sharing the same row or column address if R/C flag is set to 0 and 1, respectively. The contents of a L-bit intersection flag field are set by analyzing the intersected faults (a fault, which shares both row and column address with at least one other sparse fault). The number of buffer line which stores the information about the row and column of the sparse fault by is denoted by i and j, respectively. Then the j-th bit of this field in i-th buffer line and the i-th bit in j-th buffer line are both set to 1.

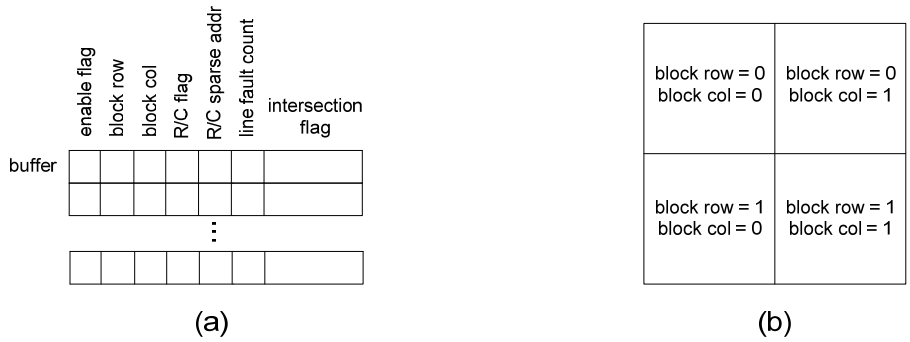

Figure 5. Auxiliary buffer structure of MSFCC.

Repair solution for sparse faults is derived by analyzing the information in auxiliary buffer. MSFCC searches the solution space by counting the number of faults covered (NFC) for each line combination from auxiliary buffer. For a combination of lines to be the correct repair condition, the value of NFC has to satisfy the following condition [5]: NFC ≥ TF – (R + C – S), where TF is total number of faults remaining in the memory after the must-repair faults have been repaired and S is the number of lines in the selected combination.

3 Example

We show the function of proposed RA algorithm on the example in Figure 6. Figure 6 (a) depicts one of four divided memory blocks of the same memory type and with same number of redundant elements (R = 2, C = 4) as in Figure 3 (d). This block has row and column addresses both equal to 0 (Figure 5 (b)). Other three blocks are fault free and are not pictured. The numbers of CAMs needed are as follows: 2x MR, 4x MC, 6x PA and 10x CH CAM. Faults in the memory are detected in the order as shown in the Figure 6 (b). After detection of the last fault, the contents of must-repair, parent and some child CAMs are shown in Figure 3 (c), (d) and (e), respectively. Column with address 1 (column 1) is repaired first, as it contains three must-repair faults (#3, #5, #6 as in Figure 6 (b)), therefore the value of C changes from 4 to 3. There now remains a total of 7 faults (4 sparse and 3 single). To repair sparse faults (#1, #8, #9, #10), auxiliary buffer structure is introduced. The contents of auxiliary buffer structure after repairing of must-repair faults are shown in Figure 7. The number of buffer lines needed is 12, but only the first 4 are shown.

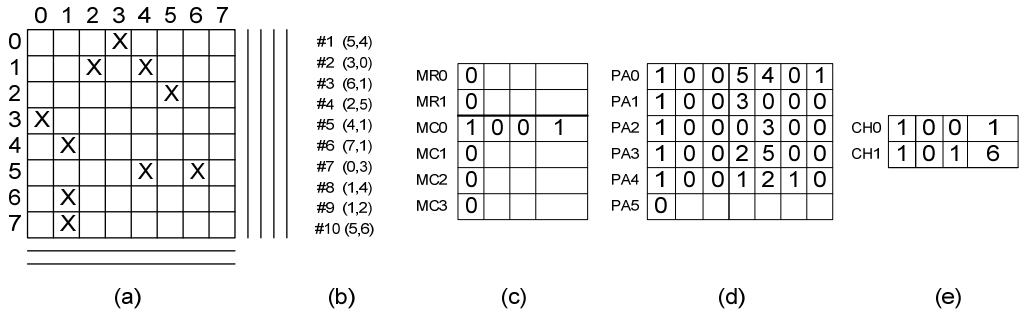

Figure 6. Example of MSFCC algorithm.

buffer							
	1	0	0	1	4	2	0...0110
	1	0	0	0	1	2	0...0001
	1	0	0	0	5	2	0...0001
	0						

Figure 7. Example of usage of auxiliary buffer structure.

In Figure 7, the first line stores the information about column 4, the second line about row with address 1 (row 1) and the third line about row 5. All of them does have the same number of 2 sparse faults in them. Intersected faults are #1 (row 5, column 4) and #8 (row 1, column 4). Therefore the intersection flags are set to indicate the intersection between first and third buffer line (for fault #1) by setting the third bit in first buffer line and the first bit in the third buffer line to 1 and likewise between the first and the second line (for fault #8).

Now, MSFCC counts the values of NFC for all possible combinations of repair solutions for sparse faults. The results are shown in Figure 8.

S	solution	NFC
1	col 4	2
1	row 1	2
1	row 5	2
2	col 4 row 1	3
2	col 4 row 5	3
2	row 1 row 5	4

Figure 8. Determining repair solution in MSFCC.

In this example, the value of TF, R and C are 7, 2 and 3, respectively. For a combination to be the correct repair solution, the value of NFC has to be more or equal to 3 for S = 1. In Figure 8, no solutions for S = 1 satisfy this condition. For S = 2, the value of NFC has to be more or equal to 4. In Figure 8, only one solution satisfies this condition, so this is selected by MSFCC as the correct repair solution for this example. Sparse faults are repaired using 2 redundant row blocks to replace rows 1 and 5. The value of R is changed from 2 to 0. The value of C remains 3.

After the must-repair and sparse faults have been repaired, MSFCC repairs the remaining single faults (#2, #4 and #7) by remaining three redundant column blocks. The final repair solution by MSFCC is shown in Figure 9 (a). For comparison, the solution for this example found by the MESP algorithm is shown in Figure 9 (b). As shown in Figure 9 (b), MESP is not able to find a repair solution for this example as one fault is left un-repaired and marks this memory as un-repairable. This shows the potential of MSFCC to improve the repair rates of previous RA algorithms used in block-based redundancy architectures.

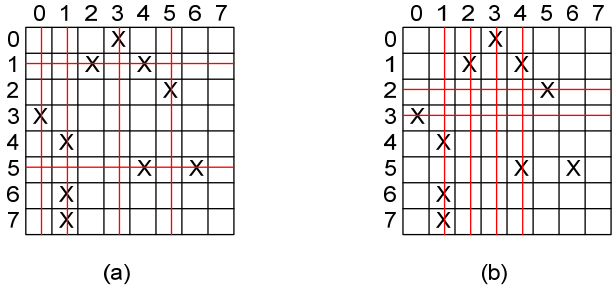

Figure 9. Comparison of MSFCC and MESP algorithms.

4 Conclusion

A new block-based redundancy architecture for built-in self-repairing of embedded memories is proposed in this paper. It is based on DWL and DBL techniques and can be used in modern SOC designs to improve manufacturing yield.

The proposed redundancy analysis approach is based on modified SFCC algorithm (MSFCC) which is supposed to have better repair rate for memories than that of previous RA algorithms used in block-based redundancy architectures. Area overhead of the proposed approach is supposed to be higher than that of previous block-based architectures since more complex RA algorithm is used. However, further experiments on this are yet to be performed.

Acknowledgement: This work was partially supported by the Slovak Science Grant Agency (VEGA 1/1008/12).

References

[1] International Technology Roadmap for Semiconductors (ITRS), *Test and Test Equipment* [Online; accessed November 15, 2011] Available at: http://www.itrs.net/Links/2009ITRS/2009Chapters_2009Tables/2009_Test.pdf

[2] S. Di Carlo, P. Prinetto: Models in Memory Testing . H.-J. Wunderlich (ed.), *Models in Hardware Testing*, Springer, (2010), 257 p. ISBN 978-90-481-3281-2, pp. 157–185.

[3] M. Fischerová, E. Gramatová: Memory Testing and Self-Repair. R. Ubar, J. Raik, H. T. Vierhaus: Design and Test Technology for Dependable Systems-on-Chip, Hershey, Pennsylvania: IGI Global, (2010), ISBN 978-1-60960-212-3, pp. 155–174.

[4] O. Novák, E. Gramatová, R. Ubar: Handbook of Testing Electronic Systems, České vysoké učení technické v Praze, (2005), 395 p. ISBN 80-01-03318-X.

[5] W. Jeong, I. Kang, K. Jin, S. Kang: A Fast Built-in Redundancy Analysis for Memories With Optimal Repair Rate Using a Line-Based Search Tree, *IEEE Transactions on VLSI systems*, (2009), Vol. 17, No. 12, pp. 1665–1678.

[6] S.-K. Lu et al.: Efficient Built-In Redundancy Analysis for Embedded Memories With 2-D Redundancy, *IEEE Transactions on VLSI systems*, (2006), vol. 14, no. 1, pp. 34–42.

[7] S.-K. Lu, C.-L. Yang et al.: Efficient BISR Techniques for Embedded Memories Considering Cluster Faults, *IEEE Transactions on VLSI systems*, (2009), Vol. 18, No. 2, pp. 184–193.

Evolution of Asynchronous Sequential Circuits

Michal KUDLAČÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kudlacak@fiit.stuba.sk

Abstract. Asynchronous sequential circuits are digital circuits, which assume binary signals and no common discrete time. These two assumptions make design challenging, due to occurrence of races and hazards. However there are some potential benefits such as low power consumption, high operating speed, better modularity, no clock distribution and skew problem and less electromagnetic emission. Asynchronous systems are also considered as very viable alternative to purely digital systems. This paper presents an evolutionary approach to designing asynchronous sequential circuits, which is based on Cartesian Genetic Programming.

A paper based in part on this paper was published elsewhere.

* Doctoral degree study programme in field: Applied Informatics
Supervisor: Assoc. Professor Pavel Čičák, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 369–374.

Contribution to Visualization of HDL Model Simulation Results

Dominik MACKO*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
macko@fiit.stuba.sk

Abstract. The role of Hardware Description Languages (HDLs) in a current digital systems development process is essential. However important their contribution is, they also bring about several disadvantages. The textual form of HDL models and common simulation results visualization are two of them. In this paper, we present our progress in developing a visualization environment, which is able to display the simulation results in the structural sphere of the model, allowing the designer to switch between individual hierarchic levels of the structure and watching the signal changes directly in a verified component.

A paper based in part on this paper was published in Proc. of World Congress on Engineering (WCE'12), Int. Association of Engineers, 1095-1100.

* Doctoral degree study programme in field: Applied Informatics
Supervisor: Dr. Katarína Jelemenská, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

New Approach for Determining a VoIP Backbone

Martin HRUBÝ, Michal OLŠOVSKÝ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
hruby@fiit.stuba.sk, olsovsky@fiit.stuba.sk

Abstract. Network throughput and bandwidth overprovisioning do not provide equal quality of service for all applications. Time characteristics of the network must also be taken in mind when deploying applications which are sensitive to delay and jitter, e.g. VoIP. By means of changing the path of traffic significant improvement of the time-variable can be achieved. In this paper we propose a methodology for optimal link selection based on modeling network characteristics using a Multivariate normal distribution model – cube model. This approach enables real-time identification of reliable links and provides input for a modified composite optimal path selection algorithm. Aside from this our model can be used for determining future network improvements to increase the quality of service.

A paper based in part on this paper was published in Proc. of the 35th Int. Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO'12), Croatian Society for Information and Communication Technology, Electronics and Microelectronics, 577-582.

* Doctoral degree study programme in field: Applied Informatics
Supervisor: Assoc. Professor Margaréta Kotočová, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

User Interaction, Computer Graphics, Image Processing

Augmented Reality as an Interface for Learning Solid Geometry

Michal BARÁT*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xbarat@fiit.stuba.sk

Abstract. Augmented reality has been spread to various areas of our lives including education. This paper presents augmented reality as an interface for an educational application. We focused on the interface design which has to serve its best to a user, while learning solid geometry. This way of interaction creates an environment for easier manipulation and more understandable curriculum, which we offer through rendered 3D objects handled as markers. The proposed interface uses only elements of augmented reality – which are used to control the whole application, e.g., show the space objects, move them, change their properties, open a task, save it, close the application etc.

1 Introduction

Application of information technologies varies. One of the ways to use them is undoubtedly in education. Information technologies not only provide a huge amount of information but they also offer different forms as how to work with them and to display them. Displaying data by using virtual reality helps to understand poorly conceived information [1]. Currently, technologies offer various kinds of displays and motion in virtual three-dimensional space is not exceptional. This can be applied for example in teaching of geography[1], physics[2], chemistry[3] or mathematics [2].

In our work we pay attention to the teaching of mathematics by using virtual and augmented reality. Specifically, we concentrate on the solid geometry and analytical geometry. Although human perception is adapted to the perception of three-dimensional space, our imaginations descend in its representation into two-dimensional space. Students learning geometry and analytical geometry in school have often problems with it. A good solution is to use augmented reality, which allows students to transfer an example from the existing area into three-dimensional virtual space. It is for them to support better imagination and can help them to solve the problem. To display mathematical problems in a three-dimensional virtual space is only one part of the solution. Another, equally important issue that needs to be addressed is how to control

* Master degree study programme in field: Information Systems
Supervisor: Dr. Alena Kovárová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

1 Google Earth 6 available at: http://www.google.com/earth/index.html

2 LearnAR available at: http://www.arlearning.co.uk/#home

3 OnlineChemLabs available at: http://www.onlinechemlabs.com/information-for-educators.aspx

and move in virtual space, what is not a trivial matter. We think that such system will be used mainly by pupils and students and not by professional computer graphic designers, because the aim of the system is to help pupils and not cause them more problems.

2 Technical background

The surrounding world offers a large amount of real information, perfect perception and perception of space. In the virtual world of computers collected information is stored, sorted, compared and evaluated. It is very complicated and nowadays difficult to achieve to create a perfect virtual world in which all the principles of the real world are displayed in a convincing manner. In augmented reality we try to join the positives of these both worlds. The aim is to achieve a state, in which we could not distinguish the real world apart from the virtual one.

2.1 Methods of displaying augmented reality

The augmented reality has been for over forty years closely related to various overhead displays, optical instruments and video see-through displays. Their appearance, ergonomics and the usage possibilities went through various changes. By synchronisation of optical components, mirrors, transparent screens and holograms, as well as video projectors, was created spatial augmented reality. In many ways it overtakes options and approaches of traditional augmented reality. Gradually the price of analogue components required for viewing augmented reality decreases, thereby their availability increases and opens opportunities for their use in schools, museums, industry, and research laboratories. Methods for imaging augmented reality [3] can be divided into three main categories: head-attached displays, hand-held displays and spatial display. Each of these augmented reality categories has its positive but also negative aspects. Some of them are suitable only for the specific needs of a user, while others let us see optional role of augmented reality.

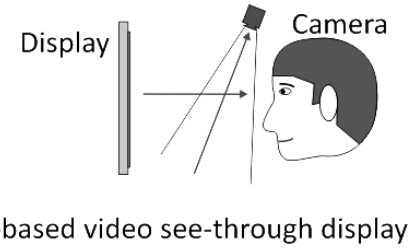

Figure 1. Detail of the principle video see-through display with the monitor [3].

To solve our problem, we have chosen the category of spatial displays (see Figure 1). In contrast to the head-attached or hand-held displays, spatial displays separate most of the technology equipment from the user and integrate it into the surrounding space. Considering the need of free hands during work and the availability of solutions, we decided to use technology of screen-based video see-through displays. They are used for connection of a captured image with a virtual one, and the combination of images is projected onto a normal screen (see Figure 1). Their disadvantage is the small field of view limited by the size of your monitor, but also low separation of the projected image after connection of real and virtual images. Their great advantage is, however, that there is no need for special equipment. Components for its implementation are owned by most schools and pupils, for which our project is proposed. In the future, we do not eliminate the possibility of extending the solution to the head-mounted or retinal displays.

2.2 Related work

There are several systems for mathematics teaching. Some of them are popular among students, for example when they need to illustrate function graph. Fewer of them, however, allow to resolve geometric or stereometric tasks. Only a few of them allow to work and display 3D space. The programs selected for analysis were such as GeoGebra 3.2.46.0[4], GEUP 3D[5], Archimedes Geo3D 1.3.5[6], StereoVR [11]. We were most inspired by Cabri 3D v2 [2] and Construct 3D [5].

- Cabri 3D v2: The most widely used program for geometry teaching in schools. It is quite popular because of its simplicity and complexity. It is possible to use it for educational tasks rather as illustrates not as a learning material, because it does not include theoretical knowledge serving to explain the relationship. The menu offers a variety of tools, prepared types of services and operations with them. The program works in three-dimensional environment in which it is possible to move with the cursor.
- Construct 3D: The link is a good example as to join the augmented reality with education in mathematics from the Technical University of Vienna, enabling the creation and visualization of objects in space. The system was designed primarily for teaching vector analysis and descriptive geometry. The control system uses a special personal interaction panel and special pens sensing cameras (see Figure 2). With the headset display students can look at the object in the scene space from random angle, because it still remains in its original location.

3 User interface

The system consists of a camera, PC, display and desktop (see Figure 3). *Camera* – The camera is located approximately at eye level following user's sight. *PC* – efficient computing equipment which is capable to process inputs from a camera, calculate properties of objects and send the input image augmented with virtual elements to display equipment in real time. *Display* – The display equipment shows the output from the scene. *Desktop* – The user will control the whole application by a physical desktop. Except of mathematical problems given by teachers or initiated at the application start, everything else should be adjusted by that. The application will be controlled by markers placed on the desktop. The desktop will be shown on the monitor, where the icons and their description are displayed instead of the markers.

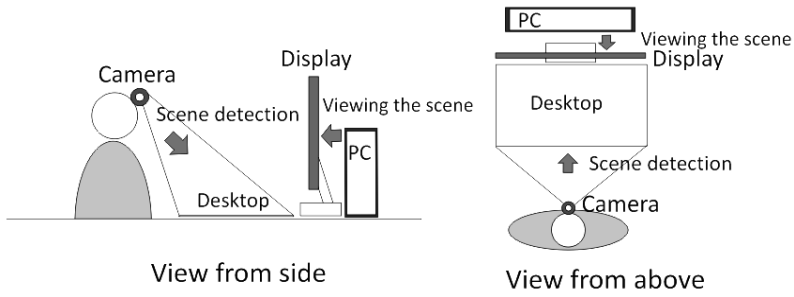

Figure 3. Schematic design of the user interface.

The elements on the desktop are included in the following three types (see Figure 4):

[4] GeoGebra 3.2.46.0 available at: http://www.geogebra.org/cms/
[5] GEUP 3D available at: http://www.geup.net/en/geup3d/index.htm
[6] Archimedes Geo3D available at: http://raumgeometrie.de/

- *Areas:* Desktop is divided into the smaller areas for storage brands. The largest of them, the *Main area* (1), is closest to the user. Here a user inserts markers of objects and tests their overlapping and slices. On the left is the *Turning area* (2) serving to the label rotation. On the right side of the Desktop a user has the *Dimension area* (3) with is an indication of the size scale. The fourth area, the *Object area* (4), is used for objects selection. The *Fixing area* (5) and the *Transparency area* (6) have the same purpose as their names. The last area is the *Instructions area* (7). It is defined as the area of using other brands which do not need to be on the scene permanently for their functionality.
- *Controls:* Controls are for direct control of the units displayed on the *Main area*. These include *Rotation* (8), which serves for rotating of the scene and allows the user to look at the object from each side. The scene is rotated by rotation defined under the marker *Rotation*. The control *Size* (9) is controlled by moving through the scene. The effects are manifested by its position from the centre of the *Dimension area*. Size modifies the dimensions of the selected unit. The control *Transparency* (11) determines the transparency of the object in the display. It helps to clarify the scene.
- *Icons:* The last group of elements in the scene are icons. The icons represent any functionality to be performed. Icons *Unit 1* (12) and *Unit 2* (13) are used to select an object whose size and transparency can be changed by controls. We anticipate working with only two departments in the main area because humans have only two hands. The user can choose the type of department by choosing a marker. The marker *Fixing* (10) is used to fix the scene in its actual state. There is no need to keep configuration because it remains in its state before fixation until its shutdown. Tags departments in this state has no effect on the scene. This state is used to view the scene without disruption. The fixing of the scene lasts while markers are at the scene. Category of icons designed to work with an example consists of *View example* (14), *View solution* (15) and *Next* (16). By using them a window with an example or another example of the solution can be displayed. The icon *Shows Intersection* (17) show departments intersection in collision. The icon *Information window* (18) appears with information about the scene on the screen, adds or detracts description and identification of bodies from the scene. Icons *Saving* (19) and *Loading* (20) open the screen window to offer deposit or download. During these operations is fixation of the scene turned on automatically until it is cancelled by the presence of marker *Fixation*. It helps to control solutions for teachers. Special marker *Termination* (21) closes the application after its display at the scene.

In addition to these elements, predefined tags of units are used on the scene as well. Those markers are different from each other, they have not only various sizes, but also various colour to better differ them on the scene.

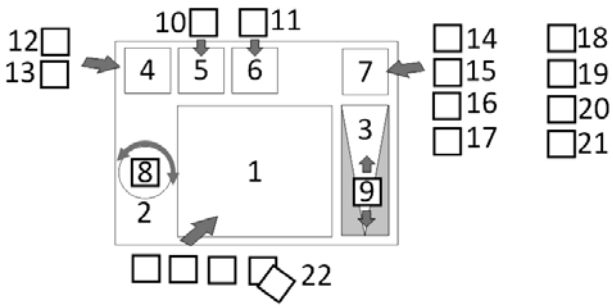

Figure 4. Proposal of the desktop.

4 System architecture and implementation

The proposed system consists of five modules. They are: Scene scanning, Scene detection, Management, Scene display and Database (see Figure 5).

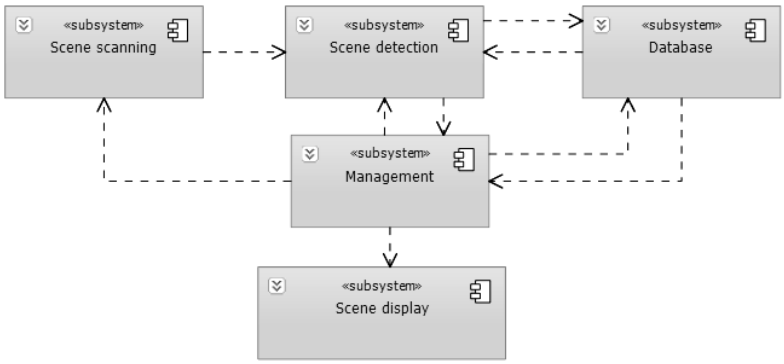

Figure 5. Modules of the proposed system.

The task of the first module is to scan the scene data and transform it into such form and shape in which it can be further processed. The role of the Scene detection module is to detect signs on the scene. Module Management is responsible for general scene management determined e.g. by location, size and rotation of objects, by calculation of collisions, by intersection of objects, etc. The role of the displaying module is to take care of the scenes view of the data on the screen or in the overhead display. The last module is the Database. This module kept stored scenes, a collection of examples and set of the signs.

Our design was implemented by using of the libraries OpenCV[7], ARToolKitPlus[8] and Freeglut[9]. A working prototype with proposed basic functionality allows each user to display features on signs and interact with their properties by using other signs on the desktop (see Figure 6). Also, using signs on his desktop helps him to display an example, its solution and other basic information about the scene, as we can see in the example.

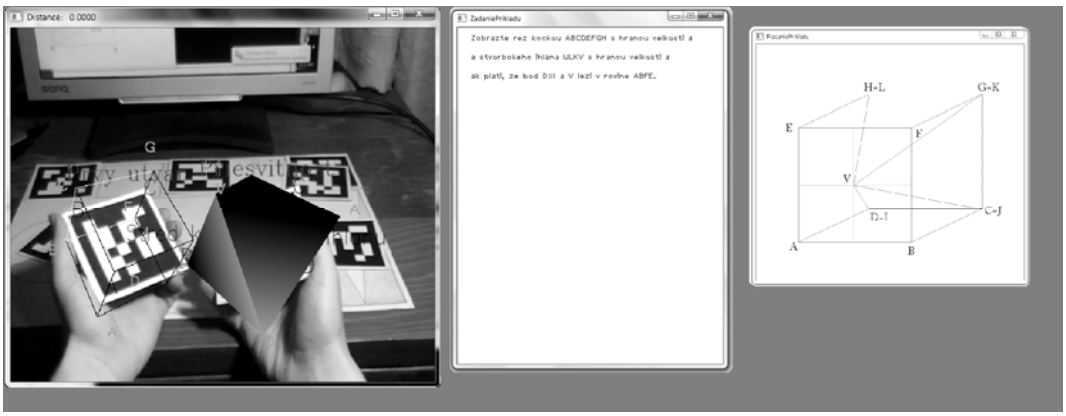

Figure 6. Proposal of our prototype.

[7] OpenCV available at: http://opencv.willowgarage.com/wiki/
[8] ARToolKitPlus 2.1.1 available at: http://handheldar.icg.tugraz.at/artoolkitplus.php
[9] Freeglut available at: http://freeglut.sourceforge.net/

The application can be completed by the special marker viewing on the scene. We continue to focus on displaying of the description of figures directly on the scene, graphical determination of penetration units and tuning some control functions by monitoring of rotation or by moving the markers. Also, the names and icons over markers are presented with their functionality. The last area we focus on is the improvement of the scene deposition, examples and solutions. To these days, hardware of common PC's is unable to offer real-time work with augmented reality. On our machine with 3 GB of RAM, a 1.86 GHz dual core processor and an 256 MB external graphic card the rendered output has less than a second delay, which is, however, still noticable and obtrusive for most users.

5 Conclusions

The outcome of our project is to analyze existing applications in the field of education in the field of 3D geometry using virtual reality respectively augmented reality. We also analyze the different types of augmented reality, where we chose screen-based video see-through displays because this type is affordable. We have designed an interface that is specific in that it requires no interaction with the keyboard or mouse, and thus more accurately mimics the interaction with 3D objects. In our interface dominate a desktop and a set of markers. The two main markers are mapped two basic 3D objects (users hold the hands exactly the same as they would hold true 3D objects), other markers are used to control the scene or the application itself. We decided to focus on interface therefore the diversity of the functions and geometric objects is not crucial. Currently we have the second version of the interface as a prototype testing revealed fundamental shortcomings of the first draft. In subsequent work, we are planning to finish the application implementation and make several tests set by appropriately selected group of users. Test results will serve us for the final tuning of the interface. Such an interface will then be able to more accurately simulate the manipulation of 3D objects. This along with the use of AR technology increases the educational potential of 3D geometry, or other areas of working with objects in three dimensions.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic under the contract No. VG 1/1134/12.

References

[1] Maqableh, W.F., Sidhu, M.S.: From Boards to Augmented Reality Learning. In: *International Conference on Information Retrieval & Knowledge Management,* IEEE, (2010), pp. 184–187.

[2] De Cotret, S., De Cotret, P. R.: Cabri 3D User Manual. Cabrilog, (2005).

[3] Bimber, O., Raskar, R.: Modern Approaches to Augmented Reality. In: *ACM SIGGRAPH 2006 Courses*, ACM, (2006).

[4] Kovárová, A., Gregor, J.: Stereometria a virtuálna realita. In: *SCO 2009 sborník 6. ročníku konference o elektronické podpoře výuky*. Masarykova univerzita, Brno, Czech Republic, (2009), pp. 93–98, (in Czech).

[5] Kaufmann, H.: Construct3D: An Augmented Reality Application for Mathematics and Geometry Education. In: *Proc. of the 10th ACM International Conference on Multimedia*, ACM, (2002), pp. 656–657.

Multi-Touch Interaction Technique Designed for Three-Dimensional Environmentson the Screens of Mobile Devices

Filip HLAVÁČEK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
filip.hlavacek@gmail.com

Abstract. In this paper we focus on multi-touch interaction techniques with the aim to design an intuitive, easy-to-learn and efficient solution that users would embrace. To reach this goal, we set out by analyzing research on advanced interaction techniques and existing approaches used in applications available on mobile devices. We design our own technique with regard to the six degrees of freedom. The efficiency of our solution shall be verified by applying this technique in an Android based application used by students to support cube cross section education.

1 Introduction

Human-computer interaction (HCI) plays an essential role in today's technology. Large displays, various input devices, high-end mobile phones, all need to adopt specific HCI approaches in order to present their true potential to the common user. Just recently multi-touch displays became a standard for mobile devices. Common interaction techniques for 2D environment manipulation have already been adopted, but 3D interaction techniques are still in development.

This paper reports on a research study investigating the use of virtual reality (VR) in conjunction with multi-touch mobile devices to facilitate the knowledge construction by middle school students of 3-dimenstional (3D) geometry by means of up-to-date education approaches.

Nowadays, technologies and high-end devices available to almost everyone can be used to motivate students with new educational approaches. In order to be able to stimulate students' knowledge construction, such educational application has to be intuitive, fast to master and efficiently provide relevant information to the students. In order to fulfill these requirements we have designed a new multi-touch technique approach with the aim to provide enhanced but easy to learn interaction possibilities.

* Master degree study programme in field: Information Systems
Supervisor: Dr. Alena Kovárová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 399–404.

2 World of 3D

With new technologies emerging daily and providing users with all kinds of different possibilities the need to evolve the interaction methods grows rapidly. The value of a VR without intuitive or at least fast learnable interaction methods degrades rapidly as the users are demotivated and unwillingly forced to concentrate on the fact that the VR environment they act in is not real, because they are not able to interact in a way they would in the real world.

Human-computer interaction (HCI) is nowadays subject of studies in many different areas. In our research we concentrate on HCI in the areas related to multi-touch interaction, virtual reality, learning environments and mobile devices. The research will be conducted in the field of 3D geometry, also known as solid geometry. Students often have problems projecting shapes drawn on paper into a three-dimensional space in their minds [4]. Further operations on these objects are difficult just to imagine, therefore difficult to comprehend and learn. Presenting such shapes and operations in VR enables the students to focus on the target objects and later on, when already acquainted with necessary experience based knowledge, to project these shapes and operations onto paper or semantics.

There have been many projects that have built virtual reality learning environments (VRLE) for geometry. In the case of VRMath [2] students are opted to complete various tasks. An advanced solution for a VRLE has been presented by Hannes Kaufmann and Dieter Schmalstieg [6] where students are allowed to interact with 3D objects in an immersive VR and therefore directly experience the knowledge.

2.1 Multi-touch interaction

In order to be able to design a usable multi-touch technique, we thoroughly analyzed existing approaches as well as related HCI. When researching interaction techniques we analyzed HCI from the following points of view:

2.1.1 Environment with intuitive control

Each environment is designed so that it fulfills its specific goal, therefore requires a different HCI approach. As these environments focus on simulating reality (VR), HCI must correspond to the interaction possibilities in the real world. It has to be as intuitive as possible and for common tasks, it should allow the users to easily replicate these actions and receive the expected feedback. On the opposite, the primary goal of application specific HCI is to find interaction methods, that effectively cover all application capabilities, rather than to provide intuitive interaction methods.

