ECCO XXXVI CONFERENCE 2023

11th - 14th May 2023, Chania, Crete, Greece

https://ecco2023.euro-online.org/

Book of Abstracts

ECCO COMBINATORIAL OPTIMIZATION

EURO THE ASSOCIATION OF EUROPEAN OPERATIONAL RESEARCH SOCIETIES

Technical University of Crete

Contents

1 Preface

Dear Participant at the ECCO 2023 conference:

ECCO (European Chapter on Combinatorial Optimization) is a working group of EURO (Association of European Operational Research Societies), which provides an excellent opportunity to discuss recent and important issues in Combinatorial Optimization and its applications. The ECCO meetings are held on a regular basis (once a year during Spring) and nicely combine scientific work and the exchange of new ideas with an exciting environment.

ECCO 2023 is the 36th Conference of the European Chapter on Combinatorial Optimization (ECCO XXXVI), which takes place in Chania, Crete, Greece, during May 11–14, 2023. The Conference includes three plenary lectures and 68 oral presentations.

Topics of interest for the conference are as follows:

- Theory and applications of combinatorial optimization
- Exact solution algorithms, approximation algorithms, heuristics, and metaheuristics for combinatorial optimization problems
- Integer programming, global optimization, stochastic integer programming, multi-objective programming, graph theory and network flows
- Application areas include logistics and supply chain optimization, manufacturing, energy production and distribution, land consolidation, telecommunications, bioinformatics, finance, discrete tomography, discrete and hybrid dynamical systems, and other fields.

A special issue of the Journal of *Combinatorial Optimization* will be dedicated to contributions presented at the conference. All articles will be refereed according to the high standards of the journal.

Nikolaos Matsatsinis
Yannis Marinakis
Silvano Martello

2 Committees

2.1 Program Committee

- Jacek Blazewicz, Poznań University of Technology
- Bo Chen, University of Warwick
- Van-Dat Cung, Université Grenoble Alpes
- Alain Hertz, Polytechnique Montréal
- Yannis Marinakis (co-Chair), Technical University of Crete
- Silvano Martello, Università di Bologna
- Nikolaos Matsatsinis (Chair), Technical University of Crete
- Paolo Toth, Università di Bologna

2.2 Organizing Committee

- Nikolaos Matsatsinis(Chair), Technical University of Crete
- Yannis Marinakis(co-Chair), Technical University of Crete
- Magdalene Marinaki(co-Chair), Technical University of Crete
- Nikolaos A. Kyriakakis, Technical University of Crete
- Garyfalia Matsatsini, Technical University of Crete
- Themistoklis Stamadianos, Technical University of Crete
- Andromachi Taxidou, Technical University of Crete
- Lia Krassadaki, Technical University of Crete

3 Plenary Speakers

3.1 Bo Chen (University of Warwick, United Kingdom)

Auctions and Bidding

The 2020 Nobel Prize in Economics was awarded to Paul Milgrom and Robert Wilson for their improvements to auction theory and inventions of new auction formats. Their theoretical discoveries have improved auctions in practice and benefited sellers, buyers and taxpayers around the world (RSAS, 2020). Auction theory provides an explicit model of price making and auctions are of consider-able practical significance. Auction theory is closely linked to game theory, combinatorial optimization and computational complexity. In the first half of my talk, I will give a brief overview of auction theory and practice. I will introduce some key concepts and results in auction theory, then provide some examples of best auction practice, and conclude with pointers to some seminal full-review articles. In the second half of my talk, I will present my recent studies on some auction problems in the electricity capacity market.

3.2 Nelson Maculan (Federal University of Rio de Janeiro, Brazil)

Euclidean Steiner Tree Problem in R^n: Optimization Models and New Heuristics

We will briefly introduce the Euclidean Steiner Tree Problem in R^n and its most important properties. We will show the construction and computational behavior of nonlinear optimization models with mixed integer variables and their continuous relaxations. Two new heuristics with their respective numerical tests will also be presented. Note: This is a joint work with Hacène Ouzia (LIP6 - Sorbonne Université, France) and Renan V. Pinto (Federal University of Rio de Janeiro – UFRJ, Brazil). Part of the topics presented at this conference were published in: 1-Hacène Ouzia, Nelson Maculan, Mixed Integer Nonlinear Optimization Models for the Euclidean Steiner Tree Problem in R^d, Journal of Global Optimization (JOGO), v. 83, pp 119-136, 2022. 2-Renan V. Pinto, Nelson Maculan, A New Heuristic for the Euclidean Steiner Tree Problem in R^n, to be published in TOP.

3.3 Greet Vanden Berghe (KU Leuven, Belgium)

Personnel rostering: trends and challenges in theory and practice

Personnel rostering represents a fascinating combinatorial optimisation problem due to its socio-economic relevance, its potential for improvement through automated decision support and its computational complexity. The optimisation problem has yielded ample practice-oriented operational research approaches. Despite the vast amount of academic research results, it remains hard for novice developers to profit from general insights or re-usable models and algorithms. This 'cold start issue can be partially explained by complicated regulations typical for personnel environments with 24/7 duties and different in almost every organisation. The very same issue also persists due to the lack of a theoretical framework for nurse rostering. From an academic point of view, interesting models have been developed for varying nurse rostering problems. The approaches range from self-rostering and manual problem decompositions to different levels of automated decision support. This plenary talk will focus on the challenging interplay between important practical and theoretical nurse rostering contributions.

4 Conference Overview

	Thursday, May 11			Friday, May 12			Saturday, May 13		Sunday, May 14
08:30 - 20:00	RECEPTION		09:30 - 18:20	RECEPTION					
	Room 1: ELPIDA	Room 2: FAIDRA		Room 1: ELPIDA	Room 2: FAIDRA		Room 1: ELPIDA		
09:30 - 10:00	*Welcome Speeches*		09:30 - 10:00			09:30 - 10:00			
10:00 - 11:20	Session 1: Scheduling Chair: Klaus Jansen	Session 2: Supply Chain Management Chair: Nikolaos Kyriakakis	10:00 - 11:20	Session 9: Scheduling Chair: Dvir Shabtay	Session 10: Graphs Chair: Alain Hertz	10:00 - 11:20	Session 17: Graphs Chair: Hadrien Melot		
11:20-11:40	*Coffe Break*		11:20-11:40	*Coffe Break*		11:20-11:40	*Coffe Break*		
11:40 - 12:40	*Chair: Silvano Martelo* *Plenary Speech:* Nelson Maculan *Title: Euclidean Steiner Tree Problem in R^n: Optimization Models and New Heuristics*		11:40 - 12:40	*Chair: Nikolaos Matsatsinis* *Plenary Speech: Bo Chen* *Title: Auctions and Bidding*		11:40 - 12:40	*Chair: Yannis Marinakis* *Plenary Speech: Greet Vanden Berghe* *Title: Personnel rostering: trends and challenges in theory and practice*	*10:00 - 16:30*	*Excursion to Lake Kournas*
12:40 - 14:00	Session 3: Routing Chair: Giovanni Righini	Session 4: Bioinformatics Chair: Jacek Blazewicz	12:40 - 14:00	Session 11: Routing Chair: Magdalene Marinaki	Session 12: Miscellaneous Chair: Paolo Toth	12:40 - 13:00	*Closing Session*		
14:00-15:00	*Light Lunch*		14:00-15:00	*Light Lunch*		*13:00 - 17:00*	*Excursion to Theriso Village*		
15:00 - 16:20	Session 5: Scheduling Chair: Natalia Shakhlevich	Session 6: Supply Chain Management Chair: Joerg Kalcsics	15:00 - 16:20	Session 13: Facility location Chair: Nikolaos Ploskas	Session 14: Miscellaneous Chair: Juan José Salazar González				
16:20-16:40	*Coffe Break*		16:20-16:40	*Coffe Break*					
16:40 - 18:20	Session 7: Logistics Chair: Filipe Rodrigues	Session 8: Mutli-objective Problems Chair: Konstantinos Zervoudakis	16:40 - 18:20	Session 15: Bioinformatics Chair: Marta Szachniuk	Session 16: Miscellaneous Chair: Maciej Drozdowski				
18:20-20:00	*Conference Photo* *Welcome Party*		18:20-18:40 20:30	Conference Dinner at Restaurant Glossitses					

