MATCOS-19

Middle-European Conference on Applied Theoretical Computer Science

October 10th and 11th 2019

Koper, Slovenia

Part of **International multiconference** ***Information Society 2019***

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Dear participants of MATCOS-19,

We are pleased to welcome you at the University of Primorska – the Faculty of Mathematics, Natural Sciences and Information Technologies (UP FAMNIT) and the Institute of Andrej Marušič (UP IAM). Although our institutions are young, we are very proud of numerous academic and research achievements of our students, professors, and researchers.

In the last few years, we achieved many important milestones; (1) last June, SCImago Journal & Country Rank portal has classified all fields covered by our journal Ars Mathematica Contemporanea – AMC in the quarter of journals with the highest values, making it the most prestigious Slovenian scientific journal for the fifth year consecutively; (2) the last results of the international university ranking programme U-Multirank 2019, brought us the title Global Top 25 performers in the field of international orientation of study programs. In addition, this year our Mathematics was placed on 15th place among 185 evaluated universities in the same field worldwide; (3) in July 2020 we are hosting the second largest scientific gathering of Mathematicians in the world – the 8th European Congress of Mathematics; and (4) finally, we are successfully implementing the biggest European project in Slovenia – the InnoRenew CoE project (H2020 WIDESPREAD-2-Teaming; #739574), which is significantly boosting the development of the research in the field of renewable materials and healthy living environment.

Our colleagues at both institutions carry a fundamental and applied research in mathematics, natural sciences and technology – foundation fields for the industry. Simultaneously, close cooperation between the faculty and the institute brings a successful spill of research results into teaching. Both institutions are continuously committing their efforts to achieve excellent results and are persistently moving closer to the top of the scientific world.

Everyone can experience the enthusiasm in young institutions like ours. It gives us proper mixture of motivation and energy needed to initiate and develop projects in various areas. Being a Faculty and Institute of science, we believe that our goals can be reached only if we open ourselves toward the future and the international community. Therefore, international cooperation and mobility has been one of our basic policies since the very beginning.

The Faculty and the Institute organise and co-organise conferences and other scientific meetings, and encourage the active participation of students at international conferences, summer schools and competitions. We encourage research collaborations with foreign experts, short and long visits from abroad and to prestigious foreign universities, placing young colleagues at the forefront of this effort. Doing this, our professors have already established a dense network of connections with professors and

researchers who visit us regularly (more than 100 annually), while a few hundred also attend our events.

We are particularly proud of the fact that 40 % of our students are from abroad and this year the number of freshmen in the undergraduate study programme Computer Science, which we offer both in Slovenian and English language, has increased to 64 %. This clearly confirms that we are becoming an institution which attracts prospective IT experts from the wider area and therefore is our commitment to provide them a qualitative modern programme.

Researchers at the Department of Information Science and Technology are active in several research areas including data structures, database, data mining, language technology, computer vision, augmented reality, personal information management and human-computer interaction. Since we are aware that innovations can be developed only in cooperation with different subjects, our research team has established numerous contacts with many European and other international institutions.

Due to our international evolvement in the research and academic field, we believe that UP FAMNIT and UP IAM are the ideal environment for a vibrant meeting like the MATSOC-19 conference and we hope that its programme will exceed your expectations. We are convinced you will establish new connections and renew old ones with the participants and that you will continue to cooperate with us and them in the future.

Klavdija Kutnar

Dean

Faculty of Mathematics, Natural Sciences and Information Technologies

Vito Vitrih

Director

Institute Andrej Marušič

Dear Colleagues,

it is our great pleasure and honour to welcome you at a Middle-European Conference on Applied Theoretical Computer Science (MATCOS 2019), hosted by two members of the University of Primorska: the Andrej Marušič Institute (UP IAM) and the Faculty of Mathematics, Natural Sciences and Information Technologies (UP FAMNIT). In the organisation of the conference also helps centre of excellence InnoRenew. The conference is part of a multiconference Information Society.

The scope of the MATCOS 2019 conference is twofold. First, we expect ideas and solutions from the field of Theoretical Computer Science which have been directly applied in real world applications. And second, we want to collect theoretical results based on some fruitful ideas that may be useful to adopt for practical problems. The schedule of the MATCOS conference consists of a Thursday invited talk, followed by the paper presentations in the afternoon and on a Friday. The invited talk will be given by Thomas Pock from Graz University of Technology, Austria. Its title is Learning better models for imaging.

This year we introduced besides regular talks also short talks. This proved to be a fruitful idea because this way we made possible a larger number of participants to attend the conference and exchange ideas with their peers. In schedule we have 21 regular papers and 16 short papers, which is a substantial increase from MATCOS 16. The contributed talks are organized in parallel sessions in order to allow ample time for discussions among participants. Moreover, we want to run talks synchronously so that you can switch between the sessions to attend the talk you would like to. We are glad to see over 50 participants joining the event and contributing to its creative atmosphere. The regular talks will be published in proceedings, of the multiconference Information Society, while the best talks of the MATCOS will be invited to appear in a special issue of journal Informatica.

At last but not least we want to thank the members of the organization committee and staff at UP IAM, UP FAMNIT and InnoRenew CoE that made this event possible to happen by their devoted work and help.

We wish you a pleasant stay and an inspiring conference in Koper!

Koper, October 10th, 2019

Rok Požar, chair of organizing committee
Andrej Brodnik, co-chair of programme committee

Organizing committee:
Balázs Dávid
Branko Kavšek
Matjaž Krnc
Rok Požar, chair

KEYNOTE SPEAKER

Thomas Pock

TU Graz, Austria

Thomas Pock, received his MSc (1998-2004) and his PhD (2005-2008) in Computer Engineering (Telematik) from Graz University of Technology. After a Post-doc position at the University of Bonn, he moved back to Graz University of Technology where he has been an Assistant Professor at the Institute for Computer Graphics and Vision. In 2013 Thomas Pock received the START price of the Austrian Science Fund (FWF) and the German Pattern recognition award of the German association for pattern recognition (DAGM) and in 2014, Thomas Pock received a starting grant from the European Research Council (ERC). Since June 2014, Thomas Pock is a Professor of Computer Science at Graz University of Technology. The focus of his research is the development of mathematical models for computer vision and image processing as well as the development of efficient convex and non-smooth optimization algorithms.

KEYNOTE LECTURE

Learning better models for imaging

In this talk I will present our ongoing activities to learn better models for inverse problems in imaging. We begin by considering classical variational approaches to inverse problems, but generalize these models by introducing a large number of free model parameters. We learn these model parameters from data using supervised learning techniques. To interpret what we have learned, we perform a nonlinear eigenvalue analysis that eventually reveals interesting properties about the regularization properties of the learned models. We show applications for various inverse problems in imaging, with special emphasis on image reconstruction from undersampled MRI data.

