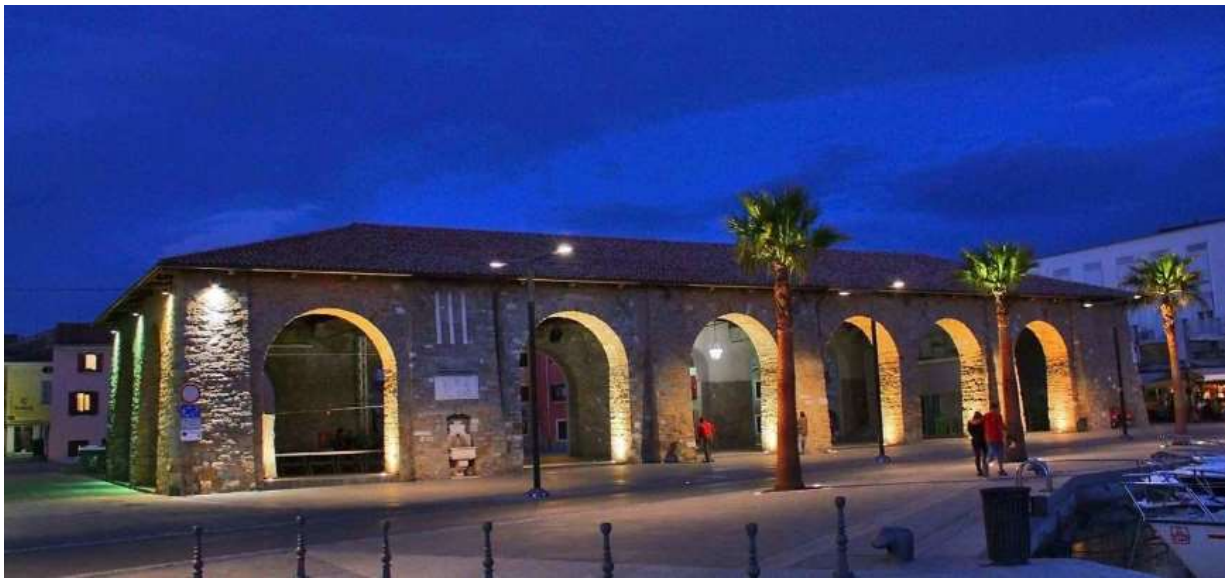
MATCOS-22

Middle-European Conference on Applied Theoretical Computer Science

13 - 14 October 2022

Koper, Slovenia



Part of **International multiconference** ***Information Society 2022***

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Dear participants of MATCOS-22,

We are pleased to welcome you at the University of Primorska – the Faculty of Mathematics, Natural Sciences and Information Technologies (UP FAMNIT) and the Andrej Marušič Institute (UP IAM).

Our driven and a relatively young teaching and research team brings flexibility and adaptability to the needs of our students, while research excellence and international involvement open up the possibility of continuing the study path also at prestigious universities abroad. We are very proud of numerous academic and research achievements of our students, professors, and researchers.

Since we last hosted the MATCOS conference in 2019, we have reached several important milestones, and we are already planning the organization of international scientific events in the future. (1) Last June, we successfully hosted the second largest scientific gathering of Mathematicians in the world – the 8th European Congress of Mathematics, which was attended by more than 1.700 participants from 77 countries. (2) The names of researchers from UP FAMNIT and UP IAM are on the list of the most cited scientists and researchers in 2020, published by Elsevier in October last year. (3) In February this year, we celebrated the opening of the the InnoRenew CoE building – the largest wooden building in Slovenia. This project, financed by the European Commission, is the biggest European project in Slovenia and is significantly boosting the development of the research in the field of renewable materials and healthy living environment. (4) In April 2023, University of Primorska is co-organizing the European Girls' Mathematical Olympiad (EGMO) 2023. The event will be attended by more than 250 competitors from more than 60 countries and is hosted by the Society of Mathematicians, Physicists and Astronomers of Slovenia (DMFA Slovenije). (5) In September 2023, we will host the 32nd World Congress of the International Association for Suicide Prevention (IASP), which is a special honor and proof of the excellent work of researchers in the field of suicide, who have been working at the University of Primorska since 2011 as part of the Slovenian Centre for Suicide Research (SCRS) at UP IAM.

Our research activities are also marked by successes in obtaining projects within the framework of various national and international programs. Each year, we continue to successfully consolidate our place in the international environment, either in the field of mathematics, where we have been at the top of the world in algebraic graph theory for many years, or in other, still developing research areas.

An indicator of the international involvement of the faculty is also a large increase in the enrollment of students from abroad. In the academic year 2022/23, their share represents as much as 47 percent of all enrolled students. Strengthening openness, accessibility and cooperation with international partners has enabled the faculty to include a greater number of foreign experts in teaching processes and in research activities, and to offer some study programs in both Slovenian and English languages. With the aim to attracts prospective IT experts from the wider area, we offer the undergraduate Computer Science programme in English as well. International cooperation and mobility of professors and researchers is therefore at the core of the faculty's activities.

Additionally, UP FAMNIT and UP IAM organise or co-organise successful international conferences, some of which have become traditional. Students, professors and researchers participate in international scientific conferences, meetings and summer schools in their fields worldwide. They frequently attend events as invited speakers, and give lectures to students at international universities.

Year after year, an increasing number of reputable foreign professors and researchers are visiting the Faculty and the Institute (more than 100 annually), while a few hundred also attend our events.

Researchers at the Department of Information Science and Technologies 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. The achievements of our researchers often attract the attention of the international environment. In one of the latest studies, our researchers and colleagues proved, that working in virtual reality (VR) has a significantly more negative impact on people’s productivity compared to working in a physical office environment. In addition to publication in the prestigious IEEE TVCG, the article also attracted the attention of New Scientist and many more popular science and technology publications.

Within the HICUP Lab (“Humans Interacting with Computers” Lab at University of Primorska) we host an international group of researchers trying to make digital world fit for humans. Our researchers strive to explore novel interaction concepts, advance sensing methods and find new ways of improving personalized services through the usage of psychological models in personalisation algorithms.

