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Encompassing Computer Science Workshop

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Book of abstracts

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GENERAL INFORMATION

Venue:

The workshop will take place at UP FAMNIT, Koper, Slovenia.

Webpage:

http://www.famnit.upr.si/en/conferences

Scientific Committee:

Klen Čopič Pucihar, Matjaž Kljun, Jernej Vičič

Organizing Committee:

Branko Kavšek, Peter Roglej, Tine Šukljan

Organized by:

DIST - Department of Information Sciences and Technologies, UP FAMNIT

UP IAM - University of Primorska, Andrej Marušič Institute

Sponsors:

MIZS - Ministry of Education, Science and Sport

Invited Speakers:

Jaroslaw Grytczuk, Jagiellonian University

Vladimir Gurvich, Rutgers University

Miklos Kresz, University of Szeged

Mark Lochrie, University of Central Lancashire

Luis Martinez Fernandez, University of the Basque Country

Alexander Pott, Universität Magdeburg

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0

The use of surrounding visual context: Peephole vs. Magic-lens Revisited

Dr. ČOPIC PUCIHAR, Klen [1]; Dr. KLJUN, Matjaž [1]

[1] *University of Primorska*

Mobile devices are becoming ever more sophisticated which makes them particularly suitable for mobile augmented reality (AR) solutions. The quality of AR libraries is improving enabling high quality implementation of novel interfaces, such as the Mag-ic Lens (ML) [1].

Yet, despite the fact that AR apps utilizing ML interaction paradigm became avail-able to a large number of users [6], it is still uncertain in which contexts could users benefit with ML interface. While some comparative studies of ML with more tradi-tional interfaces, such as the Static Peephole (SP) [7] interface, did not identify clear advantages of the ML for tasks such as navigation [2] or information browsing tasks [3], other studies demonstrated that ML is advantageous in certain circumstances (i.e. when the AR workspace was large [4] or the social setting allowed expressive spatial interaction [5]).

We hypothesize that the poor task performance of the ML is mainly the result of user studies evaluating ML paradigm on low-level tasks such as pointing , selecting, and (basic) information browsing [4, 8]. Studying performance issues of these funda-mental tasks is important as they are some of the main building blocks of human-computer interaction. Nevertheless, when performing tasks of low complexity, sur-rounding contextual information is not important for successful task completion. In other words, a list like presentation of results or a 2D map interface would already meat the requirements of the task at hand (i.e. choosing the cheapest parking space or restaurant.). However, in order to gain a better understanding of shortcomings and advantages of particular interaction method, task of higher complexity and cognitive load should be considered (i.e. navigation tasks where information from large format paper map may help us find the optimal solution, for example, the optimal cycling route that passes the best restaurants, finest beaches whilst keeping of main roads where possible).

In this talk we describe the design process behind the proposed user study design aimed at comparing static peephole and magic lens interaction method on a task with higher cognitive load. We plan to talk about main challenges and justify why method-ology of certain format was chosen as appropriate.

1

Problems of Lidar and Sonar Data Interpolation to a Single Coastal Zone Digital Terrain Model

Dr. KOLEGA, Nataša [1]

[1] *University of Primorska*

Joining sonar (bathymetric data) and lidar data (land data) in one single high precision digital terrain model (DTM) of land and sea is relatively new procedure in Slovenia as well as in the world, especially due to the fact that precise lidar and sonar data are widely available through last decade. Its main advantage is the possibility of treating coastal zones as one entity in comparison with separate treatment of land and sea zones. The joined single DTM is very useful especially for terrain analysis, geological and morphological analysis, coast line analysis, determination of characteristics of land/sea interface etc.

Joining these two data sets is problematic from various points of view: unification of coordinate systems of both data types, determination of common height reference system, interpolation of the missing data for shallow sea area, determination of coast line, as well as processing and storage complexity of large data sets interpolation. The article describes the first bigger attempt of joining sonar and lidar data in Slovenia, including accompanying problems, various interpolation methods, their pros and cons for this kind of use, the selection of the most appropriate interpolation methods and its requirements. Firstly the joining was done in 2009 and covered approximately 1 km wide coastal zone of Slovenian coast.

Key words: Geography, digital terrain model (DTM), lidar, sonar, coastal zone, interpolation.

2

Computational aspects of lifting automorphisms

Dr. POŽAR, Rok [1]

[1] *University of Primorska*

Covering techniques play an important role not only in mathematics, but also in other areas, especially in those dealing with representation and analysis of large structural objects. One of the key properties of graph coverings is that all the information about a (usually) large covering graph can be encoded combinatorially in terms of voltages assigned to directed edges of a (relatively) small base graph. Moreover, the study of structural properties of covering graphs often reduces to the study of voltage distribution on the base graph. Combinatorial techniques developed for this purpose are based on the concept of lifting automorphisms.