REGULAR PAPER ABSTRACTS

On the notion of duals of certain AB functions

Amar Bapić, Enes Pasalic, Samir Hodžić

keywords: bent vectorial Boolean function, AB power function, dual AB function, Walsh spectra

In this paper we employ two different notions of duals of certain classes of Boolean functions which are used for the purpose of deriving other interesting combinatorial objects from suitable mappings from $\mathcal{F}_2^n$ to $\mathcal{F}_2^n$. A class of particular interest in this context is almost bent (AB) functions having the property that their (Walsh) spectral characterization possess a desired structure. We give a general result regarding the Gold AB functions, state one conjecture regarding the Welch AB functions and some computational results for the Kasami AB functions. Applying another definition of dual, introduced by *Hodžić et al.* [7] we provide computational evidence that the duals of Gold AB functions may build a space of bent functions (vectorial bent) though a more rigour theoretical analysis is needed.

A new graph decomposition method for bipartite graphs

Béla Csaba

keywords: regularity, graph decomposition, embedding

We introduce a new graph decomposition method, which works for relatively small or sparse graphs, and can be used to substitute the Regularity lemma of Szemerédi in some graph embedding problems.

A polynomial-time algorithm for recognizing subgraph-symmetry-compressible graphs

Uroš Čibej, Jurij Mihelič

keywords: graph theory, compression, symmetries

Symmetries in graphs represent a natural mechanism to reduce redundancies in graph representations. We present a class of graphs that can be compressed using symmetries and an extension of this class that encompasses many more graphs from practice. We call the extended class subgraph-symmetry-compressible graphs. For this class, we demonstrate that it can be recognized in polynomial time.

Pseudo Random Number Generators Based on Compositions of Automata

Pál Dömösi, József Gáll, Géza Horváth, Norbert Tihanyi

keywords: pseudorandom number generator, automata network, products of automata

This talk is devoted to propose a novel PRNG based on compositions (temporal products of special Gluškov products) of abstract automata. By a simple example, its utility is shown. However, serious security analysis, evaluation according to the randomness, rigorous machine-independent investigation and discussion over how the PRNG proposed in this article compares to the literature on PRNG should also be necessary in the future work.

Simulation Framework for Evaluating Production Networks

Péter Egri, József Váncza, Ádám Szaller, Judit Monostori

keywords: logistics optimization, agent-based simulation, robustness

The manuscript presents the ongoing development of an agent-based production network simulation framework. The simulation is intended to analyze the high level (strategic and tactical) planning problems decomposed into simple subproblems, similarly to the practical approach applied by the Enterprise Resource Planning (ERP) systems. The background, the goals and the design of the framework are described, and some preliminary experiments with the current phase of the development are shown.

Process network solution of an extended multi-mode resource-constrained project scheduling problem with alternatives

Zsolt Ercsey, Nándor Vincze, Zoltán Kovács

keywords: multimode resource-constrained project scheduling, hydropower construction project, Process network, alternatives

When dealing with project scheduling problems, generally there are four basic parameters considered in connection with the activities, i.e. duration, resource constraints, logical connections to the other activities within the project including presence of precedence, and the mode of execution. As a special subfield, the multimode resource-constrained project scheduling problem (MRCPSP) has emerged and has gained significant attention recently. Here, the term multimode usually refers to the fact that each activity within the project can be executed within multiple duration time considering multiple resource allocations. When considering the resources that activities require, there are renewable resources, for example manpower, and nonrenewable resources, for example an overall budget. Obviously, these resources are always limited to some extent. In principle, when considering this kind of problems, during the project

the resource requirements of the activities do not change over the time. Moreover, each activity must be performed in only one of the possible modes, and mode switching is not allowed during execution.

A well known example of the above mentioned problem class is a large scale hydropower construction project, that was published by Xu and Feng (2014). They model the hydropower construction as three parallel subprojects, where uncertainties, fuzzy random environment and hybrid particle swarm optimization algorithms were considered, generating a single fixed real value as the duration of the activities, helping to minimize time and cost for the overall project.

In the current paper the MRCPSP is extended, namely MRCPSP problems are considered where each activity may be executed in parallel in two different modes. First it is shown how a directed bipartite process network should be generated that represents the original MRCPSP issue. Second, the corresponding mathematical programming model is formulated. It is explained and illustrated, how multimode activities, called alternatives, may be executed in parallel to each other and yet be considered together. Time optimal and cost optimal mathematical programming models are given. Finally, the aforementioned hydropower construction project is presented as illustration.

On the Combination of Finite State Transducers and Finite Automata with Translucent Letter

Madeeha Fatima, Benedek Nagy

keywords: t-input automata, automata with translucent letters, closure properties, Mealy automata, formal languages, finites state machines

Transduced-Input Non-deterministic Finite Automata with Translucent Letters, i.e., T-inputNFAwtl are studied. The class of languages accepted by this model is considered. Finite automata with translucent letters are extensions of the usual finite state automata allowing to proceed the input not strictly left to right manner. T-inputFAwtl is a further extension of finite automata with translucent letters. The input is preprocessed by a finite state transducer and then it is given to finite automata with translucent letters, i.e., FAwtl. T-inputFAwtl has more expressive power than FAwtl. We present that the language class accepted by T-inputNFAwtl is closed under union (if the same transducer is used), and it is closed under intersection with regular languages.

On a possible use of optimality conditions in interval Branch and Bound methods

Boglárka G.-Tóth

keywords: Interval Branch and Bound, Nonlinear Programming, Optimality conditions

Interval Branch and Bound methods (IBB) are used when rigorous solutions are needed for Nonlinear Programming (NLP) problems. Nowadays, various implementations of IBB exist, although many of them do not use the Karush-Kuhn-Tucker (KKT) or Fritz-John (FJ) optimality conditions for eliminating non-optimal boxes. When it is used, it is used only in the general form, where an interval linear system of equations needs to be solved. This is rather time-consuming, and in many cases it has a negative outcome: the tested box cannot be removed because with the overestimation on the inclusion of the gradients one can find that the optimality conditions may fulfill. In order to save unnecessary computations, the common rule is to apply such tests only when the box is "small enough". However, depending on the problem at hand "small enough" might be difficult to predict.

The idea in this research is to investigate the use of the optimality conditions from a geometrical point of view and to minimize the computational effort when the optimality conditions cannot be used to discard the given box. In this way, there is no need to predict when to apply the test on optimality conditions and so it may become more efficient. In this paper, we describe a method that checks if the conic hull of the enclosure of the gradients of the active constraints is not full, so the test can have a positive outcome.

