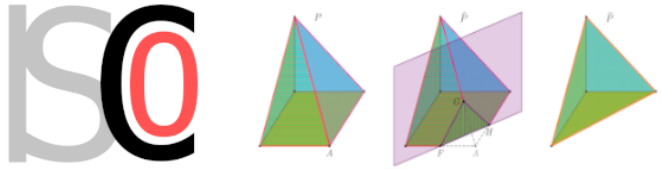
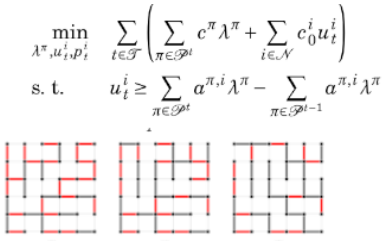


International Symposium on Combinatorial Optimization
Online conference, May 18-20, 2022
Spring School May 16-17, 2022



7th International Symposium on Combinatorial Optimization (ISCO 2022)

Online conference, France.
18-20 May 2022

Book of abstracts

Contents

Welcome to ISCO 2022!

ISCO (International Symposium on Combinatorial Optimization) is a biennial symposium whose aim is to bring together researchers from all the communities related to combinatorial optimization, including algorithms and complexity, mathematical programming, operations research, optimization under uncertainty, graphs and combinatorics. It is intended to be a forum for presenting original research in these areas and especially in their intersections. Quality papers on all aspects of combinatorial optimization, from mathematical foundations and theory of algorithms to computational studies and practical applications, are solicited.

The first issue of ISCO was held in Hammamet, Tunisia in March 2010, its second one in Athens, Greece in April 2012, its third one in Lisbon, Portugal in March 2014, its fourth one in Vietri, Italy in May 2016, its fifth one in Marrakesh, Morocco in April 2018. Originally, the sixth ISCO conference was to be held at HEC Montreal and the University of Montreal, Canada, but due to the COVID-19 pandemic the conference was held online focusing on long papers. This seventh issue will be held online too.

ISCO 2022 conference is preceded by a Spring School which is dedicated to PhD students but the lectures are also open to other colleagues.

Lecturer: Giacomo Nannicini,
Thomas J. Watson Research Center, Yorktown Heights, NY USA

Topic: An introduction to quantum algorithms for optimization

Welcome and have a great fun!

Sincerelly,
The ISCO 2022 PC chairs and OC team

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- H. Yaman (KU Leuven, Belgium)

Invited lectures

Rekha R. Thomas

University of Washington, USA

Wed 18 May
7:00pm CET

Graphical Designs

Abstract: A graphical design on an undirected graph is a quadrature rule in the following sense: Given an eigenbasis of the graph Laplacian, a design is a collection of vertices of the graph (with weights) so that the weighted average of a collection of eigenvectors on this subset equals the weighted average on the full set of vertices. Depending on which eigenvectors are to be averaged, and requirements on the weights, one obtains different types of designs. Designs can be computed via linear and integer programming. In this talk I will show that positively weighted designs can be organized on the faces of a polytope, and using this connection, we compute optimal designs in several graph families. Joint work with Catherine Babecki.

Bio: Rekha Thomas received a Ph.D. in Operations Research from Cornell University in 1994 under the supervision of Bernd Sturmfels. This was followed by two postdoctoral positions, the first at the Cowles Foundation for Economics at Yale University and the second at the Konrad-Zuse-Zentrum for Informationstechnik in Berlin. She is currently the Walker Family Endowed Professor in Mathematics at the University of Washington in Seattle. Her research interests are in optimization and applied algebraic geometry.

Thu 19 May
3:00pm CET

Rico Zenklusen

ETH Zurich, Switzerland

Advances in Approximation Algorithms for Tree Augmentation

Abstract: Augmentation problems are a fundamental class of Network Design problems. The goal is to find a cheapest way to increase the (edge-)connectivity of a graph by adding edges among a given set of options. The Minimum Spanning Tree Problem is one of its most elementary examples, which can be interpreted as determining a cheapest way to increase the edge-connectivity of a graph from 0 to 1. The "next step", to increase from 1 to 2, leads to the heavily studied Tree Augmentation Problem, which is the focus of this talk. This talk has several goals, namely:

1. Providing a brief introduction to Tree Augmentation and some related problems.

2. Discussing relevant algorithmic techniques, including the Relative Greedy method and a new link to local search procedures.

3. Showing how these techniques can be leveraged to address a long-standing open question, namely how to obtain better-than-2 approximations for (Weighted) Tree Augmentation.

Bio: Rico Zenklusen is a Professor in the Mathematics Department at ETH Zurich, heading the Combinatorial Optimization Group. Prior to joining ETH Zurich, Rico was on the faculty of the Johns Hopkins University, before which he worked several years as a postdoc at MIT, and also shortly at EPFL. Rico holds a PhD from ETH Zurich and a master's degree from EPFL. His main research interests lie broadly in Combinatorial Optimization and its applications, ranging from foundational research related to polyhedra, (poly-)matroids, and submodular functions to industrial collaborations.

Petra Mutzel

Bonn University, Germany

Fri 20 May
3:00pm CET

Algorithmic Data Science

Abstract: The area of algorithmic data science offers new opportunities for researchers in the algorithmic and the optimization community. In this talk we will first survey four fundamental problems for analysing data. The basis for these problems are concepts for distance and similarity. We will discuss similarity concepts for graphs that are relevant for analysis tasks on graph data sets. These approaches are increasingly applied in the context of data analysis tools for systems with a network structure. Applications are, e.g., learning tasks in drug design, social network analysis, and geodesy.

Bio: Petra Mutzel is professor of Computational Analytics at the University of Bonn, where she is also the scientific director of the High Performance Computing and Analytics Lab at the Digital Science Center. Before she was professor at TU Dortmund University and at Vienna University of Technology. She received her Ph.D. in Computer Science at the University of Cologne in 1994, followed by a PostDoc position at the Max Planck Institute for Informatics in Saarbrücken. Her research focuses on algorithm engineering, algorithmic data analysis, and combinatorial optimization for graphs and networks. Currently, the main application areas are in cheminformatics, social and biological network analysis, statistical physics, and geodesy. She is a member of the Steering Committees of ESA, ALENEX, and WALCOM, and Associate Editor of the ACM Journal on Experimental Algorithmics, Journal of Graph Algorithms and Applications (JGAA), and Mathematical Programming Computation (MPC).