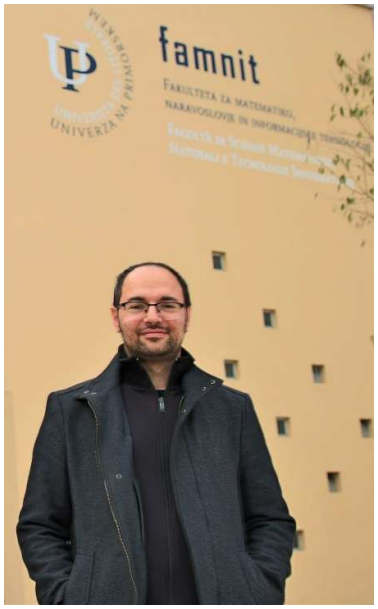
We also place great emphasis on the organization or participation in events aimed at popularizing science. Along with numerous project activities, we organize round tables, lectures and other activities aimed at different audiences. Some good examples of this kind of communication with the public are cooperation in the European Researchers’

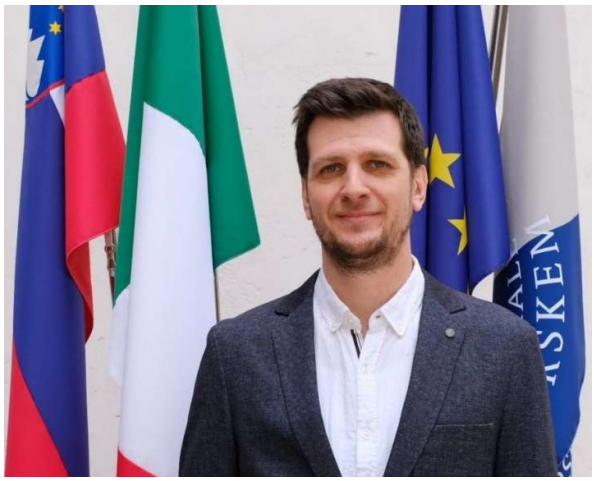
Night, organization of Mathematical Advent Calendar and Mathematics and Computer Science summer camps.

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.

Being a Faculty and Institute of science, we have been reaching our goals by opening ourselves toward the future and the international community from the beginning. We have always perceived the youth of our institutions as an advantage, that enabled us to create an enthusiastic climate full of motivation, which is often noticed by our visiting researchers, students and other partners.

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 MATCOS-22 conference and we hope that its programme will exceed your expectations. Let this year's event be another excellent opportunity to make new contacts and exchange knowledge, that opens the horizons of science.





Ademir Hujdurović

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 2022), 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 2022 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 *György Turán* from *University of Illinois at Chicago and Research Group on AI, University of Szeged*. Its title is *Interpretability of deep-learned error-correcting codes*.

This year we again introduced besides regular talks also short ones. 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 11 regular papers and 21 short papers. 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 40 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.

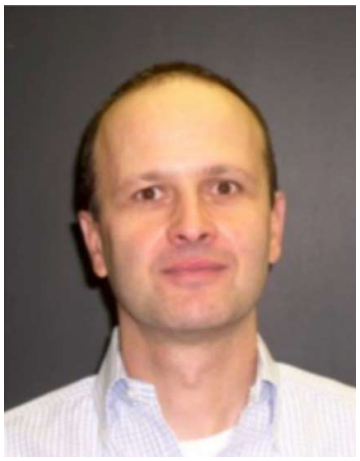
We wish you a pleasant stay and an inspiring conference in Koper!

Koper, October 10th, 2022

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



György Turán

University of Illinois at Chicago and
Research Group on AI, University of Szeged

György Turán received his Ph.D. at the Jozsef Attila University in Szeged in 1982. He was at a visiting position at the Institut fur Operations Research of the University of Bonn in 1983-84. Currently he is a Professor at the Department of Mathematics, Statistics and Computer Science at the University of Illinois at Chicago, and a Senior Research Fellow at the MTA-SZTE Research Group on AI of the ELRN at the University of Szeged. His current main interest is interpretability in machine learning. Previously he worked in complexity theory, computational learning theory, commonsense reasoning and combinatorial and logic problems related to these topics.

KEYNOTE LECTURE

Interpretability of deep-learned error-correcting codes

Error-correcting codes have been studied since Shannon's work more than 70 years ago, and many families of good codes have been designed using algebraic and combinatorial methods. Recently, codes have been constructed using deep learning. Are these codes similar to traditional ones, or do they provide new types of codes? This question is important from the practical point of view, and it is also interesting as a case study of incorporating deep learning into scientific research. We present approaches to interpreting a particular deep-learned code using techniques such as discrete optimization, influence, property testing and Fourier analysis.

Joint work with N. Devroye, N. Mohammadi, A. Mulgund, H. Naik, R. Shekhar, Y. Wei and M. Zefran.

REGULAR PAPER ABSTRACTS

Approximate Keys and Functional Dependencies in Incomplete Databases With Limited Domains--Algorithmic Perspective

Munqath Al-Atar, Attila Sali

keywords: strongly possible functional dependencies, strongly possible keys, incomplete databases, approximate functional dependencies, approximate keys

A possible world of an incomplete database table is obtained by imputing values from the attributes (infinite) domain to the place of **NULL**s. A table satisfies a possible key or possible functional dependency constraint if there exists a possible world of the table that satisfies the given key or functional dependency constraint. A certain key or functional dependency is satisfied by a table if all of its possible worlds satisfy the constraint. Recently, an intermediate concept was introduced. A strongly possible key or functional dependency is satisfied by a table if there exists a strongly possible world that satisfies the key or functional dependency. A strongly possible world is obtained by imputing values from the active domain of the attributes, that is from the values appearing in the table. In the present paper, we study approximation measures of strongly possible keys and FDs. Measure g_3 is the ratio of the minimum number of tuples to be removed in order that the remaining table satisfies the constraint. We introduce a new measure g_5, the ratio of the minimum number of tuples to be added to the table so the result satisfies the constraint. g_5 is meaningful because the addition of tuples may extend the active domains. We prove that if g_5 can be defined for a table and a constraint, then the g_3 value is always an upper bound of the g_5 value. However, the two measures are independent of each other in the sense that for any rational number $0 \leq \frac{p}{q} < 1$ there are tables of an arbitrarily large number of rows and a constant number of columns that satisfy $g_3 - g_5 = \frac{p}{q}$. A possible world is obtained usually by adding many new values not occurring in the table before. The measure g_5 measures the smallest possible distortion of the active domains.

We study complexity of determining these approximate measures.