In the talk we present adequate algorithms for solving certain natural problems regarding lifting automorphisms along combinatorially given covering projection. Speaking of algorithmic and complexity issues one would certainly first need to address the question of how difficult is to test whether an automorphisms of the base graph lifts at all. We how that for this problem, we can develop an efficient algorithm. Further, we focus on algorithms for analysing the structure of lifted group long regular covering projection: an algorithm for testing whether the lifted group is a split extension, and algorithm for testing whether the lifted group is a sectional split extension are given. All algorithms avoid explicit constructions of the covering graph as well as of the lifted group, since such constructions are time and space consuming in general. Joint work with Aleksander Malnič.

3

Acoustic seabed classification

Mr. MOŠKON, Sašo [1]

[1] *Harpha Sea, d.o.o. Koper*

The aim of our study was to show that acoustic data are suitable for seabed mapping. We developed a methodology, which includes all the necessary steps from data acquisition to seabed classification.

Mapping of the seabed can be done visually, mechanically or acoustically. All visual methods (divers, video recording, photography) and mechanical methods (in-situ sampling) are slow and require a lot of effort, and consequently they are expensive and unsuitable for mapping large areas of the seabed. Additionally, usefulness of optical and laser methods is limited in the Slovenian sea and generally in a large part of the northern Adriatic due to the very turbid water.

Multibeam sonars use audio signals, which are independent of the transparency of the water and allow us to collect high quality data even in very turbid water. Multibeam sonar provides continuous coverage along with high speed of acquisition. We used the Reson Seabat 8125 multibeam sonar for data acquisition. We obtained two types of data – bathymetries and acoustic intensities. Both types of raw data from the multibeam sonar were processed in our data processing module. The data processing module included verification of data quality, elimination of the impact of system settings, normalization for incidence angle, derivation of features and seabed classification using data mining. Verification of data quality was based on a median filter for image processing. After the verification of data quality, elimination of the impact of system settings and normalization for incidence angle was performed by means of empirically derived formulas. The interaction between the acoustic signal, sea-water and seabed under different incidence angles is too complex for theoretical treatment, which is why an empirical approach using planned experimental measurements and comparison of results was taken. Further, we derived features from pre-processed data. We divided both types of data – bathymetries and intensities of acoustic reflections – into patches sized from 1x1 meter to 4x4 meters. For every patch specific simple features like average value, standard deviation and partial derivatives were computed and more complex texture features like higher moments and grey-level co-occurrence matrix properties were derived. All features were then evaluated, the most informative features were selected and used in machine-learning algorithms to produce seabed maps.

Based on the developed methodology, measurements carried out, acoustic data processed and areas of seabed types were determined for chosen area of the Slovenian sea. We confirmed the effectiveness of our method and demonstrated that seabed classification using multibeam sonar data has great potential in seabed research. Our method enables fast and efficient mapping of large areas of seabed and provides continuous coverage throughout the region.

4

Document System Architecture

Mr. IBIC, Gregor [1]; Dr. SAVNIK, Iztok [1]

[1] *University of Primorska*

The document management systems were originally intended only for the storage and rapid access to documents. With the development of information technology document management systems evolved into a complex architecture closely related subsystems.

Standard architecture of document system embeds modules for:
• storing documents in optimized databases
• processing and analysis of text and content
• metadata tagging and linking
• query, search and retrieval
• visualization and representation
• access security
• collaboration and workflow processing
• communication channels
• others

The basic part of the document management system architecture is a system for permanent storage of documents. Storage systems are separated according to the method of data storage - structural organization and storage technology, which affects the speed of storage and documents retrieval.

The system can be realized as one of the standard storage options, such as the file system, relational database, graph-network database, so-called NoSQL database or a combination of different storages.

Relational database storage

Databases are designed on the principles of relational technology. Collections are made up of tables that are interconnected with relations. Relationships between tables are different, one record to one record, one to many or many to many. Based on these relationships and constraints, a system for querying relational databases was built - SQL (Structured Query Language), which is very effective.

File system storage

File system is a method for storing a set of related data. Streams of data is called a file that has attributed a couple of basic metadata attributes, such as size, date of creation, file name and file extension. In order to facilitate the organization of a large number of files, directories are used. Directories are virtual folders in which we sort files. Files can be also organized hierarchically. File systems enable fast storing and reading of data, but by themselves they do not allow access to structured information. Each file type can have its own structure. Identification of the structure type is typically carried out with the extension of the file name.

Graph storage

Graphs storages store data with the organization of meshes - graphs, where data is connected with network of connections. The organization of data is no longer two-dimensional but multidimensional. Graph systems allow query graph structures, such as finding the shortest path between two nodes in a network or group lookup on the network. Most real systems can be modeled with a network model. These include links of the document with other documents and information.