Fri 20 May
6:30pm CET

Jon Lee

University of Michigan, USA

Recent algorithmic advances for maximum-entropy sampling

Abstract: The maximum-entropy sampling problem (MESP) is to select a subset, of given size s, from a set of correlated Gaussian random variables, so as to maximize the differential entropy. If C is the covariance matrix, then we are simply seeking to maximize the determinant of an order-s principal submatrix. A key application is for the contraction of an environmental-monitoring network. MESP sits within the intersection of optimization and data science, and so it has attracted a lot of recent attention. The problem is NP-hard, and there have been algorithmic attacks aimed at exact solution of moderate-sized instance for three decades. It is a fascinating problem from the perspective of integer nonlinear optimization, as it does not fit within a framework that is successfully attacked via available general-purpose paradigms. I will give a broad overview of algorithmic work, concentrating on the many useful techniques related to various convex relaxations.

Bio: Jon Lee obtained his Ph.D. at Cornell University. He has held long-term positions at Yale University, University of Kentucky, IBM Research, and New York University. Now at the University of Michigan, Jon is the G. Lawton and Louise G. Johnson Professor of Engineering and Professor of Industrial and Operations Engineering. He is author of "A First Course in Combinatorial Optimization" (Cambridge University Press), "A First Course in Linear Optimization" (Reex Press), and "Maximum-Entropy Sampling: Algorithms and Application" (with M. Fampa). Jon was the founding Managing Editor of the journal Discrete Optimization, and he is currently Editor-in-Chief of Mathematical Programming, Series A. Jon is an INFORMS Fellow, and he has received the INFORMS Computing Society Prize.

Parallel sessions

Session 1 : Scheduling

Wednesday 18th
1:00pm – 2:30pm CET
Room A

Worst-Case Analysis of LPT Scheduling on Small Number of Non-Identical Processors

Takuto Mitsunobu , Reiji Suda , Vorapong Suppakitpaisarn *
[1]

[1] The University of Tokyo – Japan

The approximation ratio of the longest processing time (LPT) scheduling algorithm has been studied in several papers. While the tight approximation ratio is known for the case when all processors are identical, the ratio is not yet known when the processors have different speeds. In this work, we give a tight approximation ratio for the case when the number of processors is 3,4, and 5. We show that the ratio for those cases are no more than the lower bound provided by Gonzalez, Ibarra, and Sahni (SIAM J. Computing 1977). They are approximately 1.38 for three processors, 1.43 for four processors, and 1.46 for five processors.

*Speaker

Shift scheduling with autonomous agents

Sara Mattia [1], Fabrizio Rossi *† [2], Stefano Smriglio [3]

[1] Istituto di Analisi dei Sistemi ed Informatica "Antonio Ruberti", Consiglio Nazionale delle Ricerche – Italy

[2] Department of Information Engineering, Computer Science and Mathematics University of L'Aquila – Universitá degli Studi dell'Aquila, Via Vetoio, I-67100 L'Aquila, Italy

[3] Department of Information Engineering, Computer Science and Mathematics University of L'Aquila – Universitá degli Studi del'Aquila, Via Vetoio, I-67100 L'Aquila, Italy

Employees' work breaks can have a significant impact on the performance of production and service systems. Therefore, managers are interested in scheduling breaks so as to keep safe the level of service.
On the other hand, a rigid enforcement of breaks remarkably affects employees' well-being.
This conflict is getting harder and harder in large organizations. We propose a robust optimization model for shift scheduling, where employees are free to decide when to have breaks within the regulatory restrictions. Case studies in call center industries are documented, showing the trade off between industrial costs and employees' autonomy.

*Speaker

†Corresponding author: fabrizio.rossi@univaq.it

Tool switching problems in the context of overlay printing with multiple colours

Alberto Locatelli *† [1], Manuel Iori [1], Marco Locatelli [2], Juan José Salazar [3]

[1] Department of Sciences anMethods for Engineering, University of Modena and Reggio Emilia, – Italy

[2] Department of Engineering and Architecture, University of Parma – Italy

[3] Departament of Mathematics, Statistics and Operational Research, University of La Laguna – Spain

This paper addresses problems arising in the context of overlay printing with multiple colors, where a finite set of jobs must be sequentially performed by a printing machine which can simultaneously accommodate a limited number of colors. Each job is associated with a subset of colors that the machine must have stored in its magazine before starting the execution. Thus, some color switches may be required between the execution of two consecutive jobs. Since color switches imply a reduction of productivity, minimizing them is desirable. In this regard, we address three distinct problems of increasing difficulty. For each problem we discuss its complexity and propose a mathematical programming model.

*Speaker

†Corresponding author: alberto.locatelli@unimore.it

Session 2 : Approximation algorithms I

Wednesday 18th
1:00pm – 2:30pm CET
Room B

Polynomial-Time Approximation Schemes for a Class of Integrated Network Design and Scheduling Problems with Parallel Identical Machines

Yusuke Saito [1], Akiyoshi Shioura *† [1]

[1] Tokyo Institute of Technology – Japan

In the integrated network design and scheduling problem (INDS-P), we are asked to repair edges in a graph by using parallel machines so that the performance of the network is recovered by a certain level, and the objective is to minimize the makespan required to finish repairing edges. The main aim of this paper is to show that polynomial-time approximation schemes exist for some class of the problem (INDS-P), including the problems associated with minimum spanning tree, shortest path, maximum ow with unit capacity, and maximum-weight matching.

*Speaker

†Corresponding author: shioura.a.aa@m.titech.ac.jp

Neighborhood persistency of the linear optimization relaxation of integer linear optimization

Kei Kimura *† [1], Kotaro Nakayama [2]

[1] Kyushu University – Japan
[2] Oplan Incorporated – Japan

For an integer linear optimization (ILO) problem, persistency of its linear optimization (LO) relaxation is a property that for every optimal solution of the relaxation that assigns integer values to some variables, there exists an optimal solution of the ILO problem in which these variables retain the same values. In this paper, we propose a stronger property called neighborhood persistency and show that the LO relaxation of ILO on unit-two-variable-per-inequality (UTVPI) systems is a maximal class of ILO such that its LO relaxation has (neighborhood) persistency. Our result implies fixed-parameter tractability and two-approximability for a special ILO on UTVPI systems.