5 Conference Program

	Thursday, May 11	
	Room 1: ELPIDA	**Room 2: FAIDRA**
09:30 - 10:00	***Opening Session***	
10:00 - 11:20	**Session 1: Scheduling** **Chair: Klaus Jansen**	**Session 2: Supply Chain Management** **Chair: Nikolaos Kyriakakis**
10:00-10:20	*Optimizing Work Hours of Software Engineers through Tabu Search Scheduling Algorithm,* Kadri Sylejmani, Endrit Meziu	*Pickup and Delivery with AGVs: challenges and opportunities,* Francesco Gallesi, Manuel Iori, Marco Locatelli, Rafael Praxedes, Anand Subramanian
10:20-10:40	*A Column Generation Driven Heuristic for Order-Scheduling and Rack-Sequencing in Robotic Mobile Fulfillment Systems,* Jan-Erik Justkowiak, Erwin Pesch	*Application of Machine Learning Demand Forecasting Techniques in the Italian Processed Meat Industry* Mirko Mucciarini, Giulia Caselli, Manuel Iori, Marco Lippi
10:40-11:00	*Efficiency-Fairness Tradeoff for a Multi-Agent Single Machine Scheduling Problem* Gaia Nicosia, Alessandro Agnetis, Mario Benini, Andrea Pacifici	*Iterated Local Search for the eBuses Charging Location Problem with Multiple Ports* Cesar David, Loaiza Quintana, Laura Climent, Alejandro Arbelaez
11:00-11:20	*Load Balancing: The Long Road from Theory to Practice* Klaus Jansen	*A Genetic-based Method For Budget-constrained Charging Station €rrangement: A Case Study In Chania* Themistoklis Stamadianos, Nikolaos A. Kyriakakis, Magdalene Marinaki, Yannis (Ioannis) Marinakis
11:20-11:40	***Coffe Break***	
11:40 - 12:40	*Chair: Silvano Martelo* *Plenary Speech:* ***Nelson Maculan*** ***Title: Euclidean Steiner Tree Problem in R^n: Optimization Models and New Heuristics*** ***(Room 1: ELPIDA)***	
12:40 - 14:00	**Session 3: Routing** **Chair: Giovanni Righini**	**Session 4: Bioinformatics** **Chair: Jacek Blazewicz**
12:40-13:00	*Kalmanson heuristics for the travelling salesman problem* Vladimir Deineko, Mengke Wang	*A Branch-and-Price-and-Cut algorithm for non-adaptive two-dimensional group testing with equal group size* Tifaout Almeftah, Diego Cattaruzza, Martine Labbe, Frederic Semet
13:00-13:20	*The Hierarchical Multi-Switch Multi-Echelon Vehicle Routing Problem: Model Formulations and Solution Approaches* Marduch Tadaros	*Automated design of metaheuristics using Conditional Markov Chain Search* Daniel Karapetyan
13:20-13:40	*Swarm Intelligence Algorithms for the Two Echelon Location Routing Problem* Maria Tsiftsoglou, Yannis (Ioannis) Marinakis, Magdalene Marinaki	*WebTetrado: easygoing quadruplex buddy* Bartosz Adamczyk
13:40-14:00	*The Electric Symmetric and Asymmetric Traveling Salesman Problem* Giovanni Righini, Alberto Ceselli, Emanuele Tresoldi, Cristina Ondei	*RNA World model with inhibitors* Jaroslaw Synak, Agnieszka Rybarczyk, Jacek Blazewicz
14:00-15:00	***Light Lunch***	
15:00 - 16:20	**Session 5: Scheduling** **Chair: Natalia Shakhlevich**	**Session 6: Supply Chain Management** **Chair: Joerg Kalcsics**
15:00-15:20	*Single machine scheduling with assignable due dates to minimize maximum and total late work* Erwin Pesch, Jan-Erik Justkowiak, Sergey Kovalev, Mikhail Y. Kovalyov	*Optimization of Real-Time Multiserver System with Limited Maintenance Facilities* Joseph Kreimer
15:20-15:40	*A unified CP-based evolutionary algorithm for solving flexible job shop scheduling problems with resource constraints* Dimitris Paraskevopoulos, Grigoris Kasapidis, Yiannis Mourtos, Panagiotis Repoussis	*Swarm Intelligence Algorithms for Cold Supply Chain Management Problems* Andromachi Taxidou, Magdalene Marinaki, Yannis (Ioannis) Marinakis
15:40-16:00	*Solving a real-life multi-skill resource-constrained multi-project scheduling problem* Rahman Torba, Stephane Dauzere-Peres, Claude Yugma, Cedric Gallais, Juliette Pouzet	*Firefighter with vertex values and defence budget* Joerg Kalcsics, Marta Baldomero-Naranjo, Antonio Manuel Rodriguez-Chia, Cat Wedderburn
16:00-16:20	*Network Flow Techniques for Preemptive Scheduling on Identical Parallel Machines: Revising and Extending Horn's Conditions* Natalia Shakhlevich, Akiyoshi Shioura, Vitaly Strusevich	*Introduction to Edge-Defence Firefighter* Cat Wedderburn, Joerg Kalcsics
16:20-16:40	***Coffe Break***	
16:40 - 18:20	**Session 7: Logistics** **Chair: Filipe Rodrigues**	**Session 8: Mutli-objective Problems** **Chair: Konstantinos Zervoudakis**
16:40-17:00	*Container Dispatching and Conflict-Free Yard Crane Routing in an Automated Container Terminal* Jenny Nossack, Dirk Briskorn, Erwin Pesch	*An output-polynomial time algorithm to determine all supported efficient solutions for multi-objective integer network flow problems* David Konen
17:20-17:40	*Network Restoration Problems* Igor Averbakh	*How to efficiently cut in bi-objective Branch & Bound?* Yue Zhang, Pierre Fouilhoux, Lucas Letocart
17:40-18:00	*Design and analysis of vehicle scheduling and routing methods on a port logistics problem from the aspect of environmental impact and cost-efficiency* Tibor Dulai, Daniil Baldouski, Balazs David, Gyorgy Dosa, Miklos Kresz, Zsuzsanna Nagy, ÁgnesStark-Werner	*A Multi-Objective Perspective on the Cable-Trench Problem* Lara Lohken, Michael Stiglmayr
18:00-18:20	*Berth allocation and quay crane assignment problem under uncertainty* Filipe Rodrigues, Agostinho Agra	*Addressing the combinatorial problem of product line design using many-objective optimization* Konstantinos Zervoudakis, Stelios Tsafarakis
	Conference Photo	