NoSQL storage

NoSQL systems are systems that do not use a strict relational logic but are designed to store semi-structured data. It is also possible to nest data structures, which brings flexibility in their use. Due to the less strict data organization, the techniques of retrieval are less flexible than with relational databases. The focus in the

NoSQL systems is simple structure re/organization and fast data retrieval. Indexing structures are usually organized in simple indexes.

Other storage models

XML storage (directly storage of XML document), distributed storage, object-relational storage (combined storage), triplestore (database of triples with predicate), named graphs (graph of rdf documents), ...

The demonstration will present different techniques of documents storage and the advantages and disadvantages of each technique.

5

Spectral analysis of particulate filters: the initial findings

Dr. ROGELJ, Peter [1]; Dr. PRAŽNIKAR, Jure [1]

[1] *University of Primorska*

Particulate matter (PM10) is an important indicator of air pollution. PM10 particles are solid and liquid droplets smaller than 10 microns in diameter. Not only mass concentration (mass per volume), but also chemical composition may reveal environmental and health risks. One of the components whose concentration is of greater interest is black carbon. Black carbon concentration can be determined by measurement of aerosol light absorption in the visible spectral range. Having access to particulate filters used in the process of weighting daily concentrations of PM10 for two measurement stations in Port of Koper we performed their spectral analysis. We have acquired images of reflected light spectrum using an image spectrograph mounted to an industrial camera for daily particle filters for one year and for both available measurement stations. Although the spectrograph enabled wider spectral range, the relative filter spectrum was estimated only for the visual light wavelengths, due to limitations of the camera used. In contrast to our initial expectations we did not detect important spectral variations; on the contrary, the only observed difference among filters was in spectral attenuation. Comparison of spectral attenuation and PM10 mass concentrations revealed an expected exponential relationship, however with the relatively high residual error. Results were similar for both measurement stations, including the temporal distribution of the residual. Consequently we have also compared spectral attenuations for both stations and the obtained results revealed evidently high correlation. Based on these results we can conclude that in addition to PM10 mass concentration some other characteristics, for example chemical composition, of PM10 influences the spectral attenuation, which we could refer to as particulate brightness. For the future we tend to analyze the relation of particulate brightness with other environmental properties that could eventually enable us to draw conclusions of the particulate sources or even chemical composition.

6

Transformation of Cervix Cancer Structure Delineations Between Independently Acquired Images

Mr. MEZGEC, Simon [1]; Dr. ROGELJ, Peter [2]

[1] *Jožef Stefan Institute*

[2] *University of Primorska*

Cancer treatment with internal radiotherapy, which is how cervix cancer is treated, was traditionally planned using CT images, but those are being replaced with MR images due to the fact that they allow for a more accurate radiotherapy. The problem with MR images is that MR devices are either too expensive or are overused in most hospitals. Because of that the goal of our research was to translate as much information, gained from MR images, to CT images, as possible - the result of the research work is a procedure which transforms the cancerous tumor from the MR image to the CT image using the applicator's coordinate system. We chose this approach because the planning of the initial radiation phase, which is planned using MR devices, could support further radiation phases, planned using CT devices. The error of the developed procedure is significantly smaller than the image voxel size and its time complexity is low enough for real-time use. The procedure can be used to assist radiotherapy planning, it can be integrated into a larger radiotherapy system, but most of all it is intended as a platform for researching dependencies between MR and CT cancer images. An analysis of intensity dependencies was performed and the findings are pointing to the fact that intensity features indeed exist in the surrounding areas of the tumor. This analysis represents the first step towards discovering deeper intensity connections between MR and CT cancer images, thus presenting an incentive for further research in the field. The research work is based on images of cervix cancer, but the knowledge gained can be applied to other forms of cancer as well.

7

Generalized Stochastic Transportation Problems

Dr. ANHOLCER, Marcin [1]

[1] *Poznań University of Economics*

Very often the amount of goods transported from supppliers to destination points change during the transportation process. We can model such situation using the generalized flows. On the other hand, the demand at the destination points is usually not deterministic, but given as a set of random variables. This leads us to the stochastic version of the problem. In the talk we will discuss various types of GSTP, namely the simplest model and some variants as bi-criteria GSTP, multicommodity GSTP and two-stage GSTP. We will also show how to solve the problems of each type with various versions of the Equalization Method.

8

Using trees to speed up the Floyd-Warshall algorithm

Mr. GRGUROVIČ, Marko [1]; Prof. BRODNIK, Andrej [1]

[1] *University of Primorska*

A classic problem in algorithmic graph theory is to find shortest paths, and a common variant is the all-pairs shortest path problem (APSP). We consider non-negatively weighted APSP. Due to its simplicity and efficiency, the Floyd-Warshall algorithm is frequently used to solve APSP in practice.