On the membership problem for some classes of random context grammars

Zsolt Gazdag

keywords: Random context grammars, membership problem, complexity, NP-hardness

In this paper we show that the (uniform) membership problem for permitting random context grammars is NP-hard. A similar result is shown for a restricted class of forbidding random context grammars.

Empirical Study of S-graph Approaches for Limited-Wait Storage Policy

Máté Hegyháti, Olivér Ősz, Tibor Holczinger

keywords: scheduling, limited-wait storage policy, S-graph

Storage limitations of intermediate materials add an additional layer of complexity to the scheduling of batch chemical processes.

Not only the storage capacities have to be taken into account, the properties of the intermediates in question often pose limitations on the storage time as well.

In this paper, different techniques are discussed, which allow proper modeling of such timing limitations within the S-graph framework.

The introduced techniques were implemented and tested on literature examples and case studies, to identify the most efficient one.

Visualization of 3D Earth using GIS services

Aljaž Jeromel, Mitja Žalik, Matej Brumen, Niko Lukač

keywords: 3D Computer Graphics, Visualization, Digital Earth

In this paper, a method is presented for rendering a 3D digital Earth. The method works in three steps. Firstly, the world map is partitioned into square tiles and multiple levels of detail. Then, the transformation from 3D to 2D is reversed, vertices are calculated, and connected into triangles. In the final step, the vertices are offset to model the Earth's terrain. The RAM usage and FPS of the proposed method were measured in regard to the number of GIS map layers. Experimental results have shown that the proposed method is suitable for real-time visualization of the Earth, even when multiple map layers are used.

A simulator to study the stability of network centrality measures

Orsolya Kardos, András London, Tamás Vinkó

keywords: Network science, Centrality measures, Stability, R language

Measuring nodes' importance in a network and ranking them accordingly is a relevant task regarding many applications. Generally, this measurement is done by a real-valued function that evaluates the nodes, called node centrality measure. Nodes with the largest values by a centrality measure usually give the highest contribution in explaining some structural and functional behavior of the network. The stability of centrality measures against perturbations in the net work is of high practical importance, especially in the analysis of real network data that often contains some amount of noise. In this paper, by utilizing a simulator we implemented in R, a formal definition of stability introduced in

[13] and various perturbation methods are used to experimentally analyze the stability of some commonly used node centrality measures.

Portfolio selection based on a configuration model and hierarchical clustering for asset graphs

András London, Imre Gera

keywords: Correlation matrix, Complex networks, Clustering, Portfolio selection

In this paper we present a null model based clustering method for asset graphs constructed of correlation matrices of financial asset time series. Firstly, we utilize a standard configuration model of the correlation matrix that provides the

null model for comparison with the original one. Based on this comparison we define a distance matrix – called asset graph – on which we perform hierarchical clustering procedures. We apply this method to find clusters of similar assets in correlation based graphs obtained form various stock market data sets. We evaluate the performance of the procedure through the Markowitz portfolio selection problem by providing a simple asset allocation strategy based on the obtained cluster structure.

An ILP Formulation for a Variant of the University Timetabling Problem

Martin Milanič, Nevena Pivač, Jernej Vičič

keywords: university timetabling, integer linear programming, mathematical modelling

In the paper we consider a university timetabling problem, the problem of assigning courses to time intervals with respect to certain conditions. The problem is known to be NP-hard so no efficient solution methods are known for it. We define the Famnit Timetable Design problem, a natural generalization of the actual timetabling problem for the Faculty of Mathematics, Natural Sciences and Information Technologies at the University of Primorska (UP FAMNIT). We develop a mathematical model based on integer linear programming for solving this NP-complete problem. The model is implemented using programming language Zimpl and evaluated using Gurobi. A timetable representing the result of the implementation is compared with the one made by hand.

Energy usage minimization with the S-graph framework

Olivér Ősz, Máté Hegyháti

keywords: scheduling, combinatorial optimization, sustainability

This paper proposes an extension of the S-graph framework for minimizing energy usage. The S-graph framework is a methodology for solving batch process scheduling problems.

It was originally developed for makespan minimization of chemical batch processes. Since then, the framework has been extended to various scheduling problems arising in different applications.

The hereby presented extension aims to incorporate sustainability metrics, as objectives and constraints, into the S-graph framework. The proposed approach can be used to minimize total energy consumption while satisfying demand within a given time horizon, waste limitations, and energy availability.

Statistics-based chain code compression with decreased sensitivity to shape artefacts

David Podgorelec, Andrej Nerat, Borut Žalik

keywords: Chain code, Dynamic programming, Pseudo-statistical model

Chain codes compactly represent raster curves. To further improve the compression, several statistics-based techniques assign shorter extra codes to frequent pairs of consecutive symbols. We systematically extend this concept to sequences of up to six symbols. A curve may thus be described by exponentially many overlapped chains, and the dynamic programming is proposed to determine the optimal one. We also propose utilization of multiple averaged hard coded pseudo-statistical models, since the exact statistical models of individual curves are huge and may also significantly differ from each other. A competitive compression efficiency is assured in this way and, as a pleasant side effect, it is less affected by the shape, rasterization algorithm, noise, and resolution, than in other contemporary methods.

Conflict Resolving - A Maximum Independent Set Heuristics for Solving MaxSAT

Julian Reisch, Peter Großmann, Natalia Kliewer

keywords: Heuristics, Optimization, SAT, Maximum Independent Set

Many combinatorial optimization problems of practical relevance can be formulated as Maximum Satisfiability problems (MaxSAT). There is an easy polynomial reduction from SAT and hence MaxSAT to the Maximum Independent Set Problem (MIS). We propose a fast heuristic algorithm for the MIS called Conflict Resolving (CR) and apply it to transformed MaxSAT instances. The algorithm on the transformed instances performs equally well and sometimes even better than MaxSAT solvers directly applied to the MaxSAT instances do. We prove this with experimental results where we compare our approach to state-of-the-art MaxSAT solvers submitted for the MaxSAT challenges of 2018 and 2019 in the incomplete track.

Combining algorithms for vertex cover and clique search

Sandor Szabo, Bogdan Zavalnij

keywords: minimum vertex cover, maximum clique, kernelization

We look closely to two NP-hard problems, the minimum vertex cover and the maximum clique problem. Strictly from mathematical point of view they are absolutely the same problem. Interestingly some algorithms are better for the first one and other for the second one. Why is there such a difference? Can one make a better algorithm by combining the two approaches?