Online Bin Covering with Exact Advice

Andrej Brodnik, Bengt J. Nilsson, Gordana Vujovic

keywords: online algorithms, competitive analysis, advice complexity, bin covering

We show a $2/3$–competitive strategy for the one-dimensional bin covering problem using $O(b + \log n)$ advice, where b is the number of bits used to encode a rational value and n is the length of the input sequence.

A Neural Network Based Classification Algorithm for Asthma Using Capnography

József Békési, Gábor Galambos, András Kelemen, Imre Papp, József Tolnai

keywords: decision support, neural networks, capnography

This article presents a neural network-based method to help physicians diagnose and monitor asthma and other chronic respiratory diseases. The method is based on capnography, using measurement data from a specially developed handheld device.

After proper preparation, various parameters are calculated on the capnographic curve from which healthcare professionals can conclude the condition of the patient's respiratory system.

Another purpose of using the calculated parameters is to serve as a learning base for an artificial intelligence application that can be used in the decision support of physicians. The shape of the capnogram obtained from the gas sample exhaled by the patient and thus the parameters calculated from it are different for healthy people and those with respiratory diseases.

Subsets without arithmetic subsequences: computational experiments and unsatisfiable cores

Uroš Čibej, Ervin Győri

keywords: satisfiability, solvers, modelling, combinatorics

A reduction to satisfiability of a combinatorial problem of minimal saturated subset without arithmetic subsequences is given in this paper. We conduct an empirical evaluation and present previously unknown optimal solutions for certain instances of the problem. The results also show where the limits for computing the optimal solutions are. Finally, we present a new possibility for solving such combinatorial problems, namely the unsatisfiable cores of the SAT expressions, which could give new insights to mathematicians and possibly new methods for solving the problem computationally.

Exact time measuring challenges

Tomaž Dobravec

keywords: empirical algorithm analysis, time measuring, accuracy, reliability, comparing Java C and ASM

In this paper, we focus on implementations of the BubbleSort algorithm in three different programming languages: Java, C, and x86 assembler. Using the ALGator system we execute these implementations with different inputs and perform an empirical evaluation of the results. We discuss the importance of test repetition for achieving accurate timing results. We show that the Java and the C implementations achieve similar efficiency and that the quality order depends on the type of input data.

Systematic generation of precedence based MILP models with P-graphs for multipurpose scheduling problems

Máté Hegyháti

keywords: scheduling, model generation, precedence, MILP, P-graph

Scheduling of various processes is a widely researched topic in the literature. Different fields have their own specific constraints and parameters, thus, specialized approaches often emerge to tackle these needs efficiently. Solution methods have many flavors from general mathematical models such as mathematical programming, constraint programming; through general purpose heuristics, e.g., genetic algorithms, ant colony optimization; to problem specific tools like the ***S***-graph framework.

A general aim of any newly developed method is to perform efficiently, and provide the optimal solution quickly, preferably faster than existing approaches. However, each tool has its strengths and weaknesses, and even for a well defined problem class, it is often not trivial to select the best approach for a problem instance in advance. This work focuses on a prerequisite of this dilemma: having the set of approaches to consider.

The aim of the paper is to present a modeling approach which enables the systematic generation of sound MILP models for a problem class. To illustrate this approach, a well known scheduling problem class from the batch process industry is considered, and the investigation is limited to only a specific type of MILP formulations, namely the general precedence models.

On relations of Watson-Crick finite automata to other computational paradigms

Benedek Nagy

keywords: Watson-Crick automata, sticker systems, formal languages, finite state machines, stateless automata, external contextual grammars, linear languages

In this paper, we study some language classes that are accepted by some variants of Watson-Crick finite automata, i.e., with a 2-head model of finite automata working on Watson-Crick tape modeling DNA molecules. We show relation between sticker systems and stateless traditional Watson-Crick automata where the two heads scan the input in the same direction. We also establish a new connection between external contextual grammars with choice to the sensing $5' \rightarrow 3'$ Watson-Crick automata, i.e., to the 2-head model of finite automata where the two heads starting from the two extremes of the input and they move in opposite direction till they meet.

Local reflection symmetry detection in Earth observation data

David Podgorelec, Luka Lukač, Borut Žalik

keywords: approximate symmetry, voxelization, line segment, merging

We propose a new algorithm which detects patterns with reflection symmetry in Earth observation data. It must consider approximate symmetries as the acquisition of input datasets is not able to provide exact pairs of symmetric elements. Therefore, we look for symmetries between voxels, not between the input points. Furthermore, the nature of such data implies that the symmetric patterns in the top view are the most interesting and, thus, it suffices to detect symmetries with vertical symmetry planes. The symmetry detection may thus be split into horizontal voxel slices and the results with the same symmetry plane are then merged. At the end, the resulting symmetries are ranked with respect to the number of voxels involved. Early results obtained for some voxelisations of two LiDAR datasets of different sizes are promising both in terms of the detection speed and quality of solutions.

Surrogate Component Approach for a Synchronization Problem

Alain Quilliot

keywords: operations research, combinatorial optimization, machine learning

We deal here with electric vehicles, provided in energy by a local photovoltaic micro-plant, with limited storage and time-dependent production capacities, and one wants to synchronize energy production and consumption. Because of the complexity of resulting bi-level model, we handle with it by short-cutting the production level through surrogate estimators, whose values are computed with the help of flexible pricing and machine learning devices.

Building energy demand regression

Tamás Storcz, István Kistelegdy, Zsolt Ercsey

keywords: heating energy, regression, neural network, regression tree

In the paper the applicability of regression models for building heating energy estimation is examined. During the experiment, regression models were created to estimate annual heating energy demand of generic family houses. Non-linearity of regression models was enhanced by creating non-linearly correlated new input variables. Then performance of generated models was measured and compared. As a result, multilayer dense neural net model with original input parameters was proposed. Its performance was almost equal to linear regression with extended input variables, but its structural and functional flexibility makes it applicable in wider range of such tasks.

Clique relaxations of zero-one linear programs

Sandor Szabo, Bogdan Zavalnij

keywords: discrete optimization, clique, independent set, weighted clique, zero-one program, parallel computing, preprocessing

In an earlier work a so-called conflict graph was associated to a given zero-one linear program basically to accumulate information to construct cuts to speed up the solution of the program. Later it was noticed that the conflict graph can be used in fixing values of variables and fathoming partial solutions in enumerative type solvers. In this paper we will show that the conflict graph helps in dividing a zero-one linear program into independent smaller instances and so it opens a way for a parallel solution. Further the conflict graph suggests certain possibilities for preprocessing and simplifying the given zero-one linear program.