2.1.2 Haptic surfaces and finger gestures

Depending on the device in question, different interaction approaches have to be used. Some devices allow more straightforward techniques, minimizing the abstraction between the reality and the virtual environment. Haptic surfaces, known as touch surfaces are nowadays present in most mobile devices be it mobile phones, tablets or notebooks (trackpads). Multi-touch surfaces have several issues that need to be addressed. When designing three or more finger gestures, one has to take into account the size of the screen as larger fingers may simply not fit the screen. Fingertip blobs affect the error rate [1] and their examination may help in proposing the user interface design. Apart from straightforward touch interaction techniques, accelerometers and g-sensors have found their way of interaction.

The action of creating the input signal is categorized (based on the required stimuli) into physical or mental. Different devices and techniques aim at various user skills. Multi-touch interaction can be categorized as physical manipulation as users use the muscular system.

3 Evaluating existing approaches

Our primary goal is to find an effective interaction method for mobile devices equipped with multi-touch screens. As most multi-touch practices focus purely on 2D environments the interaction methods in 3D environments are not yet standardized.

Our interest falls onto two application types. As we want to create a 3D geometric multi-touch application, we focus on existing interactive geometry software (IGS) and Android and iOS applications that enable interaction with 3D objects. While the IGS applications in our research are analyzed to present different capabilities of geometry systems, the mobile applications section focuses mainly on the interaction techniques used to manipulate objects in 3D environments. From the analyzed applications and research (e.g. VRMath [2], Construct3D [6] etc.) it is clear that no interaction approach has yet been standardized and therefore applications interpret interactions as they best suit the specific needs. For comparison we analyze the degrees of freedom (DoF) the applications allow.

Tested applications are available at the Apple store or the Android market for free. The devices the applications were tested on are an Apple iPod 2nd generation and a HTC Desire HD. We name only a few of the tested applications: *iSculptor*[1]*, iDough*[2]*, LookAtCAD, i3dViewer, ModelView*[3]*, Nao3d Viewer Free*.

Apart from analyzing the existing applications, we examined multi-touch interaction techniques backed up by scientific research. The various techniques are analyzed in detail in tables that follow (interactions are noted as [*number of fingers touching the screen*]F [*action*], Table 1 explains the degrees of freedom mapping used in the rest of the tables).

Table 1. Degrees of freedom mapping.

DoF	Result
left / right	translate along the *X* axis
up / down	translate along the *Y* axis
forward / back	translate along the *Z* axis
pitch	rotate about the *X* axis
yaw	rotate about the *Y* axis
roll	rotate about the *Z* axis

Fiorella et al. [5] conducted an experiment comparing classic button user interfaces (UIs) with multi-touch UIs. Their multi-touch interaction technique supports only 4 DoF (see Table 2). This is probably the reasons, which lead them to the conclusion, that "further work is needed in order to achieve a completely satisfactory gesture mapping implementation".

Table 2. Fiorella et al. multi-touch interaction technique.

DoF	Action
left / right	2F horizontal drag
up / down	2F vertical drag
forward / back	N/A
pitch	1F vertical drag
yaw	1F horizontal drag
roll	N/A

Hancock, Carpendale and Cockburn have designed three interaction techniques to manipulate 3D objects on tabletop displays [7]. However, only their multi-touch techniques support six degrees of

[1] http://itunes.apple.com/us/app/isculptor/id370525280?mt=8#
[2] http://itunes.apple.com/us/app/idough/id386752314?mt=8#
[3] http://zerocredibility.wordpress.com/2010/12/07/3d-model-viewer-for-android/

freedom (see Table 3). Their aim was to develop shallow-depth interaction techniques for tabletop displays (the up/down DoF is swapped with the forward/back DoF as we look straight at the top of a table).

The first proposed is a two finger technique based on the Rotate'N Translate (RNT) algorithm [8]. This technique has problems with the yaw DoF as smaller displays (such as mobile phone displays) cannot take full advantage of the RNT algorithm.

Table 3. Hancock et al. two and three finger multi-touch interaction technique.

DoF	Two finger technique	Three finger technique
left / right	1F horizontal drag	1F horizontal drag
up / down	2F pinch	2F pinch
forward / back	1F vertical drag	1F vertical drag
pitch	2F horizontal drag	3F horizontal drag
yaw	1F moving the point of contact	2F drag
roll	2F vertical drag	3F vertical drag

In their work they state that "there has been a general consensus about the separability of rotation and translation. It is widely believed that input is superior if these are kept separate", but on the other hand at the end of their work they state that "People are not only capable of separable simultaneous control of rotation and translation, but prefer it". We believe that whether it is an advantage or a disadvantage depends from the target application. Tabletop displays require fast and imprecise manipulation with objects and therefore do not suffer from minor undesired transformations. Geometry applications on the other hand, could become frustrating to use especially on smaller screens, where finger precision is not as accurate as on larger screens.

Martinet et al. [3] embrace Hancock et al.'s three finger technique as the Z-technique and compare it to the standard viewport technique enhanced with multi-touch capabilities. Their controlled experiment shows that both techniques are equivalent in performance, but the Z-technique was preferred by most participants.

4 Implementation

Designed techniques have been evaluated on a prototype application (see Figure 1). The application is aimed for the Android platform as related devices are of different sizes and therefore enable us to evaluate our research more extensively. A custom game framework and OpenGL ES rendering of a 3D environment ensure that students are motivated to test our application.

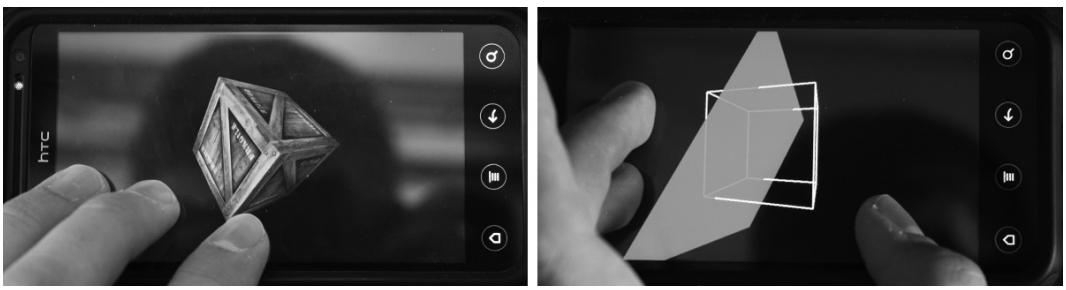

Figure 1. Two sample screens of the prototype application.

Based on the empirical evaluation of our first interaction technique, we were able to improve it and design a better one. Both will be compared in extensive user testing and upon evaluation adjustments should be made to provide the best interaction technique.

Thanks to our prototype, we were able to empirically come to the conclusion that complex three finger gestures are difficult to use because:

- three fingers obscure the objects displayed on the screen and therefore lack visual feedback,
- most phones screen sizes limit the user "workspace" as they are not big enough and finger movements are limited to only short strokes,
- gestures that in combination allow rotations around more than one axis simultaneously are difficult to adopt, unless simulate real world experience.

5 Designed interaction technique

In our work we have analyzed various applications related to interaction in 3D environments. Our primary goal is to design an effective interaction interface that will give the users maximum freedom of interaction within a 3D environment. As mentioned earlier, most existing applications lack the 6 DoF. Our aim was to experiment with various interaction approaches and evaluate them.

Based on assumptions that we developed through the examination of techniques mentioned above, we designed our own technique (Table 4) that we implemented in our prototype application.

Table 4. Custom multi-touch interaction technique.

DoF	Action
left / right	1F horizontal drag
up / down	1F vertical drag
yaw	2F horizontal drag
pitch	2F vertical drag
roll	2F circle
forward / back	3F vertical drag

Table 5. Improved interaction technique based on prototype evaluation.

DoF	Action
left / right	2F horizontal drag
up / down	2F vertical drag
forward / back	2F pinch
pitch	3F vertical drag
yaw	3F horizontal drag
roll	3F circle

The forward / backward movement could be mapped to a different gesture, e.g. 3F pinch or 3F horizontal drag. As you can see, the 2F pinch action has no DoF mapped to it. In this first technique design we purposely separated the 2 finger pinch gesture to change zoom levels from the 3F drag gesture that translates along the *Z* axis.

Based on the evaluation of the designed interaction technique on our prototype application, we were able to improve this technique. Our redesigned technique described in the table 5 focuses on the following:

- similar gestures for separate interaction categories: 1 finger for selection, 2 fingers for translation, 3 fingers for rotation,
- intuitive use: XY plane, X axis and Y axis common gesture approaches (simple dragging results in translation on the XY plane, or rotation about the Y axis for a horizontal stroke).

Based on the application domain, users might prefer 2 finger gestures for rotation if it will be the more frequent task.

6 Conclusion

We analyzed the most relevant areas related to virtual reality, human-computer interaction, multi-touch interaction techniques and virtual reality learning environments. Based on the evaluation of existing approaches, we designed an interaction technique that allows 6 DoF. This technique has been improved and redesigned after an internal prototype testing. In our research we

compare these two techniques to techniques available in mobile applications nowadays, as well as to techniques designed in other research studies on multi-touch gestures.

After extensive user testing that is planned, we will issue a final verdict, whether we managed to design a technique that can be easily embraced by both users and developers. The testing itself will be executed on our CCS 3D application, which allows students to interact with a cube and construct cube cross sections. Tests are designed so that students have to execute various tasks from simple cube rotations, to tasks where all 6 DoF have to be put to use. At the end, the collected results will be summarized and evaluated.

Through extensive research and a thorough design of an efficiently usable, intuitive, and easy to master technique we bring VR one step closer to the mobile device users.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic under the contract No. VG 1/1134/12.

References

[1] Ahsanullah, A., Mahmood, A.K.B., Sulaiman, S.: Investigation of fingertip blobs on optical multi-touch screen. In: *International Symposium in Information Technology (ITSim),* IEEE, (2010), pp. 1–6.

[2] Yeh, A.: VRMath: knowledge construction of 3D geometry in virtual reality microworlds. In: *CHI EA '04: CHI '04 extended abstracts on Human factors in computing systems*. ACM, (2004), pp. 1061–1062.

[3] Martinet, A., Casiez, G., Grisoni, L.: 3D positioning techniques for multi-touch displays. In: *VRST '09: Proceedings of the 16th ACM Symposium on Virtual Reality Software and Technology*, ACM, (2009), pp. 227–228.

[4] Cohen, C. A., Hegarty, M.: Sources of Difficulty in Imagining Cross Sections of 3D Objects. In: *The 29th Annual Conference of the Cognitive Science Society*. Nashville, Tennessee, USA, (2007).

[5] Fiorella, D., Sanna, A., Lamberti, F.: Multi-touch user interface evaluation for 3D object manipulation on mobile devices. *Journal on Multimodal User Interfaces*, (2010), Vol. 4, No. 1, pp. 3–10.

[6] Kaufmann, H., Schmalstieg, D.: Designing Immersive Virtual Reality for Geometry Education. In: *VR '06: Proceedings of the IEEE conference on Virtual Reality*, IEEE Computer Society, (2006), pp. 51–58.

[7] Hancock, M., Carpendale, S., Cockburn, A.: Shallow-depth 3d interaction: design and evaluation of one-, two- and three-touch techniques. In: *CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems,* ACM, (2007), pp. 1147–1156.

[8] Kruger, R., Carpendale, S., Scott, S.D., Tang, A.: Fluid integration of rotation and translation. In: *CHI '05: Proceedings of the SIGCHI conference on Human factors in computing systems,* ACM, (2005), pp. 601–610.

Single Modality Medical Image Registration

Matej KOMPÁNEK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
mkompanek@gmail.com

Abstract. This paper deals with medical image data processing and its registration. Ultimate goal of this work is a method proposal that would enable fusing data from two different images obtained at different times. Primary focus is set on intrasubject single modality image registrations. Paper introduces common techniques used in image registration such as feature or intensity based registration methods. Paper strives for evaluation of robustness and effectiveness individual approaches and their combinations.

1 Introduction

Image registration is a process of aligning two images that portrait the same object from different angle, time or sensor. We need fused data in medicine because it would enable automatic evaluation of the patient's data, thus improving and enhancing diagnosis assessment. In the medical field, there are several options for obtaining images in order to achieve appropriate examination of the inner regions of the human body for diagnosis of diseases or their prevention.

The problem that arises when using different ways of acquiring these images is that each of them is able to express different characteristic of the human body tissues and related biological processes. Relevance of the obtained data is much higher if we can integrate individual images to create composite images, which take into account all the characteristics of the studied area or tissue.

Registration of image data is an algorithmic procedure to obtain the fused image from multiple images based on finding corresponding areas in each of these images [1]. Subject of the medical image registration may be a specific patient and several different frames of his body (intrasubject) or image of more patients (intersubject) when the primary concern is comparison and resulting anomalies. Another approach is to create so-called atlas database of images and subsequently register patient images to this model.

If the image registration is using frame from one type of source, it is defined as monomodal, otherwise as multimodal. The source of frames is usually one of above-mentioned techniques such as PET (Positron Emission Tomography), CT (Computed Tomography), and MRI (Magnetic Resonance Imaging), X-ray or endoscopic images.

Focus of this paper is set on intersubject single modalitity (chest X-rays) image registrations and software implementation using OpenCV image processing library.

---

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Vanda Benešová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

2 Image registration

Image registration algorithms are classified into separate groups based on algorithms they use.

Algorithms which process the correlation of individual areas usually work based on image intensity in specific areas of image chosen features. Feature based methods are using specified number of characteristic points (features can be user-defined or chosen automatically, such as line intersections, corners, etc.). Other algorithms work with pixel intensities in the process of dividing whole image into smaller subareas.

Thanks to the known correspondence between two images we can define transformation which is necessary to align these images. We call this process a transformation model. Basic classification of transformation models is based on the rigidity of the underlying transformation as we recognize rigid and non/rigid transformation model. In rigid transformations we include linear transformations such as translation, rotation, and resizing as well as projective transforms. Non-rigid transformation models are bit complicated approach to transform the image, allowing local warping of the target image in order to align it with the reference image.

Basic steps of fused image acquisition [2] are thus:

- Defining the features or characteristic parts of the image
- Finding the correspondence between registered and reference image
- Calculation of the transformation model
- Transformation and alignment of the images

While the rigid image registration is a commonly used research tool and is quite usually used in clinical products, non-rigid registrations are only in the phase of adaptation and research, despite the fact that this kind of transformation is obviously necessary for correct evaluation of registered images of the many biomedical models. Most non-rigid image registration algorithms are yet to be developed and evaluated [3]. A good example of image registration, which requires use of non-rigid transformation, is the deformation of human tissues during the acquisition of images due to patient movement, heart beat or respiratory distortion [3].

Basic problems encountered by non-rigid image registration algorithms in practice are mainly the inaccuracy, insufficient robustness, and computational complexity [1].

3 Proposed method

Proposed non-rigid registration method can be briefly described as 4 step method. In the first step both images are preprocessed. Then in the second step these images are aligned on global scale and successively transformed. When we have both images roughly aligned, we can try to recover local warps and perform this non-rigid transformation as well. In the last step two images are compared.

3.1 Preprocessing

By image preprocessing we understand basic data preparation prior to data registration itself. In the process of preprocessing the ultimate goal is to correct for scanner errors, irregularities, and changes in global intensity, normalize brightness, or sharpen the image in order to improve following registration process. We used following methods in order to improve robustness of successive image registration.

3.1.1 Morphological Reconstruction

Morphological reconstruction is image processing technique that enables avoiding noise in input images, therefore obviously applicable in problems when we are forced to deal with the high amount of undesired artifacts such as medical images.

Morphological reconstruction can be thought of conceptually as repeated dilations of an image, called the marker image, until the contour of the marker image fits under a second image, called the mask image [4]. In this way we are trying to achieve elimination of local intensity peaks in the means similar to simpler morphological operations such as dilation.

The algorithm is working with two different images. One of them is input image which is called the mask, another one is called the marker image and usually is input image after constant subtraction where this constant defines the behavior of the reconstruction process. Higher the subtracted value, higher the resulting image changes.

3.1.2 Anisotropic Diffusion

When dealing with random image noise generated by the medical image sensors, there exists another similar technique such as morphological reconstruction. It is often called by its original creators Perona and Malik but much better known as anisotropic diffusion [5].

Main aim of anisotropic diffusion is noise elimination without elimination of important image edges which might cause subsequent problem in further processing.

The most important idea of the anisotropic diffusion is a correct choice of a smoothing coefficient in the diffusion process (smoothing). In the common smoothing methods, such as Gaussian smoothing, this parameter is constant among the whole image during filtering. In this way, noise is eliminated together with edges. In the process of anisotropic diffusion, this coefficient is changing during the filtration process, thus yielding differently smoothed subareas. Choice of this coefficient is based on detected image gradient which enables to avoid diffusing areas with higher image gradient.

After application on medical image anisotropic diffusion smoothed X-ray noise and persevered bone structure as well as illustrated by Figure 1.

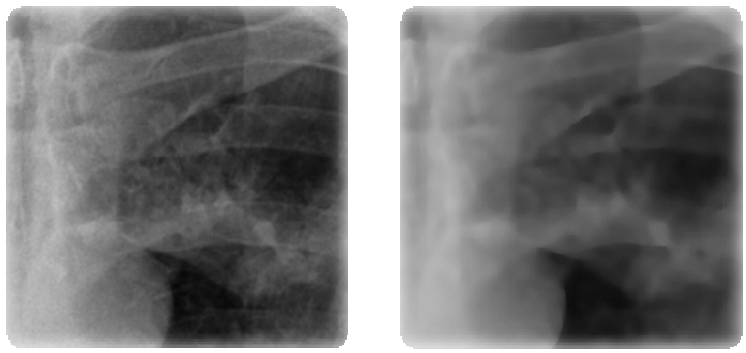

Figure 1. Subarea of image before and after application of anisotropic diffusion.

3.2 Global registration

Global transformation is a projection of one image towards the other on global scale. This kind of transformation is described by a projection matrix. In this kind of transformation whole image is warped without any of its part being individually warped in different direction.

There are two possibilities when finding projection matrix. Firstly, we can establish correspondence of chosen keypoints between the two images and try to derive projection matrix members in deterministic way.

Other approach which is suitable on this kind of problem is global optimization when we do have any information about corresponding points between two images and we are iteratively trying to maximize/minimize chosen metric that describes similarity on the basis of intensity.

Global registration was implemented with the help of template matching method of OpenCV. In order to improve performance, input images are downsampled and then used as an input, which requires less operations to evaluate correlation. Improved performance enabled implementation of scaling and rotation.

Developed algorithm starts searching and evaluating on probable scales and rotations with rough steps, in every step evaluating correlation. When the best fit is found (correlation maximum), algorithm continues with finer steps around the best combination of scale, rotation and offset. In this way it is possible to find good approximate of global transformation.

3.3 Local non-rigid registration

Finding the non-rigid transformation involves finding the so called control grid which poses a correspondence between uniformly placed points in registered and referenced image. Combination of regular control grid and spline based warping is a common choice in medical image registration [1, 2, 3] and method being proposed in this paper uses this approach as the basis and strives to apply it in the domain X-ray registration.

Control grid creation starts with definition of its size. Then registered image is divided into number of uniformly spaced areas. These areas are iteratively used as template that is matched against reference image. Template is matched against area at the same coordinates but it is allowed to move within specified offset. During this procedure we learn offsets of individual points that serve as an input into the warping process.

The most basic version of this algorithm has a number of flaws. Areas which are completely white or black might easily match other blank areas. On the other hand, areas containing many gradient changes might not match anywhere, still we will find offset that suits best the chosen metric no matter how small it may be. We avoided these complications by introducing constraints that disable matching areas that have low standard deviation, and thrashing matches that fall below defined minimum of correlation. Example of such control is shown in Figure 2.

Proposed approach is an attempt to fuse the information from raw intensities and detected edges. Detected edges are used as the base and control grid points are positioned over these edges in flood fill process. In this way we get only control points that are positioned over interesting areas of the image as well as areas are not regular squares but rather follow the structure of the edge image (Figure 2).

Whole registration process pseudo code follows.

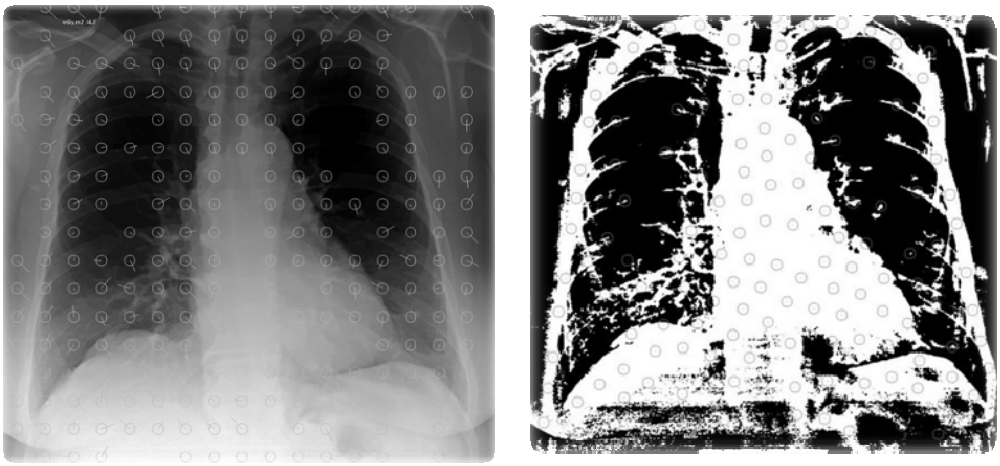

Figure 2. Visualization of regular control grid and control points placed over detected foreground.

```
Image reference, registered;
Preprocess(reference);Preprocess(registered);
FOR all scales
    FOR all angles
           FOR all offsets
                  Affine_warp(registered);
                  Compute_correlation(reference, registered);
           END
    END
END
SET registered AS Affine_warp(registered) WHERE MAX(correlation);

Find_control_points(registered, points);
FOR all control points p in points
    SET template AS Enclosing_area(registered,p);
    Match_template(template, reference, result);
    Compute_point_offset(result);
END
Thin_plate_spline_warp(registered, points);
```

3.3.1 Spline based warping

The term spline based originates from technique used to model surfaces of ships or planes. In the case of image registration we can define transformation in 2D space as two surfaces which model the displacement, one in horizontal and one in vertical direction.

Spline based registrations [6] work with assumption that a grid of matches keypoints can be found between registered images. These points are referred to as control points and at this control points the spline based transformation is either approximated or interpolated from neighboring control points. Between the control points the transformation is smoothly varying from one point to another.

When the control grid is established, generated matches of points are used as an input into thin-plate spline model in which every pixel in resulting images is affected by each of the control points. Measure of influence is defined by radial basis function (thin-plate spline) and computed distance between pixel and each control point.

Such transformation of X- ray is shown in Figure 3.

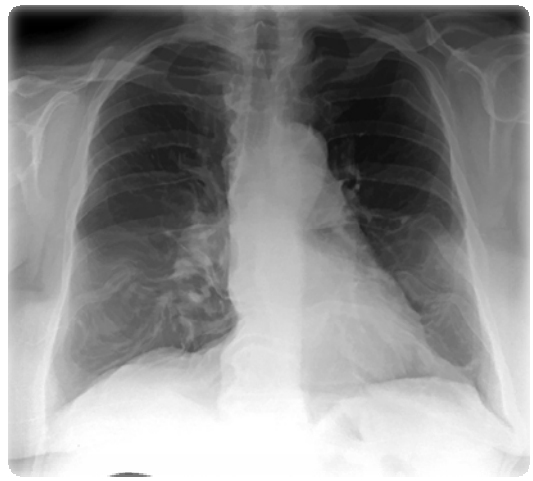

Figure 3. Registered image warped along control grid.

3.4 Evaluation

There are two implementations of visualizing differences between images. The simpler one is based on differencing two images, and successively adding the difference into red channel (original is first converted to gray-scale).

Another approach to evaluate differences was implemented with the use of the histograms and their differencing. This method divides image into small areas such as the ones defined by the control grid and then creates histograms for both areas in both images. Afterwards, these two histograms are compared and the result is added to red channel of the original image.

4 Conclusions

Paper proposes medical image registration procedure that would enable automatic evaluation of couples of image.

Its robustness and possible improvements need to be further evaluated. Future work will be focused on improving intensity based local registration method. Resulting non-rigid transformation will be based on information from intensity as well as from edge detection. All information has to be fused together into robust warping model. Proposed method will be further enhanced by improving the mechanism which defines constraints for individual control grid points to move.

Additional effort is needed to improve the functionality of the difference visualization by normalizing histograms before they are compared.

It is necessary to experiment with deformation models other than thin plate spline model. Other model might bring better results, although the perceived correctness of the warping might could strongly depend on the specific body part that is on the image. Ideal model would be parametrized in order to define effect of single keypoint match on the warping of the whole image.

References

[1] Crum, W. R., Hartkens, T., Hill, D. L. G.: Non-rigid image registration: theory and practice. *The British Journal of Radiology*, (2004), pp. 140–153.

[2] Hajnal, J. V., Hill, D. L. G., Hawkes, D. J.: *Medical Image Registration*. CRC Press, (2001).

[3] Maintz, J.B.A., Viergever, M.A.: A Survey of Medical Image Registration. *Medical Image Analysis,* (1998), Vol. 2, No. 1, pp. 1–36.

[4] Mathworks: Morphological Reconstruction. [Online; accessed November 10, 2011]. Available at: http://www.mathworks.com/help/toolbox/images/f18-16264.html

[5] Perona, P., Malik, J.: Scale-Space and Edge Detection Using Anisotropic Diffusion. *IEEE Transactions on pattern analysis and machine intelligence*, (1990), Vol. 12, No. 7, pp. 629–639.

[6] Bookstein, F. L.: Principal Warps: Thin-Plate Splines and the Decomposition of Deformations. *IEEE Transaction on pattern analysis and machine intelligence*, (1989), Vol. 11, No. 6, pp. 567–585.

Planar Object Recognition for Augmented Reality

Ján KVAK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
jan.kvak@gmail.com

Abstract. Nowadays, most of the implementations of augmented reality are based on a detection of the square framed binary markers, so called fiducial markers. These binary markers are easy to detect by very simple methods of image processing. However, the usage of this markers could be unacceptable in many other augmented reality applications. This paper is concerned with algorithms of augmented reality using a real word planar object as a marker. The description of the points of interest on the image is made using a local BRIEF descriptor. Subsequently a calculation of the actual position and rotation of the planar object is carried out. These algorithms are implemented and experimentally verified on a random generated warps of sample data. Calculated results can be then used for the visualization of a 3D object model namely by adding this model into the image captured by a camera in the correct rotation and position. Thus this methods are useful in the applications in the field of augmented reality.

1 Introduction

In the current state of development in Augmented reality, square pictures, so called "fiducial markers" are used to anchor the image in space. Recognition of them is based on information of their shape. However, the use of these markers can be undesirable in real world use, for esthetic or physical reasons. Also, as it can be easily experimentally proved, hiding even a small part of marker can render the marker useless. These disadvantages can be eliminated using planar objects as markers. Theoretically, any image, that is not symmetrical and is possible to find out its position and rotation, can be used as marker.

These planar images can be used as the higher level of anchoring objects in Augmented reality, superior to fiducial markers and then they can be considered as planar surfaces of 3D objects in space, to begin the use of 3D objects as anchors. All algorithms in this paper were developed using OpenCV library.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Juraj Štefanovič, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 411–416.

2 Image recognition using BRIEF descriptors

By the image recognition, which can be used in the field of Augmented reality, not only recognition capability is essential, but also speed. Algorithms of recognition cannot be too complicated, because of Augmented reality, they should run in real time.

If we have no prior information about the objects, that we want to use as markers, we have to choose more general approach, than the one used in existing implementations of marker recognition in Augmented reality. We have to choose points of interest in the image, describe them with descriptors and compare to each other. One of the most promising descriptors for this task is BRIEF (Binary Robust Independent Elementary Features).

2.1 BRIEF

This descriptor is based on simple comparison of pixels surrounding the point, that we want to describe. Based on these comparisons, the bit string is created. This approach allows to compare two points using operations XOR and bitcount. So the similarity of two points can be defined as their Hamming distance. In the *Figure 1* we can see comparison of four pixel pairs. The point of interest is in the middle of the window.

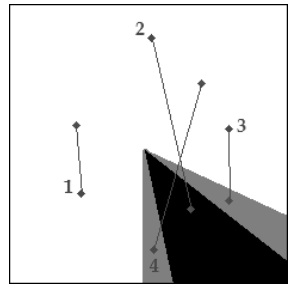

Figure 1. Four pixel pairs comparations for BRIEF descriptor.

The fact, that the pixel intensity comparisons are used, instead of intensity itself suggests, that this descriptor will have some invariance to lighting conditions. If we have two points in image, one darker than another, this difference is likely to be preserved, even if both are in lighter or darker spot.

More of these comparisons we can get, the better we are capable of describing given point of interest and compare it to other points. Authors of the article [1] estimated the best choice of points to compare to be the random points, culminating in the center of the interest points surrounding by Gauss curve as is shown in *Figure 2*. This positioning of comparison points could be made using Box-Muller algorithm.

Figure 2. Positioning of 512 pixel pairs using Box-Muller algorithm.

More information about point can be obtained using color information from three channels of color image [2]. Mainly when the input images that should be used as markers, are similar to each other (fur – feathers, corners of geometric shapes) information about color can be really useful.

2.2 Image scale normalization

Regrettably, the BRIEF descriptor has one disadvantage, it is not invariant to rotation and perspective scaling distortions. Without any aid or preprocessing, the BRIEF descriptor is capable of recognition of points rotated by only small angle or with small difference in scaling. So it is essential to provide, that descriptor can recognize rotated and scaled images.

One option, how to improve BRIEF is the image and point preprocessing. Some of the problems caused by perspective scale distortion can be avoided with image size normalization. In [5] authors recommend the size normalization as preprocessing to the recognition of handwritten characters. If we have interest points in image, defined as points with two main intensity gradients or corners in two images, that are the same, but in different scale, we can assume, that if we enlarge them enough, their surroundings will look more similar. With enough enlargement, we can get rid of artifacts, that can make the difference in points description. In the *Figure 3*, the small corner on the left side of the first two triangles is not in the points surrounding, so the points look more alike. The smaller triangle on the right side of picture is an example of image not enlarged enough, so the artifact makes it difficult to compare the point to corresponding points in first two triangles.

Figure 3. Image enlargement for size normalization.

The only information, that can be at least a little helpful in finding of scale is the density of interest points found. It is of course influenced by constants, used in interest points finding algorithm (cvGoodFeaturesToTrack in OpenCV), but still we can say with some probability, that if the count of points found is low and they are far from each other, the image is probable enlarged and vice versa. For experimenting I have made a set of images containing always the same geometric shapes, but the whole images were in different sizes and appointed one of them to be “normal”. The one normal picture was supposed to have no artifacts in surrounding of a points. The geometric shapes were always in different positions to simulate perspective distortion and scale could be told from image height and width. The point of the experiment was to find the “normal” size of scaled images based on average and minimal point distances. Target size of “normal” image was 600x600 pixels.