	Friday, May 12	
	Room 1: ELPIDA	**Room 2: FAIDRA**
09:30 - 10:00		
10:00 - 11:20	**Session 9: Scheduling** **Chair: Dvir Shabtay**	**Session 10: Graphs** **Chair: Alain Hertz**
10:00-10:20	*Lower bounds for the permutation flowshop scheduling problem,* *Sebastian Caceres Gelvez, Adam Letchford, Thu Huong Dang*	*Complexity of domination problems in graphs* *Olivier Hudry*
10:20-10:40	*Scheduling in manufacturing with transportation* *Amir Hosseini, Alena Otto, Erwin Pesch*	*Exact Algorithms and Hardness Results of Cosecure Domination in Graphs* *Kusum Sangwan, Arti Pandey*
10:40-11:00	*Scheduling Conferences with a Two-phase Matheuristic Approach* *Yaroslav Pylyavskyy, Ahmed Kheiri, Peter Jacko*	*Combinatorial techniques in the enumeration of Boolean functions,* Josep Freixas, Xavier Molinero, Dani Samaniego
11:00-11:20	*Minimizing Total Operations Rejection Cost Plus Makespan Value in a Two-Machine Flow-Shop Scheduling Problem* *Dvir Shabtay, Enrique Gerstl*	*Decycling bipartite graphs* *Alain Hertz*
11:20-11:40	***Coffe Break***	
11:40 - 12:40	*Chair: Nikolaos Matsatsinis* ***Plenary Speech: Bo Chen*** ***Title: Auctions and Bidding*** ***(Room 1: ELPIDA)***	
12:40 - 14:00	**Session 11: Routing** **Chair: Magdalene Marinaki**	**Session 12: Miscellaneous** **Chair: Paolo Toth**
12:40-13:00	*A Branch-Cut-and-Price Algorithm for the Storage Location Assignment and Picker Routing Problem* *Thibault Prunet, Nabil Absi, Valeria Borodin, Diego Cattaruzza*	*Allocation problems with minimal dissatisfaction on preference graphs* *Ulrich Pferschy*
13:00-13:20	*A column generation approach for last-mile deliveries with capacitated robot stations* *Yerlan Kuzbakov, Laurent Alfandari, Diego Delle Donne*	*Models for the two-dimensional variable-sized cutting stock problem in the honeycomb cardboard industry* *Paula Teran Viadero, Antonio Alonso-Ayuso, F. Javier Martin-Campo*
13:20-13:40	*The Ordered Travelling Salesman Problem: A comparison of formulations* *Francisco Temprano Garcia, Alfredo Marin, Ivana Ljubic, Justo Puerto*	*A mixed 0-1 linear optimisation model for the 1.5-dimensional cutting stock problem with slitting line allocation* *F. Javier Martin-Campo, Maria Sierra-Paradinas, Antonio Alonso-Ayuso, OscarSoto-Sanchez, Micael Gallego*
13:40-14:00	*The Drone Routing Problem with Pickups, Deliveries and Battery Replacement Stations* *Emmanouil Giannoulakis, Nikolaos A. Kyriakakis, Magdalene Marinaki, Yannis (Ioannis) Marinakis*	*Models and Deterministic Matheuristic Algorithms for the Quadratic Knapsack Problem with Setup* *Paolo Toth, Laura Galli, Silvano Martello, Carlos Rey*
14:00-15:00	***Light Lunch***	
15:00 - 16:20	**Session 13: Facility location** **Chair: Nikolaos Ploskas**	**Session 14: Miscellaneous** **Chair: Juan José Salazar González**
15:00-15:20	*Cost minimizing planning of container inspection and repair in multiple facilities* *Lukashevich Mikhail, Erwin Pesch, Mikhail Y. Kovalyov*	*Counting how weightedness is a simple game restricted to their weighted players* *Xavier Molinero, Josep Freixas, Salvador Roura*
15:20-15:40	*Exact Solution Methods for the p-Median Problem with Manhattan Distance and a River with Crossings* *Thomas Byrne,Atsuo Suzuki*	*Solving the flexible job-shop scheduling problem with transportation resources* *Lucas Berterottiere, Stéphane Dauzere-Peres, Claude Yugma*
15:40-16:00	*Hybrid GRASP and VNS methods for continuous facility location and transportation mode selection in the supply chain* *Abdulaziz Alageel*	*Optimization and Simulation of Renewable Energy Communities* *Nathalie Friess, Ulrich Pferschy, Joachim Schauer, Elias Feiner*
16:00-16:20	*Integer programming formulations for facility location problems with distance constraints* *Nikolaos Ploskas*	*Solving a combinatorial problem to find another planet to live on* *Juan José Salazar González*
16:20-16:40	***Coffe Break***	
16:40 - 18:20	**Session 15: Bioinformatics** **Chair: Marta Szachniuk**	**Session 16: Miscellaneous** **Chair: Maciej Drozdowski**
16:40-17:00	Analysis of k-mer characteristics for the reference genome in the Genomic Map of Poland project *Aleksandra Swiercz*	*Introduction to the Satellite Image Mosaic Combination Problem* *Jedrzej Musial, Manuel Combarro Simon, Gregoire Danoy, Mohammed Alswaitti, Andrei Tchernykh, Johnatan Pecero, Pascal Bouvry*
17:20-17:40	Genomic Map of Poland - computational and machine learning challenges *Piotr Lukasiak*	*An efficient tour construction heuristic for candidate set generation of the large Traveling Salesman Problem* *Boldizsár Tüű-Szabó, Péter Földesi, Laszlo T. Koczy*
17:40-18:00	RNApdbee 3: an RNA structure multitool with optimum pseudoknot order assignment Tomasz Żok	*Cyclic Scheduling for the Single Track Railway Problem* *Grzegorz Pawlak*
18:00-18:20	Knot hunters in the molecule world Marta Szachniuk	*The Structure of Mean-Variance and Max Entropy Frontiers in Portfolio Optimization* *Yiannis Dimotikalis, Takis Varelas*
18:20-18:40		*Quay Partitioning Problem* *Maciej Drozdowski, Jakub Wawrzyniak, Eric Sanlaville, Yoann Pigné, Frédéric Guinand*
20:30	***Conference Dinner at Restaurant Glossitses***	

	Saturday, May 13		Sunday, May 14
	Room 1: ELPIDA		
09:30 - 10:00			
10:00 - 11:20	Session 17: Graphs Chair: Hadrien Melot		
10:00-10:20	*Improving local search heuristics for the cluster editing problem* Sylwester Swat		
10:20-10:40	*On struction in k-partite graphs* Bogdan Zavalnij, Sandor Szabo		
10:40-11:00	*Extremal properties of the arithmetic geometric index* Sebastien Bonte, Alain Hertz, Hadrien Melot, Gauvain Devillez, Pierre Hauweele		
11:00-11:20	*Exploring extremal properties of graphs using PHOEG* Hadrien Melot, Sebastien Bonte, Gauvain Devillez, Pierre Hauweele		
11:20-11:40	*Coffe Break*		
11:40 - 12:40	*Chair: Yannis Marinakis* *Plenary Speech: Greet Vanden Berghe* *Title: Personnel rostering: trends and challenges in theory and practice* *(Room 1: ELPIDA)*		
12:40 - 13:00	*Closing Session*		
13:00 - 17:00	*Excursion to Theriso Village*	*10:00 - 16:30*	*Excursion to Lake Kournas*

6 Abstracts

Session 1: Scheduling

Chair: Klaus Jansen

Optimizing Work Hours Of Software Engineers Through Tabu Search Scheduling Algorithm

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(*joint work with* Endrit Meziu)

Abstract

The scheduling of work hours for software engineers is a complex optimization problem that aims to improve overall process performance and reduce losses. This involves assigning tasks to a group of engineers to be completed within a designated timeframe. The organization and assignment of tasks have a significant impact on process performance. This paper discusses the problem of Software Engineering at Scale, which was defined in the Google Hash Code Competition 2021 World Finals. We present a detailed analysis of the scheduling problem for engineers' work hours, exploring various methods and operators. In addition, we propose an algorithm for generating initial solutions and suggest the use of Tabu Search to further improve the results. The algorithm optimizes task assignments for engineers, reducing both waiting and completion times. The proposed algorithm explores the solution space using various operators to generate new solutions, which are then evaluated and selected. After defining the initial solution, the algorithm uses Tabu Search to optimize task assignments for software engineers, minimizing both waiting and completion times. This study focuses on the problem of scheduling engineering work hours and applies four specially designed operators: SwapEngineerOperations, SwapOperationBetweenEngineers, AddNotImplementedFeature, and RemoveImplementedFeature. These operators have demonstrated their efficacy in generating neighboring solutions that closely look like the structure of the initial solution in a majority of cases. Additionally, the parameters of the Tabu Search algorithm are calibrated, and the results are compared to other methods used to solve the same problem. The proposed algorithm's ability to generate high-quality solutions for scheduling software engineers' work hours is validated through experiments on a test set of five challenging instances. As a result, the algorithm is ranked among the six best known algorithms for solving this problem.

A Column Generation Driven Heuristic For Order-Scheduling And Rack-Sequencing In Robotic Mobile Fulfillment Systems

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(*joint work with* Erwin Pesch)

Abstract

The order picking process in robotic mobile fulfillment systems, a warehousing technology following the parts-to-picker concept, involves two interlinked decisions: How to schedule the processing of orders and how to sequence the racks that are lifted and transported by automated guided vehicles (robots) to the picking-station to supply the requested items (so called rack-visits)? It is shown in literature that minimizing the number of rack-visits is well suited to operate a picking-station efficiently, that is, reducing robot utilization as well as the makespan of customer-order processing. We present a heuristic solution approach for the order-scheduling and rack-sequencing problem at a single picking-station using column generation to partition the set of orders into batches, while minimizing the number of rack-assignments to batches, which in turn minimizes the rack-visits. The generated batches possess a property that allows to derive an order-processing schedule and rack-sequence straightforwardly. Then, we refine the heuristic solution by rearranging the processing of batches and their assigned racks. A comprehensive and comparative computational study demonstrates superior performance of our approach on the vast majority of instances compared to several heuristics, both in terms of solution quality and runtime. It is also shown that the heuristic provides good results on small-case data when embedded into a framework to solve the problem at multiple picking-stations.

Efficiency-Fairness Tradeoff For A Multi-Agent Single Machine Scheduling Problem

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(*joint work with* Alessandro Agnetis, Mario Benini, Andrea Pacifici)

Abstract

Fairness issues naturally arise in several real-world contexts, whenever two or more individuals compete for the use of a resource. In this work, we address fairness concepts in the context of classical single-machine scheduling. We consider a problem arising when two agents, each owning a set of jobs, compete to schedule their jobs on a common processing resource. Each schedule implies a certain utility for each agent and an overall system efficiency (system utility). We are interested in solutions that incorporate some criterion of equity for the agents and, at the same time, are efficient from a global point of view. More precisely, we are interested in investigating the tradeoff between fairness and efficiency. We present our approach when both agents want to minimize the total completion time if their respective jobs. To this purpose, we model the problem as a bicriteria problem, study the Pareto efficient frontier, propose different MILP models and study the Lagrangian Relaxation of one of them.

Load Balancing: The Long Road From Theory To Practice

Klaus Jansen

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Abstract

There is a long history of approximation schemes for the problem of scheduling jobs on identical machines to minimize the makespan. Such a scheme grants a (1+)-approximation solution for every >0, but the running time grows exponentially in 1/ . For a long time, these schemes seemed like a purely theoretical concept. Even solving instances for moderate values of seemed completely illusional. In an effort to bridge theory and practice, we refine recent ILP techniques to develop the fastest known approximation scheme for this problem. An implementation of this algorithm reaches values of lower than 2/11 18.2% within a reasonable timespan. This is the approximation guarantee of MULTIFIT, which, to the best of our knowledge, has the best proven guarantee of any non-scheme algorithm. This is joint work with S. Berndt, M. Deppert, and L. Rohwedder.