Splitting partitions and clique search algorithms

Sandor Szabo, Bogdan Zavalnij

keywords: maximum clique, branch and bound, parallelization

Dividing a graph into two smaller ones in the course of a clique search algorithm is referred to as branching. In the most commonly used clique search procedures the sizes of the resulting subgraphs may widely differ. In an earlier work a novel branching method, the method of splitting partitions, was suggested to over come this inbalance. The present paper revisits this branching idea. This time we will describe a practical technique to construct splitting partitions. In order to assess the performance of the procedure we carried out numerical experiments.

Method for estimating tensiomyography parameters from motion capture data

Dino Vlahek, Tadej Stošić, Tamara Golob, Domen Mongus, Miloš Kalc

keywords: Tensiomyography, marker-based motion capture, 3D points, geometric transformation

Tensiomyography is a muscle performance assessment technique that measures its mechanical responses. In this study, we explore a possibility to replace traditional tensiomyography measurement system with motion capture. The proposed method allows for measurement of multiple muscle's points simultaneously, while achieving measurements during a patient's movements. The results show that approximately 5mm error is achieved when estimating maximal muscle displacement, while time delay in muscle contraction and contraction time are assessed with up to 20ms error. As confirmed by physicians, the introduced errors are with the acceptable margin and, thus, the obtained results are medically valid.

ParallelGlobal with Low Thread Interactions

Dániel Zombori, Balázs Bánhelyi

keywords: Optimization algorithms, Parallel algorithms, Global optimization

Global is an optimization algorithm conceived in the '80s. Since then several papers discussed improvements to the algorithm, but adapting it to a multi-thread execution environment is only a recent branch of development [1]. Our previous work focused on a parallel implementation on a single machine but sometimes the use of distributed systems is inevitable. In this paper we introduce a new version of Global which is the first step towards a fully distributed algorithm. While the proposed implementation still works on a single machine, it is easy to see how gossip based information sharing can be built into and be utilized by the algorithm. We show that ParallelGlobal is a feasible way to implement Global on a distributed system. Further improvements must be made to have a practical algorithm for real world problems.

SHORT PAPER ABSTRACTS

Scalable Algorithms for Group Centrality in Large Graphs

Eugenio Angriman, Alexander van der Grinten, Henning Meyerhenke

keywords: group centrality, graph mining, large-scale network analysis, greedy approximation

Identifying important vertices is a fundamental task in network analysis. To this end, several vertex centrality measures have been introduced, and many of those can naturally be generalized to groups of vertices. This brings the interesting problem of maximization i.e., finding the group of vertices with highest group centrality score. For several group centrality measures this problem has been shown to be NP-hard. To address this issue, approximation algorithms were proposed, but they fail to scale to large real-world networks. In recent work, we addressed this lack of scalability from two directions.

First, we introduce GED-Walk, a novel centrality metric inspired by Katz centrality. Similarly to Katz centrality, GED-Walk takes walks of any length into account, and gives greater importance to shorter walks than longer walks. We describe efficient and parallel algorithms to compute the GED-Walk score of a given group, and to efficiently approximate the group of vertices with highest GED-Walk centrality. Our maximization algorithms keep lower and upper bounds of the marginal gain of every vertex to the GED-Walk score, and iteratively add to the (initially empty) group the vertex with highest marginal gain until the desired size is reached.

Experimental results show that GED-Walk improves the precision of popular graph mining applications, and that our algorithm for maximizing it (in approximation) is two orders of magnitude faster than group betweenness approximation and, for group sizes up to 100 vertices, one to two orders of magnitude faster than group closeness approximation. For real-world graphs with tens of millions of edges, our algorithms for GED-Walk maximization typically need less than one minute. Our experiments also indicate that GED-Walk maximization scales linearly with the size of the input graph.

Second, in the context of group closeness centrality, we present new local-search heuristics to compute highly central groups of vertices. Our local-search heuristics perform exchanges between vertices within the group and the rest of the graph until they reach a local optima. Experimental results show that this strategy is two orders of magnitude faster than the state-of-the-art greedy strategy, and achieves 99.4% of the solution quality.

All our algorithms are implemented on top of NetworKit, a growing open-source toolkit for large-scale network analysis.

A new and improved algorithm for online bin packing

János Balogh, József Békési, György Dósa, Leah Epstein, Asaf Levin

keywords: Bin packing, Online algorithms, Competitive analysis

We revisit the classic online bin packing problem. In this problem, items of positive sizes no larger than 1 are presented one by one to be packed into subsets called "bins" of total sizes no larger than 1, such that every item is assigned to a bin before the next item is presented. We use online partitioning of items into classes based on sizes, as in previous work, but we also apply a new method where items of one class can be packed into more than two types of bins, where a bin type is defined according to the number of such items grouped together. Additionally, we allow the smallest class of items to be packed in multiple kinds of bins, and not only into their own bins. We combine this with the approach of packing of sufficiently big items according to their exact sizes. Finally, we simplify the analysis of such algorithms, allowing the analysis to be based on the most standard weight functions. This simplified analysis allows us to study the algorithm which we defined based on all these ideas. This leads us to the design and analysis of the first algorithm of asymptotic competitive ratio strictly below 1.58, specifically, we break this barrier and provide an algorithm AH (Advanced Harmonic) whose asymptotic competitive ratio does not exceed 1.5783.

Generalizations of simplicial vertices and a new polynomially solvable case of the maximum weight clique problem

Jesse Beisegel, Maria Chudnovsky, Vladimir Gurvich, Martin Milanič, Mary Servatius

keywords: simplicial vertex, avoidable vertex, LexBFS, polynomial-time algorithm, maximum weight clique problem, hole-cyclically orientable graph

A vertex in a graph is simplicial if its neighborhood forms a clique. Many generalizations of this concept are known, including avoidable vertices (also known as OCF-vertices), simplicial paths, and their common generalization avoidable paths. We propose a general conjecture on the existence of avoidable paths, which, if true, would imply results due to Ohtsuki, Cheung, and Fujisawa from 1976 and due to Chvátal, Sritharan, and Rusu from 2002. In turn, both of these results generalize Dirac's classical result on the existence of simplicial vertices in chordal graphs. In August 2019, a proof of the conjecture was announced by Bonamy, Defrain, Hatzel, and Thiebaut.

We present an application of the concept of avoidable vertices to the maximum weight clique problem. A graph is said to be hole-cyclically orientable if it has an orientation such that every induced cycle of length at least four is oriented cyclically. These graphs form a generalization of the class of 1-perfectly orientable graphs and their subclasses chordal graphs and circular-arc graphs. By showing that Lex-BFS computes a bisimplicial

elimination ordering on these graphs, which is simultaneously a circular-arc elimination ordering, we derive an efficient algorithm that computes a maximum weight clique of a given vertex-weighted hole-cyclically orientable graph. This is the first known polynomial-time algorithm for the maximum clique problem in the class of 1-perfectly orientable graphs.