*Speaker
†Corresponding author: kkimura@inf.kyushu-u.ac.jp

Unified Greedy Approximability Beyond Submodular Maximization

Yann Disser [1], David Weckbecker * [1]

[1] TU Darmstadt – Germany

We consider classes of objectivs of cardinality-constrained maximization problems for which the greedy algorithm guarantees a constant approximation. We propose the new class of γ-α-augmentable functions and prove that it includes several important subclasses, such as functions of bounded submodularity ratio, α-augmentable functions, and weighted rank functions of independence systems. We show a tight bound of $\frac{\alpha e^\alpha}{\gamma(e^\alpha-1)}$ on the approximation ratio of the greedy algorithm that recovers the bounds known for previously mentioned function classes. As a by-product, we obtain a tight lower bound for α-augmentable functions.

*Speaker

Session 3 : Routing Problems

Wednesday 18th
3:00pm – 4:40pm CET
Room A

An Integer Linear Programming approach to the Time-constrained Vehicle Routing Problem with Time-windows

Maria Teresa Godinho* [1], Maria Jo ao Lopes † [2]

[1] Polytechnic Institute of Beja e CmafCio – Portugal
[2] Iscte-IUL, University Institute of Lisbon & CmafCio – Portugal

We study a problem arising in home healthcare nursing. Organizing home visits to patients involves features of various OR problems, namely scheduling, rostering and routing. In this work, we address the routing problem, modeled as a Time-constrained Vehicle Routing Problem with Time Windows (TCVRPTW). An integer linear programming formulation of the TCVRPTW is introduced. Preliminary computational results will be presented at the talk.

*Corresponding author: mtgodinho@ipbeja.pt
†Speaker

The Traveling Salesman Problem with positional consistency constraints

Mafalda Ponte * [1], Luis Gouveia [1], Ana Paias [1]

[1] CMAFCIO - Faculdade de Ciencias, Universidade de Lisboa – Portugal

In the Traveling Salesman Problem with positional consistency constraints we seek to generate a minimum cost set of routes, one for each period of the planning horizon, with each route starting and ending at the depot and visiting all the nodes that require service at the corresponding period. Nodes that are visited in several routes must appear in the same relative position in all the routes they are visited in. Vacant positions are allowed before the start of the route, but only for smaller routes, if the routes do not have the same length. Some time dependent models known from the literature were adapted, and a new aggregated model, not indexed by route, was developed for this problem.

*Speaker

Mixed-Integer Programming Formulations and Valid Inequalities for the Electric Vehicle Routing Problem

Arghavan Sharafi * [1], Nima Moradi * † [2], Beste Basciftci [3]

[1] Arghavan Sharafi – Faculty of Engineering and Natural Sciences, Sabanci University, Turkey

[2] Nima Moradi – Faculty of Engineering and Natural Sciences, Sabanci University, Turkey

[3] Beste Basciftci – Department of Business Analytics, Tippie College of Business, University of Iowa, Iowa City, IA, United States

In recent years, many companies start to use Electric Vehicles (EV) to encounter environmental issues. In the literature, Electric Vehicle Routing Problem (E-VRP) is introduced to handle the new challenges of using EVs. E-VRP aims to route a fleet of capacitated EVs to serve customers' demands while minimizing the total travel distance, considering battery restrictions. In this paper, four Mixed-Integer linear programming formulations of E-VRP and several valid inequalities are presented. The efficiencies of the models and valid inequalities are investigated based on the execution time, the number of nodes explored in the Branch-and-Bound, and LP-bounds over various-sized instances.

*Speaker

†Corresponding author: nimamoradi@sabanciuniv.edu

The Hamiltonian p-Median Problem: Polyhedral Results and Branch-and-Cut Algorithm

Michele Barbato * [1], Luis Gouveia [2]

[1] Dipartimento di Informatica Giovanni degli Antoni - Universitá degli Studi di Milano – Italy

[2] DEIO, Faculdade de Ciencias, Universidade de Lisboa, CMAFCIO – Campo Grande, Cidade Universitaria Bloco C6 - Piso 4, 1749-016, Lisbon, Portugal

The Hamiltonian p-median problem is to partition the n vertices of a graph G into p cycles of minimum total weight.
We strengthen the corresponding MILP on edge variables with two families of inequalities: quasi-Hamiltonian cycle inequalities associated to cycles not spanning all nodes; restricted cut constraints whose shores have specific cardinalities and are valid when n=3p,3p+1.
We give facet-defining conditions for subsets of these inequalities.
We develop a branch-and-cut algorithm also enhanced by cost-based inequalities.
It compares well to existing algorithms for the problem and solves 3 benchmark instances previously unsolved and 16 new larger instances with up to 400 vertices.

*Speaker

Session 4 : Heuristics

Wednesday 18th
3:00pm – 4:40pm CET
Room B

Generalized Relax-and-Fix heuristic

Sophie Michel *† [1], Cédric Joncour‡ [2], Xavier Schepler§ [3], Julien Kritter

[1] Laboratoire de Mathématiques Appliquées du Havre – Université Le Havre Normandie – Université du Havre, 25 rue Philippe Lebon, 76058 Le Havre Cedex, France
[2] Laboratoire de Mathématiques Appliquées du Havre – Université Le Havre Normandie, France. – Université du Havre, 25 rue Philippe Lebon, 76058 Le Havre Cedex, France
[3] Recommerce Solutions SA – Recommerce Group – France

This paper introduces a heuristic for mixed-integer mathematical programs, that can be seen as a generalization of the relax-and-fix heuristic: a sequence of derived subproblems is solved, progressively fixing variables in the original problem. We propose a generic implementation and report on numerical results for four well-known operational research applications: lot-sizing, vehicle routing, bin-packing and portfolio optimization. Results show that this heuristic may be competitive depending on the definition of subproblems.