We propose a combination of the Floyd-Warshall algorithm with a hourglass-like tree structure, which reduces the number of path combinations that have to be examined. Only those path combinations that provably cannot change the values in the shortest path matrix are omitted. The resulting algorithm is simple to implement and uses no fancy data structures.

In empirical tests, the new algorithm is faster than the Floyd-Warshall algorithm for random complete graphs on $256-4096$ nodes by factors of $3.5 - 4.8$x. When we inspect the number of path combinations examined compared to the Floyd-Warshall algorithm, they are reduced by a factor of $12 - 90$x. All code was written in \textit{C}.

We show that the worst-case complexity of the new algorithm does not change. In light of this, we focus our theoretical analysis on the average-case complexity, and show why it might be substantially lower than Floyd-Warshall's (this is a work in progress).

9

Application of methods of matrix factorization in blind source separation

Mr. FIČUR, Pavel [1]; Dr. ŽIBERT, Janez [1]

[1] *University of Primorska*

This research is focused on application of methods of matrix factorization in blind source separation i.e. discovering meaningful connections or subsets of variables in a large amount of data (measurements) with originally big number of observed variables (parameters). Every meaningful subset of such variables can be treated as a blind source. This is useful in situations where a smaller number of sources, usually much smaller than the number of observed variables, well describe observed situation. With such partitions of variables onto sources we can later better understand the subsystems that affect our observed data. In the literature blind source separation is used in face recognition [1] [2], identification of handwritten digits [3], document clustering [4], discovering of blind pollution sources, [5] [6] [7] [8] [9] [10], and speech recognition [11]. In all above mentioned fields there is a common fact that the measured or observed variables are positive and that the applied methods are matrix factorizations. We will describe three methods of matrix factorization and their application in blind source separation. The first is principal component analysis – factorial analysis (PCA-FA), the second is nonnegative matrix factorization (NMF), and the third is positive matrix factorization (PMF). We can say that PMF is an upgraded NMF method that uses not only measured data but includes also the uncertainty of measurements. The first part will be dedicated to the presentation of mathematical formulations of the methods and algorithms with emphasis on differences between methods. In the second part, an application of the methods on two different datasets will be presented. First dataset is a simulated dataset, the second one is a dataset of real measurement of environmental data which is supplied with EPA PMF application [12] [13]. Simulated data [14] are of utmost importance in such an analysis, because in simulated dataset we know the structure of the data and this is crucial for comparison of the methods. Repeatedly simulated datasets and their decomposition give us the possibility for statistical analysis of differences between methods upon the decomposition of all simulated datasets. In the real dataset we do not have the possibility of repetitions and consequently for statistical analysis. Also, there is a need of additional knowledge of subsystems of observed data for correct selection of the number of sources. For practical decomposition of data matrix, FApca and nnmf methods in Matlab were used. For PMF method, EPA PMF program was used. Further research of methods will be done with emphasis on combining methods with the goal of obtaining better identification of the sources, and with improvement of objective functions.

10

Mobile view reconstruction from remote stereoscopic pan-tilt camera

Dr. ROGELJ, Peter [1]; Dr. ČOPIČ PUCIHAR, Klen [1]

[1] *University of Primorska*

Web cameras enable remote observations that can benefit to various tasks, from online collaboration to safety inspection. Advancement of technology has made another step towards improved accessible observer experience by enabling not only 2D presentation, but also stereoscopic 3D representations through head-mounted virtual reality (VR) displays such as Google cardboard. This opens up space for various novel applications. In our project we aim to build a platform for stereographic remote observations that tend to make the best possible reproduction of the view from the remote location of the camera to observer with a VR display. The platform enables the observer to look in the arbitrary direction by simply moving his head (similar to VR interface). The orientation of the display controls the remote pan-tilt camera into desired direction. Live images from the stereo camera pair are transferred to the client where reconstructed into a 3D virtual representation. In addition to the realistic view reconstruction, the setup will allow us to increase or decrease the interaxial distance between the cameras, allowing us to experiment with hyper and hypo stereoscopy. The implementation of the view reproduction platform includes development of pan-tilt module linked to remote mobile device orientation, and development of module for presentation of live stereo image pair on VR device. Beside the novelty of attempting to build a system with variable interaxial distance between the two cameras, we also want to explore how will humans perceive such scene capture. The platform could be further extended with view enhancement using the principles of augmented or mediated reality.

11

Desktop, online, mobile and paper document preservation: where to from here?