SHORT PAPER ABSTRACTS

Covering a square with consecutive squares

Janos Balogh, Gyorgy Dosa, Lars Magnus Hvattum, Tomas Attila Olaj, Zsolt Tuza

keywords: covering, packing, combinatorial optimization, Saskatchewan

We define a new problem, which is the following: Given squares of size 1,2,...,n let us cover completely with these squares (allowing overlap each other) the biggest possible square. The packing version (where the squares cannot overlap and should be packed into the smallest accommodation square) is studied for a long time, but the present covering version seems a new research direction. It is clear that the square root of the sum of areas of the squares (rounding down) is an upper bound for the problem. The n=24 case is uniquely interesting and very hard, since for n=24 the sum of the squares' areas is just 70∗70, so for this n value the two problems (is it possible to pack all items into a 70∗70 board; or is it possible to completely cover the 70∗70 big square) are the same. Its investigation started already in 1966. This is the only one n value (except n=1) for which the sum is a square number. For small n values the covering problem is easy, and we give the optimal solutions. These can be calculated "by hand" or by a Cplex solver, after writing up the model of the problem. There are several ways to write up such a model, we present and discuss some of them. For moderately bigger n values as n=23, problem is already hard for Cplex. so we give a metaheuristic algorithm, that can find near optimal solutions also for big n values. We also provide an expansion-kind algorithm, that from a given good cover for some n, can generate a relatively good cover for some n'. We also prove, that a simple covering policy can generate asymptotically optimal covering.

Oriented discrepancy and anti-discrepancy in dense graphs

Bela Csaba, Andras London, Andras Pluhar

keywords: discrepancy, hypergraph, embedding

Discrepancy type problems on hypergraphs have been addressed recently. In the general setting given a hypergraph $H = (X, E)$ with vertex set X and edge set E, and a red-blue coloring of its vertices. For this coloring the imbalance of an edge $A \in E$ is the absolute value of the difference of the red and blue vertices in A. The discrepancy of H is the maximum guaranteed imbalance over all edge in E for any coloring of the vertices. Hypergraph H often originates from a graph, i.e. X is the edge set of some graph G, and E is a family of certain (spanning) subgraphs of G.

Approximations of influence diffusion inspired by exact models

Eszter Julianna Gyulainé Csókás, Tamás Vinkó

keywords: influence maximization, deterministic linear threshold, centrality metrics

Perhaps one of the most actively studied problems in network science is influence maximization (IM) which is a combinatorial optimization problem. In our recent work we proposed an exact ILP model and iterative solution approach to solve the IM problem under the so-called deterministic linear threshold spreading model. Since the solution describes how the diffusion happens for different time constraints, in every iteration we solve different optimization problem. The algorithm provides 3 types of solutions: Time-aware diffusion, Global optimum diffusion and Time-aware global optimum.

Using those solution types, every node obtains a special value which characterizes them: the timestamp when the node got already influenced. We aim to approximate these values based on the specific properties of the graph for the task by using different combinations of centrality metrics. This way we can make some kind of prediction about the course of the spread of influence based on the structure of the underlying graph.

Classes of graphs with tree-independence number at most two

Clément Dallard, Martin Milanič, Mirza Redžić

keywords: tree decomposition, treewidth, tree-independence number, induced minor, series parallel graph

Graph width parameters have become one of the most popular tools for dealing with NP-hard graph problems. In 2021, Dallard, Milanič, and Štorgel introduced a new graph width parameter called tree-independence number, which is defined similarly as the treewidth, except that, instead of minimizing the maximum size of a bag in a tree decomposition, it aims at minimizing the maximum size of an independent set of vertices contained in the same bag. Many problems related to independent sets are solvable in polynomial time on graphs with bounded tree-independence number. While the class of graphs with tree-independence number at most one coincides with the class of chordal graphs, Dallard, Fomin, Golovach, Korhonen, and Milanič showed in 2022 that for every $k \geq 4$, it is NP-complete to recognize graphs with tree-independence number at most k.

We identify several classes of graphs in which the tree-independence number is bounded by two. We also discover three graphs with tree-independence number three, but whose every proper induced minor has tree-independence number at most two. We completely characterize the property of having tree-independence number bounded by two within the class of graphs with treewidth at most two. In particular, we show that within this class of graphs the tree-independence number is at most 2 if and only the graph excludes one particular 9-vertex graph, which we denote by C_6^*, as an induced minor, and otherwise it equals 3.

Eliminating vertex coloring in clique search

Matjaž Depolli, Bogdan Zavalnij

keywords: clique, algorithm, vertex coloring

This paper discusses the use of coloring in clique search algorithms with emphasis on ***k***-clique search. Clique-search problems are NP-complete and can be efficiently implemented with a branch-and-bound algorithm, which organizes the search in form of a binary search tree. The search algorithm holds an internal state – a clique formed from consumed vertices and an ordered list of remaining vertices for consumption. It consumes vertices of the input graph one by one, modifying its internal state until the stopping condition is satisfied.

The advantages of DH-Cipher

Pál Dömösi, Géza Horváth, Adama Diene

keywords: IoT, cipher, security

The first two authors published a novel stream cipher in 2017, called DH-cipher. This cipher has several advantages comparing other stream ciphers. In more details, the cipher they have developed can replace older, out-of-date technology, and due to its simplicity it can be used well in all cases where older, more complex systems cannot be used due to memory requirements, operation requirements, or complexity. As opposed to the most common stream ciphers, the developed stream cipher is resistant to the known plaintext-ciphertext attack. We can state that the discussed cipher provides high security with simple operations, so their integration into any application is easy, even with low computing capacity, low-cost hardware. Therefore, the considered system is highly innovative compared to existing and currently used solutions. Present stream ciphers use the technologies of the 20th century, while our system is based on patent applications from 2017 and 2019, it is using the latest scientific results, and satisfying the requirements of the 21st century, such as the challenges of the IoT (Internet of Things).

A fast clustering algorithm for Interference Minimization in Future Wireless Networks

Peter L. Erdos, Tamás Róbert Mezei

keywords: clustering of edge weighted graphs, spectral clustering algorithms, next generation wireless networks

We propose a simple but fast method for providing high quality solutions for the sum-interference minimization problem in communication networks. As future networks are deployed in high density, improved clustering methods are needed to provide low interference network connectivity. The problem fits perfectly into the NP-hard edge-ratio cut clustering problem for general, edge weighted graphs. However, this particular application lives in edge weighted bipartite graphs but it is still NP-hard. Our proposed algorithm depends heavily on the underlying special structure, and it applies straightforward similarity based clustering to outperform state of the art spectral algorithms. The running times of our algorithms are dominated by one matrix multiplication.