Session 2: Supply Chain Management

Chair: Nikolaos A. Kyriakakis

Pickup And Delivery With Agvs: Challenges And Opportunities

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(*joint work with* Manuel Iori, Marco Locatelli, Rafael Praxedes, Anand Subramanian)

Abstract

Automated Guided Vehicles (AGVs) have been extensively studied in the recent literature on optimization. Promoted by the paradigm shift of Industry 4.0, AGVs have become widely known for the automatic handling of materials, goods, and containers, as they provide efficient and flexible solutions for transportation and manufacturing systems. There are two kinds of architectures for AGVs control: central and decentral; and five main optimization problems: task allocation, localization, path planning, motion planning, and vehicle management for AGVs coordination. Some variants of these problems consider additional attributes and environmental aspects, such as multi-load, battery constraints, and conflict-free routing, just to mention a few. We faced many of these problems in the real-world context of E80 Group, a company located in Italy that is one of the leaders in the world in the AGVs market. After a survey on the state of the art of AGVs systems, we focus on the task allocation problem, modeled as a Pickup and Delivery Problem (PDP) with AGVs. In particular, the main contributions of this work are: (i) proposing a survey on the state of the art of AGV systems; (ii) highlighting the difficulties encountered when facing these problems in the real-world case of E80 Group; (iii) providing a formal problem definition and a mathematical model for the PDP with AGVs; (iv) presenting several challenges and opportunities for future research in this challenging optimization area.

Application Of Machine Learning Demand Forecasting Techniques In The Italian Processed Meat Industry

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(*joint work with* Giulia Caselli, Manuel Iori, Marco Lippi)

Abstract

Demand forecasting is a crucial component of supply chain management for many industries, especially in the case of perishable goods. This work investigates the effectiveness of different machine learning methods for daily demand forecasting, specifically in the context of an Italian company that operates in the processed meat industry. We present different forecasting models, each designed to serve as a tool to support decision making, inventory management, and production planning. Our aim is to produce a forecast as accurate as possible, which will subsequently serve as a basis for implementing a good-quality production schedule. We extend our previous work [1] by proposing several forecasting models and different training procedures. In particular, we include an original training procedure that extends the demand categorization by [2] and that, in our case study, is able to outperform classic approaches of the forecasting literature. Additionally, we include an inventory simulation based on the company data set to illustrate the practical implications of using our forecasting methods on the company's inventory management. The simulation analysis shows that our best method can lead to significant improvements in inventory management, by reducing waste and increasing efficiency.

References:

Acknowledgements: We thank Inalca S.p.A. for financial support.

References:

[1] Mucciarini, M., Caselli, G., Iori, M., and Lippi, M. Demand Forecasting Methods: A Case Study in the Italian Processed Meat Industry [Conference Presentation Abstract]. ECCO XXXV - CO 2022 Joint Conference. (2022) https://ecco2022.euro-online.org/abstract_book.pdf

[2] Syntetos, A.A., Boylan, J.E., and Croston, J., On the categorization of demand patterns. *Journal of the Operational Research Society*, (2005) **56**(5):495–503

Iterated Local Search For The Ebuses Charging Location Problem With Multiple Ports

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University College Cork

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(*joint work with* Laura Climent, Alejandro Arbelaez)

Abstract

An effective transition to public transportation systems based on eBuses requires dealing with multiple concerns, such as limited driving range and battery charging/discharging time. The eBuses Charging Location Problem has been formulated to optimize the location of charging stations while addressing the concerns derived from eBuses.

However, the current model for the problem is limited to single charging ports, where eBuses have exclusive access to the charging station. This type of charging station is generally designed for small-size cities with low demand for charging. Thus, in order to design a cost-effective solution for large-size cities, the charging stations might need to be equipped with multiple charging ports or outlets, which allow multiple eBuses to be charged simultaneously.

In this work, we extend the formulation of The eBuses Charging Location Problem to account for multiple ports per charging station. The extension incorporates a new cost objective function that combines the cost of installing charging stations and the multiple ports within it. Furthermore, we propose an Iterated Local Search Algorithm to tackle the new version of the problem, which is compared against a MIP-based solution. Our empirical results suggest that the use of multiple ports would reduce the overall cost of installing charging stations in Irish cities.

A Genetic-Based Method For Budget-Constrained Charging Station Arrangement: A Case Study In Chania

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(*joint work with* Nikolaos A. Kyriakakis, Magdalene Marinaki, Yannis (Ioannis) Marinakis)

Abstract

The introduction of Electric Vehicles (EVs) as a sustainable alternative to traditional gasoline-powered vehicles has led to an increasing need for efficient and reliable charging infrastructure. Despite the growing availability of public charging stations, the current infrastructure is insufficient to meet the rising demand for EV charging. In combination with the long wait times for charging, they can pose a significant barrier to EV adoption, hindering their widespread use.

Urban spaces are among the most challenging concerning the integration of charging infrastructure. This research focuses on the development of a Cell Decomposition (CD) method based on artificial charging demands for the city of Chania, Greece. CD divides the region into smaller subspaces called cells, each representing a unique space. The city of Chania was divided into cells of approximately 200 by 200 meters, representing a distance that local residents would be willing to walk to get from their houses to their cars, and the opposite. Two types of chargers were considered and a maximum budget constraint limits the charging options.

To solve the presented problem, a Genetic Algorithm was developed. It represents potential solutions as vertices of discrete values, encoding them as chromosomes and applying genetic operators mutation to generate new solutions with improved fitness values. The preliminary results of the study are presented.

Session 3: Routing

Chair: Giovanni Righini

Kalmanson Heuristics For The Travelling Salesman Problem

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(*joint work with* Mengke Wang)

Abstract

We consider the nearest neighbour and the double-ended nearest neighbour heuristics (NN-heuristics) for the travelling salesman problem (TSP). These are the best known and the simplest heuristics for the TSP. Not that much known about the structure of the solutions obtained by these heuristics. Consider for example the Euclidean TSP and the case when the points in a TSP-instance are located on the boundary of their convex hull. The distance matrix for these points belongs to the well-known class of the so-called permuted Kalmanson matrices. It is well known that in this case the optimal TSP solution coincides with the sequence of the points on the convex hull. It is easy to construct an instance when the NN solution violates this property and hence is not optimal (or close to optimal). We suggest a simple linear transformation of a distance matrix in the TSP. We prove that the NN-heuristics find an optimal solution in the case if the initial matrix is a permuted Kalmanson matrix. Computational experiments show that this simple modification of the NN-heuristics also outperforms the standard versions on randomly generated instances.

The Hierarchical Multi-Switch Multi-Echelon Vehicle Routing Problem: Model Formulations And Solution Approaches

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Abstract

In today's society, transports are essential to secure necessary products and services to maintain our standard of living. Given the importance of transportation and logistic services and their impact on the environment, economy, and people's lives, it is in everyone's interest that these transports are as efficient as possible. This paper covers a newly introduced variant of the Vehicle Routing Problem - the Hierarchical Multi-Switch Multi-Echelon Vehicle Routing Problem. It is a real-world problem originating from the policies of a Nordic distribution company and includes; a single depot, a non-predetermined hierarchy of intermediate facilities, and two different fleets consisting of homogeneous original and homogeneous local vehicles pulling swap-bodies. The central depot dispatches vehicles with attached swap bodies, which can either directly serve customers (if only one swap body is attached) or visit one or two consecutive switch points to transfer one or two loaded swap bodies to a corresponding number of local vehicles. The local vehicles then serve customers with the transferred swap bodies, while the original vehicle continues serving customers with the remaining loaded swap body. This paper covers the problem and model formulations, properties and difficulties in solving it using a commercial solver, solution approaches for realistic-sized instances, and possible directions for further research.

Swarm Intelligence Algorithms For The Two Echelon Location Routing Problem

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(*joint work with* Yannis (Ioannis) Marinakis, Magdalene Marinaki)

Abstract

At this conference, we will present a complex supply chain problem, the Two-Echelon Location and Routing Problem, which involves simultaneous vehicle routing and facility location. At the first level, vehicles are routed from the central warehouse to peripheral warehouses, obviously with minimum cost. At the second level, the available peripheral warehouses are routed to customers. It should be noted that there is a limited number of peripheral warehouses, from which the warehouses with a more strategic location are selected in order to satisfy the overall demand of customers while minimizing the total cost of transportation and facility usage. Having acknowledged nature's abilities to solve complex problems, research turned towards adopting and applying practices, constructing algorithms that mimic natural or biological processes as well as organism behaviors. We will attempt to minimize the total cost of the problem by using three well known swarm intelligence algorithms: the ant colony optimization algorithm, the bee colony optimization algorithm, and the artificial bee colony algorithm. The purpose is to evaluate the three aforementioned methods in terms of the results they produce as the size of the problem they solve increases. They exhibit some similarities but also significant differences. Comparing these specific algorithms is useful as it leads to useful conclusions regarding the selection of algorithmic application based on the type of problem.