Dr. KLJUN, Matjaž [1]; Dr. ČOPIČ PUCIHAR, Klen [1]

[1] *University of Primorska*

With different digital devices (personal computers, cameras, tablets, smart phones) and services (Facebook, Flickr, Twitter), personal information management has become more challenging than ever before. At first digital technologies bring several advantages (taking a photo takes just a few seconds, copying information is simple, sharing as well). However, in the long run the future of information preservation looks bleak: services close down, proprietary unsupported formats cannot be open as there is no software available, the media change and deteriorates, etc. Several studies have shown that users do not have adequate procedures in place when it comes to long-term preservation and future generations will not be able to browser our shoeboxes full of memories. Our recent study shows that on personal computers even short term preservation seems to distract users from the actual work they are doing — even if automatic and persistent technologies exist, users still rely on manual backup procedures. The backup of mobile devices is generally even less frequent than the backup of personal computers. So digital information is thus in danger to be lost not only because we have a vast amount of it but also because we do not take good care of it. The question of how do we move from here is in place. The talk will present some more details behind personal information management activities, preservation problems, current solutions and possible future.

12

Evaluation of input devices for view manipulation in 3D space

Mr. ŠKRLJ, Peter [1]

[1] *University of Primorska*

We present implementation of navigational devices in application for viewing 3-d medical images obtained with CT scan. Those devices are Leap Motion - device which detects the movement of user hand in space and allows user to interact with computer with touch-less interface. And Connexion SpaceNavigator 3-d Mouse which is frequently used in 3-d modeling applications. In addition to the implementation of support for the device in the application we carried out a user study in which we assessed the usability and ease of use of devices in the application. Main goal was to obtain feedback from people who work in medical environment and are met with image analysis challenges on daily basis. The results consisted from data we collected from the users' experience while they solved various manipulation tasks and the answers received from questionnaires SUS (System Usability Scale) which constitute one of the tools with which we can assess interfaces. Analysis of the results confirmed that the 3-d mouse is more useful in such an environment and also highlighted some shortcomings of the hands free navigation device Leap Motion.

13

A Comparison of MT paradigms for Closely Related Languages

Dr. VIČIČ, Jernej [1]

[1] *University of Primorska*

The paper presents a comparison of two most popular Machine Translation paradigms for translation between related languages. Two language pairs on three different translation platforms were observed in the experiment. One pair represents really very close languages (Czech and Slovak), the other pair are slightly less similar languages (Slovenian and Croatian). The comparison is performed by means of three MT systems, one for each pair representing rule-based approach, the other one representing statistical (same system for both language pairs) approach to the task. The results were manually evaluated by native speakers of the target languages (linguists and students). The paradigms were compared and some surprising results were found (namely Statistical Machine Translation (SMT) paradigm seems to be a better choice as long as enough corpora are available and enough effort is put into the making of the translation system although the results suggest that some rule-based approach was used by the SMT system).

14

Generalized bent functions

Mr. SAMIR, Hodžić [1]

[1] *University of Primorska*

In this article we present a broader theoretical framework useful in studying the properties of so-called generalized bent functions. We give the sufficient conditions (and in many cases also necessary) for generalized bent functions when these functions are represented as a linear combination of: generalized bent; Boolean bent; and a mixture of generalized bent and Boolean bent functions. In addition, developing an efficient formula for Walsh-Hadamard transform we are able to characterize some known classes of generalized bent functions. Based on these results, we provide some generic construction methods of these functions and demonstrate that some previous methods are just special cases of the results given in this article.

15

Predicting the Population Fluctuation of the Olive Fruit Fly: A Preliminary Study

Dr. KAVŠEK, Branko [1]; Mr. JURIČ, Damjan [1]; Dr. BANDELJ, Dunja [1]; Dr. PODGORNIK, Maja [1]

[1] *University of Primorska*

The olive fruit fly is a pest that attacks olives in olive tree plantations that results in lower quality olive oil that is produced from such olives. The presence of olive fruit fly is highly dependent on meteorological factors. Knowing in advance when the olive fruit fly will attack the olive tree plantation can enable olive oil producers (plantation owners) to take appropriate actions.

The goal of this study was to develop a (mathematical) model that will help olive oil producers (plantation owners) to predict the presence/absence and amount of the olive fruit fly in their plantation using past meteorological and infestation data (no. of olive fruit flies) for the years 2006 to 2012 and to integrate this model in a web-based application.

For the development of the model we used the classical data mining approach consisting of six phases: problem understanding, data understanding, data pre-processing, modeling, evaluation and interpretation of the models, deployment. For the first two phases and the evaluation and interpretation phase we got help from biologists, experts in the olive fruit fly.

Several machine learning algorithms were tried in the modeling phase and decision trees turned out to be the best performing algorithm with prediction accuracy 73.08% where individual prediction rules reached more than 90% accuracy. The most informative attribute was “maximal leaf wetness in the last 15 days”.

Whereas, a relatively accurate prediction model was built from the meteorological data at hand, still much work has to be done in automating the data gathering process. There is also room for improvement of the prediction model in terms of both prediction accuracy and size.