Simplification of the KKT optimality test in Interval Branch and Bound method

Mihály Gencsi, Boglárka G.-Tóth

keywords: optimality conditions, Karush-Kuhn-Tucker, Fritz-John, interval branch and bound

The interval branch and bound method (IBB) is the most used method for solving nonlinear programming problems when a rigorous solution is needed. Few IBB implementations use the Karush-Kuhn-Tucker or Fritz-John optimality conditions for eliminating non-optimal boxes. In general, the solution of an interval-valued system of equations is needed. Solving this equation sometimes is difficult because the actual interval box contains more than one result or many unnecessary conditions. In many cases, this has a negative outcome and only increases the computing time. In this study, the optimization conditions are considered from a geometric point of view. We offer a geometrical optimality test, aiming to speed up the IBB method and eliminate unnecessary calculations.

The maximum number of short paths in planar and outerplanar graphs

Ervin Gyori

keywords: paths, planar graphs, outerplanar graphs, extremal graphs

In a generalized Turan problem, we are given graphs ***H*** and ***F*** and seek to maximize the number of copies of ***H*** in an ***F***-free graph of order ***n***. We consider generalized Turan problems where the host graph is planar or outerplanar. With Ghosh, Martin, Paulos, Salia, Xiao, and Zamora, we proved that the number of paths of length ***3*** in a planar graph is ***n3*** plus a negligible term. In general, we know just the order of magnitude of the number of paths of length ***k*** ...

In outerplanar graphs, the problem is somewhat easier, but surprisingly, just by somewhat. Matolcsy and Nagy proved that the number of paths of length ***2*** is at most $(n^2 + 3n – 12)/2$. With Paulos and Xiao, we proved that the number of paths of length ***3*** is at most $2n^2 - 7n + 2$ and that that the number of paths of length ***4*** is at most $17n^2/4$ plus a negligible term. For longer paths, we have just estimates ...

We show nice constructions of planar and outerplanar graphs showing the sharpness of the estimates and the conjectures.

Mapping of transition rates between matrix population models and lattice models

András G. Hubai, Géza Meszéna, Beáta Oborny

keywords: population dynamics, matrix population models, lattice population models, parameter correspondence

Population ecology relies on both matrix population models (MPM) and cellular automata simulations in understanding population dynamics and equilibrium distributions. These methods share the assumptions that individuals belong to discrete groups (based on e.g. age), and change groups with constant transition rates. It should be desirable to combine the two methods, i.e. to apply the rates of ca. 10.000 experimentally collected matrices to spatial simulations. The fundamental difficulty of this approach is that lattice population models are density-dependent while MPMs are not: the transition rates of MPMs reflect **successful** transitions while the rates of lattice models are transition **attempts**. Simultaneous attempts to the same location cannot all lead to successful transition; this is more frequent as the density increases. Here we aim to show a method that maps MPMs (cf. mean-field approximations) to lattice models with matching equilibrium distributions, considering several dispersion processes. We will proceed to show an application of such mappings in the study of clonal plants.

Intelligent system process for Home Delivery Problem in the city of Paris

Haifa Jammeli, Jerome Verny

keywords: last-mile problem, unsupervised learning, hierarchical approach

Due to the pandemic of covid-19, E-commerce (electronic commerce) keeps rising at a rapid rate. Several companies used a home delivery service model that helps customers to order products online and have them delivered directly to their front door. This paper aims to develop a model for smart green delivery in the city of Paris, one of the fastest-growing areas in France. Several multimodal fleets with a finite capacity are located at the depot. The multimodal fleet must transport the product to each potential delivery location (urban hubs). The product is then delivered to a final customer using a green smart delivery. The proposed model determines the number, the types and the routes of the fleet to be allocated to each urban hub while minimizing the delivery costs and greenhouse gas emissions as much as possible. The problem can be presented as a bi-objective optimization problem, as cost minimization will be ensured by the optimal assignment of the determined minimum number and types of multimodal fleet. This model has been initiated to solve a real-life problem of last-mile delivery problem in the city of Paris, and the results will help companies to lower environmental impact while maintaining good service quality.

Text and Graph Embeddings for the Knowledge Graph Matching task

Péter Kardos, Farkas Richard

keywords: knowledge graphs, graph embeddings, word embeddings

Knowledge Graphs are graphs consisting of real-world entities, their properties, and relations among them. Their nodes (entities) usually have textual description attached and the relation types also bear semantics, hence Knowledge Graphs are an interesting subject of joint graph- and text mining applications. In the Knowledge Graph matching task, there are two Knowledge Graphs from similar domains but constructed by different people, following different principles. The task is to find entity pairs for the two graphs which refer to the exact same entity.

In the Machine Learning community, embeddings trained via self-supervision has been very popular recently. The general objective of these embeddings is to map discrete structures, like sentences and graphs, to a continuous vector space where vector similarity measures approximate semantic similarity in the source discrete space. We shall introduce and discuss experimental results with graph and text embeddings for the Knowledge Graph matching task on the OAIE 2021 dataset.

Robust bilevel programming with uncertain follower objectives

Tamás Kis, András Kovács, Csaba Mészáros

keywords: bilevel programming, robust optimization, algorithms, demand response management

Bilevel programming addresses finding the equilibrium in decision problems whose outcome is decided by the interplay of multiple decision makers, namely, a Leader who makes its choice first, and one or more Followers who respond to the Leader's decision by optimizing their own objectives. Despite the remarkable advance in solving bilevel problems in the past decades, practical applications are very limited. One reason of this phenomenon is the assumption that the Leader is perfectly aware of the decision problem of its followers, which can hardly be satisfied in practice. This critical assumption can be relaxed by elaborating robust bilevel programming approaches, which assume that the parameters of the Followers are known imperfectly, and they are characterized by uncertainty sets.