The Electric Symmetric And Asymmetric Traveling Salesman Problem

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(*joint work with* Alberto Ceselli, Emanuele Tresoldi, Cristina Ondei)

Abstract

The widespread adoption of electric vehicles requires to reformulate the classical traveling salesman problem (TSP), in its symmetric and asymmetric versions, taking into account some specific feature of electric mobility, such as the relatively frequent need for recharge, the possibility of recharging when traveling downhill, the trade-off between recharge speed and energy price due to different recharge technologies. We have developed branch-and-cut and branch-and-price algorithms for the exact solution of the (A)TSP and we have tested them on benchmark instances. In the design of branch-and-cut algorithms, what makes the (A)TSP difficult is the need of reformulating the subtour elimination constraints, since optimal solutions of the (A)TSP are not necessarily acyclic: it may be required to achieve feasibility or profitable to achieve optimality to visit a same recharge station more than once as well as to traverse an edge/arc more than once. In the design of branch-and-price algorithms, a specific source of difficulty is that energy consumption is non-monotone. We designed and tested two branch-and-price algorithms: in one of them each column corresponds to a complete route of the vehicle, while in the other each column corresponds to a path between two consecutive visits to recharge stations. Notably, energy constraints must be suitably reformulated in the ATSP, where negative consumption arcs (downhill roads) are allowed.

Session 4: Bioinformatics

Chair: Jacek Blazewicz

A Branch-And-Price-And-Cut Algorithm For Non-Adaptive Two-Dimensional Group Testing With Equal Group Size

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(*joint work with* Diego Cattaruzza, Martine Labbé, Frédéric Semet)

Abstract

Group testing involves screening in groups a large-scale population with low prevalence to detect the presence of a disease, product defect, or system error. When a test on a group is negative, the entire group is classified as negative. Otherwise, at least one individual is positive, and the group is tested again either individually or in smaller groups. Our research focuses on a two-dimensional design with equally sized groups, where each individual belongs to exactly two different groups. Since tests used such as PCR are imperfect, the population to be tested is heterogeneous, and the effect of sample dilution must be taken into account, it is complex to design algorithms for creating groups effectively. In the literature, existing algorithms are generally based on unrealistic assumptions such as population homogeneity or perfect tests, or are primarily heuristics. In our research, we propose a quadratic set covering model with an exponential number of binary variables that minimizes a convex combination of classification error and estimated number of tests. We develop a Branch-and-Price-and-Cut algorithm, where the linear relaxation of the model is solved with column-dependent-row generation and strengthened with several families of valid inequalities (cliques, odd holes and RLT). The proposed approaches are under validation on randomly generated small instances and we plan a further validation on real SARS-CoV-2 data from hospitals in Lille in France.

Automated Design Of Metaheuristics Using Conditional Markov Chain Search

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Abstract

Design and development of combinatorial optimisation metaheuristics is an expensive and time-consuming process requiring practitioners with expertise in both the domain area and algorithm design, and maintenance of such systems is often problematic. Conditional Markov Chain Search (CMCS) is a framework that is intended to partly automate the metaheuristic design and maintenance. More specifically, CMCS is a highly configurable algorithm that controls domain-specific components during the search process. (The design and implementation of the domain-specific components such as hill climbers and mutations still have to be done by the practitioner.) Despite its simplicity, CMCS is powerful enough to model several standard metaheuristics and thus can be seen as a unified model for many single-point metaheuristics.

CMCS requires offline learning of its configuration. Algorithm configuration is a complex and computationally expensive process, however, even some simple methods have been shown to work well with CMCS.

In this talk, we will show a few examples of CMCS being applied to combinatorial optimisation problems and discuss the challenges of the approach. We will also show that CMCS allows answering questions about algorithmic components that otherwise cannot be studied objectively. Finally, we will talk about our research plans.

Webtetrado: Easygoing Quadruplex Buddy

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Abstract

Analyzing molecular structures is a time-consuming process. It requires various bioinformatic tools to perform calculations. It is also the case when exploring quadruplexes, specific motifs occurring in nucleic acid structures. Automating this process with reliable computational methods solves the problem and improves the exploration experience.

In the talk, we present WebTetrado, a web application that provides everything needed to discover and explore the properties of quadruplexes and tetrads. A set of backend functions read the 3D DNA/RNA structures in PDB or mmCIF format. Next, they identify base pair patterns to find and classify tetrads and quadruplexes. WebTetrado computes and visualizes G4 structure parameters such as rise, twist, planarity, and chi angle. The system assigns tetrads to the ONZ and Webba da Silva classifications and displays the results using the Mol* structure viewer. The web application is freely available at https://webtetrado.cs.put.poznan.pl.

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Rna World Model With Inhibitors

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(*joint work with* Agnieszka Rybarczyk, Jacek Blazewicz)

Abstract

One of the main points of RNA World hypothesis is that RNA molecules at the very beginning could have created the first stable and interdependent population, which later evolved into all lifeforms we see today. Various models which present mechanisms via which it could have happened are being researched. One of the first ideas were hypercycles proposed by Eigen, the main assumption being that there were several groups of RNA molecules and each of them could replicate RNAs from some other groups. The problem was the complexity of the aforementioned solution, hence a new straightforward approach was posited - RP (replicase-parasite) model. It was much simpler and divided RNA molecules into only two groups – able to catalyze replication of other RNAs (replicases) and those which did not possess this ability (parasites). A theoretical next stage was to form compartments – bubbles (surrounded by a membrane) separating RNA populations from each other. The authors propose a mechanism which could have given an advantage to such enclosed RNA populations based on RP model – a system of inhibitors which could have ensured that the concentration of replicases and parasites (and possibly RNAs with newly evolved special functions) stayed at the right levels. The possibility of such system was corroborated by an analytical analysis of ODE and further supported with computer simulations.

Session 5: Scheduling

Chair: Natalia Shakhlevich

Single Machine Scheduling With Assignable Due Dates To Minimize Maximum And Total Late Work

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Abstract

We consider a single machine scheduling problem with assignable job due dates to minimize total late work which is NP-hard in the ordinary sense. We present two pseudo-polynomial dynamic programming algorithms and an FPTAS for this problem. Besides, we introduce a new single machine scheduling problem to minimize maximum late work of jobs with assignable due dates and develop an O(n log n) time algorithm for it, where n is the number of jobs. An optimal solution value of this new problem is a lower bound for the optimal value of the total late work minimization problem, and it is used in the FPTAS.

A Unified Cp-Based Evolutionary Algorithm For Solving Flexible Job Shop Scheduling Problems With Resource Constraints

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Abstract

The flexible job-shop scheduling problem (FJSSP) is one of the most well-studied scheduling problems with a wide variety of practical applications. In this paper, we present a variety of FJSSPs that consider renewable, non-renewable and cumulative resources. The renewable resources can be electricity, water and gas, the non-renewable resources can be raw materials or semi-finished products, and the cumulative resources are limited capacity buffers. The main goal is to propose a problem formulation that models a wide range of shop-scheduling problems including the blocking job-shop scheduling problem (BJSSP), the unrelated parallel machine scheduling problem with resources (UPMR) and the FJSSP. We propose a constraint programming (CP) model and a CP-based evolutionary algorithm (EvoCP) to solve the incumbent variety of problems. The proposed EvoCP is equipped with learning mechanisms to identify prevalent operation-to-machine assignments and operation-to-operation relations found in high quality solutions. The proposed learning mechanisms corroborate with new constraint extraction operators that inform the proposed CP model in an integrated manner towards the exploration of promising regions of the solution space. Computational experiments on well known FJSSP, BJSSP and UPMR benchmark problems of the literature showcase the effectiveness of the proposed EvoCP compared to the state-of-the-art, while 34 new best solutions were produced. Lastly, we discuss managerial insights along with the effect of the resource constraints on the makespan.

Solving A Real-Life Multi-Skill Resource-Constrained Multi-Project Scheduling Problem

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Abstract

This work addresses a multi-skill resource-constrained multi-project scheduling problem (MSRCMPSP) with complex industrial constraints, which originates from SNCF heavy maintenance factories. A time-indexed mixed-integer linear programming model is presented. Two objective functions are independently considered: (i) Minimization of the sum of the weighted tardiness of the projects and (ii) Minimization of the sum of the weighted duration of the projects. To solve large instances with several thousand activities, a new memetic algorithm combining a genetic algorithm with a simulated annealing procedure is implemented. The memetic algorithm is compared with popular solution approaches. Computational experiments conducted on real instances validate the efficiency of the proposed algorithm. The comparison of our approach with the best priority rule-based algorithms (serial and parallel scheduling generation schemes) and other metaheuristics shows significant improvements. In the context of heavy maintenance, many operations are performed by human operators and processing times are uncertain. Moreover, uncertain tasks, with a known probability to be executed or not, may also be encountered. Therefore, we will discuss on how to integrate these uncertainties in the decision process and generate robust schedules. The objective is to maximize the probability of meeting customer deadlines.