*Speaker
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‡Corresponding author: cedric.joncour@univ-lehavre.fr
§Corresponding author: xavier.schepler@gmail.com

GRASP approaches to the Weighted Safe Set Problem

Alberto Boggio Tomasaz * [1], Roberto Cordone [1], Pierre Hosteins [2]

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[2] Université Gustave Eiffel – IFSTTAR-COSYS – Cité Descartes, 5 Boulevard Descartes â€¢ Champs-sur-Marne, 77454 Marne-la-Vallée Cedex 2, France

The Weighted Safe Set Problem aims to determine in an undirected graph a subset of vertices such that the weights of the connected components they induce exceed the weights of the adjacent components induced by the complementary subset. This paper tackles the problem with Greedy Randomized Adaptive Search Procedures based on two different randomisation schemes. Both approaches are tested on new benchmark instances up to 300 vertices, and compared with the only existing heuristic approach (that is a randomised destructive heuristic) on the original benchmark. The results suggest that the use of a restricted candidate list outperforms all the other approaches.

*Speaker

A local search heuristic for the multi-mode personnel task rescheduling problem characterized by time-resource-quality trade-offs

Tessa Borgonjon * [1], Broos Maenhout [1]

[1] University College Ghent – Ghent Belgium, Belgium

This paper considers the personnel task rescheduling problem with multiple discrete activity modes following time-resource-quality trade-offs. Due to operational uncertainty, announced baseline schedules may become infeasible and the need for rescheduling arises. Therefore changes are required to either the resource schedule or the service level. In particular the recovery action to change the operation modes of individual activities is explored, instigating a trade-off. We propose a two-stage heuristic procedure targeted at finding high-quality solutions in an efficient manner. The performance of the proposed procedure and the corresponding acceleration strategies is demonstrated.

*Speaker

The Lexicographic Minimum Gap Graph Partitioning Problem

Maurizio Bruglieri *† [1], Roberto Cordone [2]

[1] Dipartimento di Design, Politecnico di Milano – Via Durando, 38/a, 20158 Milano, Italy

[2] University of Milan – Via Festa del Perdono 7 20122 Milano, Italy

The Minimum Gap Graph Partitioning Problem consists in partitioning a vertex-weighted undirected graph into p connected subgraphs with minimum gap between the largest and the smallest vertex weight. In this work, we introduce the lexicographic version of the problem consisting in minimizing first the largest gap, then the sum of the gaps of all subgraphs. For this new variant we present a Ruin and Recreate solution approach, whose solution quality is assessed with the results provided by a mathematical programming formulation.

*Speaker

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Session 5 : Polyhedra and algorithms

Wednesday 18th
5:00pm – 6:40pm CET
Room A

New Classes of Facets for Complementarity Knapsack Problems

Alberto Del Pia [1,2], Jeff Linderoth [1], Haoran Zhu [*†] [3]

[1] University of Wisconsin Madison – United States
[2] Wisconsin Institute for Discovery – United States
[3] University of Wisconsin Madison – United States

The complementarity knapsack problem (CKP) is a knapsack problem with real-valued variables and complementarity conditions between pairs of its variables. We extend the polyhedral studies of De Farias et al. for CKP, by proposing three new families of cutting-planes that are all obtained from a combinatorial concept known as a pack. Sufficient conditions for these inequalities to be facet-defining, based on the concept of a maximal switching pack, are also provided. Moreover, we answer positively a conjecture by De Farias et al. about the separation complexity of the inequalities introduced in their work.

[*]Speaker
[†]Corresponding author: hzhu94@wisc.edu

The Constrained-Routing and Spectrum Assignment Problem: Valid Inequalities and Branch-and-Cut Algorithm.

Ibrahima Diarrassouba* [1], Youssouf Hadhbi †‡ [2]

[1] Laboratoire de Mathématiques Appliquées du Havre LMAH – Université Le Havre Normandie, France. – FR CNRS-3335, 76600 Le Havre, France
[2] Laboratoire d'Informatique, de Modélisation et d'Optimisation des Systèmes LIMOS – Université Clermont Auvergne, CNRS – 1 Rue de la Chebarde, Aubiere, 63178 Clermont Ferrand, France

In this paper, we study a variant of the Routing and Spectrum Assignment problem (RSA), namely the Constrained-Routing and Spectrum Assignment (C-RSA). First, we give an integer linear programming based on the so-called cut formulation. Moreover, we investigate the related polyhedron and describe several valid inequalities. We also prove that these inequalities are facet-defining for the polyhedron under some necessary and sufficient conditions. In addition, we devise separation routines for these inequalities. Based on this, we propose a Branch-and-Cut algorithm for the problem along with an extensive computational study showing the effectiveness of our approach.

*Corresponding author: diarrasi@univ-lehavre.fr
†Speaker
‡Corresponding author: youssouf.hadhbi@uca.fr

Polyhedral study of the Symmetrically Weighted Matrix Knapsack problem

Alexandre Heintzmann * [1], Cécile Rottner [2], Pascale Bendotti [3,4]

[1] EDF Labs, LAAS-CNRS – EDF Recherche et Développement – France
[2] EDF Labs – EDF Recherche et Développement – France
[3] EDF R&D – EDF Recherche et Développement – France
[4] Sorbonne Université, CNRS, LIP6 – Sorbonne Université, CNRS, LIP6 – France

The Symmetrically Weighted Matrix Knapsack problem (SWMK) is a knapsack with M groups of N ordered items. Precedence constraints are such that an item can only be selected in a feasible solution if the previous one in the same group is selected. Item i of any group has the same weight, thus the knapsack being symmetrically weighted. With the use of a structure called Patterns, necessary and sufficient conditions, that can be verified in polynomial time, are described for a set of facet defining inequalities for the SWMK. More recent work aim to generelize these conditions to a larger set of facet defining inequalities.

*Speaker

Branch-and-Cut for a 2-Commodity Flow Relocation Model with Time Constraints

José-L Figueroa *† [1], Mourad Baiou [1], Alain Quilliot [1], Hélène Toussaint [1], Annegret Wagler [1]

[1] Laboratoire d'Informatique, de Modélisation et d'Optimisation des Systèmes – Université Clermont Auvergne : UMR6158, Université Clermont Auvergne, Laboratoire d'Informatique, de Modélisation et d'Optimisation des Systèmes – France

We deal here with a general 2-commodity flow model for shared mobility systems on a given transit network. It involves two integral flows (for carriers and transported objects), and may be viewed as the projection on the transit network of a flow model on a time expanded network. To make this projected model compatible with the time expanded network model, we introduce specific constraints whose handling involves a separation process. We prove that this separation can be performed in polynomial time, discuss the experimental behaviour of the related Branch-and-Cut algorithm and briefly address the lift issue to turn an optimal solution of our projected model into a solution of the original problem.