We investigate robust bilevel problems where uncertainty occurs in the coefficients of the Followers' objective function in the form of polyhedral uncertainty sets, and the Followers' problems can be encoded into (robust) linear programs. The approach is illustrated on a demand response management problem in smart electricity grids. The difficulty related to solving this robust bilevel problem are discussed: while the classical bilevel variant with fully known Followers' parameters can be transformed into a single level problem by exploiting the KKT conditions, such off-the-shelf approaches are not available for the robust variant of the same bilevel problem. A column-and-constraint generation approach is proposed, which solves small or medium-sized problem instances and often proves the optimality of the computed solutions. Experimental results are presented and possible alternative solution approaches are discussed.

Using Extended Resolution to Represent Strongly Connected Components of Directed Graphs

Gábor Kusper, Imre Baják, Benedek Nagy

keywords: SAT problem, strongly connected component, extended resolution

There could be some interesting links between directed graphs and SAT problems. On the one hand, directed graphs could represent many types of objects, but in many cases, it is not so straightforward how and what type of representation lead to some advantages. Since, this problem generally seems to be very difficult, we work on a related one: represent a directed graph as a SAT problem. Here we have several models. Each of them has the following property: If the represented directed graph is strongly connected then its SAT representation has only two solutions, the one where all variables are true, and

the one where all variables are false. In this paper we study those directed graphs which consist of not only one strongly connected component (SCC), but more. In this work we show that if a directed graph consists of two components, ***A*** and ***B***, and there is an edge from ***A*** to ***B***, then the corresponding SAT representation has a third solution which is $\neg \boldsymbol{A} \cup \boldsymbol{B}$. We generalize this lemma for more complex graphs. Furthermore, we study the question how to represent an SCC by one Boolean variable to keep the previous properties. We found out that extended resolution is a suitable tool for that.

To represent the SCC which consists of only two vertices ***a*** and ***b***, we have to add to its model the following formula: $\boldsymbol{a} \wedge \boldsymbol{b}$ equals ***x***, i.e., the following clauses: $\neg \boldsymbol{a} \vee \neg \boldsymbol{b} \vee \boldsymbol{x}$, $\neg \boldsymbol{x} \vee \boldsymbol{a}$, and $\neg \boldsymbol{x} \vee \boldsymbol{b}$. This is the classical example of extended resolution, where ***x*** is a new variable.

Although, the original problem is still very difficult, this work helps us to understand better what extended resolution means, and how to represent extended resolution graphically.

Implementing the Parallel CSFLOC SAT Solver using Dynamic Variable Reordering

Gábor Kusper, Tibor Tajti, Imre Baják

keywords: SAT solver, parallel implementation, dynamic variable reordering

CSFLOC is a SAT solver which counts the subsumed full-length ordered clauses of its input SAT problem. In this work we study the question, how to create the parallel version of CSFLOC, most special, how to port it to a GPU. The basic version of CSFLOC does not create learned clauses, so it is easy to create its parallel version by portioning the problem space.

A more enhanced version creates also learned clauses which are the resolvents of the so-called touched clauses, which subsume the counted full-length ordered clauses. These new clauses have a long tail, which means that their last literal has a relatively small index. Such clauses help CSFLOC to do relatively big steps. Our question was the following: How to create and share learned clauses among parallel CSFLOC instances?

Our implementation works as follows: We assume that we have 1024 cores. We assume that the first ***n/2 – 10*** variables are negative. Then we initiate each core with a different partition of the problem with ***n/2*** variables. We share only every 5^{th} learned clauses using a shared memory. We do resolution on the results of each core. If the input is UNSAT then the result of this step is a simplified problem where the last ***n/2 + 10*** variables are not present. If there are more than ***n/2 + 10*** unpresented variables, then we gain some speed up, because the corresponding indices can be omitted. If the input SAT problem is

satisfiable, then we might be lucky to find an early solution. The parallel version, in case of a satisfiable input, is on average 500 times faster than the basic CSFLOC version with clause learning. If the input is unsatisfiable then the average speed-up is around 50 times. The new main function is the dynamic variable reordering which seems to be useful also for the sequential version which opens new research ideas.

Overlap of random spanning trees in complex networks

András London

keywords: random spanning trees, spanning tree game, small-world networks

Motivated by a previous work of Alon et al. we consider the following 2-player zero-sum game on graphs. Given a connected graph ***G***, two players ***P1*** and ***P2*** choose a spanning tree, ***T1*** and ***T2*** of ***G***, respectively, by not knowing each other's choice. ***P1***'s goal is to maximize the number of common edges of ***T1*** and ***T2***, i.e. the intersection of the two trees, while ***P2***'s goal is the opposite. Firstly, we derive some bounds on the value of the game for some graph classes. Then, we consider the case of random players that leads us to the problem of intersection of random spanning trees. That is the number of common edges, or overlap, of two spanning trees of ***G*** chosen uniformly at random. We derive a lower bound for the minimum expected intersection and applying bootstrap simulations we determine the empirical mean value for synthetic and real networks.

Experiments show that for some real networks the observed empirical mean overlap highly differs from the minimum expected. We discuss that why and how these findings provide new insights on the structure of real small-world networks.

Experimental comparison of parallel implementations of DTW algorithms

Jurij Mihelič

keywords: time series, dynamic distance warping, parallelization, experimental evaluation

There are several approaches to measuring (dis-)similarity between time series. Besides a well-known Euclidean distance, another one, called dynamic time warping, is widely used since it also considers a global alignment between the input time series. The computational effort to compute the distance is quadratic. While this is considered efficient in theory, it is often too expensive for practical purposes. To benefit from the use of modern multicore processors, we developed and implemented several parallel versions of the algorithm. In the paper, we compare these implementations and describe the results of their experimental evaluation.

Solving Data-driven Dynamic Capacitated Arc Routing Problems

Zsuzsanna Nagy, Ágnes Werner-Stark, Tibor Dulai

keywords: dynamic capacitated arc routing problem, data-driven online optimization, real-life based data, evolutionary optimization algorithms

The Dynamic Capacitated Arc Routing Problem (DCARP) is a variant of the NP-hard Capacitated Arc Routing Problem (CARP) that considers dynamic changes in it. The CARP deals with finding the most cost effective route plans (i.e., service plan) on the given road network in which all the defined demands on the road segments of the network are served exactly once by the predefined number of uniform vehicles. During the execution of the service plan, dynamic events can occur that has effect on the problem instance thus on the actuality of the currently followed plan, too. If the plan cannot be carried out anymore, then constructing a new plan is necessary as soon as possible.