Network Flow Techniques For Preemptive Scheduling On Identical Parallel Machines: Revising And Extending Horn'S Conditions

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Abstract

Network flow models are widely used in scheduling research since the 70s. A prominent example is the highly cited paper "Some simple scheduling algorithms" by Horn (1974). In that paper, Horn proposed a network flow model for preemptive processing of jobs by parallel machines, subject to job deadlines. Another result, formulated by Horn in isolation from the network flow model, is a set of inequalities for checking the feasibility of a problem instance. Both results provide a foundation for subsequent research on enhanced problems, including the versions with arbitrary release dates and deadlines, uniform machines, scheduling with controllable processing times and inverse optimization, to name a few. In our work we demonstrate that the two results, network flow model and a set of inequalities for the feasibility check, are linked via the min cost max flow theorem. It gives a solid methodology for modelling quite intricate scheduling problems via network flows, for example, an extended model with resource constraints.

Session 6: Supply Chain Management

Chair: Joerg Kalcsics

Optimization Of Real-Time Multiserver System With Limited Maintenance Facilities

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Abstract

We consider a real-time system (RTS) with multiple identical servers (e.g. unmanned aerial vehicles – UAVs, production controllers, etc.) subject to breakdowns and responsible for several different areas (with requests of real-time tasks) required to be under non-stop control. There is a limited number of identical maintenance facilities (less than the total number of servers in the system). Thus the shortage of maintenance facilities happens. This system is a so-called RTS with a zero deadline for the beginning of job execution, i.e. jobs are processed immediately upon arrival, conditional on servers availability. Tasks are arriving to such RTS, and their times are expiring, either being processed or lost (partly or completely), without any connection to servers operation. That part of the task which is not executed immediately is lost forever and cannot be served later. Thus, queueing of real-time tasks or their parts in these systems is impossible by their nature. Nevertheless, while using the duality approach of changing the roles between tasks and servers, these RTS can be treated as queueing networks. Servers after maintenance are directed to different areas according to routing probabilities which can be used as control parameters. The effectiveness of such RTS is measured by system's availability, namely its ability to process the maximal portion of real-time tasks or their parts. It is worthwhile to note, that even very large number of servers and ample maintenance facilities do not guarantee the maximal system availability without proper choice of routing probabilities. We represent the real-time system under consideration as a combinatorial optimization problem and compute analytically (for exponentially distributed service and maintenance times) optimal routing probabilities which maximize limiting system availability, as well as optimal value of this availability when the number of servers grows infinitely. We investigate also the rate of convergence.

Swarm Intelligence Algorithms For Cold Supply Chain Management Problems

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(*joint work with* Magdalene Marinaki, Yannis (Ioannis) Marinakis)

Abstract

The cold supply chain plays a crucial role in the effective management of an emergency situation, and aims to the efficient storage and distribution of refrigerated product supported by equipment that can maintain a required temperature in all process of storage and transportation. The final aim of cold supply chain is to minimize the cost of transportation, reducing the wastage of goods. Vehicle routing problem (VRP) is a classic NP-hard optimization problem. We have modified the green vehicle routing problem (GVRP), by transforming the basic objective function of minimizing traveled distance into minimizing the total cost, including the total fixed cost, the total transportation cost, the total damage cost, the total refrigerated costs and the total carbon cost. To solve the above problem, we propose five evolutionary algorithms inspired by nature. The proposed algorithms are based on swarm intelligence and consider the social behavior of animals and organisms, such as hunting, navigation, migration, movement, etc. We have combined the proposed algorithms with local search algorithms, in order to achieve better results.

Firefighter With Vertex Values And Defence Budget

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(*joint work with* Marta Baldomero-Naranjo, Antonio Manuel Rodriguez-Chia, Cat Wedderburn)

Abstract

Let G=(V,E) be an undirected graph with node set V and edge set E, F be a subset of f vertices, and d be a given number of defenders. In the Firefighter game, a fire breaks out on all vertices in F at time zero. In each subsequent time step, first the d defenders can proctect one vertex each from catching fire. Afterwards, the fire spreads from each burning vertex to every adjacent vertex that is neither burning nor defended. Both burning and defending are permanent, i.e., a vertex remains burning or defended for the rest of the game, and the game ends when the fire can not spread any further. The goal of the Firefighter game is to find a defence strategy that minimizes the number of burning vertices.

In the classical version of the Firefigher game, each vertex has the same value when saved and the same cost for being defended. In this talk, we relax this assumption and allow vertices to have different values and costs for being defended. Moreover, instead of a fixed number of defenders we are given a defence budget that we can spend each time step for defending vertices. We present a mixed-integer programming formulation for the extended problem, together with some valid inequalities and bounds on the maximal duration of the game.

Introduction To Edge-Defence Firefighter

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(*joint work with* Jörg Kalcsics)

Abstract

We present the Edge-Defence Firefighter (EDF) - a simple, discrete time model for the spread of a perfectly infectious disease and the effect of contact reduction upon it. It differs from the classic Firefighter Problem, which models the effect of vaccination. EDF is an SI model – i.e. each individual or population is either susceptible or infectious and after becoming infectious, remains so until the end of the game. Individuals or populations are represented as vertices, with edges existing between vertices if they are in sufficiently close contact for the disease to spread between them. The disease breaks out on a vertex of a graph at time 0. In subsequent time steps at most d edges are then defended and cannot spread the disease in future. This could be modelling travel or socialisation restrictions during an epidemic. The disease then spreads deterministically along all undefended edges between infected and susceptible vertices. The game ends when the disease can spread no further. Determining whether k vertices can remain uninfected is NP-complete for general graphs, but is polynomial on certain graph classes. This talk presents new polynomial time algorithms for optimal defence on finite and infinite square grids.

Session 7: Logistics

Chair: Filipe Rodrigues

Container Dispatching And Conflict-Free Yard Crane Routing In An Automated Container Terminal

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(*joint work with* Dirk Briskorn, Erwin Pesch)

Abstract

We focus on a container dispatching and conflict-free yard crane routing problem that arises at a storage yard in an automated, maritime container terminal. A storage yard serves as an intermediate buffer for import/export containers and exchanges containers between water- and landside of a maritime terminal. The considered storage yard is perpendicular to the waterside and employs two rail mounted gantry cranes that have different sizes and have thus the possibility to cross each other. The problem at hand evaluates in which order and by which crane the import/export containers are transported in order to minimize the makespan and prevent crane interferences. We solve this problem to optimality by a branch-and-cut approach that decomposes the problem into two problem classes and connects them via logic-based Benders constraints. We assess the quality of our solution method in a computational study.

Network Restoration Problems

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Abstract

We consider a class of network restoration problems where there is a transportation network that has been destroyed by a disaster which has led to its nodes being disconnected from each other, and the connectivity needs to be restored. The network is being restored by construction crews (servers) that have fixed construction speeds. It is assumed that the servers' relocation (travel) times within the network are negligible with respect to construction times. In other words, at any time a server can relocate instantaneously to any point of the network that is reachable from its present location. For any pair of nodes, its connection time is the time when the pair becomes connected by an already restored path. In network restoration problems, it is required to find a feasible construction schedule that minimizes some nondecreasing function of connection times of different node pairs (e.g., the total weighted flow time, or the maximum lateness with respect to some due dates, etc.) The talk will outline some recent results in this area, including computational complexity issues and optimization algorithms.

Design And Analysis Of Vehicle Scheduling And Routing Methods On A Port Logistics Problem From The Aspect Of Environmental Impact And Cost-Efficiency

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(*joint work with* Daniil Baldouski, Balázs Dávid, Gyorgy Dosa, Miklós Krész, Zsuzsanna Nagy, Ágnes Stark-Werner)

Abstract

The proper scheduling and routing of trucks to their container terminals in a port has significant environmental impacts in addition to financial aspects. The aim of this research is to analyze and compare the efficiency of various approaches for truck traffic control in heading to the port. To reach this goal, an event-based simulation framework was created, which includes a truck waiting queue, a pre-gate parking lot, gates, docks, and routes between them; a structure that makes all of these elements easily configurable. An efficiently scheduled vehicle, a properly chosen truck from the parking lot or a well-chosen gate to enter the port can decrease the overall cost of the transport process both in the economical and the environmental domain. Unfortunately, the interdependence of the several components of the system makes the decision process complex. We have defined several artificial input classes based on the traffic load (number of trucks and ships) and the variation of their arrival time. Multiple scheduling algorithms were implemented, their behaviour was analyzed and their performance was compared on the defined input classes. Based on the results, our further goal is to dynamically propose a solution method depending on the characteristics of the input and the state of the system.