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What role does technology play in inspiring social innovation?

Dr. LOCHRIE, Mark [1]

[1] *University of Central Lancashire*

Over the last eight years Dr Mark Lochrie researchers how communities participate in mobile services, whether it be a playful nature or through more serious applications. Mark has recently begun a new challenge working at the Media Innovation Studio, UCLan. As a Creative Technologist investigating ways creative experiences, gameful design and technology can be used to generate data, encourage participation and educate. That is achieved through the design, development and deployment of applications 'in the wild'. In his talk today, Mark will proceed through work that is of relevance to determining the role technology plays in inspiring social innovation, some cases are related works, his own and future works in the pipeline.

17

Complexity of generating

Dr. GURVICH, Vladimir [1]

[1] *Rutgers University*

I will briefly survey joint results with Leonid Khachiyan, Endre Boros, Khaled Elbassioni, and Kazuhisa Makino on the complexity of generation (also called enumeration) problems.

Several examples:

1. Generating all negative cycles of a graph is intractable.
Furthermore, it can be reduced from enumerating all vertices of a polyhedron given by linear inequalities. Thus, the latter problem is intractable too. Yet, in case of the bounded polyhedra the question remains open (so-called polytope-polyhedron problem).
2. Generating all maximal frequent sets in binary matrices is intractable, in contrast to generating all minimal infrequent sets, which is tractable.
3. Generating all minimal integer vectors x satisfying $Ax geq b$, $0 leq x leq c$ is tractable whenever A is a non-negative integer matrix. Note that without this restriction we obtain just Integer Programming and already verifying feasibility becomes NP-hard. Also generating all maximal infeasible integer vectors for the above system is not tractable.
4. Generating all minimal strongly connected arc subgraphs of a (strongly connected) digraph is tractable. In contrast, generating all maximal NOT strongly connected ones (or, in other words, all minimal directed cuts) is intractable.
5. Given a graph $G = (V,E)$ and an edge-cover $E = E_1 cup ... cup E_n$.
Generating all inclusion-minimal subsets $I' subseteq I = {1,...,n}$ such that the corresponding graph is connected on V is tractable. In contrast, generating all such subsets connecting two given vertices $v', v'' in V$ is intractable; as well as generating all "maximal not connecting subsets" in both cases.

Many of the above cases are tractable, because they belong to an important class of the so-called dual-bounded problems. Such problems, in quasi-polynomial $n^{log n}$ time can be reduced to Boolean dualization, which, in its turn, is also solvable in quasi-polynomial time.

18

Vehicle scheduling with real-world constraints in public bus transportation

Dr. KRESZ, Miklos [1]

[1] *University of Szeged*

Public transportation services usually operate on previously determined bus – or other vehicle – lines, which connect a certain number of stations. The lines and their daily services are fixed in a timetable which provides the departure and arrival time of the trips for each line. In practice the timetable – based on travel demands and logistic decisions – is given in advance.

A central problem of public transportation companies is to optimize their operational process. Since the minimization of the overall operational cost is a very complex task, the arising subproblems are considered as separeted optimization problems. The vehicle scheduling problem in public tranportation consists of scheduling a fleet of vehicles to cover the timetabled trips with a minimum cost. Apart from the general cost determined by the scheduled vehicles, the transporation costs of the timetabled trips and that of the so-called deadhead trips (trips without passangers between two geolocations) contribute to the definition of an appropriate objective function.

There are several mathematical formulations that can be used to model the vehicle scheduling problem. Most of these formulations are based on network-flow approaches and quasi-assignment models. In real-world applications, however, numerous additional constraints are considered which are not covered by the above models. In daily operation the vehicle schedules need to satisfy vehicle-specific requirements such as fueling and maintenance constraints or different parking rules. In operational management it is also a frequent situation that some unexpected events (the most common of which are vehicle breakdown and lateness) render the pre-planned schedule infeasible, which requires a rescheduling process. Vehicle assignment with respect to the daily schedules in a long-term fashion (several weeks or months) is also a crucial question in order to plan those duties of the vehicles that are not related to the timetable. Finally, since driver scheduling is also an important part of operational transport management, the constructed vehicle schedules need to consider some soft constraints induced by the driver rules.

In this talk we present efficient models and solutions methods for the above mentioned real-world vehicle scheduling problems. The solutions were developed by an implementation-oriented approach, which will be demonstrated by real-world test cases. The results were achieved in a group work at the Discrete Optimization and Data Mining Laboratory in cooperation with a regional bus transportation company.