Table 1. Size normalization algorithm results.

	Original size	Size after normalization	Difference [%]
1	*400x400*	*576x576*	*-4*
2	*500x500*	*590x590*	*-1,6*

3	*100x100*	*545x545*	*-9,2*
4	*100x100*	*529x529*	*-11,8*
5	*256x256*	*565x565*	*-5,8*
6	*300x300*	*609x609*	*+1,5*
7	*150x150*	*726x726*	*+21*
8	*100x100*	*526x526*	*-12,3*
9	*450x450*	*546x546*	*-9*

Based on the results of the experiments, we can say, that normalized size is in most of cases close to the target normalized size. Experiments were made only on simple images, used as sample data, but still it can be really helpful for BRIEF descriptor.

2.3 Preprocessing with rotation

Due to the fact, that BRIEF descriptor is not invariant to rotation, it is useful to normalize image according to rotation. We can assume, that every chosen interest point has two main intensity gradients. The simplest way to normalize image according to rotation would be, that we turn the surrounding of the points according to intensity gradient with greatest value as suggested in [4].

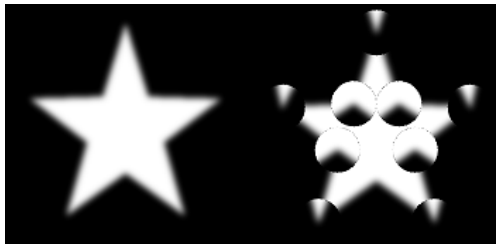

Figure 4. Normalization of rotation of interest points.

These geometrical shapes were used as sample images, so it would be easy to see, if algorithm for normalization works. After using the BRIEF descriptor, the outer corners of the star (*Figure 4*) were matched together with more than 95% probability, the same goes for inner corners, but comparison of inner corner with outer one shows really low similarity. This algorithm works, but it is demanding a lot of processor computing capacity.

Another approach can be to normalize whole image. If we can assume, that image is not symmetrical and that the rotation can be found out, we can also assume, that there will be at least one point in the image with intensity gradient with highest value. According to this gradient we can rotate the image. In the first row of *Figure 5* we can see picture of Roman helmet turned at random angle. In the second row we can see the same helmet normalized according to main intensity gradient of the picture.

Figure 5. Random rotated sample images before and after normalization.

2.4 Classification

If the interest point is described with descriptor, it is essential to save it, so it could be compared to the points found in the image of camera. OpenCV provides in its Machine learning library some algorithms, that can be used to learn classes of data and then classify input data to these classes. One of the most promising classifiers to use in this field is Bayes classifier. Its implementation is easy to use, trained model can be saved and classification of input data is really fast. However Bayes classifier is unable to learn and classify string of bits. That is, why I decided to go with recommendations of authors of paper [3] and divide the long descriptor to short bit strings – Ferns as they call it. Then these Ferns were converted to decadic numbers and tried to classify them. Regrettably, this conversion does not preserve the properties of binary descriptor. There are two types of problems : Bit strings 1000 and 0111 are absolutely different as descriptors, but close to each other as decadic numbers (8 and 7) and bit strings 1100 0000 and 1000 0000 are different only in one bit, but in decadic numbers they are far from each other (192 and 128). If it would be possible to resolve these problems at least partially, it would allow us to better classify binary descriptors and partially correct the error, when only few bits of binary string are flipped.

First of the problems is more important and needs to be resolved, so the binary strings, that are not close by Hamming distance, will not be close to each other in decadic numbers. This encoding is in the state of experimenting now. With current encoding, that I have tried working only in ideal conditions.This unfinished encoding was used in this paper to get the final recognition result.

Second problem is, that binary strings, that are close in binary are different in decadic numbers. This problem can be resolved using right type of classifier. The classifier should be able to classify data, which are grouped in more places of n-dimensional space. For this purpose the Bayes classifier can not be used, because it cannot classify data, grouped in more places.

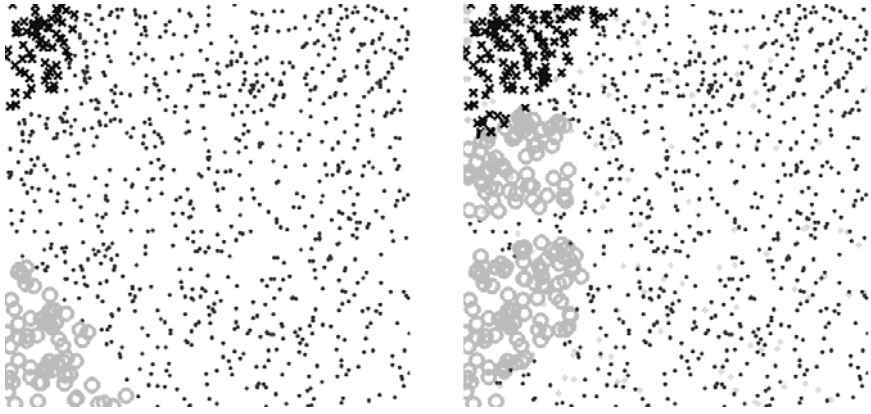

Figure 6. Bayes classifier vs. K-nearest neighbours.

Both pictures in *Figure 6* show classification of the same set of data to the same three classes, where class here shown as circles was classified in two places. In the picture on the left side they are classified with Bayes classifier and on the right side with K-nearest neighbors. As we can see, Bayes classifier combined two groups of the circle class in one making big error in data classifying. That is why K-nearest neighbors classifier is more suitable for this task. However the basic implementation of K-nearest neighbors classifier is too slow for real time use. OpenCV fortunately offers a fast approximation to this classifier in the library called FLANN (Fast Library for Approximate Nearest Neighbors). Another improvement can be to train fourth class, containing random numbers that would allow us to avoid classifying points, which do not resemble any class, to some of the classes.

3 Conclusions

Using point descriptor BRIEF, encoding of Ferns and classifier training and classifying by FLANN it is possible to recognize points in image. In current state of the project I have used approach like authors of [5]. Every image is randomly rotated and warped for a large number of times (authors suggest number to be~10 000) and every recognized point is trained to the classifier. On the *Figure 7* there are two images. First one was the one of the images trained, and second one is after recognition. It was rotated when recognizing, now displayed in normal state for better comparison. Bigger black dots are the points, that belong to the image and are successfully recognized. Crosses are the points, that supposedly do not belong to any class, so we can omit them in point recognition. Small dots are the points that supposedly belong to other classes. As we can see, most of the points are successfully classified (in this case 124 points out of 200), or not recognized at all (43 out of 200). Because algorithms for encoding and recognition are still in experimenting phase, it works only on images, that are different enough in nature (sharp corners in other training images vs. "furry" corners in cats image). In the next work I will try to compare to other methods of keypoint recognition and try to use it to estimate coordinates of image in 3D space.

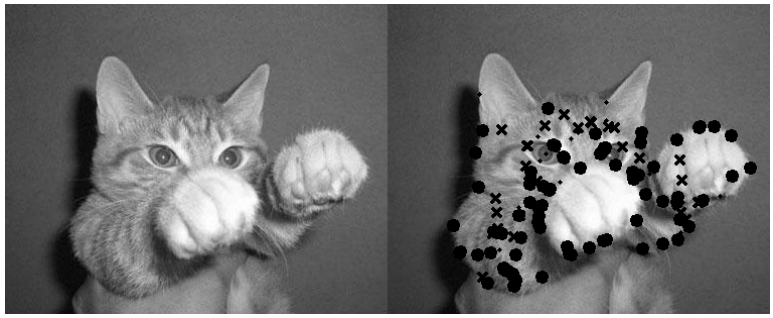

Figure 7. Third sample image with recognized points.

References

[1] Calonder M., Lepetit V., Strecha Ch., Fua P.: BRIEF: Binary Robust Independent Elementary Features. In: *ECCV'10: Proceedings of the 11th European conference on Computer vision: Part IV,* Springer-Verlag, (2010), pp. 778–792.

[2] Kottman, M.: The Color-BRIEF Feature Descriptor. In: *Spring Conference on Computer Graphics, Conference Materials and Posters*, (2011).

[3] Ozuysal M., Fua P., Lepetit V.: Fast Keypoint Recognition in Ten Lines of Code. In: *Conference on Computer Vision and Pattern Recognition,* IEEE, (2007), pp. 1–8.

[4] Rosin P.L.: Measuring corner properties. *Computer Vision and Image Understanding*, (1999), Vol. 73, No. 2, pp. 291–307.

[5] Suen C.Y., Nadal, C., Legault,R., Mai,T.A., Lam, L.: Computer recognition of unconstrained handwritten numerals. *Proceedings of the IEEE*, (1992), Vol. 80, No. 7, pp. 1162–1180.

Image Segmentation Using Methods of Distributed Agents to Obtain Information from Medical Images

Marek SOBÔTKA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
melcor.sobotka@gmail.com

Abstract. Nowadays, a large amount of information is worked with every day. Different systems for data processing have been created. These systems can be manual or fully automatic. Medicine is one area where it is necessary to process image data. Several devices are being used here that produce different types of output. Typical examples include X-rays or pictures obtained by the magnetic resonance imaging (MRI). An integral part of image processing is image segmentation. The aim of this work is to explore the possibilities of using a multi-agent system for image segmentation. Our system combines several types of basic image information to obtain the best results.

1 Introduction

Nowadays, a large amount of information is worked with every day. Different systems for data processing have been created. These systems can be manual or fully automatic. One type of data being processed is image data. Daily, countless numbers of photos are created and hours of videos are recorded around the world. With so many records there naturally arises the need for its recognition, sorting and further processing.

Medicine is one area where it is necessary to process image data. Several devices are being used here that produce different types of output. Typical examples include X-rays or pictures obtained by the magnetic resonance imaging (MRI). There is already a vast array of systems for image processing. An integral part of image processing is image segmentation.

Image segmentation is considered a long-term challenge in digital image processing. Its aim is to divide the input image into several disjoint homogeneous regions. These regions contain points of image that have a similar intensity, colour, texture or another aspect depending on what is going to be achieved by segmentation [1, 2, 3]. Thus obtained regions may be further processed at the level of recognizing objects. There are different methods by the usage of which different results are achieved.

---

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Vanda Benešová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

The greatest problem of image segmentation is that it is problem-dependent. Segmentation of photos of nature containing dominating objects is rather different from that of medical images. Many objects, such as the human brain and heart, do not have visible borders in images from the medical field, images are naturally textured and there are no clear edges among objects [4]. Medical images show similar grey shades and similar textures among objects [3]. This causes smaller variance of intensity and colours in the image, making it more difficult to distinguish the objects contained in the image.

Image segmentation is used in medicine for example in the pathology in the brain surgery [3, 5], in the study of anatomical structures, in the planning of treatment or in the determination of a patient's diagnosis [3]. Elsewhere, doctors process images from X-ray and MRI automatically by human intelligence. There are efforts to process these images automatically by computer. As a result, physicians can confront their opinions with an assessment of a computer. Though to make it work, the algorithm used for segmentation of such images would have to achieve higher reliability. Several works are already addressing this problem, among others [3, 4, 5, 6, 7]. They have achieved relatively good results, but there is still room for improvement.

2 Proposed method

2.1 Multi-agent system for segmentation

Multi-agent system which we are researching combines several types of basic image information to obtain the best results. Centralized coordination of agents similar to that in [3] is used to make the solution simple. Agents will be controlled by a moderator, who will have all current information about the image and its properties, and thus will be able to coordinate image segmentation. First, the moderator creates the image data. The most important data include edges and regions.

The agents are initiated according to gathered information. Each agent will have access to the relevant global data about the image, as well as keep information about what he has carried out. So we are creating reactive agents with memory. The types of agents in our multi-agent system were inspired by [6, 7]:

- edge agents,
- regional agents.

The goal of the edge agents is to create a set of fully closed regions. Regional agents get this set and they are designed to colour each region correctly.

2.2 Moderator

Moderator is responsible for creating a segmented image for each input image. Every image starts an extensive process.

At first, data are initiated. This includes preparation of a special data structure for each pixel of the input image. The data structure contains following information:

- the original brightness value of the input grey-tone image,
- the presence of the edge in the input image,
- the presence of the edge in the starting image for agents,
- the presence of the edge in the output segmented image,
- regional classification of the pixel in the input image,
- regional classification of the pixel in the output segmented image,
- the number of pixels that are edges around the current pixel of the input image,

- the number of pixels that are edges around the current pixel of the starting image for agents,
- information if the pixel has been visited by the agent,
- angle,
- amplitude.

By angle and amplitude we understand the values obtained using the Sobel operator, which is commonly used to detect edges. Amplitude is the strength of response if the current pixel is edge. The higher the value is, the more likely that the edge is present in that pixel. The angle is the direction of the edge.

Subsequently, agents are initialized to the specified locations in the image. Agents receive a starting image. This image is created by the intersection of edge information and regional information. Thus, we have input information confirmed by two independent methods, which increases the reliability of results. For each pixel we have calculated the number of edges in the neighbourhood. We can divide individual pixels according to this number into four groups:

1. *independent pixels* (see Figure 1 (a)) – pixels that have no edge in the neighbourhood
2. *end pixels* (see Figure 1 (b)) – pixels that have exactly one edge in the neighbourhood
3. *transit pixels* (see Figure 1 (c)) – pixels that have exactly two edges in the neighbourhood
4. *partition pixels* (see Figure 1 (d)) – pixels having more than two edges in the neighbourhood

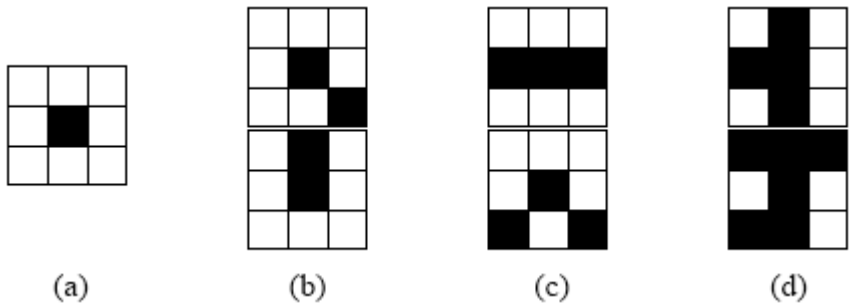

Figure 1. Categorisation of pixels according to the number of edges in the neighbourhood.

Agents take up positions of the ends of edges (end pixels) and all positions where there is a certain probability of crossing several edges (partition pixels). They are also initialized to the independent pixels because there is no guarantee that the agents will reach these positions in the process of image segmentation. Agents are, therefore, initiated to all pixels that are edges and where the number of edges in the neighbourhood is not equal to two (pixels are not transit).

Lastly, the moderator starts the agents. They operate using image data until agent has defined action or until agent has reached the maximum allowed amount of actions. The maximum amount of actions also serves as a safeguard against endless running of the agent. The results are entered directly into the global structure of image data.

2.3 Edge agents

Each agent is an autonomous entity that has defined actions to be taken using global data of the image and local data of the agent. Each agent has to remember some information, such as:

- identifier,
- position in the image,
- number of executed steps,

- number of executed steps since the last partition,
- essential flags (if agent is active, if agent is in joining mode, etc.),
- visited pixels of the image,
- agent's children.

Each agent can have their children which are created in the process of reproduction of the agent. In the process of image segmentation there may sometimes happen that the parent finishes its actions earlier than children, so it is necessary to ensure that agent's children could continue working uninterrupted, while they have actions that can be done. Therefore, if the agent is inactive, it is necessary to check if children are inactive.

Agent requires having actual data, to ensure correct functionality. Therefore, in each step agent must update its local data.

For a system as a whole moderator must have available information, when each agent completed its actions and can no longer continue in the image segmentation, or when each agent already completed all actions that were possible. That is why active flag is used. Moderator checks after each step, if there is at least one agent able to perform another action. When there is no further action for the agent to carry out, it marks itself as inactive.

Reactions of the agent can vary for different positions in the image. It depends on the number of possible movements, where the agent can move. This number is in the interval (0, 8). Agent checks whether the pixel is not on the boundary of the image, whether the pixel has never been visited by any agent and whether on the pixel there is edge for each of the eight neighbouring pixels. If the pixel meets all three conditions, it is included in the possible movements from the agent's current position.

Then the agent reacts according to the calculated number of possible steps for the current position of the agent:

1. Number of possible steps equals one. Then the agent moves to the specified point. The next action will depend on this new location.
2. The agent gets to the point from which it can go several directions (number of possible steps is more than one). Then the agent cannot determine which way is the best. Therefore, it has to reproduce itself. It chooses one way where to move. The agent creates children for each other way and settles them there. In the next step these children will behave just like any other agent. The behaviour is independent of the fact, whether the agent is parent or child.
3. Number of possible steps equals zero. Then the agent switches to joining mode. In this mode agent does not move on already existing edges in the image, but it starts creating new edges or destroying the existing edges, depending on the situation. This action directly modifies global structure of image data. Agent changes information on its current position.

Every agent has the limitation as to how many times it should move since it was reproduced. The edge is removed from the global data structure of the image if the number of moves is less than the limit. This action ensures that all small edges in the image are deleted and only the important ones remain.

When the agent is creating a new edge, we need to use some heuristics that tell which one of the neighbouring pixels is most likely an edge. For this purpose, we designed the function counting the scores of each pixel in the neighbourhood:

$$ps = am * ca + rm * cr + em * eTP + pm * ep \tag{1}$$

where:

$$ca = \left(\frac{\min(ampTP, ma)}{ma}\right) * \left(-\left(\frac{\min(|angAP - angTP|, ||angAP - angTP| - 360|)}{360} - 1\right)\right) \tag{2}$$

$$cr = \left(-\left(\left(\frac{|origAP - origTP|}{255} \right) - 1 \right) \right) * regTP \quad (3)$$

$$ep = -resTP - startTP \quad (4)$$

Legend to formulas (1), (2), (3), (4):

- *ps* – the final score of the pixel
- *am/rm/em/pm – controlled angle/controlled region/edge/penalty* multiplier obtained from settings
- *eTP/regTP/resTP/startTP* – flag if there is *edge/boundary between two regions/output edge/edge in the starting image for agents* at the target point (if yes flag = 1, if no flag = 0)
- *ampTP* – amplitude value at the target point obtained from the global data of the image
- *ma* – the maximum amplitude obtained from settings
- *angAP/angTP* – angle in degrees at the *current/target* point obtained from the global data
- *origAP/origTP* – brightness value of the original image at the *current/target* point

From the surrounding pixels the point with the highest score is selected. Then the agent moves to that location if the score is greater than the minimum threshold set in the settings, otherwise the agent destroys itself. This method combines various sources (amplitude, angle, regional image, edge image, original image, etc.). We can regulate the contributions of individual components to the result by adjusting the weights (multipliers) for each component. The idea of using penalties is to compel agents to search for alternative edges. Thanks to the fact that points of existing edges get a negative score, the agent will most likely choose another position instead, where there is a higher score.

2.4 Regional agents

At the time of writing this paper the multi-agent system was still in development. Therefore, regional agents have not been implemented yet. Individual regions are currently coloured by calculating the average brightness of all pixels in the region.

3 Results

Implemented multi-agent system can create edge image and segmented image from the input medical image (see Figure 2). This is possible by using edge agents. These agents can successfully add significant edges and delete insignificant short edges, which are often just noise. However, it has turned out that our solution still has several problems, with which we will deal soon.

Figure 2. Example of multi-agent system output.

The first problem is that in the output segmented image there are not all the regions. The agents have not closed all regions which causes problems with colouring. We will address this problem

by creating special version of edge agents that will ensure that all the regions are closed in all circumstances.

The second problem is that the resulting regions are not correctly classified into groups and, thus, not correctly coloured. This problem will be eliminated by creating regional agents. These agents will be responsible for colouring each region by multiple criteria such as size of the region, colour of neighbouring regions, the histogram of brightness of the region, average brightness of the points in the region, etc. We will experiment to get desirable results.

We are interested in the performance of our multi-agent system, as well. The solution was tested on a dataset containing 55 images at a resolution of 256x256 pixels. The test was run three times and we achieved the average value of image segmentation 525.28 ms for a single picture.

4 Conclusions

In this paper, an automatic medical image segmentation method has been presented. This method tries to combine several basic image information of an image, such as edge information and regional information, to obtain the desirable results.

The results suggest that the method currently faces a number of open problems. The output segmented image sometimes contains certain improperly coloured regions. This is caused by unclosed regions in edge image. We are aware of these problems and we are working on the solutions in order to eliminate them.

Final method will be evaluated on the reference dataset[1] and the segmentation results will be compared to other methods.

References

[1] Wei, B.C., Mandava, R.: Multi-objective nature-inspired clustering techniques for image segmentation. In: *CIS '10: IEEE Conference on Cybernetics and Intelligent Systems*, (2010), pp. 150–155.

[2] Varshney, S.S., Rajpal, N., Purwar, R.: Comparative study of image segmentation techniques and object matching using segmentation. In: *ICM2CS 2009: Proceeding of International Conference on Methods and Models in Computer Science,* (2009), pp. 1–6.

[3] Chitsaz, M., Seng, W.C.: A Multi-agent System Approach for Medical Image Segmentation. In: *ICFCC '09: International Conference on Future Computer and Communication,* (2009), pp. 408–411.

[4] Liang, J., Xu, Z., Mao, D., Cheng, X.: Multi-agent based evolutional algorithm in medicine image segmentation. *Journal of Communication and Computer*, (2009), Vol. 6, No. 6, pp. 31–35.

[5] Shariatpanahi, H.F., Batmanghelich, N., Kermani, A.R.M., Ahmadabadi, M.N., Soltanian-Zadeh, H.: Distributed Behavior-based Multi-agent System for Automatic Segmentation of Brain MR Images. In: *IJCNN '06: International Joint Conference on Neural Networks,* (2006), pp. 4535–4542.

[6] Idir, K., Merouani, H., Tlili Y.: Dual Pyramid of Agents for Image Segmentation. *World Academy of Science, Engineering and Technology*, (2005), Vol. 6, No. 47, pp. 198–201.

[7] Duchesnay, E., Montois, J.-J., Jacquelet, Y., Kinie, A.: An Agent-based Implementation of Irregular Pyramid for Distributed Image Segmentation. In: *Proc. of the 8th IEEE International Conference on Emerging Technologies and Factory Automation,* (2001), pp. 409–415.

[1] Internet Brain Segmentation Repository, http://www.cma.mgh.harvard.edu/ibsr/

Mobile Device as an Intelligent User-Adapting Music Generator

Marek TAKÁČ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xtakac@gmail.com

Abstract. Nowadays it is not unusual, that applications for mobile devices are using various sensors such as touch screen and accelerometer for their control. We aim to use these sensors of mobile for music creation. For this purpose we have developed an application simulating the three musical instruments – piano, flute and drums. The control is designed to be as similar as possible to their real equivalents. The application also includes a metronome, editable rhythms and other configuration settings. A special feature of the application is an adaptation to the user, namely the adaptation of the user's tempo during the playing on one of the virtual instruments.

1 Introduction

Mobile devices are undoubtedly one of the phenomena of this time. Almost everybody from not only developed countries own some type of mobile device or at least had worked with it few times. It is evident that progress of today's technology has also caught these devices. Nowadays there is not a problem to find on market device with huge touch screen, GPS navigation, with multiple integrated sensors and only a few millimetres thick. This technological shift significantly increases the range of applications on mobiles in terms of computing, but also in ways that users are interacting with the device.

All of these benefits can be also used for interactive music creation. Creating sound output by mobile device sensors is relatively young and, therefore, studied only in the last few years. Thus this area of research can be further developed and that is the aim of this work.

In our project we focused on three (virtual) musical instruments, which were used to explore the potential of today's mobile devices (in way of sensors combination). We design instrument controls to be similiar to playing on real ones, which also means that application controls should be intuitive for users. In addition, computing power, device memory and sensors creates more space for programmers to create additional features which user might like (e.g. metronome, rhythms or automatic tempo adjustment). User can thus obtain very interesting audio output.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Alena Kovárová, Institute of Applied, Faculty of Informatics and Information Technologies STU in Bratislava

2 Related work

At present, although not every model of mobile is offering such wide list of sensors required by proposed application (see section 3.2), but there are few ones that meet such specification. These devices differ from each other in technological aspects of these sensors, programmatic access to them, but also in operating system they run on. It is therefore necessary to choose a specific device for implementation of the designed application. In choosing process, we mainly focused on:

- Provided sensors (touch screen, microphone, accelerometer, gyroscope, proximity sensor etc.)
- Provided libraries or frameworks for sensor's data access and availability of their documentation
- Operating system that runs on device and programming languages used for development on this system
- Existence of programming tools for developing applications on device (IDE, computer emulator of device, drag-and-drop graphical user interface builder etc.)
- Availability of mobile device

Until now it has been created several interactive applications aimed on creating musical tones directly on mobile devices (also on iPhone, which was chosen for the implementation part of project). We have analysed several applications for music generation. For example, application Gyro Air Drums[1] is controlled by number of device sensors (touch screen, accelerometer and gyroscope). Probably the most famous application of this kind is iPhone Smule's Ocarina [1] which represents a wind instrument ocarina controlled via the touch screen and blowing into microphone. Both applications focus only on playing the one musical instrument.

3 Description of the project

The application implemented in this project is focused to playing on several virtual instruments via mobile device. For implementation have been selected three musical instruments – piano, flute and drums. In addition, we have focused on two other significant changes compared to other applications while playing on musical instrument. The first was the incorporation of "non-interactive instruments" (in our case rhythm and metronome), which user only configure and application take control of playing sounds based on this configuration. The second was to come up with some sort of adaption of applications to user. We chose to adapt tempo of rhythm played in a loop by the user interaction with one of three interactive virtual instruments. Application is designed and implemented only for the iPhone.

3.1 Audio output playing

In principle, audio output can be played via MIDI interface on external device, operating as a sequencer or by direct playback of prepared audio samples stored on device. The first approach was used in application Camus [2]. However, this application is not designed to generate music, but only to modify existing songs with musical effects. But our application should use to audio playback only the iPhone device so we have decided to use the sound samples. They are stored in memory of device as files containing samples of tones. The great advantage of this approach is that it possible to use high-quality music samples, which could significantly improve the quality of audio output. However, to minimize memory requirements (one our average sample has 84 kilobytes) application contains only a small number of samples (e.g. virtual piano contains only 20 samples out of 88). Then we can increase or decrease the frequency (pitch) of these samples by

[1] http://www.gyroairdrums.com/

so-called pitch shifting algorithm. This algorithm in real time adjusts pitch of any tone in playback by selected interval. With the tone frequency change is also related the change of song duration. Pitch shifting algorithms are designed to adjust only frequency and sound duration is maintained (the reverse process of this algorithm is known as time stretching).

3.2 Sensors for mobile music performance

Today's mobile devices contain variety of sensors which can be used to generate music in very different ways. Michael Rohs and Georg Essl described in their publication named Interactivity for Mobile Music-Making [3] current available sensors in mobile devices that are relevant to making music according to different dimensions. In figure 1 is shown matrix, in which are defined four different dimensions for mobile music performance.

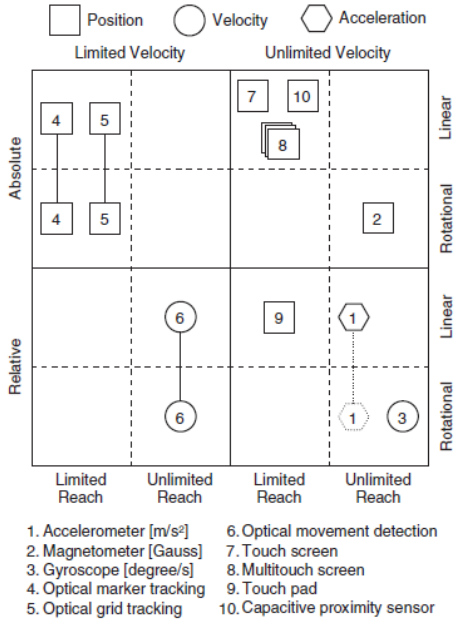

Figure 1. Design space of sensors for mobile music performance [3].

In general, sensors can measure *linear* or *rotational movement*. In addition, there are sensors that can measure both linear and rotational movement, which is shown in figure by connecting line between two equal numbers.

In context of mobile music creation is also very important how we can use potential of particular sensor. They are usable only if they work in available space for users. This means that in some cases is user limited by sensor (e.g. in optical sensing at low frame rates), which is shown in the figure by dimension *limited/unlimited velocity*. That means in case of music creation that if speed necessary to make some musical phrase is faster than sensor technology, the phrase become unavailable. Sensors placed in unlimited velocity dimension are able to detect rapid movements so user is not limited.

Dimension *limited/unlimited reach* means that sensor is limited (or not) by physical interaction space. For example, touch screen is limited by its size, or proximity sensor is limited by maximum sensing distance. It means in musical context that task of mapping specific sounds to interaction are more difficult on sensors that falls under limited reach dimension.

Data provided by sensors can be *absolute* or *relative*. With absolute data sensors are generally easier to work in a musical context because they can be easily mapped to particular tone

pitch or volume. The same is possible with relative data, but it is necessary to propose more complex transformation of data to get specific sounds [3].

In our application (for screens see Figure 2), the sensors of iPhone that we are using are touch screen, accelerometer and microphone. At the piano we simulate by touching the screen the piano keystroke and by dragging, keyboard shift to keys which are not shown. Movement to other keys is also possible to achieve by changing the tilt of device which is detected by 3-axis accelerometer. Flute is controlled by touching the screen at those places where are holes and this contact will "cover" them. Playback of sounds starts if application detects user's blowing into the microphone. Our plan was to use camera of device as sensor which will detect "covering" of flute's thumbhole by real-time analysis of captured images. But in chosen device camera is in opposite position to microphone therefore it would be very hard for user to control virtual flute. Also we were forced to make flute with 5 holes on front side (instead of flute with 7 holes) because device's touch screen can simultaneously detect only 5 touches. Drums at this moment use only touch screen to produce sounds. But our plan is to implement detection (by accelerometer) of user's shaking and making drum stroke gestures with device to play sounds of shaker and tambourine.

Figure 2. Some views from prototype's user interface. From left: piano, flute, drums, settings of non-interactive instruments and automatic tempo adjustment view and rhythm editor view.

3.3 Adaptation of tempo based by user's interaction

There are several types of algorithms that detects tempo of the song. Tempo is measured in units called BPM (Beats per Minute), which determines the number of "beats" (or more precisely – quarter notes) per minute. The process, which is behind the detection of beats (hence the tempo) is an audio signal analysis, including finding the positions with greater amplitude which usually represents snare drum hits in tempo. Song can be split to parts and then are started process of finding regional maxima from which can be separated "real" beats in tempo from soft dynamics hits [4].