*Speaker

†Corresponding author: jfg77_sigma@hotmail.com

Session 6 : Cutting and Packing

Wednesday 18th
5:00pm – 6:40pm CET
Room B

High Multiplicity Strip Packing with Three Rectangle Types

Andrew Bloch-Hansen *† [1], Roberto Solis-Oba [1], Andy Yu [1]

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The two-dimensional strip packing problem consists of packing in a rectangular strip of width 1 and minimum height a set of n rectangles, where each rectangle has width $0 < w \leq 1$ and height $0 < h \leq h_{max}$. We consider the high-multiplicity version of the problem in which there are only K different types of rectangles. For the case when $K = 3$, we give an algorithm providing a solution requiring at most height $3/2\ h_{max} + \epsilon$ plus the height of an optimal solution, where ϵ is any positive constant.

*Speaker

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Improved Bounds for Stochastic Extensible Bin Packing under Distributional Assumptions

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In the stochastic extensible bin packing problem, n items of random size must be packed into m bins of unit capacity. The number of bins is fixed, but their capacity can be extended at extra cost. This model plays an important role in surgery scheduling, where the extension of bin capacity represents overtime of operating rooms. It is known that this problem has a (1+e–1)-approximation algorithm for arbitrary probability distributions of the item sizes. Using the theory of second-order stochastic dominance, we obtain improved bounds when the sizes have a bounded Pietra or Gini index, and when they belong to specific parametric families, such as Gamma, Lognormal or Weibull distributions.

*Speaker

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Open-End Bin Packing Problem with Conflicts

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In this paper, we study the Open-End Bin Packing Problem with Conflicts (OEBPPC) which is a combination of two variants of the famous bin packing problem: Open-End Bin Packing Problem and Bin Packing Problem with Conflicts. In OEBPPC, the aim is to pack all of the items into minimum number of bins where the bin capacity is allowed to be exceeded only by the last item placed and there exist conflicts between some item pairs. We introduce a mathematical formulation for the problem and adapted some known heuristics and a metaheuristic algorithm to this new problem.

*Speaker

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An integer programming approach for the hyper-rectangular clustering problem with axis-parallel clusters and outliers

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We present a mixed integer programming formulation for the problem of clustering a set of points in the d-dimensional space with axis-parallel clusters, while allowing to discard a pre-specified number of points, thus declared to be outliers. We identify a family of valid inequalities separable in polynomial time, we prove that some of them induce facets of the associated polytope, and we show that the dynamic addition of cuts coming from this family is effective in practice.

*Speaker

Session 7 : Game theory and Multiobjective Optimization

Thursday 19th
1:00pm – 2:30pm CET
Room A

On computing the Edgeworth-Pareto hull for certain classes of multi-objective optimization problems

Fritz Bökler [1], Sophie N. Parragh [2], Markus Sinnl [*†], Fabien Tricoire [3]

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[2] Johannes Kepler University Linz – Austria
[3] Institute for Transport and Logistics Management,Vienna University of Economics and Business, Vienna – Austria

In this work, we present the first outer approximation algorithm which can compute the Edgeworth-Pareto hull for multi-objective mixed-integer linear programming problems (MOMILP) and certain classes of non-linear problems. Our algorithm relies on an oracle which solves single-objective weighted-sum problems and we show that the required number of oracle calls is polynomial in the number of facets of the convex hull of the non-dominated extreme points. As a consequence, for problems for which the weighted-sum problem is solvable in polynomial time, the facets can be computed in incremental polynomial time. A computational study on a large set of benchmark instances, including non-linear instances, is conducted to assess the efficiency of our algorithm. We give empirical results on the numerical accuracy of our approach and provide a comparison with PolySCIP, which is an inner approximation solver for MOMILP.

[*]Speaker
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Exact Price of Anarchy for Weighted Congestion Games with Two Players

Joran Van Den Bosse [1], Marc Uetz [1], Matthias Walter *† [1]

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We provide a complete analysis of worst-case equilibria for various versions of weighted congestion games with two players and affine cost functions. The results are exact price-of-anarchy bounds which are parametric in the weights of the two players, and establish exactly how the primitives of the game enter into the quality of equilibria. Interestingly, some of the worst-cases are attained when the players' weights only differ slightly. Our findings show that sequential play improves the price of anarchy in all cases. Methodologically, we obtain algebraic price of anarchy bounds based on the solutions of linear programs.

*Speaker

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Nash balanced assignment problem

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We consider the Balanced Assignment Problem (BAP) that seeks to find an assignment solution which has the smallest value of max-min distance: the difference between the maximum assignment cost and the minimum one. However, by minimizing only the max-min distance, it may lead to a very inefficient solution in terms of total cost. Hence, we propose a fair way based on Nash equilibrium for finding assignment solutions having a better trade-off between the two objectives. For that, we introduce the concept of Nash Fairness (NF) solutions based on the definition of proportional-fair scheduling. The main result of this paper is to show that finding all NF solutions can be done in polynomial time.

*Speaker
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Session 8 : Decomposition Methods

Thursday 19th
1:00pm – 2:30pm CET
Room B

On blocking the spread of harmful contagions in networks with integer programming

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In this work, we introduce the Measure-based Spread Minimization Problem, which can be used to model the way how to optimally minimize the spread of harmful contagions in networks. We are given a directed graph representing a network, a stochastic diffusion model, a set of initially infected nodes, and also a set of arc labels each of which represents a certain relationship (contact) type. Blocking a label means taking a measure that prevents the contact between every pair of nodes connected via an arc having that label. The objective is to find a set of measures to take (labels to block) within a budget such that the expected number of infected nodes is minimized. We propose a Benders decomposition method with subproblems that can be solved using graph search methods and test its performance on the instances which we generate using several real social network data.