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Bent functions, difference sets and strongly regular graphs

Prof. POTT, Alexander [1]

[1] *Universität Magdeburg*

Boolean bent functions are a fascinating topic in Discrete Mathematics because there are many connections with other fields of mathematics. For example, bent functions are related to the covering radius problem of the first order Reed Muller code, they give symmetric designs and Hadamard matrices as well as strongly regular graphs. Some of theses connections will be described in my talk. A little less known are p-ary bent functions where p is an odd prime. I will show that such p-ary bent functions are related to many different fields in Discrete Mathematics, too, in particular to strongly regular graphs.

20

Heuristic Approaches to Solve the Shortest Common Superstring Problem

Dr. MARTÍNEZ FERNÁNDEZ, Luis [1]

[1] *University of the Basque Country*

The shortest common superstring problem has important applications in bioinformatics, and several approaches have been proposed in the literature to find good approximations to its solutions. In this talk we survey some heuristic algorithms used to get such approximations, and present a new method based on the use of “estimation of distribution algorithms” (EDAs).

(Joint work with Iker Malaina, Martín Blas Pérez and Ildefonso Martínez de la Fuente).

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Basic algorithms in theory of maps

Dr. KARABÁŠ, Ján [1]

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A map is an embedding of a (finite) graph into a (compact) surface. We may imagine a map as a graph G drawn on a surface such that no pair of edges of G intersects. Many questions in science reduced to problems which can be formulated in the language of theory of maps: just to mention, solutions of differential equations in particle physics, shapes of molecules in chemistry and many others. As follows, the maps with symmetries plays the prominent role in all areas and the algorithms to compute symmetries or to generate symmetric maps are mainly of interest.

The most algorithms to attack the problems in the theory of maps are based on two basic algorithms: Schreier-Sims algorithm and Todd-Coxeter procedure. In the talk we will show the basic data structures for representing maps (as subgroups of a permutation groups), and the crucial basic algorithms to solve standard problems. We will also discuss some contemporary systems of computational algebra: their advantages and disadvantages in the field of theory of maps.

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Vectorial quadratic bent functions as a product of two linearized polynomials

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To identify and specify trace bent functions of the form *Tr_*1^*n *(*P*(*x*)), where *P*(*x*) *∈* *GF*(2^*n*) [*x*], has been an important research topic lately. We show that an infinite class of quadratic vectorial bent functions can be specified in the univariate polynomial form as *F*(*x*) = *Tr_**k^n *(*αx^{*2^*i}*(*x *+ *x^{*2^*k}*)), where *n *= 2*k*, *i *= 0*, . . . , n **− *1, and *α not in **GF*(2^*k*). Most notably, apart from the cases *i **∈ {*0*,k**} *for which the polynomial *x^{*2^*i}*(*x*+*x^{*2^*k}*) is affinely equivalent to the monomial *x^{*2^*k}*+1, for the remaining indices *i *the function *x^{*2^*i}*(*x*+*x^{*2^*k}*) seems to be affinely inequivalent to *x^{*2^*k}*+1, as confirmed by computer simulations for small *n*. It is well-known that *Tr_*1^*n *(*αx^{*2^*k}*+1) is Boolean bent for exactly 2^{2^*k} **− *2^*k *values (this is at the same time the maximum cardinality possible) of *α **∈ **GF* (2^*n*) and the same is true for our class of quadratic bent functions of the form *Tr_*1^ *n*(*αx^{*2^*i}*(*x *+ *x^{*2^*k}*)), though for *i > *0 the associated functions *F *: *GF*(2^*n*) *⟶ **GF*(2^*n*) are in general CCZ inequivalent and also have different differential distributions.

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On van Dam's and Fon-Der-Flaass's results about codes, graphs and nonlinear functions

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In this talk results published in European Journal of Combinatorics by E.R. van Dam and D. Fon-Der-Flaass will be presented. In particular, functions on binary vector space which are far removed from linear functions in different senses will be considered comparing three existing notions: almost perfect nonlinear (APN) functions, almost bent (AB) functions, and crooked (CR) functions. Such functions are of importance in cryptography because of their resistance to linear and differential attacks on certain cryptosystems. A combinatorial characterization of AB functions in terms of the number of solutions to a certain system of equations, and a characterization of CR in terms of the Fourier transformation, obtained by van Dam and Fon-Der-Flaass, as well as examples how these functions can be used to construct several combinatorial structures such as semi-biplanes, difference sets, distance regular graphs, symmetric association schemes and uniformly packed codes, will be presented.

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Solving an NP hard problem of finding independent dominating sets of minimum cardinality for hypercube graphs of size 2^n with n=2^r-1

Prof. PASALIC, Enes [1]

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Let G = (V, E) be a hypercube of dimension n, that is, |V| = 2^n where V=GF(2)^n.

There is an edge between u,v in G if the Hamming distance between u and v is one, i.e., d_H(u,v)=1.