In our previous work, we proposed a data-driven DCARP framework that utilizes the available data on the service vehicles' activity, the changes in the road network, and the changes in the demands. The framework handles the events that may modify the feasibility and the completeness of the currently followed service plan and constructs a new plan only when it is necessary. Until now, we evaluated the effectiveness of optimization algorithms for DCARP only on simple DCARP scenarios that are artificially generated from real-life based CARP instances and in which only one event occurred.

In this work, the above mentioned data-driven DCARP framework is improved and the improved version is used to evaluate optimization algorithms for DCARP. Inspired by the DCARP benchmarking framework introduced by Tong et al., 2022, "Benchmarking Dynamic Capacitated Arc Routing Algorithms Using Real-World Traffic Simulation.", the improved data-driven DCARP framework also handles the events that increase the total cost of the currently followed service plan and constructs a new plan if the increase exceeds a defined limit. Furthermore, in order to test the optimization algorithms for DCARP in more realistic scenarios, we use real-world traffic data to generate changes in the road network within the DCARP scenarios that are used for testing. As optimization algorithms, we use the evolutionary optimization algorithms and the deterministic algorithms, which are currently available in the literature.

Notes on Identification of Monotone Boolean Functions with Machine Learning methods

Hasmik Sahakyan, Levon Aslanyan, Gyula Katona

keywords: monotone Boolean functions, reinforcement learning, combinatorial optimization

This paper is a brief note on the main ideas, challenges and procedures solving combinatorial optimization problems with Machine Learning methods. A particular focus is on monotone models of optimization problems. We consider using machine learning components for identification of monotone Boolean function, and discuss main points of applying Reinforcement Learning algorithms.

A new exact bound for the length of a 2-increasing sequence

Boštjan Slivnik, Uroš Čibej

keywords: upper-bound, experimental results, search algorithm

This paper discussed the problem of finding the longest 2-increasing sequence of triplets. We construct a new upper-bound which is easier to compute and might give us some new insights into the general problem. We give an empirical evaluation demonstrating the new bound is indeed less time consuming.

New methods for maximizing the smallest eigenvalue of grounded Laplacian matrix

Tamás Vinkó

keywords: grounded Laplacian, linear algebra, graph vertex cover

Given a graph $G = (V,E)$ with n nodes and its Laplacian matrix L, the task is to remove $k << n$ rows and columns (corresponding to k selected nodes in G) from L such that the smallest eigenvalue of this so-called grounded Laplacian matrix of size $(n – k) \times (n – k)$ is maximal. This problem is proved to be NP-hard and it has applications in, e.g., dynamical systems. In this talk we introduce some new approaches based on classical linear algebra and vertex cover.

PROGRAM

Thursday

12:30	**Registration**	
13:45	**Official opening** – VP1	
14:00	**Invited talk** – VP1 *Chair: Gábor Galambos* *György Turán*: Interpretability of deep-learned error-correcting codes	
15:00	**Coffee break**	
15:30 – 17:00	**Machine learning** – VP2 *Chair: György Turán*	**Algorithms complexity** – MP1 *Chair: Benedek Nagy*
15:30	*Alain Quilliot*: Surrogate Component Approach for a Synchronization Problem	*Munqath Al-Atar and Attila Sali*: Approximate Keys and Functional Dependencies in Incomplete Databases with Limited Domains--Algorithmic Perspective
16:00	*Tamás Storcz, István Kistelegdy and Zsolt Ercsey*: Building energy demand regression	*David Podgorelec, Luka Lukač and Borut Žalik*: Local reflection symmetry detection in Earth observation data
16:30	*József Békési, Gábor Galambos, András Kelemen, Imre Papp and József Tolnai*: A Neural Network Based Classification Algorithm for Asthma Using Capnography	*Tomaž Dobravec*: Exact time measuring challenges
17:00	**Coffee break**	
17:30 – 18:50	**Graph theory 1** – VP2 *Chair: Ervin Győri*	**Discrete optimization** – MP1 *Chair: Borut Žalik*
17:30	*Bela Csaba, Andras London and Andras Pluhar*: Oriented discrepancy and anti-discrepancy in dense graphs	*Zsuzsanna Nagy, Ágnes Werner-Stark and Tibor Dulai*: Solving Data-driven Dynamic Capacitated Arc Routing Problems
17:50	*András London*: Overlap of random spanning trees in complex networks	*Haifa Jammeli and Jerome Verny*: Intelligent system process for Home Delivery Problem in the city of Paris
18:10	*Peter L. Erdos and Tamás Róbert Mezei*: A fast clustering algorithm for Interference Minimization in Future Wireless Networks	*Janos Balogh, Gyorgy Dosa, Lars Magnus Hvattum, Tomas Attila Olaj and Zsolt Tuza*: Covering a square with consecutive squares
18:30	*Péter Kardos and Richard Farkas*: Text and Graph Embeddings for the Knowledge Graph Matching task	*Boštjan Slivnik and Uroš Čibej*: A new exact bound for the length of a 2-increasing sequence
19:00	**Conference dinner**	

Friday – morning

08:30	**Registration**	
09:00 – 10:00	**Graph theory 2** – VP2 *Chair: Uroš Čibej*	**Optimization 1** – MP1 *Chair: Andrej Brodnik*
09:00	*Ervin Gyori*: The maximum number of short paths in planar and outerplanar graphs	*Tamás Kis, András Kovács and Csaba Mészáros*: Robust bilevel programming with uncertain follower objectives
09:20	*Clément Dallard, Martin Milanič and Mirza Redžić*: Classes of graphs with tree-independence number at most two	*Eszter Julianna Gyulainé Csókás and Tamás Vinkó*: Approximations of influence diffusion inspired by exact models
09:40	*Matjaž Depolli and Bogdan Zavalnij*: Eliminating vertex coloring in clique search	*Mihály Gencsi and Boglárka G.-Tóth*: Simplification of the KKT optimality test in Interval Branch and Bound method
10:00	**Coffee break**	
10:30 – 12:00	**Miscellaneous 1** – VP2 *Chair: Gyorgy Dosa*	**Optimization 2** – MP1 *Chair: Gerhard Reinelt*
10:30	*Uroš Čibej and Ervin Győri*: Subsets without arithmetic subsequences: computational experiments and unsatisfiable cores	*Andrej Brodnik, Bengt J. Nilsson and Gordana Vujovic*: Online Bin Covering with Exact Advice
11:00	*Benedek Nagy*: On relations of Watson-Crick finite automata to other computational paradigms	*Máté Hegyháti*: Systematic generation of precedence based MILP models with P-graphs for multipurpose scheduling problems
11:30	*Hasmik Sahakyan, Levon Aslanyan and Gyula Katona*: Notes on Identification of Monotone Boolean Functions with Machine Learning methods	*Sandor Szabo and Bogdan Zavalnij*: Clique relaxations of zero-one linear programs
12:00	**Lunch**	