Graph-based structure estimation and correlated motion tracking in queueing situations

Csaba Beleznai, Daniel Steininger

keywords: graph-based structure estimation, computer vision based crowd analysis, deformable structure estimation, visual tracking

In recent years Computer Vision based crowd analysis has been receiving an increasing amount of attention mainly driven by applications such as crowd management for transportation efficiency or for public safety. At the same time, key enabling algorithms such as pedestrian detection and tracking have experienced a substantial improvement in terms of robustness to occlusion and clutter. However, crowd analysis continues to remain a highly ambitious topic. When many humans mutually interact within a spatially confined space, the interaction often results in complex crowd phenomena, where spatial and temporal characterization of collective human behavior by Computer Vision represents a challenge.

In this short paper we address the problem of capturing relevant correlated movement within a line formed by waiting pedestrians to estimate the time needed for the last person to reach the queue front. Pedestrians within the observed scene are detected by a passive stereo vision system using a common occupancy map clustering technique. To obtain a waiting time estimate we propose to solve two interlinked problems: queue shape delineation and motion characterization estimating the propagation velocity along the segmented queue. To obtain the most plausible path delineating the queue shape we formulate the search as an open Traveling Salesman Problem (oTSP) with a fixed start. This optimization scheme implies that we seek to find the shortest path - starting from a predefined point - which visits all the vertices (where vertices represent an unordered set of locations within the crowd where correlated motion occurs) exactly once, without returning to the starting point. The optimality condition of this path search refers to minimizing its length while maximizing its overlap with observed correlated motion patterns. To capture the collective motion of the crowd within the queue we employ a deformable chain structure to temporally aggregate the relevant short-term forward movement by tracking. The resulting tracked chain structure is used to generate a mean forward propagation velocity estimate. The presented approach represents a general analysis scheme, requiring only a set of tracked pedestrians on a calibrated ground plane at every frame.

Our main contribution is a graph-based optimization and temporal update scheme relying on tracked, coherently moving local clusters, enabling a temporally smooth queue shape variation. Furthermore, a chain-shaped structure is introduced accumulating individual forward motion in order to accomplish an ensemble tracking mechanism capturing the time- and space-averaged forward motion for large queue segments. We validate our approach on two long video sequences with different queue characteristics, demonstrating that the proposed approach accomplishes accurate results in terms of shape, mean velocity and waiting time, when compared to manually annotated ground truth. Our approach is agnostic with respect to the employed human detection and tracking scheme generating the input tracking data. Its parameters based on meaningful metric units, thus the same set of parameters can be used in different scenarios while maintaining the same high quality of statistical estimates.

Fair division of indivisible goods with conflict constraints

Nina Chiarelli, Matjaž Krnc, Martin Milanič, Ulrich Pferschy, Nevena Pivač, Joachim Schauer

keywords: Fair Division, Special Graph Classes, Pseudo-Polynomial Algorithms

We study a variant of the fair division problem of indivisible goods, where a set of items has to be divided among agents such that the least satisfied agent is as satisfied as possible.

In our variant, we consider the case that the number of agents is constant, however an additional graph structure on the items to be divided is introduced. This structure represents possible incompatibilities or conflicts between the items under consideration. We call the problem fair k-division with conflicts.

We give several negative complexity results for special graph classes, for example we prove strong NP-completeness for bipartite conflict graphs and only two agents by a reduction from maximum clique. Moreover we also give pseudo-polynomial algorithms for various other conflict graph classes like chordal graphs and co-comparability graphs. Due to the connection of the fair k-division with conflicts to the knapsack problem, these positive results are indeed best possible.

On the solutions of an exact model for influence maximization

Eszter Csókás, Tamás Vinkó

keywords: influence maximization, integer linear programming, centrality, community detection

Influence maximization (IM) is a challenging combinatorial optimization problem, which attracted lots of attention from network science research. Recently, an interesting formalization was proposed by Keskin & Gürel which describes the problem as integer linear optimization (ILP) for the linear threshold spreading model. In this paper we report

the preliminary results on our closer look on the solution provided by the slightly modified ILP model. As one of the possibilities, some basic heuristics are obtained which can be applied for selection of the seed nodes of the original IM problem.

Online scheduling with estimates on the total size

György Dósa, Hans Kellerer, Attila Tomas Olaj, Zsolt Tuza

keywords: semi online, competitive ratio, makespan minimization

We deal with the semi online scheduling model, where in advance given a lower bound and an upper bound for the total size of jobs, and we have two identical machines to schedule the jobs, and the makespan is minimized. In the previous similar semi online model the exact value of the total size was given. So now we have a little bit fewer information in advance, and this model is never considered before.

We give tight or almost tight estimates of the best possible competitive ratio of any algorithm with respect of r, where r is the ratio of the upper and lower bound of the total size.

Cycle Traversability for Claw-free Graphs and Polyhedral Maps

Ervin Gyori, Michael Plummer, Dong Ye, Xiaoya Zha

keywords: claw-free graph, cyclability, topological wheel minor, k-link, Perfect's Theorem, polyhedral map

Let *G* be a graph, and $v \in V(G)$ and $S \subseteq V(G) \backslash v$ of size at least *k*.

An important result on graph connectivity due to Perfect states that, if *v* and *S* are *k*-linked, then a *(k-1)*-link between a vertex *v* and *S* can be extended to a *k*-link between *v* and *S* such that the endvertices of the *(k-1)*-link are also the endvertices of the *k*-link. We begin by proving a generalization of Perfect's result by showing that, if two disjoint sets S_1 and S_2 are *k*-linked, then a *t*-link ($t < k$) between two disjoint sets S_1 and S_2 can be extended to a *k*-link between S_1 and S_2 such that the endvertices of the *t*-link are preserved in the *k*-link.

Next, we are able to use these results to show that a 3-connected claw-free graph always has a cycle passing through any given five vertices, but avoiding any other one specified vertex.

We also show that this result is sharp by exhibiting an infinite family of 3-connected claw-free graphs

in which there is no cycle containing a certain set of six vertices but avoiding a seventh specified vertex.

A direct corollary of our main result shows that, a 3-connected claw-free graph has a topological wheel minor W_k with $k \leq 5$ if and only if it has a vertex of degree at least *k*.

Finally, we also show that a graph polyhedrally embedded in a surface always has a cycle passing through any given three vertices, but avoiding any other specified vertex. The result is best possible in the sense that the polyhedral embedding assumption is necessary, and there are infinitely many graphs polyhedrally embedded in surfaces having no cycle containing a certain set of four vertices but avoiding a fifth specified vertex.