There are several algorithms that are applicable to tempo detection [5, 6] but these algorithms are used to find out tempo of existing track and not during its formation as in our case. To detect tempo we are using our suggested algorithm (see section 4.2), inspired by Goto and Muraoka [5]. This algorithm is based on regular analysis of IBI (inter-beat interval – interval between two successive strokes in rhythm). The tempo is not changed if last interval is a multiple of the current interval. It is evident that human is not capable of playing tones accurately to milliseconds in the tempo so in this algorithm we are using error tolerance value. Tempo is

changed if interval IBI shows at least the specified number of times in a row approximately same value, but other than the original interval between beats in tempo.

4 Implementation

At this point we have implemented the majority of every part in application prototype. During the implementation we have used a number of frameworks (Core Motion, Core Media, AVFoundation, UIKit etc.) and for audio playback was used OpenAL API.

4.1 Algorithm of sound playback

Sound playback algorithms can be divided into two groups according to type of instrument. A non-interactive instrument plays pre-defined sounds without user's interaction. These sounds are defined in configuration file and during the playback application must calculate time when concrete sound should be played. This can be determined by formula:

$$time_n = time_{n-1} + \frac{240}{tempo \cdot duration_{n-1}} \tag{1}$$

where $time_n$ is n-th tone, *tempo* is tempo of non-interactive instrument $duration_{n-1}$ is duration of $n-1$ tone. Using this recursive formula we can calculate the specific time when should be n-th tone played. This time is represented in seconds and so the numerator is number 240, which is the multiplication of seconds in a minute with number four, because in music theory tempo is defined as number of quarter tones played in one minute. Instruments are using OpenAL API to generate tones because it supports pitch-shifting algorithm, working in real-time and more configurations for sound playback in 3D space. Playback of sounds is triggered by user interaction with device depending on the instrument.

4.2 Algorithm for automatic tempo adjustment

Tempo of selected rhythm adapts when user interacts with one of three virtual instruments but in different tempo. As mentioned earlier, if new tempo is in same ratio (usually multiple is square of number two, but it is not a rule) to the original value, tempo change is considered natural and therefore it will not be changed. So the situation can be divided into two options. In first case, if new tempo is in natural ratio to original it should not be changed and in second case, if is it not tempo is changed. To find this information was used and experimental fine-tuned following formula:

$$tempo = \begin{cases} 1 & \text{if } \forall i \left| \frac{\text{newIBI}}{\text{oldIBI}} - multi_i \right| > \frac{\text{error}}{\text{multi}_\text{i}} \\ 0 & \text{else} \end{cases} \tag{2}$$

where *tempo* is information whether is necessary or not to change the tempo, *newIBI* is time interval between the last played tones, *oldIBI* is time interval between the tones in the original tempo. Variable $multi_i$ stores i-th multiple of old tempo which can be considered in natural ratio with new tempo and *error* is time error value which can be tolerated musical timing of user. The result says that the tempo change is necessary if in *tempo* variable is number 1; otherwise new tempo is in natural ratio to original. In application we are using five multiples stored in variables $multi_1$-$multi_5$, namely the numbers: $\frac{1}{4}$, $\frac{1}{2}$, 1, 2 and 4. We also use value 0.2 stored in variable *error*, because during the tests it gives us the best and most natural results for tempo adaptation. From implementation point of view automatic tempo adjustment algorithm is based on observer design patterns.

5 Conclusions

In this paper we describe our research which consists of study how can be mobile device used like smart virtual music instrument. We have designed 3 basic (interactive) instruments, each controlled by variety of iPhone sensors, with which we have been experimenting. In addition, we focused on design and implementation of non-interactive instruments in which we had successfully implemented our formula for automatic tempo adjustment.

To this date, our prototype consists of all three designed instruments, non-interactive instruments, and most of the configuration settings. Our plan is to fix all known bugs, optimize the application and test it. Testing by a few users will help us to find existing bugs. According to test observation we can tune tempo adjustment configuration or detect errors related to control of instruments. After this fine-tuning we will start with final testing of application. It will consist of quantitative tests (measuring time needed to finish specific task in application) and qualitative tests (users will fill questionnaire after working with application). Group of users will provide statistical data which will help us to compare with referenced applications and finally formulate the results of this project.

This application could be used for fun or after extension it also could be used as simple educational musical instrument application.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic under the contract No. VG 1/1134/12.

References

[1] Wang, G.: Designing Smule's iPhone Ocarina. In: *Proceedings of the 2009 International Conference on New Interfaces for Musical Expression (NIME09)*, (2009), 5 s.

[2] Rohs, M., Essl, G., Roth, M.: CaMus: Live Music Performance using Camera Phones and Visual Grid Tracking. In: *Proceedings of the 2006 International Conference on New Interfaces for Musical Expression (NIME06)*, IRCAM – Centre Pompidou, (2006), pp. 31–36.

[3] Essl, G., Rohs, M.: Interactivity for Mobile Music-Making. *Organised Sound,* (2009), Vol. 14, No. 2, pp. 197–207.

[4] Sauer, D., Yang, Y.-H.: Music-Driven Character Animation. *ACM Transactions on Multimedia Computing, Communications, and Applications*, (2009), Vol. 5, No. 4, pp. 27:1–27:16.

[5] Goto, M., Muraoka, Y.: Real-time beat tracking for drumless audio signals: Chord change detection for musical decisions. *Speech Communication,* (1999), Vol. 27, No. 3-4, pp. 311–335.

[6] Tzanetakis, G., Essl, G., Cook, P.: Audio Analysis using the Discrete Wavelet Transform. In: *Proceeding of Conference in Acoustics and Music Theory Applications,* Priceton University Press, (2001).

Evaluation of Image Segmentation Based on Histograms

Andrej FOGELTON*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
fogelton@fiit.stuba.sk

Abstract. The presented paper evaluates an experiment on image class segmentation based on Hue-Saturation histograms. Training is based on histogram calculation for every object class separately. Sliding window is performed to segment (label) individual pixels of the evaluation image. Sliding window around the given pixel encloses the local appearance from which the histogram is calculated. Local appearance histogram is subsequently used to be compared with the precomputed class histograms. Given pixel is labeled according the best match using the intersection method. We show how this method depends on data character and window size. Unfortunately, this algorithm suffers from both quality and speed performance.

1 Introduction

Object recognition is the dreamed future of computer vision algorithms. The state of the art algorithms performance is not sufficient neither in speed nor in precision performance. The idea is to develop an algorithm which would be similar to the human vision system. Human vision combines different recognition cues such as object color, shape (contour, 3D model), semantics and object's abilities with possible appearance changes. It works with scale and time precision. Firstly, object class is recognized (e.g. tree) and then the exact type of the class (lime tree) by other discriminative features (the shape of the leaves).

We believe that the important step is proper object class recognition algorithm in order to imitate human vision system. There are several algorithms using different cues and classification methods. Object class recognition based on contour fragments can also provide reliable results [5]. *TextonBoost* presents a new kind of feature, which stores appearance, shape and context cue data [7] with boosting classification algorithm. Semantic Texton Forest shows a very good performance of randomized forest classifier using *Texton* features (color based) for image pixel segmentation [6]. A very good review of different object recognition methods can be found in [4]. Conditional Random Field (CRF) is often used for precision improvements of the classification methods for image pixel labeling [3].

* Doctoral study programme in field: Applied Informatics
Supervisor: Dr. Wanda Benešová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

2 Image Segmentation

The idea is to experiment on solving object class recognition problem using only one cue – color represented by histogram. Histograms are experimentally used for object recognition in [2], while tested with different color models on luminance changes. Our idea is to use manually segmented images to create object class histograms. We will calculate the histogram from the local appearance on the evaluation image and compare it with precomputed object class histograms to get the most probable label (object class of the given pixel).

The HSV color model is chosen to achieve partial luminance invariance by dropping the *Value* channel [1]. Histogram is calculated using only *Hue* and *Saturation* channels with the common bin configuration, 30 bins to represent Hue and 32 bins to Saturation [1].

MSCR-21 dataset

MSCR-21 dataset[1] is very often used to refer and compare segmentation results [6, 7]. It consists of 591 weakly labeled images of 21 object categories (tree, car, horse, flower, etc.). In Figure 1 we can see that weakly segmented images can also consist of not specified regions (void class).

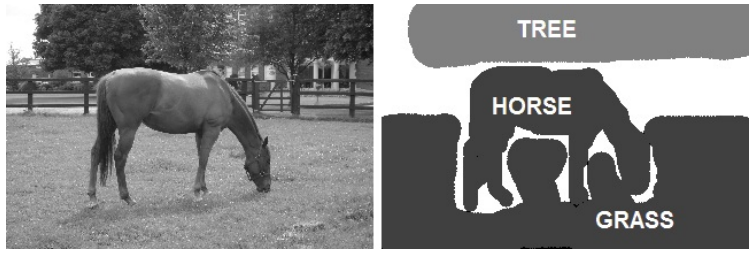

Figure 1. Image and its ground truth (weakly labeled segmentation) from MSCR-21 dataset. Class labels are added manually for better understanding of different gray levels. White color represents void class (not specified).

Algorithm

Before performing the learning procedure (training), the dataset needs to be split into training and evaluation set. This is done along the interested class occurrence over the images. Half of the images of given class (e.g. flowers) are used for training and the other half for evaluation. Learning consists of histogram calculations for every object class separately. For each pixel in every training image, algorithm checks the assigned label from the ground truth image to distinguish in which histogram will the bin value be given by the pixel values of Hue and Saturation incremented. Image pixels segmented in the ground truth images as void class are not used for histogram calculations.

Normalization of these histograms is needed, because the values in the histograms strongly depend on the amount of training images (pixels) of given class occurrence. To be able to get proper comparison results, we normalize the sum of histogram bins to the number of pixels in the sliding window (e.g. for window size 15×15 it is 225). Sliding window of the given size is performed on the evaluation image. The evaluating pixel is the middle one of the sliding window. Sliding window method results in a smaller resulted image than the original, exactly half of the window size from each image side.

[1] http://research.microsoft.com/en-us/projects/ObjectClassRecognition/

Intersection histogram comparison

For every pixel a histogram from the window around the given pixel is calculated. Intersection comparison method is subsequently used to compare the sliding window histogram with class histograms. Equation 1 represents the intersection method[2] as the sum of the minimum bin values over the compared histograms $H1, H2$. Higher distance d means better histogram match. Pixel label is assigned based on the maximum value of histogram comparisons.

$$d(H_1, H_2) = \sum_I min(H_1(I), H_2(I)) \tag{1}$$

The overview of the entire algorithm is listed in Listing 1.

Listing 1. Algorithm overview: Image segmentation based on object class.

```
1 Compute object class histograms from images using their ground truth
   information
2 Normalize histograms
3 For each image to segment do
4   For each pixel of given image do
5     Compute histogram around the given pixel within a sliding window
6     Compare computed histogram with the object class histograms
       using the intersection method
7     Pixel label (color segmentation) is chosen based on the best
       histogram match
```

3 Evaluation

As already mentioned, half of the MSCR-21 dataset images are used for the evaluation of the given method. Table 1 presents achieved results. The average correct pixel segmentation value represents the percentage of correctly labeled pixels on evaluation images in total. The segmentation percentage per class represents the number of correctly labeled pixels of the given class to all pixels belonging to the given class. Both values are important to get a sense of accuracy of the presented system, because we can distinguish from the influence of classes occurrences. In our case, high percentage of grass occurrence increases the average correct pixel percentage.

The results suffer in quality, but few classes achieve good performance, mostly sky, grass, road and face. From this we can conclude that the given algorithm is good for classes of objects which are in monotone color. There is no red sky, only blue or the grass is only green. Their colors do not differ as much as between the other classes (e.g. there are different colors of cars). If the color is not the most specific cue of the given object, it is proven that it is not suitable to be used as the main cue for object recognition. The different size of the sliding window does not influence the segmentation results much. From the values presented in Table 1 and the analyze of the images we can deduce, that the window size influences mostly the percentage of smaller objects, classes like book, body, sheep, cow, etc., which decreases with larger window size.

We can also see in Figure 2, that the image segmentation quality – precision performance is very low. It is interesting to see how the sliding window influences pixel labeling around the object borders. Pixels around the border are assigned by labels of the most dominant histograms as we can see on the flower in the presented image. The flower leaves are thinner in the segmented image compared to the original (Figure 2). This is because the grass histogram is much stronger at green colors than the flower histogram at pink colors (the presented flower is pink in color).

[2] http://opencv.itseez.com

Table 1. Percentage of the correctly labeled pixels of given categories using different sliding window size.

object class	11×11	15×15	19×19
Building	0.44%	0.29%	2.46%
Grass	52.69%	53.01%	55.23%
Tree	9.00%	8.39%	0.88%
Cow	2.24%	2.20%	1.97%
Sheep	2.21%	2.44%	0.88%
Sky	71.77%	59.34%	75.19%
Airplane	2.23%	1.90%	1.39%
Water	8.73%	8.55%	5.66%
Face	24.47%	27.15%	23.40%
Car	1.01%	1.72%	0.14%
Bicycle	0.88%	1.31%	0.05%
Flower	6.68%	6.35%	2.60%
Sign	4.35%	12.69%	4.58%
Bird	0.07%	0.12%	0.00%
Book	4.58%	3.53%	1.84%
Chair	1.99%	2.00%	0.32%
Road	31.72%	36.48%	30.63%
Cat	0.23%	0.37%	0.00%
Dog	5.35%	4.75%	5.11%
Body	2.47%	1.86%	0.00%
Boat	3.75%	4.11%	0.31%
Average per category	11.28%	11.36%	11.13%
Correctly labeled pixels in total	17.53%	16.49%	17.66%

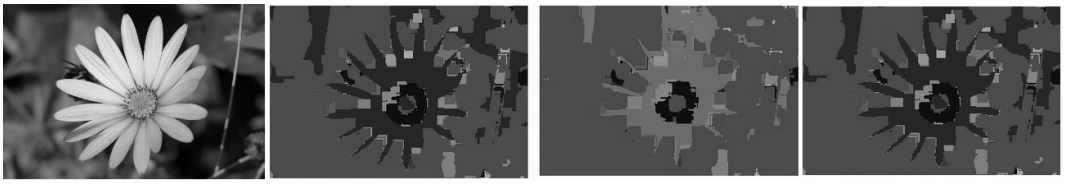

Figure 2. Original image, segmentation results using 11×11, 15×15, 19×19 sliding window.

Training performance is excellent, it takes only about 5 seconds to train 21 class histograms from approximately 300 images. On the other side, evaluation takes much more, about 2 minutes for every image. Because of the processing time and segmentation quality performance, this method is not suitable for processing large datasets. It can be used for specific purpose, when the object colors within a class do not differ much and when the processing time is not very relevant.

To compare, one of the state of the art method [6] performs recognition and image segmentation in 0.1 second but with learning time about 15 minutes, achieving average precision about 64% while using multiple cues. These results are much above ours.

4 Conclusions

This paper presents an experiment of object recognition and segmentation on MSCR-21 dataset. It uses just one cue – color represented by the Hue-Saturation histogram. Precomputed histograms of object classes are compared to the histogram of local region (sliding window) in the given image

using the intersection method. To the center pixel of the given region, label of the most probable class is assigned. Results are good for classes of objects which do not differ in color much like grass, sky, road. For other classes the results are quite insufficient. The average correct recognition rate per class is about 11% and the average per pixel labeling rate in total about 17%.

Acknowledgement: This work was supported by KEGA 068UK-4/2011.

References

[1] Bradski, D.G.R., Kaehler, A.: *Learning opencv, 1st edition*. O'Reilly Media, Inc., 2008.

[2] Gevers, T., Smeulders, A.: Color based object recognition. In Del Bimbo, A., ed.: *Image Analysis and Processing*. Volume 1310 of *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg, 1997, pp. 319–326.

[3] Ladicky and, L., Russell, C., Kohli, P., Torr, P.: Associative hierarchical CRFs for object class image segmentation. In: *Computer Vision, 2009 IEEE 12th International Conference on*, 2009, pp. 739 –746.

[4] Roberto Cipolla, S.B., Farinella, G.M., eds.: *Computer Vision - Detection, Recognition and Reconstruction*. Volume 285 of *Studies in Computational Intelligence*. Springer Berlin / Heidelberg, 2010.

[5] Shotton, J., Blake, A., Cipolla, R.: Multiscale Categorical Object Recognition Using Contour Fragments. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, 2008, vol. 30, no. 7, pp. 1270 –1281.

[6] Shotton, J., Johnson, M., Cipolla, R.: Semantic texton forests for image categorization and segmentation. In: *Computer Vision and Pattern Recognition, 2008. CVPR 2008. IEEE Conference on*, 2008.

[7] Shotton, J., Winn, J., Rother, C., Criminisi, A.: TextonBoost: Joint Appearance, Shape and Context Modeling for Multi-class Object Recognition and Segmentation. In Leonardis, A., Bischof, H., Pinz, A., eds.: *Computer Vision – ECCV 2006*. Volume 3951 of *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg, 2006, pp. 1–15.

Performance Evaluation of Feature Descriptors for Visual Vocabulary Based Methods

Michal KOTTMAN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
kottman@fiit.stuba.sk

Abstract. Visual vocabularies represent a rising trend in computer vision techniques, mainly for classification and recognition tasks. The performance of methods using visual vocabularies depends on several factors, such as the feature type used and vocabulary size. This paper presents a performance evaluation of various types of features, such as normalized image patches, SIFT, SURF and Daisy descriptors, and different codebook sizes. The clustering is performed using the H-Means algorithm, which is implemented for GPU using OpenCL. We measure clustering characteristics, and also the recognition rate for object recognition, which is evaluated on our method used for detecting hazardous signs in high resolution images.

Amended version published in Information Sciences and Technologies Bulletin of the ACM Slovakia, Vol. 4, No. 2 (2012) 38-42.

* Doctoral study programme in field: Applied Informatics
Supervisor: Dr. Wanda Benešová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pages of original paper 434–441.

Extended abstracts

Interactive Allocation of Taxi Customers for Taxi Services

Michal BEHÚŇ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
michal.behun@gmail.com

Extended Abstract

This extended abstract provides a case study focused on creating applications for embedded multimedia system from company Funtoro (http://www.funtoroeurope.com/sk/). I focused on creating system for taxi dispatch system, specifically to improve allocation of customers to taxi drivers.

One area where the cars are widely used is taxi service. It is one of the quickest ways of passenger transport. Therefore, for many years enjoyed great success and interest from customers. The aim of this paper is to describe system for taxi drivers, the work of a taxi driver or employee of the dispatching. This system is using embedded server designed for passenger cars from the company Funtoro. Possibilities of this server provide land for the creation of interactive applications for the allocation of taxi customer to taxi drivers. The advantage of this solution is to clarify information that a taxi drivers needs to effectively do their job as reflected by the increase in the number of customers and also gains the taxi service. It also provides opportunities for future improvement solutions, optionally adding additional functionality and use of new technologies. Described system can be used in substantially all smaller or bigger taxi service which has an interest in increasing travel convenience for customers and improve their work.

Technology used in the automotive industry is on a high level nowadays. In addition to the various systems to improve driving safety, the advanced technologies are applied in increasing passenger's comfort. An example of such system is the Media on Demand Server System. These systems have been successfully applied in aircrafts. These systems are already being used in trains, buses and even in personal automotive transport. The possibilities of use are many, as this system offers a wide range of services. Similar systems have already been installed and implemented in industry. An example is a taxi service, where these systems replaced classical radio.

Media on Demand is new form of entertainment in buses, ships, trains or cars. Basically it is embedded system which integrates multimedia server and various connected devices such a touch screens, GPS antennas, GRPS, 3G and WiFi modules, parking cameras and DVB-T receivers. Similar systems are widely implemented in airplanes whey they offer free form of entertainment. Passenger can choose from a wide range of movies, music library, pictures or photos. The flight data like

* Master study programme in field: Computer Engineering
Supervisor: Peter Pištek, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 445–446.

speed, altitude, distance to destination with estimated arrival time and current position are available too. In last few years Media on Demand systems are implementing to other means of transport. There are successful implementations to buses, ships or trains. Basis of such system is server and several monitors connected to it. When it comes to implementation in a car, the number of screens is not more than three pieces. On the other hand, systems in trains or ship can be way more complex including several servers, hubs and large amount of screens.

Architecture of described the system is based on client-server communication. Server represents dispatching and clients are embedded Funtoro servers in cars (`http://www.funtoroeurope.com/sk/riesenia/c11/osobne-auta.html`). Server side of systems is handling network connections and list of all orders (active, accepted, done) and keeps actual list of all active drivers. Client side is representing by application running on Funtoro server with touch screen display. This application is offering list of active orders and some basic manipulation with them. Communication between server and clients is handled by mobile internet access via GPRS network.

Application of the client side will be activated in each vehicle of the taxi service on the Futoro system. Leading role of the application will be providing active orders for the taxi driver, manipulations with orders and communication with the dispatching. Application can be in several states Disconnected, Connected, Free, Occupied and Break.

The server side is dispatching service. Dispatching will serve as a central hub across the architecture. The main tasks of dispatching will primarily be accepting orders from customers and their distribution via the Internet to all drivers, setting up and maintaining connections with all active drivers, updating the list of active drivers and storing order history.

The system can be extended in several directions in the future. One of these is the implementation of GPS to vehicles. This would allow the allocation of orders based on position of vehicles, the GPS vehicle-tracking and vehicle routes, possible integration of navigation software to client application.

Acknowledgement: This work was partially supported by Young researchers support program on STU: Embedded system's usage in automotive industry and the Slovak Science Grant Agency (VEGA 1/1008/12 "Optimization of low-power design of digital and mixed integrated systems").

Automatic Control of Internet Radio

Michal BYSTRICKY*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
bystricky@nena.sk

Extended Abstract

Abstract deals with the software design, implementation and testing for Internet radio, which is becoming increasingly popular [3]. It describes efficient controlling of the radio with minimum or none influence from provider. The key point of maximum efficiency is that provider is able to control radio from all over the world. This could be done by implementing whole solution as WEB based application. System is able to create, mark and play groups of songs by user defined algorithm. Another option allows listeners to create their own jukebox group. These songs are sent to the standard microphone interface which can be connected to any software platform. There is an interface where user can describe and manage program consisting of groups. Users can also record audio from microphone and create live stream. All streaming data are exported to a document from which statistics and reports are generated. Software was implemented and this abstract contains also results from testing. System is put into operation 24 hours a day. Another related works can be found in references [1–3].

Users of system interact with the WEB application all the time. Provider can upload songs to the WEB application. After that these songs are sent to the FTP server located in streaming controller server where they can be processed. Provider can control streaming using AJAX requests which actually send TCP messages through network to streaming controller server. Components of system can communicate through network and provide standard inputs and outputs which allow many user interface types. WEB application uses PHP, SQL, Javascript, HTML and CSS programming languages.

Streaming controller server application written in Python scripting language is responsible for receiving commands from GUI (WEB application) and controlling stream. It selects next program item from database every five minutes. If it is time to play next program item, application will create data structure from which it is possible quickly select next songs to buffer. Provider can change next songs in buffer from GUI. After choosing next songs, application will play these songs into standard ALSA output. For playing application uses library Mpylayer. It is package to easily control Mplayer. Mplayer is movie player and supports most of audio and video codecs. Therefore provider can upload file in all formats that support Mplayer. He is also able to set software volume with Mplayer. Using this feature application can provide smooth crossing between songs.

---

* Bachelor study programme in field: Computer Engineering
Supervisor: Assoc. Professor Ivan Kotuliak, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 447–448.

Icecast is reliable and stable streaming server application and is responsible for sending encoded audio through reliable TCP to listeners. Audio is encoded and sent to Icecast by source client application. Open-source application Ices can be used as a source client.

At this point there is Mplayer playing audio on ALSA output and source client application which can listen only on ALSA input. To connect these two devices we use Linux kernel module called `snd-aloop`. This module allows to create two virtual devices where output of first device is copied to input of second device. Whole model of software can be seen on deployment diagram in Figure 1.

Live streaming application is written as JAVA applet. It is recording audio from microphone, encoding and sending data to streaming controller server.

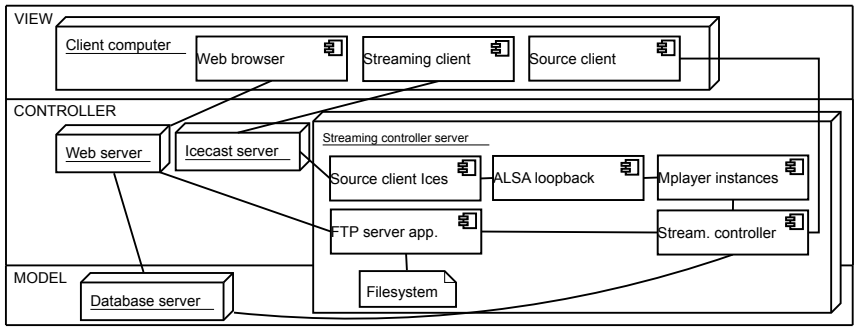

Figure 1. Deployment diagram of the Internet radio solution.

Requirements on server meaning CPU, RAM usage and traffic can be divided into many servers to process as much requests as possible. This model allows user to use whole application in a mobile phone or tablet. System is scalable and supports cloud model.

System was tested on QEMU/KVM virtual host running Gentoo Linux, generic 64bit kernel. Processor (AMD Athlon(tm) 64 X2 Dual Core Processor 5600+) of host machine has 2900 MHz and 512 KB cache. RAM (DIMM DDR2 667 MHz) assigned to virtual host was 768 MB. All components of system were installed on one host. One third of listeners in test browsed site every random time from 5 to 15 seconds and were playing radio. WEB server generated content where few SQL select commands were used. One request took approximately 0.22 seconds to generate.

Maximum of 70 listeners was accepted. Server could not handle high load and it disconnected few listeners. Nevertheless, request's time was constant (approximately 0.655 second). With 50 listeners the time of request was doubled, with 70 tripled and so on.

System was tested also with 256 MB of RAM. After increasing listeners number to 50, Mysql server became swapping and server was not responding because of high I/O operations. In another test listeners were just listening to the radio. Without browsing the site, 750 listeners were playing radio and CPU usage was only 47% and RAM usage 69%. Parameters constantly rose, therefore this hardware configuration should handle 1000 listeners, maybe more.

References

[1] Huang, C.M., Liu, P.C.: IDRS: an interactive digital radio station over Internet. In: *Journal of Systems and Software*, Elsevier Science Inc., 2000.

[2] Melendi, D., Vilas, M., García, R., Pañeda, X.G., García, V.: Characterization of a Real Internet Radio Service. In: *Software Engineering and Advanced Applications, 2006. SEAA '06. 32nd EUROMICRO Conference on*, IEEE Press, 2006.

[3] Pfaff, K., Toma, C.: Audio Quality of Internet Radio Systems. In: *Signals, Circuits and Systems, 2003. SCS 2003. International Symposium on*, IEEE Press, 2003.

Music Melody Retrieval and Analysis

Gabriel DUCHOŇ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xduchon@fiit.stuba.sk

Extended abstract

Music Information Retrieval (MIR) is area, which offers wide range of problems and fields for research and development, since music is type of art, and processing of artwork is generally more difficult than data processing or information analysis. In order to be able to deal with polyphonic music, we should implement methods, which can transform polyphonic music into separated sequences of monophonic melodies, since processing of monophonic melody is easier and more accurate. The MIDI (*Musical Instrument Digital Interface*) standard/format allows place notes into different channels or/and tracks (depending on version of MIDI standard) which separate melodies in the score, but usually these channels/tracks (hereafter referred to as *tracks*) can hold *chords* too.

Every note of melody (which is dedicated to index) will be expressed with text string as tokens. In our method the first character of the tokens expresses the direction of the change of the pitch between two adjacent notes. Next double digit integer expresses value of absolute difference of pitch between adjacent notes. The last double digit integer of the tokens expresses the duration of the first note of the pair of adjacent notes. This representation is useful for standard search, melody search (takes into account only the pitch of notes), search by *Parsons code* (takes into account only the direction of pitch change) or rhythm search (focus only the duration of the notes).

In case of polyphonic melody source, we have to extract more strings for maintaining multiple melodies, for this reason we process each track separately. One track can hold multiple melodies, which are formed from more notes and/or chords. Proposed algorithm for generating textual representation of track is described as follows:

1. First is ascertained, if processed track contains at least one chord. If not, then generate one text string from the sequence of notes; else continue with the second step.
2. Creating array of *n* strings, where *n* is equal to maximal count of notes within chords if this value is lower than or equal to 4, else *n* has value 4.
3. Appending text representation of notes into strings with manner in which: First string will contain text representation of notes which are not included into chords and notes which are included into chords and which has the highest pitch. Second string will contain text representation of notes which are not included into chords and notes which are included into chords and which has the second highest pitch. Third string will contain text representation of notes which are not included into chords and notes which are included into chords and which has the third highest pitch (if chord consist only from two notes, then the note with

* Master degree study programme in field: Information Systems
Supervisor: Nikoleta Hrušková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 449–450.

lower pitch is selected). Fourth string contains text representation of notes which are not included into chords and notes of chords which has the lowest pitch.

Generated strings should represent monophonic melodies which are the most significant from the polyphonic track, and it is the reason why are exactly extracted notes with the highest and the lowest pitches. Advantages of this solution for melody representation are the lower amount of output strings compared with amount of outputs using combinations of notes in chords. Disadvantage is, this conversion is lossy, and in case of chords with many notes, some notes can be omitted, but the more notes are in the track, the lower is the probability that notes with relatively lower pitch are significant and will figure in future queries.

Within searching, user often searches *phrase* queries because he is interested in melody which is exact sequence of notes. Query can include or exclude some notes, therefore the searching should tolerate some deviation. In case of using the n-gram approach in the search process, we slice the query string into *n-grams*. Original principle of n-grams generates sequence of adjacent characters of the length *n*, but in our case it would not be effective, since divided token is inapplicable. For this reason we generate n-gram of adjacent tokens, so called *shingles* (but hereafter referred to as n-grams whereas the principle is the same). Using n-grams can improve the searching, since there is comparing smaller block of strings and hence the search is less susceptible to uncertainties in query. Besides using n-grams for increasing the recall of the search we can increase precision (or modify the sort of retrieved documents) considering the genre of the music scores. We can set the genre manually, but also using genre classifier. Genre determination is done based on the features/properties of the music score [1] or/and based on pattern extraction. The genre classification can be useful in case of grouping the source music works, but also in MIR, when user is searching music work by its content, and he knows only fragments of melody, but maybe he can choose the set of probably relevant genres of the searched music work, so in this way he can decrease the count of not relevant items.

We tested the duration of the music retrieval process by comparing times consuming music retrieval with different configurations: tolerance, minimal and maximal length of n-grams, query-length. In the test we measure search delay depending on query-length (5-11 notes), length of n-grams (4-9) and tolerance (0 or 1). Testing corpus for melody retrieval are scores from the United Catholic Songbook [3]. It includes more than 500 polyphonic songs written mostly for 4 voices: soprano, alto, tenor and bass. We conclude, that tolerance has nearly no impact on the time of the melody retrieval process, so we can take it to account and set the configuration with enabled tolerance by default. Retrieving melody with n-grams will be implicitly disabled, because its worse time complexity and its use should evaluate the user.