*Speaker
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A particular Quadratic Transportation Problem

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Consider a set of observations consisting of measures on two variables. A statistical test of independence of the two variables is the maximum Pearson's Chi-square index, defined as a Quadratic Transportation Problem (QTP). The QTP is derived from the Linear Transportation Problem: they are both defined on the transportation polytope, but the QTP has an objective function quadratic and convex in the flow variables. Since the solution is one of the many extreme points of the transportation polytope, it is hard to certify the optimality. We introduce a combinatorial relaxation of QTP, and we propose a decomposition method to compute upper bounds, in which the QTP is reduced to 0-1 knapsack problems.

*Speaker
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A fractional programming method for optimal assortment under the nested-logit model

Laurent Alfandari * [1], Alborz Hassanzadeh [2], Ivana Ljubić [3]

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We look at finding an assortment of products maximizing the expected revenue, where customer preferences are modeled by a nested logit choice model. This combinatorial problem is polynomial in a specific case and NP-hard otherwise. We provide an exact general method that embeds a tailored Branch-and-Bound algorithm into a fractional programming framework. We show that the fractional programming parameterized subproblem, a highly non-linear binary optimization problem, is decomposable by nests. The non-linear subproblem for each nest is solved by a tailored Branch-and-Bound algorithm with specific upper bounds. Our approach can solve instances with 5 nests and up to 5000 products per nest.

*Speaker

Session 9 : SDP

Thursday 19th
4:30pm – 6:10pm CET
Room A

A new Exact-Subgraph-Based Hierarchy for Stable Set

Elisabeth Gaar *† [1]

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One of several hierarchies towards the stability number of a graph is the exact subgraph hierarchy (ESH). On the first level it computes the Lovász theta function as semidefinite program (SDP) with a matrix variable of order n+1 and n+m+1 constraints. On the k-th level it adds all exact subgraph constraints for subgraphs of order k to the SDP.

We introduce the compressed ESH (CESH), a variant of the ESH that computes the Lovász theta function through a smaller SDP, which seems favorable. Furthermore, we investiage scaled ESCs (SESCs), which are a more natural way to represent exactness for the CESH. We present both computational and theoretical findings for the CESH and SECSs.

*Speaker

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Semidefinite approximations for bicliques and biindependent pairs

Monique Laurent* [1,2], Sven Polak †‡ [1], Luis Felipe Vargas§ [1]

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A (bipartite) biindependent pair in a bipartite graph $G = (V_1 \cup V_2, E)$ is a pair (A, B), where $A \subseteq V_1$, $B \subseteq V_2$ and the union $A \cup B$ is independent in G. We study the parameters $g(G)$ and $h(G)$, defined, respectively, as the maximum product $|A||B|$ and the maximum ratio $\frac{|A||B|}{|A|+|B|}$, over all such biindependent pairs (A, B) in G. We define semidefinite programming upper bounds on $g(G)$ and $h(G)$. We show they are quadratic variations of Lovász's theta number, and we show links among them and with a parameter by Haemers. We formulate closed-form eigenvalue bounds, coinciding with the semidefinite bounds for edge-transitive graphs.

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Finite convergence of sum-of-squares hierarchies for the stability number of a graph

Luis Felipe Vargas * [1], Monique Laurent [1,2]

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[2] Tilburg University – Netherlands

Computing the stability number of a graph is an NP-hard problem and some approximations via semidefinite optimization have been developed. One of them is a hierarchy proposed by de Klerk and Pasechnik by following an idea given by Parrilo for approximating problems over the copositive. One open question asks for the finite convergence of this hierarchy. We prove finite convergence for the class of acritical graphs. Our analysis relies on exploiting a link to the Lasserre hierarchy for the Motzkin-Straus formulation and using a known sufficient condition for its finite convergence. As an application we show that deciding whether a standard quadratic problem has finitely many minimizers is hard

*Speaker

Application of the Lovász-Schrijver M+ operator to graph coloring

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[2] Universitá degli Studi dell'Aquila – Italy

Computing strong lower bounds for the chromatic number of a graph is a well-researched topic. A reference lower bound is represented by the Lovász theta number, which can be computed via semidefinite programing (SDP). Further relaxations have been investigated, by adding linear inequalities to the Lovász relaxation. These experiences show that achieving lower bounds over the fractional chromatic number is a hard task. We present a new SDP relaxation obtained by the application of the Lovász-Schrijver lifting operator to a compact ILP formulation. Computational experiments on small graphs shows that this relaxation yields lower bounds which can lie above the fractional chromatic number.

*Speaker
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Session 10 : Approximation algorithms II

Thursday 19th
4:30pm – 6:10pm CET
Room B

Autonomous transportation using platoons: approximation and hardness results

Tiberiu-Iulian Sirbu * [1], Alexandru Popa† [1]

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In this paper we consider a scenario of travelling between different cities using a partial autonomous car. In our scenario, various platoons travel along preset paths. The goal is to find a path between two vertices that is shorter than a given value and the overlap with the paths of the platoons is maximized. We formulate two versions of the Platooning Problem using graphs. In this versions, we aim to maximize either the time spent as member of a platoon or the percentage of the total time spent as member of a platoon. We prove that the two versions are not solvable in polynomial time, so we propose three polynomial time approximation algorithms, one for the first version and two for the second version.

*Speaker

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Pervasive Domination

Gennaro Cordasco *† [1], Luisa Gargano [2], Adele Rescigno [2]

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Inspired by the implicit or explicit persuasion scenario, which characterizes social media platforms, we analyze a novel domination problem named Pervasive Domination. We consider a social network modeled by a digraph $G = (V, E)$ where an arc $(u, v) \in E$ represents the capability of an individual u to persuade an individual v. We are looking for a set $S \subset V$ of social change individuals, of minimum cost, who combined enable to reach the desired behavior. The impact of S is measured by a set function $f(S)$. We show that the natural greedy algorithm provides an approximation guarantee, $(\ln \frac{p-f(\emptyset)}{\beta} + 2$ where $\beta > 0$ represents the minimum gain on the function f.