Sketch-Based Influence Maximization in Generalized Negative Model

László Hajdu, Miklós Krész

keywords: Generalized negative model, Influence maximization, Sketch-based method

To understand and control the spread of different effects between individuals, the key is to analyse the real-world process, and create a model which fits to the actual case. One of the most well-known models is the Independent Cascade (IC) by Kempe et. al [1], which was generalized and extended by Bóta et. al. [2]. The Generalized Independent Cascade (GIC) provides possibility to include real world processes and structure independent probabilities into the model. To use the structure of the connections and control the spread on a network, the general solution is the influence maximization in which the objective is to maximize the spread on the network with k initial infectors. Nevertheless, the basic IC problem is not able to handle initial knowledge about the individuals, and distinguish the different cases based on our interactions with the network.

To overcome the above constraints, in the negative model, we use the network from the Generalized Independent Cascade model, where initial probabilities on the nodes are given. Nevertheless, based on the influence maximization part, each node has an additional probability -which is generally lower than the original probability- and it is activated with this additional probability when the actual node is in the initial infected set. The objective of the negative model is to decrease the final expected value of the simulation by targeting nodes and changing their initial probabilities to the negative probability.

In this talk, we will introduce the negative model, to decrease the network effect with targeted infectors, furthermore we will extend the sketch-based influence maximization method Cohen et. al [3] to the generalized negative model. The extension of the method is far from trivial with considering the two different probabilities on the nodes. The different application areas in the sensor network placement problem, and churn minimization will be also presented.

Centrality measures and matrix factorization in weighted signed networks

Viktor Homolya, Tamás Vinkó

keywords: weighted signed network, centrality measure, low-rank matrix factorization

The mutual assessment of users in trust networks can be modeled by weighted signed graphs (WSN). Link prediction in WSNs has great theoretical and practical interest as it can lead to insights on the nodes of the graph as well as applicable solutions of real-life problems. Among many possibilities, the usage of fairness and goodness measures of Kumar et al. ICDM 2016 leads to scalable, accurate and robust prediction results. As the approach shows similarities to low-rank matrix factorization methods and node centrality measures we take a journey into these exciting fields as they are, to our knowledge, relatively undiscovered for weighted signed networks.

It's not whom you know, it' what you (or your friends!) can (help you) do: game-theoretic measures of helping centrality in social networks

Gabriel Istrate, Cosmin Bonchis, Claudiu Gatina

keywords: cooperative game theory, centrality measures, social networks, helping centrality

We advocate the representation of measures of network centrality using a framework that explicitly encodes agent capabilities and tasks to be completed. One concrete such proposal blends a social network representation with the coalitional game-theoretic formalism of coalitional skill games (Bachrach and Rosenschein, AAMAS'2008).

The main application of our framework is the introduction of some new network centrality measures that attempt to quantify the extent to which a node in a social network can enlist its neighbors to help a random coalition complete certain tasks.

Advanced facility location models for the placement of charging stations in e-mobility

Anna Elisabeth Kastner, Peter Greistorfer, Rostislav Staněk

keywords: electric vehicles, recharging, facility location

In order to propagate reduction in environmental pollution, it is essential to stimulate the use of electric vehicles (EVs). Compared to conventional-fuel vehicles, nowadays EVs have a relatively small driving range. Thus a dense network of charging stations (CSs), guaranteeing that vehicles can reach their destinations without running out of fuel, is essential. This requirement usually contrasts with a limited CSs construction budget, which makes it necessary to choose their locations deliberately.

In the deterministic flow refuelling location problem (DFRLP), described by de Vries and Duijzer (2017), the number of EVs, which can make their trip without running out of fuel, is maximized, while the number of CSs is given. In our talk four extensions considering different objectives and various constraints to the DFRLP are introduced and evaluated:

1) In the first extension we ask how many CSs are necessary to cover a pre-specified number of EVs and therefore exchange the original objective function for a minimizing cost function.

2) Further, our research shows that, when considering location-dependent construction costs, results heavily depend on the relations of said cost differences. Tests for different cost scenarios are carried out and policy implications are discussed.

3) The DFRLP assumes that the capacity of a charging station is sufficient to refuel all traffic flows, using it, regardless of the EVs number, which want to be refuelled there. In contrast, we believe that an increasing acceptance of EVs requires the consideration of a restricted capacity at each CS. This capacity is put into relation to the total sum of demands generated by all EVs, passing a particular CS, which means that our model determines the placement and the sizes of all CSs simultaneously.

4) The last extension considers the probability of failures at potential facility locations while deploying an infrastructure in order to guarantee a so-called minimum path reliability for a certain number of EVs.

All model extensions are finally analysed using randomly generated problem instances based on test instances introduced for the DFRLP.

Graph Clustering via Generalized Colorings

András London, András Pluhár

keywords: Graph clustering, graph coloring, embeddedness

Graph clustering is a well studied problem and has important applications in developing models. The usual methods try to achieve lots of edges inside clusters and only a few between those. To measure their efficacy the parameter Newman modularity is used in general. However, this approach is not always justified. Certain bipartite graphs, e.g. pollinator networks, or trade graphs suggest different structure, especially the notion of *embeddedness*. That is the vertices of each color class can be ordered, and the smaller ranked vertex neighborhood contains the neighborhood of any higher ranked one. We offer a new kind of clustering of general, not necessary bipartite, transaction graphs via colorings. The clusters are the color classes, and we restrict the structure of the edges between the pairs of classes. In general, if a good coloring of a graph *G* does not contain the induced copy of a graph *H*, it is a good *H*-coloring, and $\chi_H(G)$ is the minimal number of colors in a good *H*-coloring of *G*. We show that that computation of $\chi_H(G)$ is NP-hard

for some graphs, and polynomially computable for others. The most interesting case when $H \cong 2K_2$ gives back embeddedness mentioned above. For these generalized chromatic numbers we derive some

theoretical results and propose heuristics for finding good *H*-colorings.

Interaction of hardware and implementation in large-scale optimization

Csaba Meszaros

keywords: large-scale optimization, vector instructions, multithreading, implementation

The talk concerns the implementation of interior point methods for solving large-scale optimization problems. In our investigation we focus on the exploitation of the vector and parallel processing capabilities of modern processors and show the benefits and limitations of these features in the framework of large-scale optimization. We discuss how the different vector instructions influence the data structures and algorithms implemented and the benefits in the performance of the optimization software.