Testing the melody retrieval in terms of precision and recall would be difficult, since the tester would need to know the melodies of all songs in the set of indexed songs. In the cases, when we deliberately add songs to the index which contain the same melody sequence, then the list of results always contains the relevant songs, so the recall is always exactly 1. Precision in case of using n-grams is always lower, but this method guarantees higher recall and better order compared with retrieval without using of n-grams, or in case of imperfect queried melody.

References

[1] McKay, C.: Automatic Genre Classification of MIDI Recordings. Master's thesis, (2004).

[2] Ruppin, A., Yeshurun, H.: MIDI Music Genre Classification by Invariant Features. In *Proc. of the 7th International Conference on Music Information Retrieval*, University of Victoria, Canada, (2006), pp. 397–399.

[3] Schneider-Trnavský, M.: Jednotný katolícky spevník (United Catholic Songbook), Spolok sv. Vojtecha, ISBN 80-7162-173-0, (1996).

Forensic Tool for Collection of Digital Evidence in Linux Environment

Pavol HELEBRANDT*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
pavol.helebrandt@gmail.com

Extended Abstract

With growing importance of many computer systems in almost all aspects of everyday life in modern world, security of these systems and data contained in them is paramount and active protection measures are critical in securing them. However, none of the safeguards implementations are infallible and digital forensics is very important for the purposes of collecting evidence of security incidents.

Digital forensic process can be considered identification, collection, examination and analysis of data while maintaining integrity of the information contained within. Collection of volatile data from running system can cause alteration of collected data and lower integrity of the data. Papers [5, 6] describe novel solutions to collect volatile data by using specialised hardware or using hibernate function of system to store memory contents to hard drive.

Outcome of rising number and sophistication of attacks that leave very little if any evidence in non-volatile data is growing importance of live over dead analysis. In Table 1 are key attributes for comparing current tools for live analysis of Linux operating system.

Table 1. Comparison of forensic tools.

	Operation	Data collected	Collects non-volatile data from OS	Collects volatile data from OS	Capable of analysing volatile data
EnCase	application	non-volatile and volatile	Windows, Mac OS X, Linux	Windows, Mac OS X, Linux	yes
Helix3	live Linux and application	non-volatile and volatile	Windows, Mac OS X, Linux	Windows, Mac OS X, Linux	yes
Live Response	application	volatile	none	Windows, Mac OS X, Linux	no
LECT	application	volatile	none	Linux	yes

* Master degree study programme in field: Computer Engineering
Supervisor: Assoc. Professor Ladislav Hudec, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

One of the most common forensic tools used in the world is EnCase, which is professional toolkit for digital forensic analysis and system monitoring with its final report format accepted in many judicial systems around the world.

Helix3 evolved from free live Linux CD designed for data recovery and dead analysis into sophisticated commercial tool for digital forensics of non-volatile as well as volatile data. There is also lightweight version Live Response - application for fast collection-only of volatile data.

LECT (Linux Evidence Collection Tool) is the result of cooperation between Italian and South Korean universities, designed to deal with all phases of forensic investigation of volatile data from Linux operating system.

All forensic tools mentioned above have shortcomings when it comes to live analysis of Linux operating system. Our solution was to design and implement versatile forensic tool capable of collecting and analysing volatile data from any Linux operating system. To reduce impact of running the tool on collected volatile data, program should have minimal requirements on resources of investigated system. However, this is a limiting factor for examination and analysis later on during forensic process, so it is desirable to split the functionality into collection and analysis modules.

For collection module, which is usable by itself as a stand-alone application to acquire volatile data from target system according to a predefined by plan, control by CLI (Command-Line Interface) is sufficient. To maintain integrity of the tool, it uses statically linked standard programs from its own external media to gather required volatile data.

The analysis module processes and sorts gathered data into categories for a better transparency, but also allows viewing them in raw form for a more in depth analysis by experts. To maintain the integrity of collected data and information processed into evidence hash value for every file is logged in protocol. The report is not made automatically by the program, but forensic investigator is assisted by refined information from analysis and forensic protocol, which should be added to final report.

Our approach offers several advantages over other existing solutions – easy recompilation of tool allows for greater flexibility regarding collection from different Linux distribution, while minimising impact on volatile data of target system. In our future work on the project, we wish to develop provisions for more automated processing of raw collected data.

References

[1] Kent, K., et al.: *Guide to Integrating Forensic Techniques into Incident response*. NIST Special Publication 800–86, (2006).

[2] Pogue, Ch., Altheide, C., Haverkos, T.: *UNIX and Linux forensic analysis DVD toolkit*. Syngress, 2008.

[3] Brezinski, D. and Killalea, T.: *RFC3227: Guidelines for Evidence Collection and Archiving*. Network Working Group, (2002).

[4] Choi, J., Savoldi, A., Gubian, P., et al.: Live Forensic Analysis of a Compromised Linux System Using LECT (Linux Evidence Collection Tool). In: *Proc IEEE of international conference on Information Security and Assurance (ISA 2008)*, Busan, Korea, (2008), pp. 231–236.

[5] Hay, B., Nance, K., Bishop, M.: *Live Analysis: Progress and Challenges*. IEEE Security & Privacy, (2009), Vol.7, No.2, pp. 30–37.

[6] Mrdovic, S., Huseinovic, A.; Zajko, E.: *Combining static and live digital forensic analysis in virtual environment*. XXII International Symposium on Information, Communication and Automation Technologies (ICAT 2009), (2009), pp. 1–6.

Gathering Information on User Environment

Tomáš JENDEK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
jendek.tomas@gmail.com

Extended abstract

Nowadays people use mobile devices on daily basis. Coverage of wireless networks, mobile devices and software platforms is making mobile computing mainstream issue. Every user is situated in certain environment, which provides contextual information. Context represents situation or condition [2]. Context can be simple as location, or complex like emotions. In our work we focus on obtaining location context as contribution to social context acquiring. We need to define effective way of obtaining location context. We propose method for tracking user's location in time, estimate future location of user and define user's important places. These information can be further used in recommendation systems.

There are existing solutions based on acquisition location using GPS module on mobile devices. This is not very battery efficient, so our solution use GSM transmitters. We map GSM transmitter towers to GPS positions which solves problem with energy consumption. There is certain lack of accuracy in using position obtained by using GSM transmitter, but it is still pretty accurate for our purposes and we can use this lack of accuracy for privacy and security improvement.

There are services for obtaining user's and friend's location. They are mostly oriented for real time tracking. It means that user needs internet connection for obtaining location and also GPS module. There are cons for these solutions, for example high energy consumption due to using GPS module. The advantage is that these solutions are relatively accurate (less than 10 – 20 meters).

People visit various places daily and their location can form connection between people, friend via places. People's co-presence in places provides linkage between people or between places [1]. This can be useful for us determine social context for user. If we can determine social connection between user and his friend, we can easily suggest, for instance, meeting or any other activity using other context – calendar. Our concept of obtaining user's location lies in implementing mobile application, which provides useful service for user and also helps to obtain location context. User is motivated to use our application when he wants prediction of his friend's location. He gets estimation of friend's location and then he can contact friend and arrange meeting.

Our method is based on tracking user location and analyzing this data. First we find important places for user to filter other unimportant places, i.e. when user is commuting. Important

* Bachelor degree study programme in field: Informatics
Supervisor: Dušan Zeleník, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

places are those, where user spent certain time. The most important for us is to determine whether user is at home or at work. Assuming that average person sleeps at night and works during day we estimate whether user is at home or at work/school. In our experiment we estimate user's home with success 93% and user's work with success 68%. For predicting user's future location in time, we create time vector and try to find appropriate similar vector in our database of user's logs.

Table 1. Time vector sample.

Minute / 60	Hour / 24	Day / 7	Week / 4	Month / 12	Year / 10000
0.232	0.543	0.468	0.887	0.229	0.2012

Time vector (see Table 1) consists of five columns. Minute of the hour, hour of the day, day of week, week of month, month of year and year / 10000. This time vector is compared with history using cosine similarity to estimate future location. There are some options of adjustment for vector components, i.e. hour of the day is more important component than year, or month. Day of week and hour of day are more important vector components than month or year in discovering user's behavior pattern, so we adjust cosine similarity vectors.

To evaluate our solution, we use retrospective analysis – implicit feedback. We predict location in future time and we are able to verify whether our prediction was correct or not. For verification user's home/work location we use explicit feedback. To sum up we presented method for location prediction, which supports contact between people by implementing mobile application for Android OS. This application tracks user position and estimates future position of user's friend and important locations. In future work we want to discover relationships between friends based on common location as contribution to social context acquiring.

Acknowledgement: This work was partially supported by the Slovak Research and Development Agency under the contract No. APVV-0208-10.

References

[1] Konomi S.: Colocation networks: exploring the use of social and geographical patterns in context-aware services. In: *Proceedings of the 13th international conference on Ubiquitous computing*.

[2] Zeleník D.: An Approach to Context Aware Event Reminding. In *Proc. of the Information Sciences and Technologies Bulletin of the ACM Slovakia*, ACM, (2011), pp. 126–130.

Full-Text Search in Email Archives Using Social Evaluation, Attached and Linked Resources

Vojtech JUHÁSZ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
jbeluska@gmail.com

Extended abstract

Email is the second most popular service of the Internet. Emails are important tools for communication and cooperation, they contain large amount of information and connections to knowledge and data sources of a community or company. In this paper we propose a search system aimed at fine grained indexing and search result personalisation using social relations.

We can consider email archives as a redundant collection of related data. This redundancy is caused by the messages often citing previous messages of the communication thread. This redundancy may cause a noticeable increase of the size of the index. This problem can be solved by dividing textual content of a file into segments using Rabin-Karp or winnowing algorithms. The number of segments may vary depending on the text. These redundant files have more similar segments which are indexed only once.

The proposed system provides full-text search, social search and combined search capabilities. Central functionality of the system is text and social relation extraction from emails. During the indexing process the messages are divided into various segments (i.e. the message, subject, attached or linked content), which are included into the index with various weights.

The most challenging task is the segmentation of the raw body into segments: message body, quotation and signature. This task is accomplished using pre-defined regular expression patterns inspired by the paper of Carvalho and Cohen. The patterns presented in that work are modified regarding the needs of this project and the format of the email representation. The raw body of a message is processed line by line – to each line we can assign features (by the regular expressions). Beyond current line features we also consider the features of previous and next lines.

Basic concept of the proposed system is based on abstraction of emails, attachments and linked contents. The system's architecture is built around the abstract email object and the index structure. The index itself is divided into two parts: the *Content index*: it is implemented using Lucene[1] and it stores all the extracted contents (considering different weights for the different segments) and the *Social index* (implemented as a relational database using SQLite[2]).

To search through the index there are three methods available:

- *full-text search*: searches the *Content index* by the user's query,

---

* Master degree study programme in field: Information Systems
Supervisor: Michal Laclavik, researcher at Institute of Informatics Slovak Academy of Sciences

[1] Apache Lucene: Overview. Available at: http://lucene.apache.org/java/docs/index.html. 2011.

[2] Sqlite3. Available at: http://www.sqlite.org. 2011.

- *social search*: searches the *Social index*, it can be useful for statistical queries and for determining a contact's importance relatively to a given user (*social score*),
- *combined search*: combines full-text and the social search: full-text search determines the search results while social search personalizes search results by determining social scores.

To determine social importance [R_S] of a contact, we proposed the following equation:

$$R_S = \frac{\log\left(\frac{(M_{RA} + M_{SA}) - (M_{RS} + M_{SR})}{M_{ALL}}\right)}{\log\left(\frac{1}{M_{RS} + M_{SR}}\right)} (TD_S + TD_R) \cdot \vartheta$$

where: M_{ALL} – all the messages sent among all the users, M_{RA} – all the messages sent from the recipient for any users, M_{SA} – all the messages sent from the sender for any users, M_{RS} – messages sent from the recipient to the sender, M_{SR} – messages sent from the sender to the recipient, TD_S – sender's total degree of centrality, TD_R – receiver's total degree of centrality, ϑ – is the merging factor, which is used to transform the value of R_S to be comparable to the order of textual relevance (R_T). While determining TD_S and TD_R we also takes into account the different types of relations between contacts (different weights for To or BCC relations).

The above formula considers communication intensity between contacts and also the centrality of nodes. We assume, that combining these common social measures we can achieve a precise social score calculation.

The system is intended for searching email archives. It takes advantage of three main features: segmentation, attached/linked resource processing and social evaluation. Segmentation ensures fine grained index while inclusion of attached and remote content extends it in some other way. The main purpose of social evaluation is to personalize the results of the textual search.

During the evaluation phase we will compare the implemented system regarding metrics such as precision, recall and average precision[3]. Except of these metrics we will evaluate some not functional features of the system, such as: usability, interactivity, configurability, transparency. For the evaluation we use the PST version of *Enron corpus*[4] with attachments included. Using this dataset we will evaluate the efficiency of the search system during some experiments. We will use these experiments to determine the impact of the proposed social evaluation onto the search results. During the evaluation we will do experiments. First we construct queries which are going to be executed regardless of the users by each of the tested systems than we will compare the results regarding the mentioned metrics. In the next step we will execute the same queries but also considering social relevance. The benefits of the proposed social evaluation can be then evaluated by comparing search results. The social evaluation itself can be evaluated by comparing the results of queries executed regarding different users. In the last phase, we will compare proposed and implemented search system to existing systems such as MS Outlook, Thunderbird, Beagle.

References

[1] Vitor R. Carvalho, William W. Cohen: Learning to Extract Signature and Reply Lines from Email. *CEAS-2004* (Conference on Email and Anti-Spam), (Mountain View, CA, 2004).

[2] Shinjae Yoo, Yiming Yang, Frank Lin, Il-Chul Moon: Mining Social Networks for Personalized Email Prioritization. *KDD'09* (Paris, France, 2009).

[3] Jiangong Zhang, Torsten Suel: Efficient Search in Large Textual Collections with Redundancy. *WWW 2007* (Banff, Alberta, Canada, 2007).

[3] Monica Cahill McJunkin, Precision and recall in title keyword searches, Information *Technology and Libraries, v.14 n.3*, p. 161–171, Sept. 1995

[4] Enron corpus is available at http://enrondata.org/ – database of over 600,000 emails generated by 158 employees of the Enron Corporation

Visual Based Query Construction to RDF Graph

Matúš MICHALKO*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
matus.michalko@gmail.sk

Extended abstract

In this paper we briefly introduce an approach of visual based searching of data stored in a semantic repository. The approach is based on creating RDF graph that can be transformed to SPARQL tuple query. The main requirement for our searching approach is to make it user friendly as much as it is possible.

Current web offers enormous amount of information that grows at exponential speed [1]. This growth increases difficulty of information retrieval and search on the web. Moreover, a search engines on common web pages do not support semantics of data, i.e. search is mainly based on methods that originate from the beginning of web era. Technologies of web 3.0 (also known as semantic web) offer possibility of describing meaning of shared information in a computer interpretable form. Thanks to information processing performance of modern computing systems we can process these data with emphasis on their semantics. In this paper we will focus on searching and information retrieval in a web portal with real estates that is build upon latest web 3.0 technologies. This project is semantic backend to other project (price map of real estates), that should improve data matching by utilizing latest semantic technologies. Both these projects are developed by Datalan, a.s [2]. We will try to identify advantages of view based search in mentioned domain of real estates.

SPARQL became current standard language for querying RDF triple stores [3]. SPARQL queries are intuitive; however they require former knowledge of underlying information space [4]. Such a query can be modelled also graphically. Advantage of this approach lays in data visualisation. If end user can examine stored data and their interconnectedness, he can build much more efficient queries and retrieve results that closer fit his search intention [5]. Our goal is to made this search intuitive and user friendly. User interface should be easy to use also for users that do not have any former knowledge about semantic web and RDF graphs. This software is developed as a widget with emphasis on its reusability in possible further projects.

In ontology which is our search domain, every offered real estate is built up of 3 main nodes – address, offer and real estate itself. All these main nodes are connected with other object and data properties that together form concrete offer of concrete estate on concrete address.

In the beginning of query construction, all these 3 main nodes must be present in a graph as they are main structural parts of every real estate molecule. User can examine these nodes by clicking on them. After clicking on node, this node is unpacked, so user can see which properties desired node can have. There are two types of properties in RDF graphs – object and data

---

* Bachelor degree study programme in field: Informatics
Supervisor: Dr. Miroslav Líška, Datalan, a.s., Bratislava

properties. Object properties are resources of certain type that can be described with some additional properties. Data properties are literals that represent certain numerical or textual value. By choosing appropriate object property, user gets list of available resources, from which he can select desired one. If user chooses data property, he can fill in desired literal value.

Query construction can be performed also on molecule of existing real estate. From visualisation of its properties as they are interconnected and stored directly in database, he can better understand underlying data model. In such visualization end user can simply mark nodes he consider important by clicking on them. These properties will be considered as a compulsory for all real estates that will be returned by new search. In the future this approach in combination with spreading activation and RDF Priming might enhance search experience even more and return also results that are semantically similar to marked real estate [6, 7].

To make this kind of search usable, few technical details have to be considered:

- All displayed resources need proper labels, or there should be way how to construct label from subsistent data properties.
- RDF graphs might contain huge amount of information with high degree of interconnectedness [4]. Some metadata that are useless for search purpose should be filtered out from visualisation.
- Visual based exploratory search exposes data structure to end users. Therefore quality of stored data is very important. Data obtained from crawling need former cleaning and transformation.

References

[1] Odlyzko A., Coffman K.: Growth of the Internet. (2001) AT&T Labs.

[2] Datalan, a.s. Sestate. [Online] 2012. http://www.datalan.sk/semweb/sestate.

[3] W3C. SPARQL 1.1 Query Language. [Online] W3C, 2012. http://www.w3.org/TR/sparql11-query/.

[4] Tvarožek, M., Bieliková, M.: Generating Exploratory Search Interfaces for the Semantic Web. In *P. Forbrig, F. Paternň, & A. M. Pejtersen (Ed.), IFIP – World Computer Congress 2010: Human-Computer Interaction Symposium*, Brisbane, Australia: Springer, 2010, pp. 175–186.

[5] Rástočný, K., Tvarožek, M., Bieliková, M.: *Supporting Search Result Browsing and Exploration via Cluster-based Views and Zoom-based navigation*. WIRSS 2011: Proceedings of IEEE/WIC/ACM International Joint Conferences on Web Intelligence and Intelligent Agent Technologies, Workshop on Web Information Retrieval Support Systems, Lyon, France: IEEE CS, 2011, pp. 297–300.

[6] Berthold M., Brandes U., Kötter T., Mader M., Nagel U., Thiel K.: *Pure Spreading Activation is Pointless*. CIKM, 2009.

[7] OWLIM. OWLIM-SE Experimental Features: RDF Priming. [Online] 2012. http://owlim.ontotext.com/display/OWLIMv43/OWLIM-SE+Experimental+Features#OWLIM-SEExperimentalFeatures-RDFPriming.

Software Evaluation Driven Tool for Mobile Device

Peter PALÁT*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
peter.palat@gmail.com

Extended abstract

Fast-paced digitalization of data, as witnessed in the past few years, has made a lot of data accessible to people. As a result, the requirements on human memory have grown very high. Several different devices, ranging from simpler ones to smart phones and tablets, were introduced to the market. Thanks to gradual expansion of wifi networks, these devices offer unlimited possibilities in the process of acquisition, processing and creation of new data which can be used for education.

The education process in particular has undergone an update recently. Mobile technologies' continuing development enables education at any place and at any time. Such form of education is called m-learning. However, since its dawn it has been under fire due to certain limitations, such as size of device display.

The term m-learning is relatively new and therefore general principles, which the m-learning applications should follow, have not been defined yet. Because of this particular reason, many experts in different fields try to discover the mobile devices' potential in the education process

There have been many projects, whose aim was to discover possibilities of mobile devices, "Learning on the Move" being one of them. The project lasted for more than four years, meaning that several technologies have been used in this period – from text messages to emails. The problem was that the students attended only one English class a week: it was not enough to build up an encompassing word stock. Because of this they were sent three messages, containing a short description of a more difficult vocabulary item, always at specific time of the day, which could be read even on small displays of that time's cellular phones. At the end of the project the students were tested and filled in a questionnaire. Result showed that these students had better results, than students, who were reading these materials through web browser on computer. They also showed that, majority of them preferred more to read such texts in their cellular phones than on computer, and the display size was not seen as an obstacle. Students also did not feel comfortable with the messages arrival at fixed time. These results confirm that using the correct formatting of text and the formulation can be used to display complicated text on smaller screens.

Another very successful project in this area is K-NECT. The first and foremost goal of the project was to motivate pupils, who struggled with mathematics, to learn more. The application granted them access to documents and allowed interaction with their classmates and teachers from

---

* Bachelor degree study programme in field: Informatics
Supervisor: Dr. Ján Lang, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

several schools of South Carolina in the United States. The application was used in smart phones and was using wifi networks to obtain data. The project's aim was to retain the mobile devices' potential; the problem was that the application would not work in off-line mode which severely hindered this form of education. On the other hand, the K-NECT project offered the opportunity for the pupils to cooperate in their free time. Such opportunity is also provided by social networks, yet they are not primarily intended for education and contain many elements which quickly detract students' attention.

The two mentioned projects were facing major problems, which our application is trying to eliminate. This application must first of all use basic features of a mobile device, such as mobility. The user's comfort has to be taken in account too; he or she is not to be occupied with new installations every time the contents of the application change. Such data should be synchronized via internet in the application's background so that no action by the user is required.

It is obvious that internet access is not readily available everywhere – this is why the application should be able to run in offline mode too. Its functionality in this mode should retain all features except for downloading new data; the user should still be able to the application and data which have been downloaded previously. This principle keeps the fundamental idea of m-learning operational.

A feasible solution to the problem of the "Learning on the Move" project, i.e. fixed time of messages' arrival, is to provide opportunity for planning and scheduling of one's studying. Modern operating systems used in mobile devices contain programs which help with planning and organizing of different events, as well as remind users of important deadlines, meetings, etc. The problem is that the operating systems are not adjusted for providing a clear overview of such planning process. For this particular reason, the proposed application should in itself contain a module for such planning, to avoid problems which had students, who partitioned in Learning on the move. Fixed time for reminding didn't work well, and students were complaining about it.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/1221/12.

References

[1] Song, J: *Mobile Learning:* What is Going on?, *International Symposium on Knowledge Acquisition and Modeling*, (2008).

[2] Winters N.: *What is mobile learning*, *Big Issues in Mobile Learning*. Nottingham: University of Nottingham, (2007).

[3] Geddes, S.: *Mobile learning in the 21 st century*. Knowledge Tree, (2008).

[4] Thornton, P., Houser, C.: Learning on the move: Foreign language vocabulary via SMS. *Proceedings of ED-Media* (2001), pp. 1846–1847.

[5] Project K-NECT: *K-NECT Summary.* http://www.projectknect.org/Project%20K-Nect/K-Nect%20Summary%20.html, (2009).

Environment for Low-Power Optimalization of Multiplexer Trees

Jakub POLÁK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
polak.ja@gmail.com

Extended Abstract

Multiplexers and their cascade connections are significant part of VLSI circuits. Algorithm described in the document is focused on optimizing multiplexer trees produced the most currently used technology production of integrated circuits CMOS. The total power for a circuit consists of dynamic power and static power. Dynamic power is the power consumed when the device is active that is, when signals are changing values. Static power is the power consumed when the device is powered up but no signals are changing value [1].

The proposed system optimizes the circuit in two steps:

- eliminating the number of multiplexers in the circuit using an algorithm employing modifications of the truth tables,
- reducing switching activity in circuit.

The first step of the algorithm is analysis of all canonical matrix constructed from modified truth table. Each of canonical matrix is created for one permutation of input variables. Canonical matrix will be analyzed for finding certain segments. Each of these segments represents one multiplexer in final circuit. These segments are created by rules defined by user (allowed types of multiplexers, enabled/disabled creation of multiplexer with unconnected inputs, default values unconnected inputs). Rules of elimination are following:

- the multiplexer which has the same data inputs as another multiplexer in the same layer of a circuit can be eliminated from the circuit,
- the multiplexer which has all the data inputs the same can be eliminated from the circuit.

This data entry is transformed to internal representation of circuit.

Second step of algorithm is based on reducing switching activity in circuit. To minimize those unnecessary switches of selection signals, each multiplexer has its own independent selection input and a dedicated controller is responsible for generating individual selection control for each multiplexer (See Figure 1). Multiplexer at the same level no longer share the same selection signal. Whenever a different data input is chosen, the controller dynamically adjusts only

* Master study programme in field: Computer Engineering
Supervisor: Peter Pištek, Institute of Computer Systems and Networks, Faculty of Informatics and Information Technologies STU in Bratislava

the selection signals of multiplexers lying on the path from the chosen data input to the tree output to ensure correct functionality and leaves other multiplexers unaltered [3].

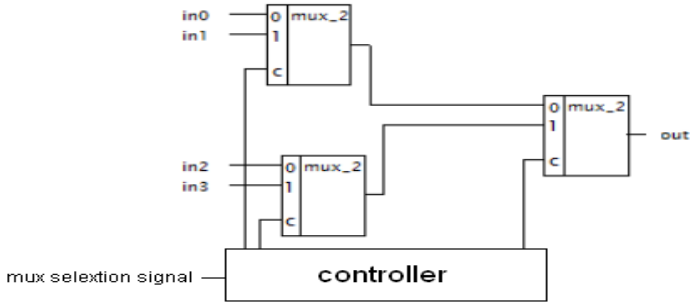

Figure 1. Multiplexer tree with controller.

Algorithm is adapted to work effectively with multicore processor. During the startup program finds the maximum number of threads which the processor is able to process simultaneously. User can select the number of threads in which the program will run and enable or disable accelerated optimalisation. Each of threads works with its own range of vectors of residual functions and looking for the best circuit in its range. This local winner is compared with the local winners of the other threads. The best of local winners is marked as the best circuit found.

The number of permutations for witch the program compiled vector of residue functions is equal to the factorial the number of inputs. In program are therefore implemented restrictions that do not allow the user to specify more than 10 inputs in circuit with automatic optimization and more than 20 inputs in circuit where order vector of residual function is given by user.

Output of the optimization process is the best found circuit (circuit with minimal power consumption) in the form of a structural description in Verilog.

Acknowledgements: This work was partially supported by the Slovak Science Grant Agency (VEGA 1/1008/12 “Optimization of low-power design of digital and mixed integrated systems”).

References

[1] Keating, M., Flynn, D., Aitken, R., Gibbons, A., Kaijian S.: *Low Power Methodology Manual For System-on-Chip Design*. New York: Springer, 2007. 300p. ISBN 978-0-387-71818-7.

[2] Pištek, P.; Kolesár, M.; Jelemenská, K.: "*Optimization of multiplexer trees using modified truth table*," Applied Electronics (AE), 2010 International Conference on, (2010), pp.1–4.

[3] Nan-Shing Li; Juinn-Dar Huang; Han-Jung Huang: "*Low power multiplexer tree design using dynamic propagation path control*," Circuits and Systems, 2008. APCCAS 2008. IEEE Asia Pacific Conference on, (2008), pp.838–841.

Mobile Document Management

Michal RAČKO*

Slovak University of Technology
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
xracko@fiit.stuba.sk

Extended Abstract

We are now at a time when mobile devices provide similar comfort when working with documents as desktop computers. The aim of this project is to verify the concept of filling out forms saved in PDF format through native application for mobile device.

Overview. Effort to digitalize society led people from filling paper forms to processing and filling them in digital form [1]. However, there still exist both ways, making it difficult to process them. The answer in the future can become a single system adapted to fill out documents in digital form [2] by the users. This project is aimed to design and verify the concept for working with such data and its comparison with other existing solutions. It also discusses the suitability of this design in field of mobile device usage and user comfort [3] when working with documents.

Competitive solutions. Currently, there are several solutions for working with documents containing forms for mobile devices. Motivation for finding a solution was to provide a functional and user-intuitive system that can fulfill even more challenging tasks and provide functionality that are users expecting.

PDFExpert is application that can interact with PDF forms on mobile devices. It is possible to work with documents while user sees the entire document, which can confuse user. Through gestures, he can move in the document and by selecting the boxes work with them. This solution, does not provide filter for essential form information.

Fill and Sign PDF Forms. Application is designed for the Android operating system and allows to fill in and sign [1] forms saved in PDF format by extracting individual fields. Downside of solution is, when it can not determine field description, it is presented blank.

---

* Bachelor study programme in field: Informatics
Supervisor: Assoc. Professor Michal Čerňanský, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

[1] finger signature only, no electronic signature and only while using a free plugin

IIT.SRC 2011, Bratislava, May 4, 2011, pp. 463–464.

System structure. System is divided to sever- and client-side applications. Server application takes care of decomposition of PDF forms and editing their descriptive structures. It can be done partially automatically, while user can edit wrongly parsed fields. Client presents native interface of corresponding document, filters important data and present fillable elements on mobile device. It also provides way to fill them in form and then way to send it or print.

Conclusion. The proposed system focuses on user experience when working with forms and presents them in a way in which users are accustomed to mobile platforms. It provides a simple user interface, through which user can work on documents anywhere. The solution of application with a central database of descriptive structures makes it easier to display elements without modification of the document itself. This system is a concept that is demonstrated on the iOS application and presents possibilities of mobile devices. The solution described in the project can be applied with minor changes to a wide range of solutions.

The proposed system offers significant improvements over other:

- usage of native preview of forms on mobile devices while maintaining the necessary information
- usage of backend system for processing and storing information about the documents on a publicly accessible place
- usage of a unified database to store information about documents
- usage of the web application to edit and modify incorrect or incomplete descriptive structures
- separation of description of the physical form from the document and link these documents through a relational database
- possibility of creation similar applications using a single backend for different platforms

In terms of implementation we were able to design, develop and test the application and its components. Prototype demonstrates the applicability of the solution and its suitability in a given area.

References

[1] Liu, X., Doermann, D.: Mobile Retriever: access to digital documents from their physical source. *International Journal on Document Analysis and Recognition*, 2008, vol. 11, no. 1, pp. 19–27.

[2] Rukzio, E., et. al.: Automatic form filling on mobile devices. *Pervasive and Mobile Computing*, 2008, vol. 4, no. 2, pp. 161–181.

[3] Shibuya, Y., Nagata, K., Murata, K.: An efficient document browsing method with floating diagram window on mobile device. *HCII'11 Proceedings of the 14th international conference on Human-computer interaction: towards mobile and intelligent interaction environments*, 2011, vol. 3, pp. 101–106.

Active Conceptual Modelling of Learning Content

Ondrej URBAN*

Slovak University of Technology
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
bc.ondrej.urban@gmail.com

Extended abstract

Nowadays during process of creation of learning content usually no modelling techniques are used because no proper method exists. Conceptual modelling has always been used in software development process. Existing approaches to conceptual modelling like entity-relationship, object-oriented and ontological modelling are mainly focused on static aspects of domain and cannot fully describe changing world .So a new approach called active conceptual modelling was proposed. One of its possible applications is modelling of learning content.