*Speaker
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Beyond Symmetry: Best Submatrix Selection for the Sparse SVD

Yongchun Li * [1], Weijun Xie [1]

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This paper presents a novel Sparse truncated Singular Value Decomposition (SSVD) formulation that can select the best submatrix precisely up to a given size to maximize its truncated Ky Fan norm. The fact that the proposed SSVD problem is NP-hard motivates us to study effective algorithms. To do so, we first reformulate SSVD as a mixed-integer semidefinite program, which can be solved exactly for small- or medium-sized instances. We next develop three selection algorithms and two searching algorithms. We prove the approximation ratios for all algorithms. Our numerical study demonstrates the efficiency of the proposed algorithms. Finally, all our analysis can be extended to row-sparse PCA.

*Speaker

Session 11 : Polyhedra and combinatoric

Thursday 19th
6:30pm – 8:10pm CET
Room A

Top-k List Aggregation: Mathematical Formulations and Polyhedral Comparisons

Sina Akbari * [1], Adolfo Escobedo [1]

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Top-k lists are being increasingly utilized in various fields including information retrieval, machine learning, and recommendation systems. Since multiple top-k lists may be generated by different algorithms to evaluate the same set of entities or a system of interest, there is often a need to consolidate this collection of heterogeneous top-k lists to obtain a more robust and coherent list. This work introduces various exact mathematical formulations of the top-k lists aggregation problem under the generalized Kendall tau distance. Furthermore, the strength of the proposed formulations is analyzed from a polyhedral point of view.

*Speaker

Bounded variation in binary sequences

Maja Hügging *† [1], Christoph Buchheim‡ [1]

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In many applications it arises as a subproblem to optimize a linear function over a set of binary, finite-length vectors satisfying certain practical constraints, such as a minimum dwell time or a bound on the overall number of changes. While the former constraint has been studied intensively, no results seem to exist for the latter. We investigate two variants of the problem, depending on whether the number of changes in a switch is penalized in the objective function or whether it is bounded by a hard constraint. We show that, while the former variant is easy to deal with, the latter is more complex, but still tractable. We present a full polyhedral description of the set of feasible switchings for this case.

*Speaker

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On Permuting some Coordinates of Polytopes

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Motivated by a result of Kaibel and Pashkovich, We study the change in extension complexity of a polytope when some of its coordinates are permuted in all possible ways, or when some of its coordinate values are "sorted" for each of its vertices. We show that the extension complexity can increase exponentially in each case even if every coordinate contains only three values 0,1, or 2, for each vertex. We also discuss the implications of the 0/1 case.

*Speaker

Few Induced Disjoint Paths for H-Free Graphs

Barnaby Martin * [1], Daniel Paulusma [1], Siani Smith [1], Erik Jan Van Leeuwen [2]

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[2] Utrecht University – Netherlands

Paths $P_1, ..., P_k$ in a graph $G = (V, E)$ are mutually induced if any two distinct P_i and P_j have neither common vertices nor adjacent vertices. For a fixed integer k, the k-Induced Disjoint Paths problem is to decide if a graph G with k pairs of specified vertices (s_i, t_i) contains k mutually induced paths P_i such that each P_i starts from s_i and ends at t_i. We prove new complexity results for k-Induced Disjoint Paths if the input is restricted to H-free graphs, that is, graphs without a fixed graph H as an induced subgraph. We compare our results with a complexity dichotomy for Induced Disjoint Paths, the variant where k is part of the input.

*Speaker

Session 12 : Non-linear optimization

Thursday 19th
6:30pm – 8:10pm CET
Room B

Piecewise linearization of bivariate nonlinear functions: minimizing the number of pieces under a bounded approximation error

Aloïs Duguet * [1], Sandra Ulrich Ngueveu [2]

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This work focuses on the approximation of bivariate functions into piecewise linear ones with a minimal number of pieces and under a bounded approximation error. Applications include the approximation of mixed integer nonlinear optimization problems into mixed integer linear ones that are in general easier to solve. A framework to build dedicated linearization algorithms is introduced, and a comparison to the state of the art heuristics shows their efficiency.

*Speaker

An outer-approximation algorithm for maximum-entropy sampling

Marcia Fampa *† [1], John Lee [2]

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We apply the well-known MINLO outer-approximation algorithm (OA) to the maximum-entropy sampling problem (MESP), using the linx and NLP convex relaxations for MESP. We enhance our approach using disjunctive cuts.

*Speaker

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Mitigating Anomalies in Parallel Branch-and-Bound Based Algorithms for Mixed-Integer Nonlinear Optimization

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[2] Ashutosh Mahajan – Indian Institute of Technology Bombay, Mumbai, MH 400076, India

We address detrimental anomalies in parallel versions of two well-known algorithms for convex mixed-integer nonlinear programs (MINLPs): nonlinear branch-and-bound and LP/NLP based branch-and-bound. A detrimental anomaly is when a parallel algorithm performs worse than its sequential counterpart. We extend the existing notion of unambiguity in node selection functions to branching and cut-generating subroutines to avoid these anomalies and implement them in the open-source MINLP solver Minotaur. Our computational results show that opportunistic versions are faster while the deterministic versions avoid detrimental anomalies and ensure reproducibility of results.

*Speaker
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A Quadratic Simplex Algorithm for Primal Optimization over Zero-One Polytopes

Sven Mallach * [1]

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A quadratic simplex algorithm tailored to the primal optimization over the vertices of zero-one polytopes is presented. It computes a locally optimum basic feasible solution and it so generalizes over local improvement heuristics for corresponding applications such as unconstrained binary quadratic programming, maximum cut, or the quadratic assignment problem.

*Speaker

Session 13 : Graphs and Trees

Friday 20th
1:00pm – 2:30pm CET
Room A

On the Thinness of Trees

Flavia Bonomo [1], Eric Brandwein * [1], Carolina Lucía Gonzalez [1], Agustín Sansone [1]

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The "thinness" of a graph is an invariant presented as a generalization of interval graphs, which are exactly the graphs with thinness equal to one. If a representation of a graph as a k-thin graph is given for a constant value k, then some known NP-complete problems can be solved in polynomial time. Some examples are the maximum weighted independent set problem and the bounded coloring with fixed number of colors. In this work we present a constructive O(n log n)-time algorithm to compute the thinness for any given tree, along with an optimal consistent solution (ordering and partition). We use some intermediate results of this construction to improve known bounds of the thinness in some special trees.