Complexity and Approximation of the Product Knapsack Problem

Ulrich Pferschy, Joachim Schauer, Clemens Thielen

keywords: knapsack problem, complexity, approximation

In the classical 0-1 knapsack problem (KP) the objective function consists of maximizing the sum of profits over all selected items. In this contribution we consider the product knapsack problem (PKP), where the product of profits over the chosen items is maximized. This problem was recently introduced by D'Ambrosio, Furini, Monaci and Traversi in the paper On the Product Knapsack Problem,

Optimization Letters (2018). While for strictly positive profits the problem could be transformed to KP by simply taking the logarithm of the objective function, the problem becomes more interesting if also negative profits are allowed. Of course, it only makes sense to have an even number of them in a solution.

We show by a non-trivial reduction that this recently introduced variant of KP is weakly NP-hard. Then we present a fully polynomial-time approximation scheme (FPTAS) for the problem based on dynamic programming by profits. Again, it is not enough to apply a logarithm to the well-known FPTAS for KP.

Note that the standard greedy-type algorithm fails to give a constant approximation ratio for PKP. However, we also analyze the approximation quality achieved by a natural extension of the classical greedy procedure to the product knapsack problem and state asymptotically tight bounds depending on the instance data.

Graph model for machine configuration and workload balancing problem in multiple product PCB assembly

Attila Tóth

keywords: scheduling, workload balancing, printed circuit board

In recent electronic industry, the assembly of electronic components on Printed Circuit Boards (PCB) is one of the most crucial tasks. Here, gantry type placement machines are popular because of the flexibility of their configurations. The Machine Configuration and workLoad Balancing (MCLB) problem determines the proper configurations of the machine modules in the assembly line and the allocation of the component placements among the modules minimizing the total production time. This is a hard optimization problem, especially in multi-model case, when the assembly line produces several batches of multiple PCB types using a common machine setup for all PCB types. In this study, a graph model is presented for the multi-model problem (MCLB-M). Such an exact definition of an optimization problem gives a chance to find the critical points of the problem which make a problem instance difficult or easy. Knowing of these key features is important for developing effective algorithms and evaluation of the solution methods.

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PROGRAM

Thursday

12:30	**Registration**	
13:45	**Official opening** - VP1	
14:00	**Invited talk** - VP1	
	Chair: Gábor Galambos	
	Thomas Pock: Learning better models for imaging	
15:00	**Coffee break**	
	Session A - VP2	Session B - MP1
15:30 -- 16:45	**Practical applications 1**	**Formal languages and automata**
	Chair: Thomas Pock	*Chair: Miklós Krész*
15:30	*Dino Vlahek, Tadej Stošić, Tamara Golob, Domen Mongus and Miloš Kalc*: Method for estimating tensiomyography parameters from motion capture data	*Pál Dömösi, József Gáll, Géza Horváth and Norbert Tihanyi*: Pseudorandom Number Generators Based on Compositions of Automata
15:55	*Aljaž Jeromel, Mitja Žalik, Matej Brumen and Niko Lukač*: Visualization of 3D Earth using GIS services	*Madeeha Fatima and Benedek Nagy*: On the Combination of Finite State Transducers and Finite Automata with Translucent Letter
16:20	*Orsolya Kardos, András London and Tamás Vinkó*: A simulator to study the stability of network centrality measures	*Zsolt Gazdag*: On the membership problem for some classes of random context grammars
16:45	**Coffee break**	
17:15 -- 18:30	**Practical applications 2**	**Scheduling**
	Chair: Gerhard Reinelt	*Chair: Ulrich Pferschy*
17:15	*András London and Imre Gera*: Portfolio selection based on a configuration model and hierarchical clustering for asset graphs	*Zsolt Ercsey, Nándor Vincze and Zoltán Kovács*: Process network solution of an extended multi-mode resource-constrained project scheduling problem with alternatives
17:40	*David Podgorelec, Andrej Nerat and Borut* Žalik: Statistics-based chain code compression with decreased sensitivity to shape artefacts	*Olivér Ősz and Máté Hegyháti*: Energy usage minimization with the S-graph framework
18:05	*Amar Bapić, Enes Pasalic and Samir Hodžić*: On the notion of duals of certain AB functions	*Máté Hegyháti, Olivér Ősz and Tibor Holczinger*: Empirical Study of S-graph Approaches for Limited-Wait Storage Policy
19:30	**Conference dinner**	