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Berth Allocation And Quay Crane Assignment Problem Under Uncertainty

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(*joint work with* Agostinho Agra)

Abstract

Port terminals play a critical role in maritime transportation. Efficiently allocating vessels to berths in a port is a major challenge because the number of berths is limited. This task is strongly affected by uncertainty, which should be taken into account when designing solutions. In this talk, we present a robust optimization approach for the berth allocation and quay crane assignment problem under uncertain arrival times of vessels. Our approach is based on an exact decomposition algorithm. The main limitations of our algorithm are identified and a different improvement strategy is proposed to overcome each of them. The proposed strategies drastically reduce computational times, as empirically demonstrated by the computational results.

Session 8: Mutli-objective Problems

Chair: Konstantinos Zervoudakis

An Output-Polynomial Time Algorithm To Determine All Supported Efficient Solutions For Multi-Objective Integer Network Flow Problems

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Abstract

This paper addresses the problem of enumerating all supported efficient solutions for a linear multi-objective integer minimum cost flow problem (MOIMCF). First, we highlight an inconsistency in various definitions of supported nondominated vectors for multi-objective integer linear programs (MOILP). Several characterizations for supported nondominated vectors/efficient solutions are used in the literature, which are equivalent in the non-integer case. However, they may lead to different sets of supported nondominated vectors/efficient solutions for MOILPs. This motivates us to summarize equivalent definitions and characterizations for supported efficient solutions and to distinguish between supported and weakly supported efficient solutions. In this paper we derive an output-polynomial time algorithm to determine all supported efficient solutions for MOIMCF problems. This is the first approach that solves this general problem in output-polynomial time. Moreover, we prove that the existence of an output-polynomial time algorithm to determine all weakly supported nondominated vectors (or all weakly supported efficient solutions) for a MOIMCF problem with a fixed number of d 3 objectives can be excluded, unless P = NP. We also investigate some results about determining all supported nondominated vectors in MOIMCF problems.

How To Efficiently Cut In Bi-Objective Branch&Bound?

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Abstract

Many real-world applications are characterized by multiple, usually conflicting objectives, then it's very unlikely to happen that a solution optimizes every goal at the meantime. Therefore, in the multiobjective context, we are interested in enumerating the complete set of all Pareto optimal (so-called efficient) solutions.

In this work, we propose a generic approach to solve the NP-hard bi-objective binary linear problem. We divise a tree-search strategy, known as the bi-objective Branch&Bound (BOB&B) algorithm, exploring the decision space, together with the objective space by (Extended) Pareto branching. The key feature is that, at each node of the B&B tree, two bound sets are considered: the local lower bound set obtained by solving the current bi-objective subproblem in linear relaxation; and the global upper bound set storing the best-known solutions that have been encountered so far or have been heuristically generated. We speed up this BOB&B method by helping to fathom nodes using a polyhedral approach to tighten the lower bound set. To do so, we first propose a multi-point cutting plane scheme that efficiently applies valid inequalities cutting off several points simultaneously, or alternatively invoke a state-of-the-art solver as a black box to obtain a stronger primal relaxation. Preliminary experiments on various types of instances show the efficiency of several variants of our method.

A Multi-Objective Perspective On The Cable-Trench Problem

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(*joint work with* Michael Stiglmayr)

Abstract

The Cable-Trench Problem is defined as a combination of the Shortest Path and the Minimum Spanning Tree Problem. In particular, the goal is to find a spanning tree that simultaneously minimizes its total length and the total path length from a pre-defined starting vertex to all other vertices. Both, the Minimum Spanning Tree and the Shortest Path Problem are known to be efficiently solvable. However, a linear combination of these two objectives results in a highly complex problem.

While in the original publication by Vasko et al. (2002) the Cable-Trench Problem is introduced as a single-objective problem, namely a linear combination of Minimum Spanning Tree and the Shortest Path objective, we consider it as a bi-objective problem separating the two cost functions. In this sense the original form of the Cable-Trench Problem corresponds to a weighted sum scalarization of the bi-objective formulation. We show that in general the bi-objective approach may imply additional compromise solutions that cannot be found by solving the Cable-Trench Problem in its originally formulation. In order to determine the set of non-dominated points and efficient solutions, we use epsilon-constraint scalarizations in combination with problem specific cutting planes which can be adapted from the fixed-charge network flow problem. We show preliminary numerical results.

Addressing The Combinatorial Problem Of Product Line Design Using Many-Objective Optimization

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(*joint work with* Stelios Tsafarakis)

Abstract

Introducing new products has an important role in the sustainability and profitability of a firm. Product Line Design (PLD) is a key area that product managers have to deal with in the early stages of product development, to estimate the potential success of a product. Even though several objectives may be simultaneously pursued during the product configuration process, most reported studies have focused on single or multi-objective optimization approaches. In this research, the many-objective PLD (MOPLD) problem is addressed, by taking into account more than three objectives, to provide product managers with a better tradeoff among them, using Genetic Algorithms (GAs) that are fully adapted to the MOPLD problem, using popular diversity controlling operators of the non-dominated solutions. According to the findings of this research, the selection of the diversity controlling operators significantly affects the performance of the algorithms. Moreover, it is demonstrated that the selection of a diversity controlling operator should be done according to the number of the objective functions to be optimized.

Session 9: Scheduling

Chair: Dvir Shabtay

Lower Bounds For The Permutation Flowshop Scheduling Problem

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(*joint work with* Adam Letchford, Thu Huong Dang)

Abstract

The permutation flowshop problem with makespan objective is a classic machine scheduling problem, known to be NP-hard in the strong sense. We analyse some of the existing lower bounds for the problem, including the "job-based" and "machine-based" bounds, a bound from linear programming (LP), and a recent bound of Kumar and co-authors. We show that the Kumar et al. bound dominates the machine-based bound, but the LP bound is stronger still. On the other hand, the LP bound does not, in general, dominate the job-based bound. Based on this, we devise simple iterative procedures for strengthening the Kumar et al. and LP bounds. Computational results are encouraging. In particular, we are able to obtain improved lower bounds for the "hard, small" instances of Vallada, Ruiz and Framinan.

Scheduling In Manufacturing With Transportation

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(*joint work with* Alena Otto, Erwin Pesch)

Abstract

Many modern manufacturing settings feature especially close relationship of the transportation of workpieces between production steps with the scheduling of manufacturing operations. Consider flexible manufacturing systems, reconfigurable manufacturing systems or flexible assembly lines, to name a few. In this talk, we share the results of our literature survey, in which we review over 100 papers on Scheduling Problems in manufacturing with Transportation (SchedPT). Specifically, SchedPT refer to optimization problems, where (i) at least one of the machine scheduling decisions is to be made – either sequencing of jobs on machines or, in case several alternative machines are available, the assignment of jobs to machines; and (ii) transportation is considered, such as transportation time or transportation-related decisions, e.g., assignment of jobs to transporters, routing of transporters or sequencing of jobs moved by transporters. We classify the reviewed papers according to an extension of the three-field notation of Graham et al. (1979) and outline relevant problem settings, such as characteristics of transporters, material flow or of the buffer system. Based on the reviewed literature, we highlight main algorithmic approaches to solve SchedPT. We also collected more than 50 results on polynomially solvable problem variants and performance guarantees. Based on our analysis, we formulate promising directions for future research.

Scheduling Conferences With A Two-Phase Matheuristic Approach

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(*joint work with* Ahmed Kheiri, Peter Jacko)

Abstract

Conferences are a key aspect of academia, and their schedule plays a vital role in meeting the expectations of participants. Organizers usually create the schedule manually, which is an arduous and error-prone process. The conference scheduling process is an NP-Hard real-world combinatorial optimization problem which has not been studied as much as related problems, such as class and exam scheduling. Given that many conferences have different constraints and objectives, different mathematical models and heuristic methods have been designed to address rather specific requirements of the conferences being studied per se. In this work, we present a two-phase matheuristic algorithm which follows a weighted sum approach to solve conference scheduling problems. In the first phase, we use an integer programming model to create a high-level schedule by assigning tracks into sessions and rooms. Based on this solution, we create the low-level schedule where submissions are allocated into sessions and time slots. In phase two, we make use of hyper-heuristics to further optimize both schedules. Our solution method creates the schedule in a fully automated manner and has already been used to create high quality schedules for four well-known conferences in operational research. Finally, we present results from the implementation of our method on these conferences to demonstrate its suitability to optimize schedules for in-person, hybrid, and online conferences.

Minimizing Total Operations Rejection Cost Plus Makespan Value In A Two-Machine Flow-Shop Scheduling Problem

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(*joint work with* Enrique Gerstl)

Abstract

We study a two-machine flow-shop scheduling problem where either one of the two operations of each job can be rejected at a certain cost. A solution our problem requires two sets of decisions. The first involves the partition of the set of operations into two subsets: the set of operation that are accepted to be scheduled in the shop, and the set of rejected operations. The second involves the scheduling of the set of the set of accepted operations in the shop. The objective is to find a solution minimizing the sum of makespan and total rejection cost. We prove that the problem is NP-hard even if all processing operations have identical processing time on either one of the two machines. We provide a pseudo-polynomial time algorithm for the problem which we convert into a fully polynomial approximation scheme (FPTAS). This is done by subdividing the problem into a set of subproblems and presenting an FPTAS for each one of them, separately. We also present an integer linear programming (ILP) formulation of the problem and two simple 2-approximation algorithms.