A subset S of V is said to dominate G if every node in V \S is adjacent to at least one node in S. Furthermore, if no two elements in S (that dominates G) are adjacent in G, then S is called an independent dominating set (IDS). The problem of finding minimum cardinality of S has been proved to be NP hard for arbitrary graphs and for hypercube graphs there are some greedy algorithms that give good estimates for the minimum cardinality of S, being closed to the lower bound. Using the Hamming codes and a simple modification technique applied to so-called root Boolean functions we derive the exact value (in a constructive way thus specifying a portion of these sets) of the minimum cardinality when n=2^r-1, for r >1.

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Anonymous messaging system

Mr. TODOROVIĆ, Aleksandar [1]; Dr. VIČIČ, Jernej [1]

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The paper presents an anonymous messaging system based on mesh networking. It provides an overview of wireless technologies, and a comparison between them, for the purpose of implementing the messaging system. The article describes also some algorithms for data transfer. The article also shows the results and measurements of a pilot implementation of the proposed architecture in a mobile application used to test the messaging system.

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Optimization of traffic networks by using genetic algorithms

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The amount of motor vehicles has been increasing over the years, mostly because of the new technology in automation. Today cars are relatively cheep and accessible, which enables most of the population to own one. Motor vehicles have been around for many years and most of the traffic networks were built in the past when the frequency was not as high as today. A lot of research has been done on optimizing the currently existing networks to provide to users the best service possible. Most of the solutions are focused on traffic management systems that simulate the current traffic of
a given network and can predict traffic in near future. Some solutions even offer a way to increase the flow of the network. Our approach optimizes the network by changing the type of intersections in the network to increase traffic flow and decrease cost.

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Onset and Offset Detection in EMG signal

Mr. PANJAN, Andrej [1]

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Onset and offset detection of the muscle contraction is an important part of the electromyography (EMG) signal processing. It is used to find important parts of the EMG signal that are further analysed. Many methods for onset and offset detection of the muscle contraction in the EMG signal were proposed in the past. However, all these methods have limitations and/or must be used manually. Our aim was to develop a new method for onset and offset detection in the EMG signal that can be used automatically without a user interaction. We used EMG signals from the human trunk while performing quick arm rise test and postural reactions on sudden loading test. We proposed a new method for onset and offset detection of muscle contraction based on local changes in amplitude of the EMG signal. The proposed method uses two adjacent sliding windows to calculate a ratio of standard deviations between the two windows. The ratio of standard deviations represents local changes in the EMG signal. Additional processing steps on the ratio of standard deviations are used to precisely locate the onset and offset of the muscle contraction in the EMG signal. The proposed method was evaluated for detection of presence of muscle contraction in the EMG signal and was compared with the existing methods for the accuracy of the onset detection. Proposed method proved to be reliable for the detection of muscle contraction in the EMG signal and it was more accurate in the onset detection compared to existing methods.

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ECG artefacts removal from EMG signal

Mr. PANJAN, Andrej [1]

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Electromyography (EMG) signal from human trunk is often contaminated with electrocardiographic (ECG) noise (ECG artefacts), which originates from the activity of the heart muscle. ECG artefacts must be properly removed from the EMG signal, before it is further processed. Many methods for ECG artefacts removal from the EMG signal were proposed in the past. However, all these methods have limitations and/or must be used manually. Our aim was to develop a new method for ECG artefacts removal from the EMG signal that can be used automatically without a user interaction. We used EMG signals from the human trunk while performing quick arm rise test and postural reactions on sudden loading test. We proposed a new method for ECG artefacts removal from the EMG signal based on the dynamic time warping approach. Dynamic time warping is used to find ECG artefact patterns in the EMG signal with the use of predefined ECG artefact templates. ECG artefact patterns are further processed to eliminate potentially false ECG artefacts and to find missing ECG artefacts. The proposed method was evaluated for detection of the presence of the ECG artefacts in the EMG signal and for successfulness of the ECG artefacts removal from the EMG signal. Proposed method proved to be reliable for detection of the presence of ECG artefacts in the EMG signal and was successful in the ECG artefacts removal from the EMG signal.

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The entropy compression method in graph coloring and combinatorics on words

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The "entropy compression" is a term coined by Terrence Tao to describe algorithmic version of the Lovasz Local Lemma discovered recently by Robin Moser and Gabor Tardos. A basic idea is surprisingly simple and can be described as a random greedy procedure: color a given structure randomly, fixing eventual local errors by random recoloring (of just a small part of the structure where the error occurs). This looks like a naive idea since recoloring may cause occurrence of new errors in neighboring substructures. Do not worry and keep on fixing these new errors in the same way. The surprising result of Moser and Tardos asserts that, under certain conditions, this procedure gives a desired coloring with non-zero probability in expected polynomial time. In the talk I will present some spectacular applications of the entropy compression method in graph coloring and combinatorics on words.