Friday – morning

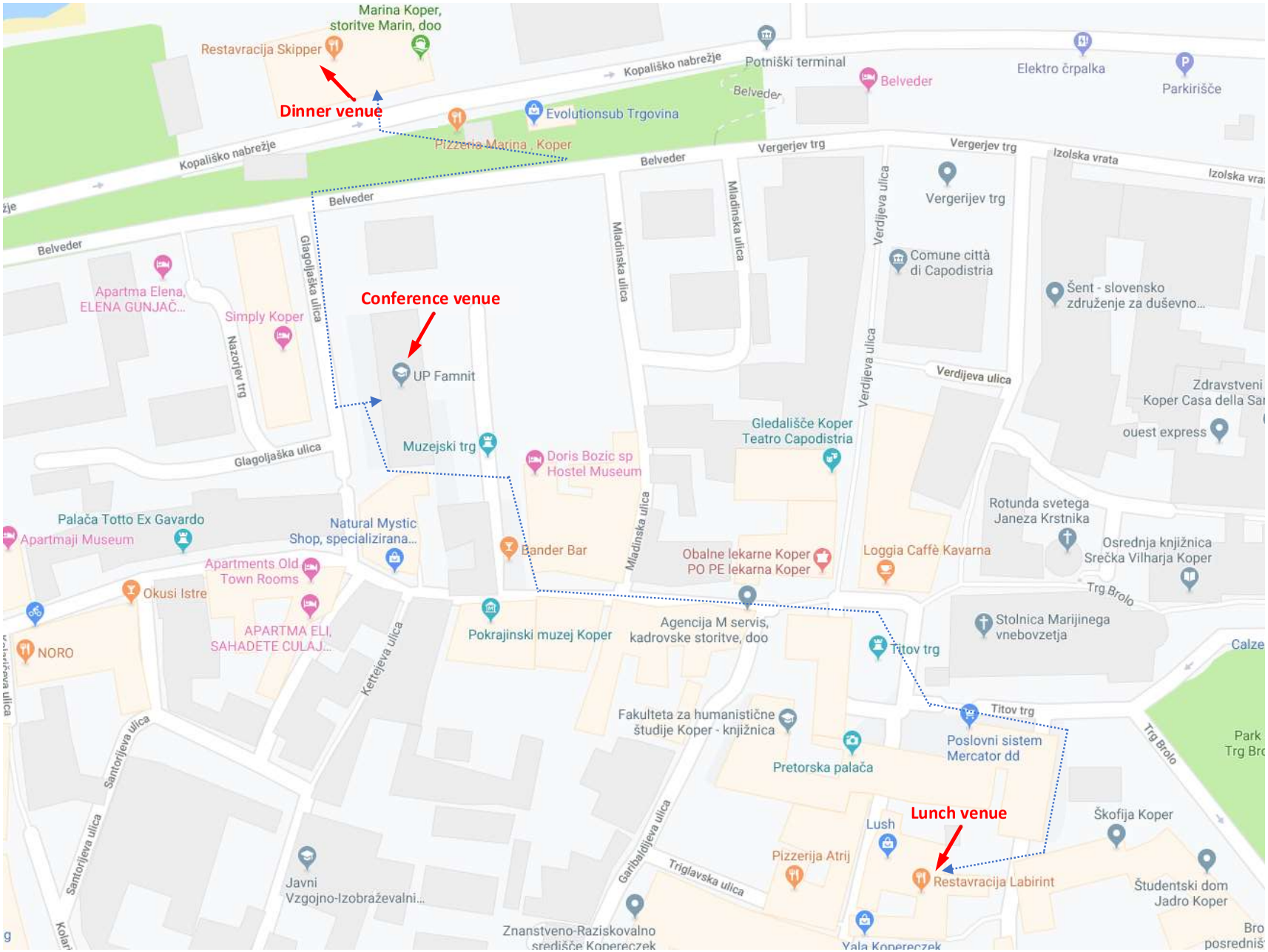
08:30	**Registration**	
	Session A - VP2	Session B - MP1
09:00 -- 10:00	**Influence maximization and centrality**	**Knapsacks, bins and facility location**
	Chair: Ervin Győri	*Chair: Benedek Nagy*
09:00	*László Hajdu and Miklós Krész*: Sketch-Based Influence Maximization in Generalized Negative Model	*Ulrich Pferschy, Joachim Schauer and Clemens Thielen*: Complexity and Approximation of the Product Knapsack Problem
09:15	*Eszter Csókás and Tamas Vinko*: On the solutions of an exact model for influence maximization	*János Balogh, József Békési, György Dósa, Leah Epstein and Asaf Levin*: A new and improved algorithm for online bin packing
09:30	*Eugenio Angriman, Alexander van der Grinten and Henning Meyerhenke*: Scalable Algorithms for Group Centrality in Large Graphs	*Nina Chiarelli, Matjaž Krnc, Martin Milanič, Ulrich Pferschy, Nevena Pivač and Joachim Schauer*: Fair division of indivisible goods with conflict constraints
09:45	*Viktor Homolya and Tamas Vinko*: Centrality measures and matrix factorization in weighted signed networks	*Anna Elisabeth Kastner, Peter Greistorfer and Rostislav Staněk*: Advanced facility location models for the placement of charging stations in e-mobility
10:00	**Coffee break**	
10:30 -- 12:10	**Practical solving hard problems 1**	**Graphs 1**
	Chair: Borut Žalik	*Chair: Gabriel Istrate*
10:30	*Boglárka G.-Tóth*: On a possible use of optimality conditions in interval Branch and Bound methods	*Sandor Szabo and Bogdan Zavalnij*: Splitting partitions and clique search algorithms
10:55	*Martin Milanič, Nevena Pivač and Jernej Vičič*: An ILP Formulation for the University Timetabling Problem at UP FAMNIT	*Sandor Szabo and Bogdan Zavalnij*: Combining algorithms for vertex cover and clique search
11:20	*Julian Reisch, Peter Großmann and Natalia Kliewer*: Conflict Resolving - A Maximum Independent Set Heuristics for Solving MaxSAT	*Bela Csaba*: A new graph decomposition method for bipartite graphs
11:45	*Péter Egri, József Váncza, Ádám Szaller and Judit Monostori*: Simulation Framework for Evaluating Production Networks	
12:15	**Lunch**	

Friday – after lunch

14:00 -- 15:25	Practical solving hard problems 2	Graphs 2
	Chair: Andrej Brodnik	*Chair: József Békési*
14:00	*Dániel Zombori and Balázs Bánhelyi*: Parallel Global with Low Thread Interactions	*Uroš Čibej and Jurij Mihelič*: A polynomial-time algorithm for recognizing subgraph-symmetry-compressible graphs
14:25	*Csaba Meszaros*: Interaction of hardware and implementation in large-scale optimization	*Csaba Beleznai and Daniel Steininger*: Graph-based structure estimation and correlated motion tracking in queueing situations
14:40	*Jesse Beisegel, Maria Chudnovsky, Vladimir Gurvich, Martin Milanič and Mary Servatius*: Generalizations of simplicial vertices and a new polynomially solvable case of the maximum weight clique problem	*Attila Tóth*: Graph model for machine configuration and workload balancing problem in multiple product PCB assembly
14:55	*György Dósa, Hans Kellerer, Attila Tomas Olaj and Zsolt Tuza*: Online scheduling with estimates on the total size	*András London and András Pluhár*: Graph Clustering via Generalized Colorings
15:10	*Gabriel Istrate, Cosmin Bonchis and Claudiu Gatina*: It's not whom you know, it' what you (or your friends !) can (help you) do: game-theoretic measures of helping centrality in social networks	*Ervin Gyori, Michael Plummer, Dong Ye and Xiaoya Zha*: Cycle Traversability for Claw-free Graphs and Polyhedral Maps
15:25	**Conference closing** - VP2	

All 3 lecture rooms – **VP1**, **VP2** and **MP1** – are located on the **1st floor** of the "conference venue" building.

Coffee break will be available on the hallway and in the small meeting room on the **1st floor** of the "conference venue" building.


Dinner venue
Conference venue
Lunch venue
Marina Koper, storitve Marin, doo
Restavracija Skipper
Kopališko nabrežje
Potniški terminal
Belveder
Elektro črpalka
Parkirišče
Evolutionsub Trgovina
Pizzeria Marina , Koper
Vergerjev trg
Izolska vrata
Vergerijev trg
Mladinska ulica
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Comune città di Capodistria
Šent - slovensko združenje za duševno...
Apartma Elena, ELENA GUNJAČ...
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UP Famnit
Muzejski trg
Doris Bozic sp Hostel Museum
Gledališče Koper Teatro Capodistria
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Pokrajinski muzej Koper
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Titov trg
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Fakulteta za humanistične študije Koper - knjižnica
Pretorska palača
Poslovni sistem Mercator dd
Park Trg Bro
Lush
Škofija Koper
Pizzerija Atrij
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Garibaldijeva ulica
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Javni Vzgojno-Izobraževalni...
Znanstveno-Raziskovalno središče Koperčzek
Yala Koperczek