Active conceptual modelling is defined as "constant process describing all aspects of domain, its activities and changes from varying perspectives. It enables to put together static and dynamic concepts of domain into single model. It can model time, space and cause-consequence relations. Existing methods that partially supports active conceptual modelling are extended entity-relationship, temporal RDF and MADS data modelling. But none of them is sufficient enough to model real world. So we propose a new method based on UML

The model consists of two parts – static and dynamic – that are joined together. For modelling of static concepts is used simplified class diagram. Static concept (concept) can be any domain entity. On conceptual layer attributes are called knowledge and methods are called behaviour and both can be sentences. For modelling of dynamic concepts is used modified use case diagram. Dynamic concept (procedure) can by any process in domain. Special type of concept is participant. It can be anybody who executes the procedures in domain. Basic relations among these concepts are association, generalization, aggregation and dependency.

As example domain was chosen library. In Figure 1 you can see part of the diagram. This example model represents in a simple way whole domain of library service and can be further used in process of creation of learning content. To create this diagram we used our modelling tool called TinyUML2 which is extended version of open-source project. We added new functionality for active modelling as well as for generating of content later presented. This tool should help content authors in process of content creation. The result content is now simple so they would have to edit it for real usage. But we are planning to improve quality of generated content in later releases.

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Ján Lang, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

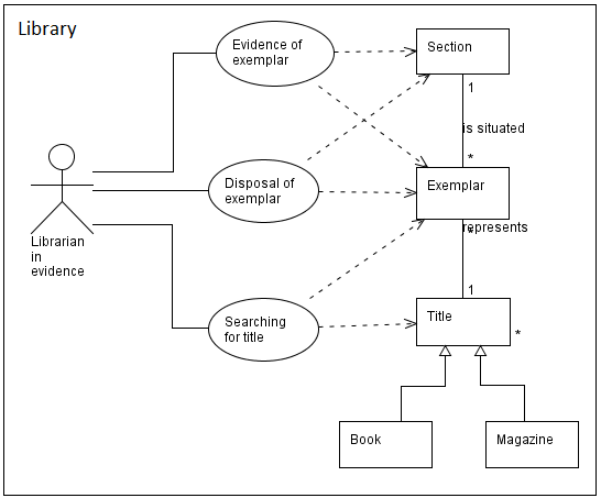

Figure 1. Active conceptual model of library.

After an active conceptual model of some domain was created using presented method it can be transformed into learning content in the following process that has three steps:

1. Add content assets (text, picture) to properties of elements of model.
2. Create learning objects for every element of model in format of single HTML page.
3. Generate so-called manifest file that contains metadata about content, description of learning objects and sequencing information of how to traverse through the objects.

Now this SCORM content package so it can be immediately imported to any LMS system. For purpose of verification of correctness of presented process sample content was created from the model in Figure 1. This simple course could be used in school for librarians to learn basic terms used in field of libraries and what processes there are in library.

In this paper a new approach for conceptual modelling was presented together with new method of active conceptual modelling. Process of creation of learning content from active conceptual model was presented too. The results are promising that it could be used for learning content modelling widely. However these methods need to be validated on real learning content and tested by people as users of LMS. It needs to be compared with existing content and evaluated. And this will be the main goal of future work.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0971/11.

References

[1] Chen, P. P.: Suggested research directions for new frontier – active conceptual modeling. In: International Conference on Conceptual Modeling - ER 2006, (2006), pp. 1–4.

[2] Liddle, S. W., Embley D. W. A common core for active conceptual modeling for learning from surprises. In: Active conceptual modeling of learning. Springer-Verlag Berlin, (2007), pp. 47–56.

[3] Polsani, P. R. Use and Abuse of Reusable Learning Objects. Journal of Digital Information. Learning Technology Center, University of Arizona, (2003), Vol. 3, No. 4, pp. 164–173.

[4] Thalheim, B.: Achievements and problems of conceptual modeling. In: Active conceptual modeling of learning: next generation learning-base system development, (2007), pp. 72–96.

Solution Quality in Context of Web Service Composition

Lukáš ZBOROŇ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
zboron.lukas@gmail.com

Extended abstract

Number of available services keeps growing and many services perform the same or very similar tasks. Although these services may perform the same function, there are other characteristics of service that must be taken into consideration if composition is to be used in real world application. Such characteristics are speed, availability, reliability, price and many others. To create usable composition, services with the best characteristics must be chosen.

There are many ways to create web service compositions. The simplest solution is to create composition manually, but that is often not possible. Another way is to use some semi-automatic or automatic algorithm that can create composition. One of the problems with these algorithms is the fact that many of them do not take qualitative properties of composition into consideration and even if they do, they do not offer enough possibilities and they are not flexible enough to satisfy needs of real world applications.

If several tasks in composition can be performed by multiple services, total number of possible combinations can quickly raise so high, that manual selection is ineffective. In fact, even when using automatic algorithm, number of possible combinations is serious problem, because computational time required to test all possibilities is often too high. For example, if we have composition consisting of ten tasks and each task can be performed by ten different services, there are 10^{10} possible combinations.

In order to create algorithm that could perform such selection, user requirements and service properties have to be described in formal language. This algorithm also needs to be efficient enough to find composition with satisfactory quality in reasonable time. To find such solution, there are four problems that must be addressed:

- Describe properties of service
- Describe user requirements
- Describe composition
- Find composition

---

* Master degree study programme in field: Software Engineering
Supervisor: Michal Kasan, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 467–468.

If user wants to create web service composition that meets certain qualitative properties, it is crucial to be able to choose web services with appropriate properties. The first obvious problem is to get information about quality of available services.

Services are usually described using WSDL files. WSDL describes service contains all information that is required to use it, but it does not contain description of properties like speed, cost, availability etc. In order to overcome this limitation, there is extension of WSDL called WSDL-S, which allows extending description of service defined by WSDL with additional properties, which can also include qualitative properties of service.

Another problem that needs to be addressed is decision which properties should be considered when creating composition. It is possible to define dozens of properties and there is not one widely adopted standard which would define and list all properties that service can have.

Most papers concerning quality of web services define a small set of properties they consider and ignore any other. In this paper I have chosen several of the most important properties (price, response time, maximum number of simultaneous services, success rate, availability, reputation, encryption, signing).

These properties should cover needs of most users, but because of this variability of user demands, it is not a very good idea to implement solution that restricts user to use only these specific properties without possibility to add new. When we look at considered properties closely, we can notice that they have a lot in common and we can describe them by defining several Meta properties. Proposed solution reads configuration file containing the list of properties before reading service definitions or user requirements. Adding new property is a simple matter of changing configuration file.

Choosing the best composition is time consuming problem, because number of all possible combinations can be quite large. Large number of combinations makes it impossible to evaluate all of them. We need to choose the best solution from large set of possible solutions. This is a common problem in information technologies and it has many solutions. In this paper I chose to use evolution algorithms.

Basic idea behind evolution algorithms is to start with some solution or solutions and improve them step by step until they reach desired result. In terms of web service composition it means to create one composition and then start replacing services with poor quality with high quality web services.

When starting evolution algorithm, it is useful to have good starting point. Good starting point can lead to fewer iterations of algorithm and therefore faster return of result. In this paper the first composition is created using the best service available service for every task and then continues with replacing these services with others.

Creating high quality web service compositions is necessary for wider adoption of web service compositions. Current approaches allow user to choose the best available services, but they are very limited when we consider their flexibility and their performance is also often insufficient.

Proposed solution allows user to define several kinds of custom service properties, allows him to define scope of his requirements and use multiple composition plans. It uses evolution algorithms to fight performance issues when searching for solution among large amounts of possible combinations.

References

[1] Baligand, F., Rivierre, N., Ledoux, T.: A Declarative Approach for QoS-Aware Web Service Compositions. ICSOC '07, Volume 4749/2007, (2007), pp. 422–428.

[2] Ko, J., Kim, C., Kwon, I.: Quality-of-service oriented web service composition algorithm and planning architecture. Journal of Systems and Software, Volume 81, Issue 11, (2008).

[3] Motahari-Nezhad, H. R., Li, J., Stephenson, B., Graupner, S., Singhal, S.: Solution Reuse for Service Composition and Integration. Congress on Services – I, (2009), pp. 400–407.

Accompanying Events

RoboCup Presentation at IIT.SRC 2012

Pavol NÁVRAT, Ivan KAPUSTÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{navrat,kapustik}@fiit.stuba.sk

Abstract. RoboCup is an attractive project theme with a free participation, designed to support education and research in artificial intelligence, robotics and information technologies. During the last few years, our students achieved some interesting results, which were presented during our student research conference.

1 Motivation

RoboCup is an international joint project to promote research in artificial intelligence, robotics and information technologies. It is an attempt to advance artificial intelligence and intelligent robotics study and research by providing a popular problem where wide range of technologies can be integrated and examined. RoboCup chose to use soccer game as a central topic of research. The ultimate goal of the RoboCup project is to develop by 2050 a team of fully autonomous humanoid robots that can win against the current human world champion team in soccer.

In order for a robot team to actually perform a soccer game, various technologies must be incorporated, including design principles of autonomous agents, multi-agent collaboration, strategy acquisition, real-time reasoning, multi-level decision making, robotics and sensor-fusion. RoboCup is a task for a team of multiple fast-moving and skilled robots within a dynamic environment. It offers also a software platform for research on the software aspects. RoboCup is divided into four main fields: RoboCup Soccer – defined by the original domain of soccer, RoboCup Rescue – intended to do search and rescue in large scale disaster area, RoboCup Junior – aimed to child education and motivation and RoboCup@Home – oriented to provide various help not only at home.

From our point of view, the main goal of RoboCup is to promote research in areas of artificial intelligence and information technologies, especially in the area of multi-agent systems. This is a benefit for the students, making their studies more interesting and attractive. Students can meet with robotic soccer in courses like Artificial Intelligence, Team Project and others. Students are facing an interesting problem, which demands invention as well as use of modern artificial intelligence approaches. Teams of students have the possibility to directly compare their results in tournaments. This encourages the students to even higher effort and motivates them for better results. More fundamentally, achieving progress requires tackling serious open research problems in artificial intelligence, such as planning of cooperation of multiple agents etc. That is why this area is of interest also for our doctorate students.

* Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 471–472.

We have been organizing this tournament regularly for several years. Starting as a local event in 2000, it has grown to a regional contest under the official RoboCup authorization. Our Faculty organizes tournaments in the simulated category only, but we gradually include other categories. Our current contest event has three parts.

First part is a tournament of two-dimensional (2D) simulated player teams, where students try to make their own players win soccer game. 2D players are simple entities, ready to follow any possible action in their virtual environment. Students' main research is aimed to team tactics and autonomous player decision. It covers team formations and planning, player communication, and use of a team coach. Recent projects are oriented on decision skill improvement. Methods here cover planning and player's action selection based on diverse sources – success evaluation of similar situation, teammate decision model and prediction of opponent behaviour.

Second and third parts of this tournament involve three-dimensional (3D) robotic simulation. These robots are true copies of their real master. They have limbs and joints. Primary students' task was to teach robots reliably walk, turn, stand up and kick the ball. It was followed by design of a proper composition of these basic skills to achieve simple goals, like walking to the best game position or getting the ball. Then, the training support framework has been developed and test modules for robot learning were created. Currently, students train robots to recognize situation and choose the best action to reach the main goal – win the soccer game.

Any soccer player must be good with physical skills and must make good and fast decisions during the game. So the second part of our tournament contains skills match. Robots compete in speed and accuracy of given tasks. They can get a few points for "unusual" useful skills as well. Finally, third and most valued part of this tournament holds soccer contest, where both skills and decision making are verified.

2 Results presentation

For this student conference we decided to hold an exhibition of results achieved in 3D soccer simulation. Two student groups work on new skills and decision making for 3D soccer robotic players. Every group presented details about their own ideas and methods. These methods involve adaptive annotation design, new movement and skill design, optimal robot trajectory building, structured skill handling, simple opponent movement prediction, autonomous robot training and others. Students also presented useful graphical user interface for convenient robot training, which they designed and implemented this year.

Presentations were enhanced by show of robot skills performance. Our students improved all old movement sequences and added few combined movements. All movements are at least twenty percent faster than last year movements. New skills included mainly adaptive walking with combination of turning and work with ball. Faster player actions were also more attractive for audience.

The extension of the soccer game simulation to the third dimension shows the continuous progress in RoboCup and in our students' skills, too. Decision making of these robots is very complex and brings new challenge to everyone concerned. We hope that exhibition of robotic simulation will attract many present and future students and give them motivation for their study and research work.

More information about our annual tournament can be found on the web page `http://www.fiit.stuba.sk/robocup/`.

Programming Contest at IIT.SRC 2012

Peter TREBATICKÝ[*], Mária BIELIKOVÁ[†]

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{trebaticky,bielik}@fiit.stuba.sk

Abstract. Programming contests has a long tradition at the Slovak university of Technology in Bratislava. As the student research conference offers an open day without any lectures for all our students, we are looking for ways how to attract them. Now, fifth year we have prepared an accompanying event – the programming contest for all our students.

1 Background of the Contest

Programming contests have a long tradition at our university and the faculty. From the beginning in 1998 local contests were organized for our students in order to form teams to represent the Slovak University of Technology in Bratislava at the ACM International Collegiate Programming Contest (ICPC) for Central Europe region. Since 2002 our faculty participates in organization of Czech Technical University Open, which is joint event where universities of Czech and Slovak Republic compete with the aim to select their respective representatives for ACM ICPC Central Europe region.

We prepare our students for this type of programming contest already before they enter the university. We organize for our future students the ProFIIT contest since 2004. It consists of two rounds. In the correspondence round the contestants compete in solving several (around 10) programming problems. They are allowed to compete either on their own or in pairs. The best teams advance into onsite round organized at our faculty. They compete on their own in this round as they can gain bonus points into the admission process. This year is the first time we moved the final round of ProFIIT to coincide with the IIT.SRC in order to show our potential future students exciting research opportunities awaiting them at our faculty. The main reason for this move was that many high school students have only hazy idea what are the projects they will be able to work on during their university study.

Students at our faculty can choose an elective course *Construction of Effective Algorithms* which further develops the algorithmic thinking in them and teaches them the more advanced techniques specifically usable in programming contests. We prepare four 3 hour contests during this one semester course. Participants gain bonus points in them, but these contests are not limited to course participants, everyone can compete for fun. Moreover, our bachelor students selected for the research track have more possibilities in algorithms training, mainly in seminar on advanced algorithms.

[*] Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava
[†] Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 473–474.

2 Structure of Programming Contest at IIT.SRC

The structure of the programming contest at IIT.SRC closely copies the structure of ACM ICPC. Contestants compete on their own onsite in our computer labs. They have two hours to solve four problems. Problems contain a basic description of what should be solved, exactly specify the format of textual input to the program as well as the format of output and the end of problem statement is the sample input and corresponding sample output.

The task of contestants is to create a program in either C/C++ or Pascal that transforms test input, which has described format but is unknown to contestant, into correct output according to problem statement and in correct format. They submit the source code through our system for programming contests, which compiles the code, runs it against test input, evaluates the given output and informs the contestant of the result. Result is only in the form of simple statement, e.g. "Accepted", "Wrong answer" or "Presentation error" which means the output is not formatted correctly but otherwise appears to have given the correct answer.

The order of contestants is primarily determined by the number of solved problems and in the case of tie, by the sum of the times taken to solve each problem since the beginning of the contest. There is also a 10 minutes penalty for each submitted incorrect solution, but only for the eventually solved problems. This type of order determination favors of course primarily those who solve more problems, but secondarily those who first solve easier problems and also those with lower number of incorrect submissions. The ability to decide fast which problem is the easiest one and to create solution without bugs is also very important apart from the ability to come up with working idea. These skills are mainly trained by practice and learning that is where we help the students through activities mentioned here.

The contest is made more attractive for participants by the fact that during last 45 minutes the preliminary results are not updated. This way, one cannot be sure about her final standing until the awards ceremony. The time interval of not displaying preliminary results was chosen in accordance with conference schedule, because there is another contest ending right before the second poster presentations in which the other conference attendants can tip the winner.

More information about our programming contests can be found on the Web:

- ACM programming contest – `http://www.fiit.stuba.sk/acm/`
- ProFIIT programming contest – `http://profiit.fiit.stuba.sk/`

TP Cup – The Best Team Competition Showcase at IIT.SRC 2012

Mária BIELIKOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
bielik@fiit.stuba.sk

Abstract. Best team competition TP-CUP is organized fourth time this year. The competition is aimed at excellence in development information technologies solution within two semester long team project module in master degree programmes. This year 12 students' teams presented in form of showcase their projects at the IIT.SRC 2012. Key concepts of their projects are included in following sections of the proceedings.

1 Background of the Competition

Team projects play an important role in the education of engineers. Team projects have a long tradition in informatics and information technologies study programmes at our university. Module firstly named *Team project* was introduced in the academic year 1997/1998 in software engineering and in subsequent years it was adopted as compulsory module for all master degree students. Its intake is each year 25-30 teams of 5-7 students in all study programmes. The main objective is to give students a hands-on experience with different aspects of working in team on a relative large task.

In designing a team project as a part of a curriculum, we considered several aspects or different alternatives to particular issues such as team formation, team communication methods, team assessment, problem assignment, development process and team supervision. Our experience with such projects is that a satisfiable solution (in terms of the team project objectives, i.e. experience with different aspects of working in team on a large problem) requires time longer than one term, so we designed our team project as two semester module. Supervisors who are available (either academic staff or an industry partner) determine problems being solved. Teams consist of 5-7 students. They are created under our active control. Our criteria aim at balancing differing specific knowledge of team members and different experience in various team roles. We also respect the students' preferences to some extent (a student can specify one student to become a member of the same team).

We let teams bid for problems proposed by supervisors. A competition between teams is established and students have opportunity to exercise writing and presenting the bid. The students bid with their knowledge, skills and achievements related to the selected problem, and with

* Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 475–476.

a preliminary sketch of solution based on the open question-answer session with a customer (mostly a supervisor).

Although the quality of the final result is an important measure of a success of a team, we markedly concentrate on the process applied. We adopted the development process with at least two iterations. Several teams use agile development methods each year (e.g. this year we have teams working according the Scrum methodology).

The amount of freedom and supervision should be balanced in order to create a true learning experience for students. To simulate the reality, students should have a considerable amount of freedom. On the other hand, since students usually have no or just little project experience, some amount of supervision, monitoring and guidance is needed to ensure sufficient progress and a successful result. In order to reach balance between freedom of students and supervision we specify in advance certain requirements on the content of documentation to be produced. Students have to prepare and follow a detailed project plan. We prescribe certain parts of the project plan, such as list of activities, milestones, dependencies, and responsibilities according to established team process. Students are free to define the activities that are necessary to successful accomplishing of the project. We accompany the Team project by lectures on project management, teamwork, and quality assurance.

2 Stages of the Best Team Competition

In order to emphasize excellence of the students' teams we established the Best Team Competition called TP Cup in academic year 2008/2009. The competition is aimed at excellence in development information technologies solution within our two semester long team project module in master degree programmes.

The competition has several stages. It starts with an application in the middle of the first semester. First stage finishes by the end of first semester when the teams submit interim report. We filter out teams which do not fulfil basic criteria on quality of work performed. Second stage culminates in the middle of second semester when students submit key concepts in form of two page report into IIT.SRC proceedings and present their projects in the TP Cup showcase organized as a part of the IIT.SRC conference. This year 12 students' teams presented in form of showcase their projects at the IIT.SRC 2012. Third stage presents finalizing the projects. It ends by our grand finals where board of judges consisting experts from academy and industry selects the winner team which lands the challenge cup – "best student team of the year".

More information about TP Cup can be found on the Web:
`http://www.fiit.stuba.sk/tp-cup/`

Motivating People to Increase Physical Activity

Pavol BIELIK, Peter KRÁTKY, Štefan MITRÍK
Michal TOMLEIN*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
move2play@gmail.com

Over the last few decades, there has been a considerable decrease in the amount of daily physical activity among people of all ages. This concerns both developed and developing countries and the consequences are severe. Diabetes, obesity, heart related diseases and many others are all too often the result of improper lifestyle. The lack of physical activity affects not only our physical but also mental health. We live busy lives in stressful environments. Physical activity is an effective way to reduce the effects of accumulated stress and tension. The positive benefits of a better lifestyle can significantly improve the quality of life for people of all age groups.

Our solution aims to help people increase their level of physical activity and to provide them with both short-term and long-term motivation. Motivation is a key factor in keeping people engaged in this process. We have introduced several motivational factors which take advantage of one's natural competitiveness and social connections between users and their real-world friends, colleagues or family members. We have identified the cycle of daily physical activity which consists of activity tracking, evaluation and recommendation, all powered by motivation. Activity tracking is performed by the mobile application. The main advantage of this approach is that users do not have to wear any additional bulky sensor device as they are already used to carrying a smartphone throughout the day.

The biggest challenge was to ensure that activity tracking can be left turned on throughout the day and that it does not drain the battery too quickly. We use the GPS receiver in order to track one's physical activity. There are many applications which use the GPS for activity tracking but they require the user to start or stop tracking manually because of GPS battery consumption. This is not only inconvenient but also easily forgotten [1]. We have put a lot of effort into designing and developing algorithms which detect the user's movement, based on which we are able to turn tracking on and off automatically. Furthermore, our application uses advanced algorithms and techniques in order to filter out tracking imperfections and activities such as driving or riding a bus. For instance, we use Kalman filtering to smooth out inaccurate GPS data, which is a common problem of many GPS receivers found in lower quality phones.

We visualise the measured data in the mobile phone application in a user-friendly manner, so that users can see their progress, plan fulfilment and an overall evaluation of their physical activity. Having an overview of one's physical activity is an important step towards improvement [2]. Moreover, users can easily track their friends' progress and compare one other. The mobile application also offers challenges and other motivational factors which allow users to compete and have fun.

---

* Master study programme in field: Software Engineering
Supervisor: Dr. Michal Barla, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 477–478.

Recommendation of physical activity is tailored to the users' condition, age and other factors, so that they can progressively improve. It also guarantees that users in a poorer condition do not feel discriminated against but rather motivated instead.

Move2Play is based on a client-server architecture. At the present time, we have an Android client application (Fig. 1), but we see opportunity in expanding to other platforms in future. Off-line usability is an important feature of our client application. We invested a lot of effort in making sure that the application is usable without the need for continuous Internet connectivity. The architecture reflects this design decision in its reliance on synchronisation and preference of local data persistence as opposed to repeated requests to the server in order to fetch the most up-to-date data.

On the server, we use state-of-the-art technology such as Ruby on Rails as the application framework and PostgreSQL as the database back-end. We have created RESTful services to accommodate the need for a platform-independent synchronisation back-end, which would scale effortlessly to support client applications for other mobile phone operating systems.

(a) Home screen (b) Charts (c) Past activity statistics (d) Speed & altitude

Figure 1: Move2Play Android application screenshots.

The Move2Play project is an ongoing effort to bring a new and innovative approach to the world of activity tracking and evaluation. While there are numerous other applications capable of tracking your activity, they fall short in their reliance on manual control of tracking and generally target already physically active people. Our goal is to achieve wide use of our service by people who would otherwise not be motivated to track their activity. We believe this can be achieved by removing the need to manually turn tracking on and off and providing an engaging user experience with a graphical evaluation of tracked activity and motivation through challenges and social interaction.

From a technical point of view, our Move2Play application innovates in the field of efficient use of energy while tracking activity. Based on the available Wi-Fi networks, we are able to detect whether the user is moving and turn the more energy-consuming sensors on or off accordingly. To account for inaccuracy in the measured GPS coordinates, we employ Kalman filtering to obtain a smoother and more accurate track of the user's movements. Moreover, we have developed sophisticated algorithms to account for losses of GPS signal and filtering out activities such as driving or riding a bus.

References

[1] Consolvo, S., Everitt, K., Smith, I., Landay, J.A.: Design requirements for technologies that encourage physical activity. In: *Proceedings of the SIGCHI conference on Human Factors in computing systems*. CHI '06, New York, NY, USA, ACM, 2006, pp. 457–466.

[2] Kang, M., Marshall, S., Barreira, T., Lee, J.: Effect of pedometer-based physical activity interventions: a meta-analysis. *Res Q Exerc Sport*, 2009, vol. 80, no. 3, pp. 648–655.

Motivating People to Healthy Lifestyle via Mobile Game

Roman BURGER*, Martin DŽÚR†, Peter MELIŠKO*, Balázs NAGY*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
icgd2012fiit@goglegroups.com

The rushed lifestyle, stress and daily problems make almost impossible for people to pay attention to the healthy diet. Still, there are also a considerable number of simple improvements and tips which can improve one's life. One way how to inform and teach people about such beneficial habits is through video games [1]. We would like to point out these helpful tips and provide them for people using our mobile arcade-platform game called *The Health Squad*.

During the creation of the game one must pay attention to two basic issues. The first issue is to create a really entertaining and catchy game [2, 3]. If the game is not fun enough, it can immediately discourage potential players. If the game is not catchy, what might happen is that players will not play long enough to get to the real results of learning about healthy tips. The other issue is how to integrate these tips into the game. It is very important to not force learning, otherwise players may abandon playing. Also, tips should not be too abstract, because players may not realize them.

The Health Squad is a platform/arcade game with logic elements set into the human body environment. It contains various human tissues represented by different tile sets, items such as vitamins or oxygen, enemies represented by bacteria and finally our main characters the Health Squad (see Figure 1).

The main characters represent the useful elements of human body: the Red Cell, the White Cell and the Platelet. They are a task force in hands of the player with objectives of defending the body against foreign microorganisms, sustaining and repairing the body system.

The goal of this game is to set focus of the player onto healthy lifestyle with a secondary benefit of gaining basic knowledge about processes in human body. The game promotes the healthy diet and the necessity to avoid bad habits: through mission (level) briefings it introduces an everyday condition and reflects it accordingly throughout the gameplay. The main characters eventually overcome these issues, sometimes using various substances entering the body through good habits.

An unconventional feature of our game is the "dynamical ergonomics" involved in puzzle solving. The player can control the characters through various interface features (dragging, panning, pressing buttons, hitting a free space). However, some character basic actions (moving, jumping) can be done in multiple ways and for certain puzzles, some "virtually correct" and logical solutions are physically impossible for the player to execute (e.g. player can't see what's

---

* Master degree study programme in field: Software Engineering

† Master degree study programme in field: Computer and Communication Systems and Networks
Supervisor: Jakub Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 479–480.

under his finger, player is not fast enough to move his fingers) so he have to think out a different configuration for his fingers than he usually uses, to solve the puzzle.

Level solving is not linear and player may implement different tactics to reach the same objective. The key always lies in combining different skills that each character possesses.

Each level has its own short story which defines environment, key elements and objective which should be achieved by a player. Player sees every mission from side view. By phone rotating he can change perspective from wide to narrow screen and vice versa (e.g. to scout the level). Each character is influenced by gravity and has applied physics.

Figure 1. Screenshot from the game The Health Squad.

We described our concept for motivate and educate people to healthy lifestyle using a mobile game. This concept is not only useful for young people and children, but for everyone who likes to play games in his free time.

Over time we would like to develop a newer version of the level editor available for players too. Then they will be able to create their own levels and through them share their experience among others.

References

[1] Papastergiou, M.: Exploring the potential of computer and video games for health and physical education: A literature review. *Computers & Education*, *53*(3), (2009), pp. 603–622.

[2] Hunicke, R., & LeBlanc, M.: MDA: A formal approach to game design and game research. *AAAI Workshop on Challenges in Game*. (2004).

[3] Crawford, C.: The Art of Computer Game Design, (2000).

Plagiarism Detection on the Web

Jozef LAČNÝ, Maroš MARŠALEK, Pavel MICHALKO, Ján SÚKENÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
timak2011-03@googlegroups.com

Nowadays, access to all kinds of information is greatly simplified. The Web contains enormous amount of documents available for free. One negative consequence of this is the increase of plagiarism, mainly in the fields of research and education. Authors incline to plagiarism for various reasons and the Internet makes it extremely easy. While it is a good practice to use the information from as many sources as possible, it is important to remember that quoted parts must be clearly identified, so that author's own effort can be determined correctly.

In the field of plagiarism detection, there has been done a lot of research and many tools have been created. Some of them analyze set of documents locally [1, 2], others are able to detect plagiarism in the documents available online. Latest research in the field is devoted to the second group [3, 4] and we have focused our efforts on this area as well.

Currently there are multiple tools which detect plagiarism among the documents on the Web. We divided them into 3 groups, based on how they work. First group are tools that use existing search engines and no significant pre-processing or post-processing, then there are tools that use some algorithms or heuristics to narrow down the number of results from search engines and tools in the last group use custom index of the Web and perform search only within this index. While majority of these tools worked correctly during our tests (some had better results than the others), we have found room for improvements. First of all, they are designed to work with English texts and therefore their accuracy for Slovak texts is not satisfactory. Moreover, the presentation of the results to the user was often very unintuitive and limited. We would like to overcome these drawbacks by developing our own tool for web-based plagiarism detection that would utilize reliable search engines like Google and Bing. Main advantage of this approach is that it does not require building a custom index of the Web which would be time and resource consuming.

The workflow we designed for our application is presented in Figure 1. Right after user submits a document, we divide it into many parts with varying sizes (from one sentence up to a small paragraph) since only small parts of documents are usually copied from one source. Each part is then analyzed so that we can build a relevant query for search engines. Then we let search engines do the heavy lifting for us. After they are done, we compare search results with the submitted document using standard plagiarism detection algorithms. Finally, we present results in a convenient way that enables users to easily evaluate them.

---

* Master degree study programme in field: Software Engineering
Supervisor: Assoc. Professor Daniela Chudá, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 481–482.

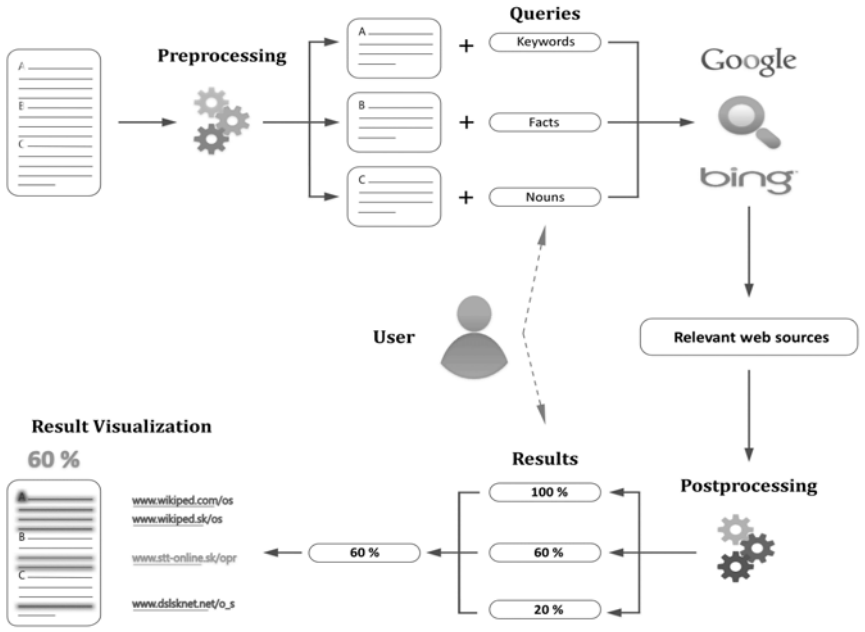

Figure 1. Visualization of our plagiarism detection process.