*Speaker

Generating Spanning Tree Sequences of a Fan Graph in Lexicographic Order and Ranking/Unranking Algorithms

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[3] Department of Product Innovation and Entrepreneurship, National Taipei University of Business – Taiwan

Cameron et al. recently presented an algorithm for generating all spanning trees of a fan graph that fulfill the so-called pivot Gray code property in O(1)-amortized time. They also presented algorithms for ranking and unranking a spanning tree in the listing in O(n) time using O(n) space. This paper first observes that all spanning trees of a fan graph can be naturally represented by integer sequences with regular properties. We propose a simple algorithm for generating spanning-tree sequences in lexicographic order in O(1)-amortized time according to these properties. Additionally, based on the lexicographic order, we develop ranking and unranking algorithms in O(n)-time using n+O(1) space.

*Speaker

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Session 14 : Biology/Health applications

Friday 20th
1:00pm – 2:30pm CET
Room B

Optimal Vaccination Strategies for Multiple Dose Vaccinations

Jenny Segschneider *† [1], Arie M.C.A. Koster‡ [1]

[1] RWTH Aachen University – Germany

Due to the recent pandemic and the shortage of vaccinations during its roll-out, the question regarding the best strategy to achieve immunity in the population by adjusting the time between the two necessary vaccination doses was discussed. Strategies have already been studied from various angles. However, the combinatorial optimization problem and its complexity has not been the focus of attention.

In this paper, we study different versions of this problem by first proposing a simple model using a matching algorithm. Then, we extend the model by adding constraints and multiple vaccines. Finally, we discuss a variation of the problem where three vaccinations are necessary and show NP-hardness.

*Speaker

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One transfer per patient suffices: Structural insights about patient-to-room assignment

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[3] University of Osnabrück – Germany

Assigning patients to rooms is a fundamental task in hospitals and, especially, within wards. For this so-called patient-to-room assignment problem (PRA) many heuristics have been proposed with a large variety of dierent practical constraints. However, a thorough investigation of the problem's structure itself has been neglected so far. In this paper, we present insights about the basic, underlying combinatorial problem of PRA with a focus on minimizing the number of patient transfers which occur if patients have to change rooms during their stay. Particularly, we prove that in the case of double bedrooms, each patient has to be transferred at most once.

*Speaker

Finding synonymous coding DNA sequences with maximum base pairing

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A Coding DNA Sequence (CDS) is a sequence of bases that, organized into triplets (codons), encodes for a protein. As different codons can encode the same amino acid, the same protein is encoded by a very large number of CDSs and a problem arises of finding optimal CDSs with respect to given indicators. Here the Base Pairing Number is considered, the largest number of hydrogen bonds the bases can form in a feasible folding. We developed an implicit enumeration algorithm based on dynamic programming to maximize base pairing, and tested it on random and human genome CDSs. The method performs an effective reduction of the search space and turns out to be more efficient than integer programming to solve the problem.

*Speaker

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Session 15 : Theory of combinatorics

Friday 20th
4:30pm – 6:00pm CET
Room A

On Minimally Non-Firm Binary Matrices

Reka Agnes Kovacs * [1]

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For a binary matrix X, the Boolean rank br(X) is the smallest integer k for which X equals the Boolean sum of k rank-1 binary matrices, and the isolation number i(X) is the maximum number of 1s no two of which are in a same row, column and a 2x2 submatrix of all 1s. We continue Lubiw's study of firm matrices, X is firm if i(X)=br(X) and this equality holds for all its submatrices. We show that a stronger concept of superfirmness of X is equivalent to having no odd holes in a graph defined from X. Then we introduce two matrix operations that lead to generalised binary matrices and use them to derive four infinite classes of minimally non-firm matrices, matrices which are not firm but all of their proper submatrices are.

*Speaker

Characterizing Path-Length Matrices of Unrooted Binary Trees

Daniele Catanzaro *† [1]

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We address a long standing open question concerning the existence of sufficient conditions that a $n \times n$ symmetric integer matrix must satisfy to encode the Path-Length Matrix (PLM) of an Unrooted Binary Tree (UBT) with n leaves. This question is central in the applications of matrix fitting as well as in the combinatorics of the Balanced Minimum Evolution Problem (BMEP), an APX-hard network design problem having fundamental applications in epidemiology and life sciences. We show here that Kraft's equalities and Buneman's four-point conditions, in addition to the symmetry and integrality conditions on the entries of a candidate matrix, are necessary and sufficient to ensure that it encodes the PLM of an UBT. We also show that alternative characterizations are possible by exploiting the combinatorics of UBTs. These results provide insights on the polyhedral combinatorics of the BMEP and enable the development of integer linear programming formulations for the problem able to solve instances that are currently intractable via the current exact solution algorithms.

*Speaker

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Session 16 : Algorithms

Friday 20th
4:30pm – 6:00pm CET
Room B

Locating Obnoxious Facilities on a Line Segment

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In this paper, we consider the problem of locating k obnoxious facilities of maximum radius, centered on a line segment $\overline{pq}$, amidst n demand points in the plane so that none of the existing facility sites are affected. An $(1-\epsilon)$-approximation algorithm was given recently to solve the problem (CCCG 2021), where $\epsilon > 0$. Here, we present two polynomial-time exact algorithms based on two different approaches: (i) the algorithm is based on doing a binary search on all candidate radii L computed explicitly and runs in $O((nk)^2 \log(nk) + (n+k)\log(nk))$ time, and (ii) the algorithm is based on Megiddo's parametric search and runs in $O((n+k)^2)$ time.

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An Efficient Post-Synthesis of Reversible Circuits

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The theory of reversible circuits is fundamental for quantum computing, since the postulates of quantum mechanics establish that the evolution of closed quantum systems is unitary and thus reversible. The process of transforming a given reversible function into a reversible circuit is known as circuit synthesis and its optimization process is known as post-synthesis. We present a post-synthesis algorithm to reduce the gate count of reversible circuits. Our method identifies each maximal sub-circuit with up to three different lines, finds the permutations associated and replaces them with minimum sub-circuits. Our method successfully optimized most circuits well-known benchmark functions.

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