Friday – after lunch

14:00 – 15:00	**Miscellaneous 2** – VP2 *Chair: Miklós Krész*	**Parallel computation** – MP1 *Chair: Gyula Katona*
14:00	*Tamás Vinkó*: New methods for maximizing the smallest eigenvalue of grounded Laplacian matrix	*Gábor Kusper, Tibor Tajti and Imre Baják*: Implementing the Parallel CSFLOC SAT Solver using Dynamic Variable Reordering
14:20	*András G. Hubai, Géza Meszéna and Beáta Oborny*: Mapping of transition rates between matrix population models and lattice models	*Jurij Mihelič*: Experimental comparison of parallel implementations of DTW algorithms
14:40	*Pál Dömösi, Géza Horváth and Adama Diene*: The advantages of DH-Cipher	*Gábor Kusper, Imre Baják and Benedek Nagy*: Using Extended Resolution to Represent Strongly Connected Components of Directed Graphs
15:00	**Conference closing** – VP1	

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.

NOTES

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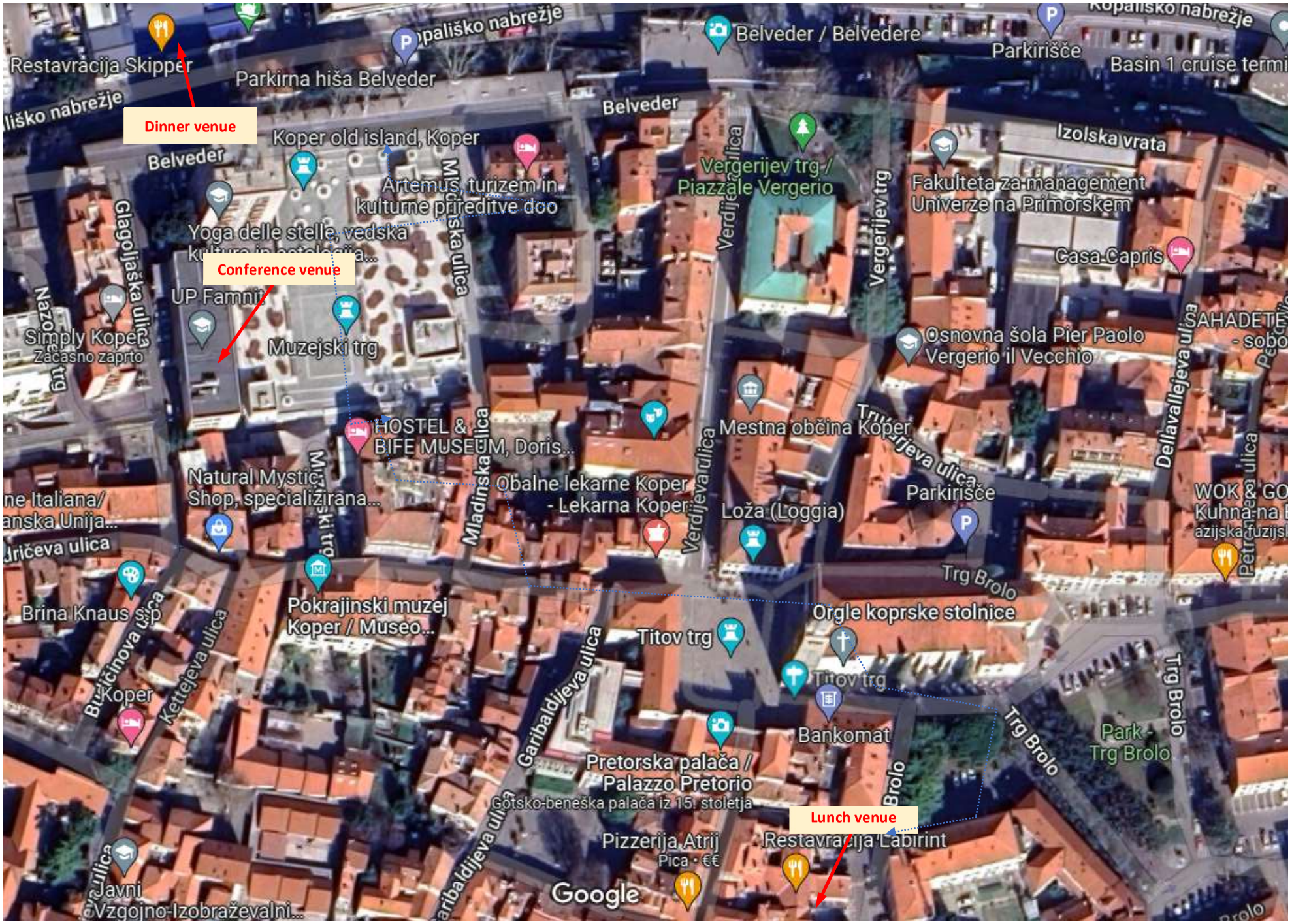
Restavracija Skipper
Dinner venue
Parkirna hiša Belveder
Belveder / Belvedere
Parkirišče
Basin 1 cruise termi
Belveder
Koper old island, Koper
Artemus, turizem in kulturne prireditve doo
Vergerijev trg / Piazzale Vergerio
Izolska vrata
Fakulteta za management Univerze na Primorskem
Yoga delle stelle, vedska
Conference venue
Casa Capris
UP Famnit
Simply Koper
Začasno zaprto
Muzejski trg
Osnovna šola Pier Paolo Vergerio il Vecchio
HOSTEL & BIFE MUSEUM, Doris...
Mestna občina Koper
Natural Mystic Shop, specializirana...
Obalne lekarne Koper - Lekarna Koper
Loža (Loggia)
Parkirišče
Brina Knaus s.p.
Pokrajinski muzej Koper / Museo...
Orgle koprske stolnice
Titov trg
Koper
Bankomat
Pretorska palača / Palazzo Pretorio
Gotsko-beneška palača iz 15. stoletja
Park - Trg Brolo
Lunch venue
Pizzerija Atrij
Pica · €€
Restavracija Labirint
Javni Vzgojno-Izobraževalni...
Google