The limitations of our approach are obvious – it is only possible to find documents that are already indexed by the search engines, we have no control over the search process and we can analyze only limited number of search results.

So far, we have focused on the deep analysis of the problems that we have encountered. They included plagiarism detection, web search, text pre-processing, analysis, etc. We have also been building a prototype of our application. That allowed us to verify our conclusions and quickly respond to any problems. Our prototype is able to analyse input documents, search the Web and calculate similarity between documents in the search results and the document that is being analysed. In near future we are planning to do further testing and to improve algorithms for building search queries. We also have to enhance calculation of plagiarism level for the whole document and we would like to do some performance improvements. Last but not least, we would like to create more sophisticated visualization tools.

Our primary goal is to build an application which will provide automated plagiarism detection among the documents on the Web. We hope that it will improve overall levels of education and research by forcing authors to do individual and much more creative work.

References

[1] Freml, M., Chalupa, D., et al.: *CopyPaste*. [Online; accessed March 16, 2012]. Available at: http://labss2.fiit.stuba.sk/TeamProject/2009/team09is-si/

[2] Chudá, D., Kučečka, T.: PlaDeS – Effective Way to Plagiarism detection of Student Assignments Written in Natural Language. In: *Proceedings of the Int. Conf. on e-Learning and the Knowledge Society*, (2011), Bucharest, Romania, pp. 47–52.

[3] Yi-Ting, L., et al.: Extending Web Search for Online Plagiarism Detection. In: *IEEE International Conference on Information Reuse and Integration*, (2007), pp. 164–169.

[4] Maurer, H., Kappe, F., Zaka, B.: Plagiarism – A Survey. *Journal of Universal Computer Science*, (2006), Vol. 12, No. 8, pp. 1050–1084.

Statistical Full Text Machine Translation

Róbert HORVÁTH*, Peter JURČÍK+, Peter MACKO*, Vladimír RUMAN*,
Peter SLÁDEČEK*, Maroš UBREŽI*, Matúš VACULA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
adictit@googlegroups.com

There are more than 6900 different languages in the world which creates a significant language barrier and enhances the demand for a universal machine translator. Even though the history of machine translation backdates to the period of time after the world war two it still has not got fully satisfying results [1].

Today the most famous machine translator is Google Translate. In the experiment we performed on the set of random sentences Google translate obtained 74% success rate in translation. This was the best result in comparison to the Bing, WordLingo and PcTranslator. The main disadvantage is that Google API is no longer free and therefore cannot be used freely to translate large amount of text.

We have developed a method of statistical machine translation which is language independent. The most significant difference from the other statistical approaches is that we use only one sided corpus of text for the translation from one language to another. This is a huge advantage in comparison to methods used in systems like Moses which needs parallel corpus which are very difficult to find [2]. Our method preserves the advantage of statistical methods that the translated sentence is with a high probability a valid sentence of the language because it is extracted from the corpus.

Our method of text translation consists of the four main steps (see Figure 1):

1. translation of each single word,
2. generating possible candidates for translated sentence,
3. corpus lookup,
4. statistically best translation selection.

To successfully provide user with translation, our method uses simple dictionary in first step to translate each single word except for name entities or numeric expressions. Those text entities are ignored to maximize success rate of corpus lookup process because they can be replaced without text changing its meaning. In the next step all word translations are used to generate translation candidates which are searched in the corpus of target language. Speed of this process is crucial therefore the method picks up sentences for corpus lookup by their probability to become a correct translation. For this purpose the word term frequency is used as an indicator so that the sentences

---

+ Master degree study programme in field: Information Systems
* Master degree study programme in field: Software Engineering
Supervisor: Dušan Zeleník, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 483–484.

with a higher value of combined probability have higher priority. In case that exact translation is not found, statistically best match is offered.

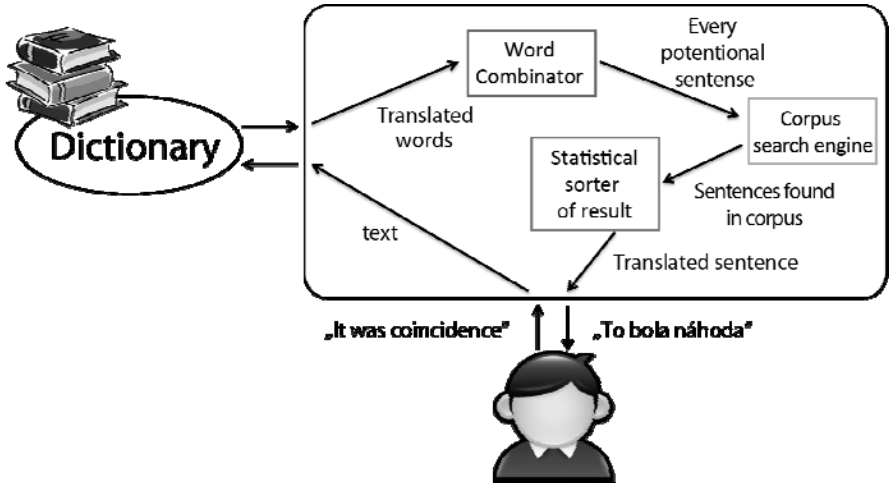

Figure 1. Process of text translation.

The most significant advantage is of our approach already mentioned language independence. The method can be extended to translate even programming or machine languages.

Disadvantage of proposed method is the time complexity which rises exponentially with the rising number of words in sentence. We are compensating this negative aspect using heuristics and distributed computation on Hadoop framework. Although the complexity of translating sentence grows exponentially with the number of words it cannot grow infinitely because every sentence has a finite word count. We are able to assess the time needed to translate the sentence with mean number of words and assume this to be constant. The complexity of text translation then grows linear depending on sentence count.

To create a solution that can reach the level of existing translators our method needs to be able to translate sentences with high success rate. We propose experiment in which we compare success rate of the most used online translators to our solution using set of pre-chosen sentences. To perform this experiment we need to enlarge our corpus.

We presented existing approaches to text translation and found that existing methods are able to translate text at maximum of 75% accuracy. We propose our statistical method which needs only one sided corpus and simple dictionary to translate from one language to another. It connects word translation, sentence generation and translation evaluation using statistical methods.

References

[1] Adam Lopez. Statistical machine translation. In ACM Computing Surveys, 40(3): pp. 1–49, ACM New York, (2008).

[2] Philipp Koehn, Hieu Hoang, et al. Moses: open source toolkit for statistical machine translation. In Proceedings of the 45th Annual Meeting of the ACL on Interactive Poster and Demonstration Sessions (ACL '07). Association for Computational Linguistics, Stroudsburg, PA, USA, pp. 177–180, (2007).

Crowd Simulation

Michal FORNÁDEĽ*, Marek HLAVÁČ♦, Martin KOŠICKÝ♦, Lukáš PAVLECH*,
Daniel PETRÁŠ♦, Adam POMOTHY*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
tim08@googlegroups.com

Our goal is to develop a tool that is able to simulate large amount of autonomous individuals. We focus on realistic behaviour of simulated crowd during evacuate situations. Presently, our tool executes simulations in interiors. In future, it might be also used to simulate outdoor crowd situations such as demonstrations. Tool combines and uses several proved approaches. In compare to other tools, it can execute and visualize simulation in real-time. Real-time computing and rendering is possible because of special application architecture, which is designed to exploit capabilities of distributed computing. Concluding visualization is converted to 3D to deliver the most realistic view of evacuate situations.

Human behaviour is fascinating social phenomenon. There are situations, where people act like one organism with strong internal structure and high power. However, there are also situations, where every individual in crowd acts selfish and regardless to other human beings (for example evacuations during fire). Such situations are quite common and result in many injuries or even deaths.

Behaviour of individuals in crowd is always affected by crowd itself – by means of psychological, physiologic or social factors. Research and observations in this area show, that individual behaves completely different in situation where he is among large amount of people from situations when he is alone [3].

Macroscopic techniques for simulation see crowd as one entity. These types of simulation ignore many aspects of human behaviour, which results in not so realistic simulation. On the other hand, such techniques are very effective.

One of the most popular macroscopic models is so called *flow field* [2]. It is based on properties of fluids. Crowd acts as fluid, which flows through environment. As it ignores some aspects of human behaviour it is used especially in simulations of very large crowds.

Microscopic approach for crowd simulation tries to deliberate as many characteristics of human behaviour as possible to deliver the most realistic simulation possible. Movement of individuals is calculated in regard of other individuals and objects using special algorithms. This technique is used for simulating crowd in interiors, where there are many obstacles, which affect the movement of individuals.

---

* Master study programme in field: Information Systems

♦ Master study programme in field: Software Engineering
Supervisor: Dr. Peter Lacko, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

In this type of simulations, every human is defined as intelligent autonomous being – agent. Every agents keep information about the environment. He chooses next movement regarding to this information and certain decision rules.

In our solution, we try to find compromise between realism of simulation and visualization by combining a few different approaches. Every agent is aware of other agents and objects in environment and tries to avoid direct contact with them, which is typical for microscopic types of simulation. To achieve such behaviour, we use steering vectors approach [1]. Every step, agent compute the direction, he would like to move. Afterwards, environment computes, if there is an agent or any obstacle in the way of computed vector. If so, the movement vector is diverted as much as necessary to avoid collision. Behaviour and also speed of agents are also influenced by the level of fear of each agent. Moreover, fear spreads from agent to agent.

However, we also implemented some aspects of macroscopic behaviour – the concluding movement of every agent is also affected by the surrounding agents, as they were one entity (like fluid). This approach is called *flow field*, or *continuum crowds*. To reduce computing complexity, we use only few aspects of this approach. We take a certain area around the agent, compute the vector which is resultant movement vector of all agents in this area at given moment. After steering vector of movement is computed, we let this area movement vector to affect resultant steering vector of agent. This simulates fact, that human in evacuate situations usually follow the rest of the crowd.

Agent's decisions are controlled by state machine. State machine contains all necessary states such as agent in calm, search path, evacuation and final state (which is exit from the building). Machine also contains transition rules for states. At the beginning, all agents are calm, but as soon as they see fire, or they are passed information about fire from other agents, their state changes and they try to evacuate from building. Evacuation state is also triggered by alarm, which starts after user-defined period of time.

Our solutions also focuses on visualization and user experience. Therefore, our simulation is calculated and visualized in real-time. Moreover, concluding visualization is transformed in 3D – which enables the great views of evacuation situations.

Such solution needs a lot of computing power. Having this fact in mind from very beginning, we designed the application architecture, so that it can be used on more than one computer simultaneously. Usage of distributed computing makes development much more difficult, but it also gives us brand new possibilities in crowd simulation. So far, we manage to simulate up to 1500 agents on one map at same time in 3D – without any sign of computing problems. As we focus on interior simulations, we are limited only by the area of maps.

The main contribution of our tool is combination of existing and proved approaches, which makes our solution very realistic in terms of human behaviour.

References

[1] Shawn Singh, Mubbasir Kapadia, Glenn Reinman, and Petros Faloutsos. 2011. Footstep navigation for dynamic crowds. In Symposium on Interactive 3D Graphics and Games (I3D '11). ACM, New York, NY, USA, 203–203.

[2] Treuille, Adrien and Cooper, Seth and Popovic, Zoran. Continuum crowds. ACM Trans. Graph. 25, (2006), Vol. 3, 25, pp. 1160–1168.

[3] Zhou, Suiping and Chen, Dan and Cai, Wentong and Luo, Linbo and Low, Malcolm Yoke Hean and Tian, Feng and Tay, Victor Su-Han and Ong, Darren Wee Sze and Hamilton, Benjamin D. Crowd modeling and simulation technologies. ACM Trans. Model. Comput. Simul. 4, (2010), Vol. 4, 20, pp. 1–35.

Mobile Navigation in Indoor Spaces Using QR Codes

Igor AUFRICHT*, Samo FORUS†, Jozef KUJAN†,
Dušan POIZL†, Matej ŠKODA*, Juraj TÓTH†, Juraj VOLENTIER†

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
tim9@wx.sk

Today, intelligent smartphones are used by many people. They have become versatile assistants. Integrated GPS is very common for them. It is useable only outdoors, therefore we must depend on other forms of navigation indoors. The last year project, created by the team SW7D, contains high quality web application for navigation and presentation of the new FIIT building in three dimensional space (the current version of Virtual FIIT project can be found online [1]). We searched for another ways to resolve the navigation in buildings effectively using mobile devices.

Inspired by projects realized at the Technical University in Graz [2] or the project of University de Vigo [3], we decided to use QR codes located at strategic points of the building. These codes will include information about their physical location in the building. This navigation is very simple, user friendly and consists of the following four steps: The user scans the nearest QR code with the camera of his mobile device. Application reads the current position from the code and asks the user to specify the endpoint of navigation (classroom number or name of an employee). Then the application displays a map with the shortest route from the actual to the final destination.

The special characteristic about our project is that it represents two different solutions joined in one application. The first part is the mobile navigation mentioned above. The second part is the information system that provides all relevant information not only for visitors but also for students and university staff. These data will be obtained directly from the academic information system (AIS). This includes information about schedules, names of employees along with their workplaces. Other information includes departures of buses as well as the current canteen menu. It is possible to get this information from other sources but we believe that such centralization is more convenient. These information are logically linked together so users can easily find them (e.g. the schedules are linked to the staff, the staff is linked to the rooms, etc.).

There is a wide variety of mobile operating systems for mobile devices which are also completely incompatible. Naturally, we want our application to be supported by many mobile devices so we searched for a fully multiplatform solution. We selected the open source framework PhoneGap. This framework allows us to create an application using the modern technology of HTML5 and JavaScript for the most used operation systems such as Android, iOS, Blackberry OS, WebOS, Windows Mobile or Symbian.

---

* Master degree study programme in field: Software Engineering

† Master degree study programme in field: Information Systems
Supervisor: Dr. Alena Kovárová, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU, Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 487–488.

The important objective is to implement the application in a way that it could be easily deployed for other buildings through the exchange of data packages. These data packages must include a plan of building in the form of 2D model, the list of rooms, stairways and elevators along with their positions. This feature is designed in such a way that it can be easily deployed by people without technical and programming skills.

The main data are stored locally in the application because of the data communication savings. The application will include support for updating the data via Wi-Fi or 3G.

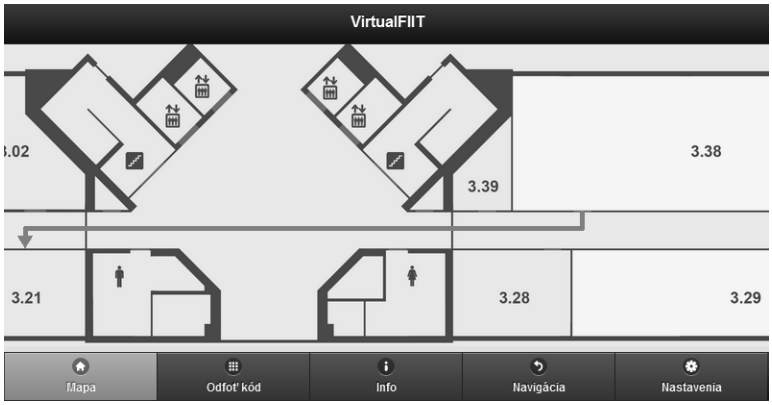

Figure 1. Example of navigation on a mobile device.

We believe that our team can create a successful mobile application using modern and progressive technologies. There are several ideas for new features that can be implemented in the future as well. Surely, we would like also the future teams or other fans all over the world to further develop the additional features for the application. There are many possible extensions such as lists of opening hours, helpful links, actual room occupancy, the number of free parking spaces, interactive 3D avatars, boards and chat. Unlimited are the future possibilities of using such a system. The extensions are, of course, not limited to the mobile version. The 3D desktop version can be a part of the interactive kiosks, which not only capture one's attention but also give an advice every time the visitor feels helpless.

Acknowledgement: This work was partially supported by the Scientific Grant Agency of Slovak Republic under the contract No. VG 1/1134/12.

References

[1] Hlaváček, F., Hudec, J., Mešťaník, P., Novotný, M., Pečík, R., Polko, I., Palček, M.: *The Conjunction of Spatial Navigation and Information Systems through Virtual Reality*. IIT.SRC 2011, Bratislava, (2011). Project available at: http://stavba.fiit.stuba.sk/virtfiit

[2] Mulloni, A., Wagner, D., Schmalstieg, D. and Barakonyi, I.: Indoor Positioning and Navigation with Camera Phones. *Pervasive Computing*, IEEE, (2009), Vol. 8, pp. 22–31. [Online; accessed February 21, 2012]. Available at: http://wiki.fluidproject.org/download/attachments/6819626/indoor_positioning_camera.pdf

[3] Costa-montenegro, E., González-castaño, F. J., Conde-lagoa, D., Barragáns-martínez, A.B., Rodríguez-hernández, P.S., and Gil-castiñeira, F.: QR-Maps: An efficient tool for indoor user location based on QR-Codes and Google maps. *Consumer Communications and Networking Conference (CCNC)*, IEEE, (2011), pp. 928–932.

TrollEdit – Different Approach in Editing of Source Code Using Graphic Elements

Lukáš TURSKÝ, Jozef KRAJČOVIČ, Maroš JENDREJ, Marek BRATH,
Ľuboš STARÁČEK, Adrián FEJEŠ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
tp-team-10@googlegroups.com

1 Introduction

Today programmers use editors and IDEs that usually use simple color highlighting without any sign of graphic enrichment features. However enriching the source code with graphic elements can be beneficial for the understanding of the structure of given code and thus lead to better understanding of its structure and meaning for the programmer. This basic observation is the driving idea behind *TrollEdit*.

TrollEdit is an experimental editor that tries to enrich source code with graphical elements for easier manipulation. Source code editing can sometimes be very problematic especially when reviewing unknown code that the programmer is not familiar with. Most of the time programmers are trying to familiarize themselves with the syntax of the source and only then follow to analyze its semantic meaning. *TrollEdit* tries to address both of these steps by enriching the text editor with graphical elements instead of relying on colorized text.

TrollEdit is a running project, which started as a research idea by team *Ufopak*. The team explored the possibility of using abstract syntactic trees instead of simple coloring rules to enrich the presentation of source code and its manipulation. Our goal is to further improve upon the existing core functionalities so *TrollEdit* can be deployed for real development tasks.

2 Motivation and current achievements

The core functionality of *TrollEdit* is based on the use of *LPeg* pattern matching library. Using this library we are able to parse source code according to its grammar into an abstract syntactic tree (AST). This data is then used to enhance the text visualization using the *Qt framework*, which provides the needed graphic functionalities. The proper combination of these two technologies made this editor possible by utilizing the *Lua* programming language and an interface between the two technologies. For performance reasons the current project relies on the much faster *LuaJIT2* implementation.

Using a scripting language and the *LPeg* [1] library we are able to parse the content on any open file into abstract syntactic three (AST) assuming that we have a matching language grammar.

---

* Master degree study programme in field: Software Engineering
Supervisor: Dr. Peter Drahoš, Institute of Applied Informatics, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 489–490.

Created hierarchical order is then used to visualize and interactively manipulate the structure of the program. Users can than easily control and shift whole blocks just as they are displayed without any usual problems from conventional text editors (text indent, selection etc.).

On top of that, the idea of *literate programming* by Donald E. Knuth [2] is explored as we can easily document parts of source code with comments that can contain rich text content for documentation purposes.

Based on the work done by *Ufopak* we aim to optimize the generation of the AST by utilizing parallel processing and a more efficient way to access the generated data. Among other prominent changes we are introducing, is the ability to switch between graphically enhanced and legacy visualization of the source code. In *text-mode* the editor works as any other common editor and does not interfere with the editing process so productivity of programmers is not affected when writing code. However in second mode user gets the full potential of enhanced editor, where edited text is represented in graphic blocks as we can see on *Figure 1*. This can be interactively manipulated, printed, exported as PDF or saved for documentation.

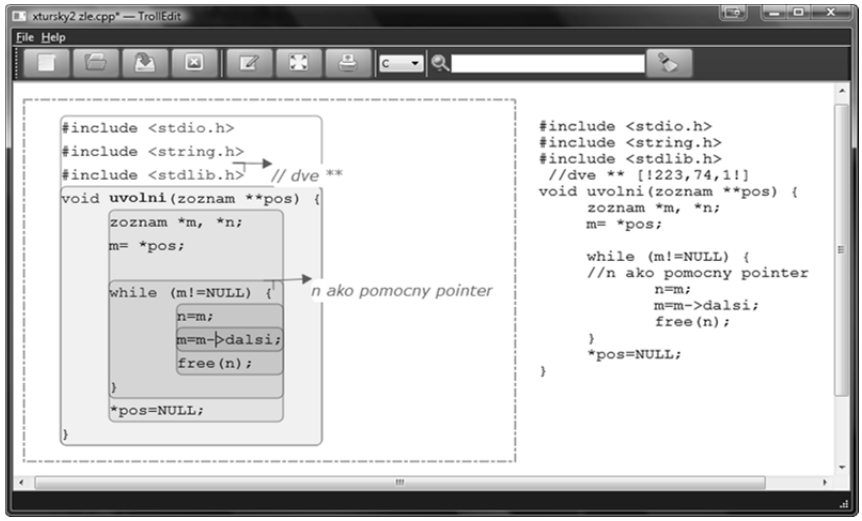

Figure 1.Visualization of two files opened in editor, one in graphic-mode and other one in text-mode.

3 Conclusion

All our contributions are aimed to ensure that TrollEdit will be a practical editor designated with extensibility, efficiency and flexibility in mind. New grammar can always be added for support of new languages without any invasion to editor. For example we can use the editor features to create a grammar for simple ToDo list management as part of the evaluation process. The visual presentation of the editor is also extensible as it relies on style sheets defined using the CSS format.

References

[1] Roberto Ierusalimschy: A text pattern-matching tool based on Parsing Expression Grammars, (2009), PUC-Rio, Rio de Janeiro, Brazil.

[2] Knuth, D.E.: Literate Programming, 1992, Stanford University Center for the Study of Language and Information, Stanford, CA, USA, (1992).

Digital Scene – Kinect Based Gesture Recognizer in a Task of Event Management

Matej KVITKOVIČ†, Andrej LEZO*, Peter MAČUGA†, Lenka NESLUŠANOVÁ†,
Marek RAČEV*, Michal ŽILINČÍK†

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
team11_fiit@googlegroups.com

Computer vision is currently experiencing considerable progress and is constantly expanding its scope. One of the major steps in its rapid development was undoubtedly Kinect device invention, which mainly affected the world of computer games. Its potential usage has been considerably expanded after SDK was released, which offered access to the features of this device to all programmers.

Today Kinect is still mainly used in the game and we decided to use it in new way. The aim of our team is to offer an usage of this device to the art and education by creating application for creating presentations, controlled by user gestures. In addition, we attempt to create also our own library with functions for working with Kinect device, intended for further usage (see Figure 1).

An important part of the application is the possibility of learning own gestures. The user is not bound to a defined set of gestures that can be used, but is able to define a large number of gestures, which are comfortable and easy to use for him. The project also includes configuration files, gallery of trained gestures, mulitimedia files and their complete management.

Figure 1. Block design of the system [1].

We used C++ for whole implementation and several libraries, of which OpenCV library is quite important [2]. For GUI creation, we used Qt framework.

Structure of the application is composed of several modules. The meaning and function of each module are described in the next section:

- *Module for Kinect management* is module that handles all communication with the Kinect device and can simulate its activity (for example, if the device is missing). It transformes data got from the device into the form, which other managers are able work with.

---

* Master degree study programme in field: Software Engineering*, Information Systems†
Supervisor: Dr. Vanda Benešová, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

- *Module for gesture training and recognizing* first processes data provided by KinectManager module. Output, which module produces, depends on whether the gesture is recognized or trained. Either it is information about successful training and the gesture representing data, or it is a flag of success or failure of recognition.
- *Module for gesture management* – the aim of this module is the management of gestures and manipulation with them. The gesture is defined as the 3D coordinates of 20 points of skeleton at the time. An important function, which also provides this module, is the import and export of learned gestures. Different users can move their gestures and use them anywhere, or import other gestures.
- *Module for action management* is similar to gesture module. Action means a multimedia file or group of files sorted in time sequence. Manager's task is to load files, add necessary data and make them available to other modules. It also provides import and export.
- *Presentation module* takes care of presentations. Presentation means a sequence of multimedia files or individual files separately, triggered by user gestures. Each gesture is assigned to the action. This module is responsible for creating ang managing such couples.

One of the key tasks of the project was the selection of methods for training gestures. For this, Markov models or Dynamic time warping are most suitable. Since the Markov models require the input of relatively large set of statistics, we used the second algorithm.

Training is based on the principle of tracking points of the hand, which move relatively to a set of fixed points. We consider these points as the center of the chest and abdomen area. First, the user's hand is stopped at the certain point. Based on the movement of the hand, the system creates a coordinates vector, which defines the performed gesture. The coordinates vector of the performed gesture is compared with the vectors of the recorded gestures. Euclidean distance metric is used to make a decision if the performed gesture is equal to one of the trained gestures. In deciding, pre-defined threshold has an important role, because it determines the degree of sensitivity.

Application is created for the domain Museum, where it will interfere in an interactive way with the interpretation of the ordinary encyclopedic and sometimes boring interpretations. Its importance lies in the restoration of interest in knowledge, its retrieval, extraction, and effective learning. It is intended clso for artists, who can use it to present their ideas, imagination and artistic creations in a modern and interesting way.

References

[1] Jana A.: Using NUI APIs with Camera. In: *Development With Kinect* .NET SDK, (2011).

[2] Bradski, G., Kaehler, A.: Learning OpenCV: *Computer Vision with the OpenCV Library*. Vol 1, Sebastopol: O'Reilly, (2008). 555 p. ISBN 978-0-596-51613-0.

Recommendation as a Service

Michal CÁDRIK*, Martin DETKO*, Matej MIHALIK*, Igor SLOTÍK*,
Jakub ŠEVCECH*, Ľudovít MYDLA†

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
tim12tp@googlegroups.com

More and more often we are interacting with different recommendation systems that recommend interesting information or product and help user – the consumer of recommendation – to face up information overloading on the today's web. Most of today's recommenders are not only domain, but also site dependent. We propose a recommender framework that can be used as a service within different domains and for different purposes. We aimed to design framework, easily extensible not only by the means of new recommendation approaches but also by the means of adding new recommender implementations created by users themselves.

There are various techniques used to create recommendations. These techniques recommend the most appropriate documents using information about users' preferences, document content and a number of other features and attributes or their combination. The role of evaluation in the context of recommender systems is very important not only from the viewpoint of recommender systems comparison, but it allows a designer to find an optimal settings. Proposed framework allows user to evaluate designed recommender approaches by means of various test environments (e.g. real-time AB evaluation). The solution is designed as a REST service, where each user can configure his own recommendation system and create recommendation approach based on specific needs. Developer of proposed service provides documents to recommend and information about users to recommend for. User model is built using feedback in form of viewed documents, but stereotype user model is supported as well.

We focused on designing framework, which supports use of various recommendation methods, extensibility by new recommendation algorithms and evaluation of particular methods.

Currently two basic methods for creating recommendations are supported, content based [2] and collaborative recommendation [1]. To support these two approaches, we proposed a general data model that is capable of representing detailed information about documents necessary for content-based recommendation and information about the relationship between users, which is necessary for collaborative recommendation.

To enhance extensibility of proposed system, we added the features allowing user to create his own implementation of recommendation algorithm in Java programming language. These implementations can be used along with other algorithms in system, can be evaluated and compared with them.

To motivate users and simplify the process of implementation of users' own recommenders, we designed a simple API, which makes available to users the set of basic functions, such as

---

* Master degree study programme in field Software Engineering

† Master degree study programme in field Information Systems
Supervisor: Michal Kompan, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 493–494.

computation of similarity between term vectors. The possibility to implement new recommender systems is provided by means of plugins and theirs combinations. We divided proposed framework into smaller parts (Figure 1) and defined the interface for each of them. When appropriate interface is used to implement parts of custom-made approaches, user can upload created implementations as plugins and apply them in his own recommendation system. By using a tool for combining these parts, everyone can create and configure his own recommender system. When configuring new recommender system, user can utilize not only his own implementations, but also implementations of other users. However, he cannot change implementations of other users. He can only use them and change their parameters.

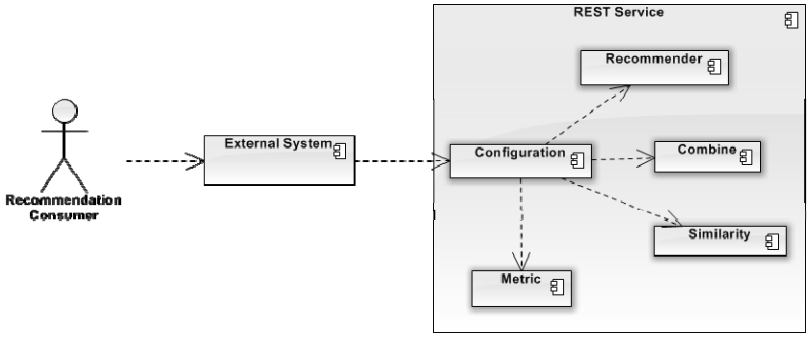

Figure 1. Recommendation service components.

Embedding custom implementations into such a system however entails a number of risks, such as misuse of data of other users. To address this problem, we have created an interface to access the data layer. Through this interface we control access to stored data and we make sure that each user has access only to data that belongs to his implementation and can not affect other users. Another risk we have to face up is protection against invalid implementations from users. Such faults could cause service overload or completely break down the service. The majority of these problems can be treated automatically by means of timeouts and exception handling.

We do not focus on extraction of feedback from consumers, instead extraction of feedback remains on users themselves. Users decide what kind of feedback they want to use, whether it is implicit or explicit feedback. We only provide functions to collect feedback about consumers' usage of recommendations and we use this feedback to evaluate systems and to compare them with each other. Systems are evaluated using various metrics, where user can provide implementations of other metrics in form of plugins.

The main contribution of our work is a proposition of framework providing recommendation as a service for different systems from different domains. User can easily build their own recommendation system by means of combining pre-defined implementations or by extending framework by users' own implementations. We designed general data model, which can represent data for content-bases, collaborative and most of other types of recommenders. We provide means to evaluate and compare recommenders using feedback from consumers of recommendations.

References

[1] Herlocker, J. L., Konstan, J. A., Terveen, L. G., Riedl, J. T.: *Evaluating collaborative filtering recommender systems*. ACM Transactions on Information Systems, (2004), pp. 5–53.

[2] Pazzani, M. J., Billsus, D.: *Content-Based Recommendation Systems*, (2007), pp. 325–341.

Management of Lightweight Semantic Content for an Adaptive Web-Based (Learning) Portal

Martin FRANTA*, Martin GAJDOŠ*, Martin HABDÁK*, Róbert KOCIAN†,
Petra VRABLECOVÁ*, Zuzana ZIMOVÁ†

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
tim13@googlegroups.com

With the emergence of the Semantic Web initiative [2] the need for semantic descriptions (metadata) necessary for machine-readable processing of the Web content is significantly increased. Semantics is required on the Web in order to enable advanced functionality (e.g., intelligent search or content adaptation). However, it is reported that there is still a lack of semantic data on the Web [3]. One of the possible reasons is difficulty of manual metadata creation and maintenance.

Moreover, nowadays in relation to the Web 2.0, a passive user is changing into an active author – a contributor – who tags, rates or assesses the content [1]. User-generated annotations are becoming an intrinsic part of the Web content. The content management as such faces new challenges related to metadata and collaborative aspects of the Web. It is important to design tools, which facilitate the management of content enriched with semantics and user annotations for a user (e.g., a teacher, or a domain expert).

We designed COME^{2}T tool, which supports management of semantically enhanced and collaboratively created content and, moreover, it is architectonically adapted for this purpose. COME^{2}T tool (*COllaboration- and MEtadata-oriented COntent Management EnvironmenT*) is a service designed to be utilized by other systems for advanced management and maintenance of existing content (see Figure 1). Its functionality covers three areas: (i) documents, (ii) semantics over documents, and (iii) annotations assigned to documents, particularly focusing on management of user annotations and content metadata.

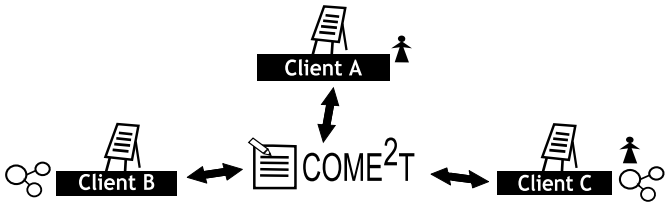

Figure 1. COME^{2}T tool is used by multiple clients for managing content metadata and/or user annotations.

* Master degree study programme in field: Software Engineering
† Master degree study programme in field: Information Systems
Supervisor: Marián Šimko, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 495–496.

Documents. COME^{2}T stores XML-based documents in repositories according to their topic or other criteria. It is also possible to import and export whole repositories including all file attachments associated to the documents. Support for document editing is focused mainly on easy modifications, such as error correction or addition of content. The system offers a comfortable working environment and helps to create valid XML content. Documents are versioned and it is possible to revert them to the state of any available version.

Annotations. Annotations can be added by users to highlight some errors or inaccuracy or to select certain fragment of a document and assign a comment or a remark. Annotations can be crucial for document editor who edits documents based on their content. The system notifies about potential conflicts that occur between annotation and edited document's content. If existing annotations no longer match document's content, a user can easily remove or modify them. Annotations are visualized in different forms (in table, using the annotation strip displayed next to the document reflecting actual text position) in order to facilitate manipulation.

Content metadata (semantics). Metadata consists of set of *Relevant Domain Terms* (RDT) and relations between them. They can be created, edited and assigned to documents. Furthermore, it is possible to make relations between documents. The existence of more metadata variants allows users to choose interconnections, which would be applied for aggregate documents. More metadata variants can be assigned to one repository in order to create more semantic descriptions for different purposes. Metadata are separated from documents and can be independently processed. With the aim to make the work with lots of interconnections easier, the system allows to work with them in the form of tables or a transparent interactive graph. This graph is represented by a set of nodes and edges, which connects them. In our case, nodes are relevant domain terms, while edges represent different relationships between these nodes. We are promoting ease of use by making graph interface as much user friendly as possible.

We use adaptive web-based learning portal ALEF [4] to verify our solution. The content of this portal consists of documents referred to as learning objects and lightweight semantics based on relevant domain terms descriptions. An important distinguishing feature is ability to assign various forms of annotations by students. In the case of ALEF, lightweight semantics is used by adaptation engine to perform recommendation for students. Rigid content management disabled to flexibly change and update learning content according to the teacher's needs. Many errors remained in the content and overall quality of content was reduced. By introducing COME^{2}T the learning content will be conveniently managed separately from ALEF and allowing sending change updates independently from other activity flows in ALEF.

References

[1] Berners-Lee, T.: Berners-Lee on the read/write web. *BBC News online*, 2005 [Online; accessed February 20, 2012]. Available at: http://news.bbc.co.uk/1/hi/technology/4132752.stm

[2] Berners-Lee, T., Hendler, J., Lassila, O.: The Semantic Web. In: *Scientific American Magazin*, (2001), Vol. 284, No. 5, pp.34–43.

[3] Sabou, M., Gracia, J., Angeletou, S., D'Aquin, M., Motta, E.: Evaluating the semantic web: a task-based approach. In: *ISWC 2007: Proc. of the 6th Int. Semantic Web Conf.*, LNCS 4825. Springer, (2007).

[4] Šimko, M., Barla, M., Bieliková, M.: ALEF: A Framework for Adaptive Web-based Learning 2.0. In: Reynolds, N., Turcsányi-Szabó, M. (Eds.): *KCKS 2010, IFIP Advances in Information and Communication Technology*, vol. 324. Held as Part of World Computer Congress 2010. Springer, (2010), pp. 367–378.

An Intelligent Game for Smart Phones

Máté FEJES*, Ľuboš GELÁNYI*, Ľuboš MASNÝ*,
Juraj MÄSIAR†, Adam MIHALIK†, Dávid PSZOTA*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
fiit-team14@googlegroups.com

The aim of this project is to put human thinking into non-living creatures, called *avatars*. Users are trying to teach these avatars play the way the people are playing. Our goal is also to boost up social feeling, so the whole game is motivating people to personal meetings and communication.

Everything is incorporated in our game, called *Smart Bomber*. Smart Bomber is a standard action game based on main idea to eliminate opponents by bombs. The principal difference lays in player himself. The user is not only controlling his player but he also owns an avatar. Player's goal is to train his avatar and let him compete with other avatars.

The game contains a couple of different game modes. First of all, a player can play a *classic* game mode in which he throws down the gauntlet with standard game bots. The main game mode, supporting teaching goals, is *training*. In this mode the player is training and pulling his avatar up.

The *Online game* is a game mode strictly for avatars where user is not present. Avatars are competing against each other and gaining important points for theirs real users. Players can see only final statistics or video replay. The *Multiplayer* game mode has two main purposes: socialization and comparing skills with other players and their avatars. Competition can be played between players, avatars and also between players with their avatars together.

As mentioned before, one of the most important part of the game is training the avatar. The intelligence of avatar can be influenced by choosing avatar's type of brain and teaching strategy.

The aim is not to train the best avatar of the game. At least it is not our goal (its player's goal). The intent was to create avatar's brain which can take over player's behavior [1]. Player can choose between brains based on *neural networks* or *Markov network*. Both types of brains are trying to reproduce player's behavior. During the training process the avatars are trying to link actual situation with player's move. Actual situation stands basically for the position of player, the distance between him and the opponent and whether the player is threatened by bomb or player.

Brain based on *Markov network* is simple and fast. The whole principle is in the mapping of the actual situation with player's moves. When there are two or more possible moves for one situation, the selection depends on frequency of using moves by player. The weak point of this type of brain is improvisation. When there is no record of some situation, the closest option is selected (but the closest situation does not have to be the player's option).

Neural network is more complicated and more challenging. Gathered data, what are actual positions and player's actions, are used for calculation of neural brain. Output is information where avatar should move or put bomb. It takes more time for avatar to learn. The big advantage is high effectivity of similarity with player's moves in new situations.

---

* Master degree study programme in field: Software Engineering
† Master degree study programme in field: Information Systems
Supervisor: Marek Tomša, enprovia Software Engineering s.r.o.

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 497–498.

Choosing brain type is important, but player's training style is even more important. Player needs to have appropriate strategy of teaching. He can choose simple way of teaching, so avatar is doing mostly the same moves all the time or he can choose more complex strategy, where avatar's using more moves, but mistakes could occur. It is also very important, if the player is training him all game modes and all kinds of maps. If player is playing just one game mode, avatar will be the master in copying player's behavior for this game mode, but in other game modes avatar will lost. It works the same way with maps. It is up to player what kind of strategy is chosen.

The *architecture* consists of two main subsystems. The two types of communicating nodes are the *local* application on mobile device and the *remote server* (see Figure 1).

There are two cases of communication between the nodes. In the first case a *multiplayer* game is played by two (or more) players that have met physically. *Multiplayer* game is supported by peer-to-peer communication between mobile devices (via Wi-Fi or Bluetooth).

Regardless to eventual peer-to-peer communication, every single device communicates with the remote server. The server provides certain services used by client applications on mobile devices. There is persistent data storage present on the server that keeps data of all user profiles, avatars and statistics of games played. All the data is regularly synchronized between the server and clients, however certain data on the mobile devices are only transient. The second server component is the *online* game mode, where the competitions between avatars take place. Another service of the server is the *geo-platform*, which provides information about the users' position on the map. This feature is utilized for notification of users if another user is in the vicinity.

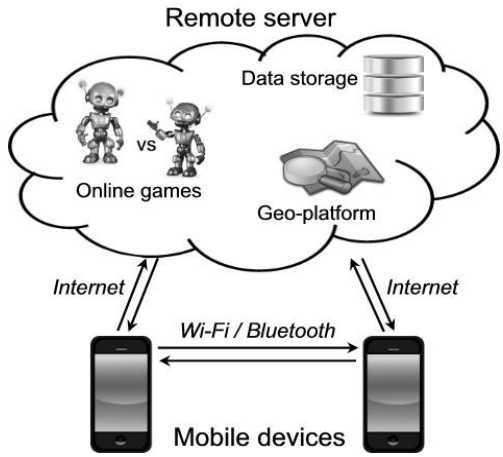

Figure 1. Architecture of communication between devices and server.

There are two ways of how we are *planning to evaluate* our project. First way lays in automatic test. We are going to repeat the same game with the same opponent couple of times. This test evaluates the similarity between player's and avatar's behavior. First observed aspect will be number of winning rounds, the second aspect will be average number of putted bombs.

The second way of evaluation is going to be done via usability testing. We are planning to let multiple players try out the game and let them fill out questionnaires on how they perceive the learning process and the game in general.

References

[1] Conroy, D., Wyeth, P., Johnson, D.: Modeling Player-like Behavior for Game AI Design. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*. ACE '11, New York, USA, (2011).

Knowledge and Skills of Students

Peter IVANEC, Jakub ŠALMÍK, Patrik POLAKOVIČ, Michal CHYLIK, Anton SZÓRÁD*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
timovy-projekt-16@googlegroups.com

Each student has some knowledge and skills. These data can be very interesting and valuable to many people. With gathered and evaluated data, it is possible to extract and categorize valuable information and use them for several purposes, e.g. to group students with same interests, classmates to form better team for projects. Teachers can simply see who of available students are well suited for their projects. From these data they can get important information about students' absolved courses, known informatics, language, or soft skills. These data are very valuable not just for academic purposes, but they can be also mediated to potential employers, who can find suitable new employee. We assume that this kind of information would be useful if we find a way to gather and process it.

There is currently no system in our university environment, which can collect these data and evaluate them. These data are very valuable in more ways, e.g. choosing bachelor/master thesis or for companies, which are interested about students at the university. We created a system that gather information about students' knowledge and skills, and also provide search among them. It is possible to add notes and descriptions wherever it is relevant. As shown in Figure 1, the core of our system consists of user himself with his skills and knowledge. System has pre-defined contents, like some of most common skills or knowledge so user can select just from this list, but they have freedom to write their own skills or knowledge too. To avoid duplicity and variety of added skills or knowledge, every new item is added to separate location for further checking. If it is relevant, it will be added to pre-defined contents or in case of mistyping corrected. Either way, user will not see difference on his profile and will not be limited. With adding skills and knowledge to their profiles, users have option to choose a level, how they are familiar with particular knowledge or skill. Also there is note available to add to specific skill or knowledge, so user can specify more detailed his experience with it. As seen on figure 1, there are two associations from user to note. It is because we allow noting user's skill or knowledge not only from student himself, but also from teacher. So we differ who is noting, and who has been noted. According to gathering knowledge and skills about students from themselves, teachers are authorized to add knowledge and skills to students as well. It is obvious that these types of information have different credibility. Therefore they differ logically and visually, so the user browsing other's profiles knows which skills and knowledge were added by students, and which of them by teachers.

Our system can be generalized by focusing not only on information technologies, but also other fields as well. Therefore our product could be used at the other faculties or companies to provide better overview about employees' skills. Our system can be strong support tool for

* Master degree study programme in field: Software Engineering
Supervisor: Michal Holub, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 499–500.

managers in many ways. They could simply see which employee is suitable for certain project. That helps to create better organized employee structure in project. Also it could provide a self-reflection for employees to see which skills they should improve. Working not only with basic knowledge and skills, but also soft skills can be very useful for teachers or managers. These soft skills are separated from other (technical) skills. All data collected by our system can be used for further research. Therefore the plan is to implement API in our system, which will provide access to data from outside or data export for other systems and academic purposes.

Main goal of our project is defined by two different ways. First is for academic environment where students can add their knowledge or skills, and also teachers can add skills to students. In this way we improve e.g. bachelor/diploma project choosing and selecting, making better teams in Team project or choosing suitable student for international internship. With our API we can provide data for other students, who make similar research or who need large samples of data about students. Second way is more interesting for companies. Through this way, we see an opportunity how to motivate students to fill in and periodically update their skills and knowledge. This way allows companies to search best and most suitable students for available jobs and contact them. They can search students by their skills, experiences or by success in various courses. Students gain opportunity to find better job, and companies gain best students by their criteria.

Skills and knowledge we are working with are just from specific academic field. But with a large number of various users we can create a map of skills and knowledge. We could use it to extend our existing set of terms and also to form better hierarchy within these terms. Not only it will improve the quality of our system's functionality, but it will also test if our system can handle a heavy load. We hope that both aspects will make this system more attractive to other users and potential companies.

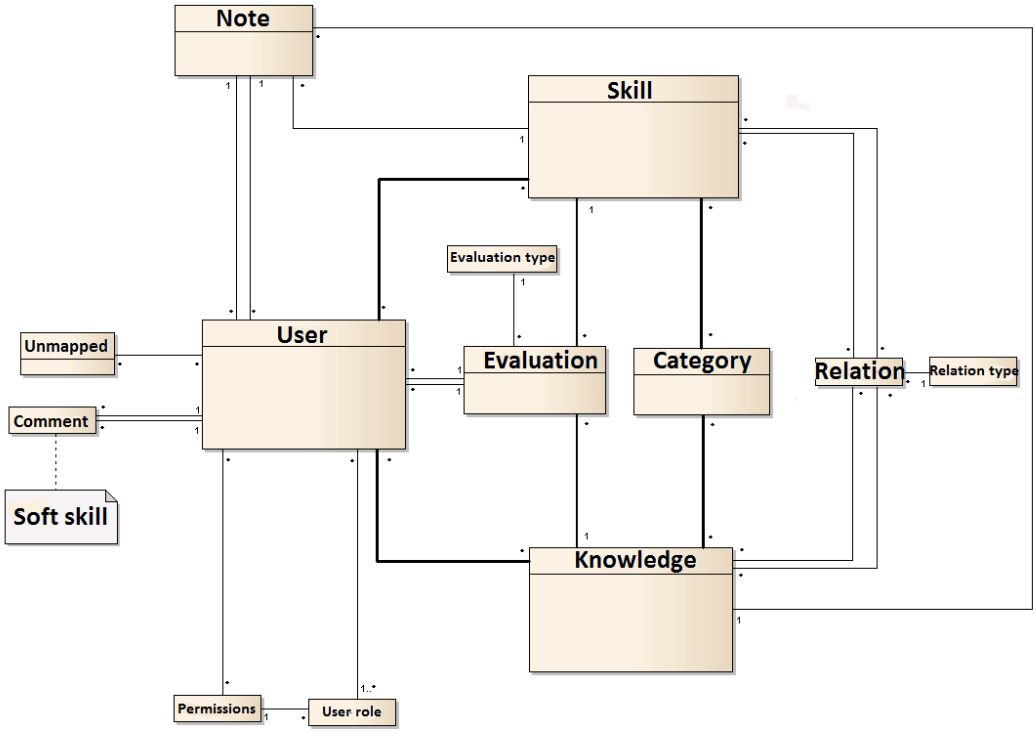

Figure 1. Logical model of our system.

Nokia Lab at IIT.SRC 2012

Valentino VRANIĆ[*], Ján LANG[*], Michal ČERŇANSKÝ[†], Ivan KOTULIAK[‡]

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{vranic,lang,cernansky,kotuliak}@fiit.stuba.sk

Abstract. Nokia Lab is a joint initiative of Faculty of Informatics and Information Technologies, Slovak University of Technology in Bratislava and Nokia Slovakia to promote and support mobile technologies. At IIT.SRC 2012, Nokia Lab will present its activities at its presentation spot via several interesting applications whose development has been supported by Nokia Lab. The portfolio of Nokia platforms will be represented by some well-known Nokia phone models including Nokia Windows Phone.

1 Nokia Lab and FIIT STU

A year ago Faculty of Informatics and Information Technologies STU opened its Nokia Lab (http://www.nokialab.sk/) as a joint initiative of the faculty and Nokia Slovakia. Nokia Lab was introduced by a student competition *Design a Mobile Application* that attracted almost twenty proposals out of which six have been selected for presentation at IIT.SRC Invent 2011 with three of them being awarded.

As a part of its regular activities, Nokia Lab makes newest Nokia mobile hardware and software technologies available to students and promotes introducing mobile technologies into teaching and into student projects in particular. Nokia Lab also organizes lectures devoted to Nokia mobile platforms in order to help students develop their applications for these platforms.

2 The Presentation Spot

At this year's IIT.SRC, Nokia Lab will present its activities at its presentation spot via several interesting student applications whose development has been supported by Nokia Lab. These applications target such important areas as emergency situations, transportation, and education, but also sport and leisure activities. Apart from strictly student applications, Nokia Lab supports also iTransit, a joint project by Apptives and FIIT STU.

The portfolio of Nokia platforms will be represented by some well-known Nokia phone models including Nokia Windows Phone. Nokia Lab staff will be available to answer any inquiries.

[*] Institute of Informatics and Software Engineering, FIIT STU
[†] Institute of Applied Informatics, FIIT STU
[‡] Institute of Computer Systems and Networks, FIIT STU

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 501–502.

3 Applications to Be Presented

Applications to be presented at the Nokia Lab presentation spot at IIT.SRC 2012 include:

- *iTransit* – a joint project by Apptives (Martin Jačala) and FIIT STU (supervised by Michal Čerňanský), `http://www.itransit.apptives.com/`
- *NoMEd* (Nokia Mobile Education) by Peter Palát (supervised by Ján Lang), `http://www.nomed.tym.sk/nastiahnutie.php`
- *PexMind* by Maroš Urbančok (supervised by Ján Lang), `http://student.fiit.stuba.sk/~urbancok09/OOP/`
- *Travel Companion* by Peter Šinský (supervised by Valentino Vranić)
- *Motion Companion* by Róbert Puckallér (supervised by Valentino Vranić)

Games with a Purpose at IIT.SRC 2012

Jakub ŠIMKO, Mária BIELIKOVÁ*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{jsimko,bielik}@fiit.stuba.sk

Abstract. Games with a purpose are one of the points of interest for our research community, not only for the research opportunity itself but also for promotion and popularization of research. For a third time at IIT.SRC, we organized an accompanying event involving our games to promote its concepts, entertain conference participants and collect experimental data, valuable in our research efforts.

1 Why Games with a Purpose?

The phenomenon of *Games with a Purpose* (GWAP) has emerged in the past few years as an interesting research field. The GWAPs represent a way of harnessing the power of the human brain for producing useful artifacts or solving computational problems through computer gaming. GWAPs achieve this by their special game-dynamics design which aligns the solution of a problem with the winning conditions or strategy of the game. Instead of monetary values (e.g. money), the GWAPs reward player with entertainment, which makes this problem solving approach very scalable. The GWAPs are especially effective for solving *human intelligence tasks*, i.e. problems which are very hard or impossible to solve by machines.

For some time, the research in the field of GWAPs has also been an interest for our community. Games with a Purpose are a part of the IIT.SRC conference not just as research works but also as accompanying events. Because of their ability to entertain, they bring students' attention to our event. They popularize the research as good demonstrations of how it may look like and that everyone can take a part in it, at least as a knowledge contributing player. The important benefit of such GWAP showcases is that they bring us valuable game-play logs and allows us to conduct larger scale experiments.

2 Game-related research works

We currently have several GWAPs developed within the research efforts of our students.

2.1 Acquisition of annotations for images via PexAce

The *PexAce* game focuses on acquisition of annotations for images. It is a single-player modification of the popular *Concentration* game (also known as *Pexeso*), where the player's goal

* Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

is to discover pairs of cards laid out on the table in the lowest possible number of turns. In *PexAce*, the player is allowed to write notes on the cards to help him in identifying pairs. This can significantly decrease the turn count, but only if the cards (with the images) are annotated effectively, i.e. with semantically relevant texts. After images are annotated by multiple players, relevant image tags are extracted.

This year, the *PexAce* comes in a modification tailored for personal multimedia annotation called *PexAce-Personal*. The game aims to saturate the need for descriptive metadata over personal multimedia (to increase their manageability). So, in the game, the player interacts with his own multimedia content and annotates it. The game adds to the initial player motivation (lust for entertainment) also the benefits for annotating one's own images.

2.2 Validation of music metadata via CityLights

The *CityLights* game aims to filter out noisy and poor quality music metadata, which are present on the Web in significant numbers, hindering music retrieval tools. In the game, the player hears a short music track and is presented with multiple bags of keyword, from which one represents the real metadata for the track assessed from the Web. His task is to guess, which bag it is. His behavior in this task discloses, how descriptive the true metadata are, or whether there are suitable tags present in other tag-bags.

2.3 Building domain models via TermBlaster

Another of our previously presented GWAPs, the *Little Search Game,* also comes in a new fashion, and is called the *TermBlaster*. Originally it is a search query formulation game designed for collecting term relationship to build domain models. It exploits the principle of negative search – the players' task is to reduce the number of search results by writing search queries in a special format, which forces them to disclose their opinion on relatedness of search terms.

In *TermBlaster*, the term typing is substituted by term hitting. The player's task is to simply hit bubbles with terms he considers to be most related to the term he is given as a task term. The game is also working in a specific domain of a software engineering course at our faculty, with a goal of creating the domain model usable in our e-learning systems.

To try out our games, you may visit the following web page:
`http://pewe.fiit.stuba.sk/gwaps/`

FIITAPIXEL Exhibition at IIT.SRC 2012

Pavol NÁVRAT, Mária BIELIKOVÁ, Ján LANG*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{navrat,bielik,lang}@fiit.stuba.sk

Abstract. FIITAPIXEL is an initiative of the Faculty of Informatics and Information Technologies that brings together its members (both students and staff) as well as its potential students and alumni in an effort to create, share and judge pictures. It is organized as an ongoing event, where anyone can contribute pictures to certain categories of photographs. The submitted photographs take part in a contest that is organized annually. Besides best photographs, also best photographers are announced based on their success with their photos. The contest has an expert panel of jurors who give their lists of best photos in each category. In parallel, visitors vote for any photo they like and their votes are counted to result in list of best photos according to popular voting. For the third time we organized at the IIT.SRC an exhibition of the best pictures this year contest.

1 FIITAPIXEL as an inspiration

FIITAPIXEL is an initiative of the Faculty of Informatics and Information Technologies to contribute in providing to its members, students and staff alike, an inspiring, creative, stimulating environment to study or to work in. Studying is mostly demanding and hard, and so is working at an institution which faces such a level of competition as is the case in the higher education sector in informatics and information technologies related fields in this region of Europe. From Budapest to Prague, from Vienna to Brno, in a relatively close proximity of Bratislava there several respected institutions with a similar scope of interest. Moreover, in the city itself, there are several other competing institutions.

We try to offer something that may make a little difference. By providing a platform and other forms of support, the Faculty creates an environment that allows expressing its members in a completely different way as it is usual in their professional work. Instead of writing programs or designing chips, they get a chance to express themselves by way of pictures. The language of pictures is intended as a language of artistic expression, even when respecting all the limitations given by the simple fact that these professionals in one (informatics related) field are complete amateurs in another (photography) and similar limitations apply when e.g. elements of journalism are involved.

* Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

IIT.SRC 2012, Bratislava, April 25, 2012, pp. 505–506.

2 FIITAPIXEL Organization

FIITAPIXEL started in 2009 and it has been organized ever since then. It takes place as a contest organized annually. The final results are usually announced and prizes awarded around the time of our student research conference IIT.SRC. Immediately after one year of the contest is closed, themes for the next one are published and the contest is open again. The contest is organized in two legs during one year that last approximately half a year each.

There are usually four themes open for each particular leg, but some of them may be adopted for the next period. For example, in 2011/12 contest there were these four themes for the first leg (Summer and Autumn):

- Enchantment of tininess
- Colourful nature
- Utterance about a human
- A sign of life

with My motherland replacing the latter one for the second leg (Winter and Spring).

Each participant can submit up to five pictures to each category both in the first and the second legs. These up to 40 pictures are published on the contest portal, where they are freely visible from anywhere in the world. Anyone can express her/his likes which are treated as votes for the particular picture. At the end of each period, votes are simply counted and the best dozen pictures are announced as winners, according to a popular vote, in each category.

There is also an expert jury formed by experts in visual arts which gives its opinion resulting in another set of lists of dozen winning photos in each category. Results of both opinions, expert and popular, are then used to determine a list of best photographers based on how their photos are placed in particular results.

In the 2011/12 contest, we have had 1 564 pictures taken by 183 authors. They received nearly 6 000 votes from visitors. Pictures and wining photos are available on the contest portal: `http://foto.fiit.stuba.sk`.

3 IIT.SRC Exhibition

Annual evaluation of the best photographers of the FIITAPIXEL Contest takes place at the student research conference award ceremony. Moreover, we give conference participants the opportunity to enjoy an exhibition of the winning photos of each category in both legs, i.e. we exhibit two dozens of winning pictures. IIT.SRC participants can cast their vote for the best photo during the conference. At the end of the day, winner of the participants'vote is announced and awarded.

FIITAPIXEL brings new dimension into our living space at the Faculty together with much inspiration for our activities.

High School Students at IIT.SRC Junior 2012

Mária BIELIKOVÁ, Jakub ŠIMKO, Dušan ZELENÍK*

Slovak University of Technology in Bratislava
Faculty of Informatics and Information Technologies
Ilkovičova 3, 842 16 Bratislava, Slovakia
{bielik,jsimko,zelenik}@fiit.stuba.sk

Abstract. The IIT.SRC Junior track is a platform for talented high school students interested in informatics and information technologies to present their innovative ideas and projects to their senior colleagues – university students and staff. During poster sessions, works accepted to the IIT.SRC Junior track have been presented by their authors, who subsequently received feedback on their projects throughout discussions.

1 Seeking the talent

Seeking for the talented high school students is essential for maintaining quality of future IIT.SRC conference submissions as well as the life of the faculty. Therefore, we started this year the IIT.SRC Junior track – a platform for high school students to present and discuss their innovative ideas and projects in the field of informatics and information technologies.

Student works accepted to this track have been presented by their authors during regular poster sessions. Here, the authors had the opportunity to receive valuable feedback from the faculty members as well as from their older colleagues. The authors had also the opportunity to view and discuss other works presented at the conference to gain experience and inspiration for their future projects.

This year, three submissions were selected, first two dealing with an actual topic of electronic parliamentary elections (presenting either the potential platform and result analysis apparatus), the third presenting a smart portal for delivery of IT news and updates, focused on young audience.

More information about the IIT.SRC Junior track can be found on the Web:
http://junior.fiit.stuba.sk/

2 IIT.SRC Junior 2012 projects

2.1 Universal system for organizing electronic parliamentary elections

Marián Kulfan, Jur Hronec High school, Bratislava

The contribution authored by Marián Kulfan presents the method for organizing electronic elections with minimum use of paper. The key feature is to use modern means of information technologies to simplify voting act for citizens with suffrage. Apart from that, it also enables easier

* Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies STU in Bratislava

evaluation of votes because results can be displayed automatically several seconds the end of voting. This voting system can be used not only once, but it is reusable for several types of elections through easy module inclusion feature. This modularity sources from benefits of objected orienting programming languages.

To enable participation for every elector, the voting possible by three main ways:

1. The substitution for traditional voting rooms. The voter uses a voting terminal, for example with a touch screen to fill an e-ballot and submits a vote. Then the vote is processed by database servers using secured connection.
2. A use of mobile voting terminal to be taken to hospital or any rural to reach disabled voters.
3. The most comfortable option is using a web interface from any place on Earth. Only internet connection is needed. Before voting by this way a voter must request for special unique ID which would be generated and send to voter.

The approach has also many financial advantages because paper is used only for transporting unique ID only once and salaries for members of electoral comities are reduced too. It also helps to increase election participation. For example in Estonia were e-referendum organized and it brought positive results.

2.2 Statistical apparatus for electronic elections

Michal Ďurina, Jur Hronec High school, Bratislava

In relationship to the previous contribution, Michal Ďurina authored an apparatus for election result analysis. This approach is usable not just for parliamentary seats assignment but also for more advanced statistics and demographical projections. Statistical data are displayed in cake graphs and shows participation of voters in individual districts. The map is able to display various information views such as major party in every district or election participation percentage. Additionally, displayed demographics help to disclose various correlations with election results, for example the influence of a national minority.

It is also partly possible according to number of votes and Benford's law to find out whether the results were not manipulated: votes of every single party putted in graph and sorted by size should be on one line due to Benford's law. If there is bigger digression it may indicate the manipulations with results of elections.

2.3 Internet magazine dedicated to IT

Ľuboš Perniš, Ján Papánek High school, Bratislava

TeenIT.sk is the first internet magazine about information technologies (IT) with an aim at teenage readers. The idea of Ľuboš Perniš is to educate, inform and collect people in this certain topic. The technology is our future and everything begins from young people. Young people live with IT, like IT but simply many of them are on educated in this field. Author strongly believes that this project is really answering on real need and has big potential and future.

Now *TeenIT.sk* provides articles about topics connected with IT, internet, social media, gaming and internet. All articles are written with the language which is easy and simple. Authors have just established cooperation with TV Bratislava and will record high quality video interviews with IT people.

The content is for *TeenIT.sk* the most important part of the idea itself. Content is also the reason why people are visit this internet magazine. Moreover, besides internet magazine, authors decided to start with a new service as a helpdesk to help young people with their IT problems.

This idea and its potential has been already proved by 100 UIP per month, 20 stable coworkers, special award from Junior Internet conference and victory in the competition for the best START-UP project (Birdz.sk).

Author Index

Mária Bieliková (Ed.)

IIT.SRC 2012: Student Research Conference
in Informatics and Information Technologies

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

532 pages, e-print: http://iit-src.stuba.sk
Print Nakladateľstvo STU Bratislava
2012

ISBN 978-80-227-3837-8

ISBN 978-80-227-3837-8