Session 10: Graphs

Chair: Alain Hertz

Complexity Of Domination Problems In Graphs

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Abstract

Let $G = (V, E)$ be an undirected graph. A subset D of V is said to be a dominating set if any vertex not in D admits a neighbour belonging to D. This definition can be extended, for any integer $r > 0$, to r-dominating sets: D is an r-dominating set if, for any vertex v, there exists an element of D whose distance to v is at most r. The usual combinatorial optimization problem dealing with domination in graphs consists in looking for a dominating set of minimum size. This problem is NP-hard for any $r > 0$ (more precisely, the associated decision problem is NP-complete). We consider here the complexity of several related problems, still for $r > 0$:

- computing the minimum size of an r-dominating set;
- computing a minimum-sized r-dominating set;
- the existence and the computation, if any, of a minimum-sized r-dominating set including a prescribed vertex (problem sometimes known as "membership problem").

The NP-completeness of the usual decision problem easily shows that these problems are NP-hard. Since NP-hardness only provides a kind of "lower bound" ("the considered problem is at least as difficult as any problem belonging to NP"), our aim is to locate these problems more precisely in the complexity classes linked to the polynomial hierarchy by providing "upper bounds" of their complexities ("the considered problem belongs to the class… and thus is at most as difficult as…", depending on the class which it belongs to). In particular, we may precisely locate the membership problem by showing that it is K-complete for an appropriate class K which contains NP and co-NP.

Exact Algorithms And Hardness Results Of Cosecure Domination In Graphs

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(*joint work with* Arti Pandey)

Abstract

A dominating set S of a graph G is a cosecure dominating set of G, if for every vertex v in S, there exists a vertex u outside S such that u is adjacent to v, and replacing u with v in S results in another dominating set of G. The minimum cardinality of a cosecure dominating set of G is called the cosecure domination number (CSDN) of G. The Minimum Cosecure Domination (MCSD) problem is to find a cosecure dominating set of a graph G of minimum cardinality. It is already known that the decision version of the MCSD problem is NP-complete for bipartite, chordal, and planar graphs. Also, the problem is known to be efficiently solvable for proper interval graphs.

Extending the systematic study of the computational complexity of the MCSD problem in graphs, we work on various graph classes. We strengthen the hardness results by showing that the decision version of the problem remains NP-complete for the following classes of graphs: split, circle, doubly chordal, chordal bipartite, and tree-convex bipartite graphs. On the positive side, we present efficient algorithms to compute the CSDN of cographs, a subclass of circle graphs, and chain graphs, a subclass of chordal bipartite graphs. Also, we show that the problem is linear-time solvable for bounded tree-width graphs. In addition, we demonstrate that the computational complexity of the MCSD problem varies from that of the classical domination problem in certain graph classes. Moreover, we study the approximation aspects of the MCSD Problem and prove that the MCSD problem is APX-hard for graphs with maximum degree four. Further, we show that the problem becomes APX-complete for bounded degree perfect graphs and we provide a lower bound on the approximation ratio of the MCSD problem.

Combinatorial Techniques In The Enumeration Of Boolean Functions

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(*joint work with* Xavier Molinero, Dani Samaniego)

Abstract

The Dedekind numbers are a rapidly growing sequence of integers named after Richard Dedekind, who defined them in 1897. The Dedekind number M(n) counts the number of monotonic Boolean functions of n variables. A Boolean function is a function that takes as input n Boolean variables (that is, values that can be 0 or 1), and produces as output another Boolean variable. It is monotonic if, for every combination of inputs, switching one of the inputs from false to true can only cause the output to switch from false to true and not from true to false. The Dedekind number M(n) is the number of different monotonic Boolean functions on n variables.

In this work we specialize, by considering inequivalent monotonic Boolean functions. Two monotonic Boolean functions are equivalent if one can be obtained from the other by permuting the variables. The purpose of this work is to find enumerations of inequivalent monotonic Boolean functions according to the number of symmetric variables they have. In particular we focus on the case of two, three and four types of distinguished symmetric variables.

By using recurrence relations, difference equations and several techniques of combinatorics and optimization, we determine a closed (exponential) formula T(n) for the number of inequivalent monotonic functions of two types of symmetric variables. It is worth mention that the enumeration of the most important subclass of these functions follows a variant of a Fibonacci sequence, which is modified by a polynomial.

When we generalize to three and four types of symmetric variables we obtain new (exponential) closed formulas if some of the variables are either dominant or dominated.

Some of these enumerations have also been included in Online Encyclopedia of Integer Sequences, while some others obtained recently will appear there in the near future.

We point out that the problem we deal with in this work is very versatile since inequivalent monotonic Boolean functions are monotonic simple games, structures that are used in many fields such as game theory, neural networks, artificial intelligence, reliability or multi-criteria decision-making.

Decycling Bipartite Graphs

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Abstract

Let G be a graph and let S be a subset of its vertices. If the induced subgraph of G obtained by removing all vertices of S is acyclic, then S is said to be a decycling set of G. The size of a smallest decycling set of G is called the decycling number of G. Determining the decycling number of a graph G is NP-hard, even if G is bipartite. We describe a tabu search procedure that generates decycling sets of small size for arbitrary bipartite graphs. Tests on challenging families of graphs show that the proposed algorithm improves many best-known solutions, thus closing or narrowing the gap to the best-known lower bounds.

Session 11: Routing

Chair: Magdalene Marinaki

A Branch-Cut-And-Price Algorithm For The Storage Location Assignment And Picker Routing Problem

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(*joint work with* Nabil Absi, Valeria Borodin, Diego Cattaruzza)

Abstract

Within warehousing logistics, the Storage Location Assignment Problem (SLAP) and the Picker Routing Problem have receive a lot of attention from the literature, because of their importance when optimizing the Order Picking (OP) operations, the most resource-intensive process of warehousing logistics. The two problems are traditionally considered at different levels of decision: tactical for the SLAP, and operational for the PRP. However, this paradigm has been challenged by the development of modern practices in e-commerce warehouses where storage decisions are becoming more dynamic. The joint optimization of both operations, called the Storage Location Assignment and Picker Routing Problem (SLAPRP), has seen limited attention. Several variants of the SLAPRP have been investigated with exact and heuristic methods, including different warehouse layout and routing policies. Nevertheless, the computational results available suggest that each variant requires an ad hoc formulation. Moreover, the complete integration of the two problems, where the routing is solved optimally, stays out of reach for commercial solvers, even on trivial instances.

In this talk we present an exact solution framework that addresses a large class of SLAPRP variants, including all the previously existing ones. The method relies on a novel extended formulation based on a Dantzig-Wolfe reformulation. No assumption is made on the warehouse layout and routing policy, providing a very generic formulation where the operational details are convexified in the subproblems. The formulation is further strengthened by the introduction of a novel family of non-robust valid inequalities. The problem is tackled by column generation and cutting plane, embedded in a Branch-Cut-and-Price framework. Particular attention is paid to the management of the non-robust valid inequalities, and several branching schemes have been developed to break symmetries and keep the size of the enumeration tree manageable. Computational experiments show that the algorithm can solve medium size instances of several SLAPRP variants and outperforms the state-of-the-art methods from the literature.

A Column Generation Approach For Last-Mile Deliveries With Capacitated Robot Stations

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Abstract

We define the capacitated routing-scheduling problem (CRSP) for a multimodal delivery system where the first leg is performed by a truck that makes a tour starting from the depot, visiting some facilities from a set of candidates. The second and last leg of the delivery is performed by robots starting from the facilities and ending at the doorsteps of the customer. The capacity to serve customers of each facility is limited. Each customer has a scheduled time of delivery and has to be served from a single facility. If the robot arrives after this time, the difference between the time of the delivery and the scheduled time is counted as the delay for the customer. The CRSP asks to select a tour for the truck and a feasible assignment of customers to facilities such that the total delay of delivery is minimized. The problem is NP-hard. Existing literature tackles a version of this problem that does not consider capacity limits for the facilities. We propose an extended formulation and a column generation-based method to solve the problem. We further refine this method by adding valid inequalities and proposing methods to prune nodes during the branching phase, for heuristically generating feasible solutions even if the algorithm reaches a time limit before finishing. We perform a theoretical analysis showing that the linear relaxation of the extended formulation usually gives better lower bounds than those which can be achieved by a straightforward compact formulation.

The Ordered Travelling Salesman Problem: A Comparison Of Formulations

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(*joint work with* Ivana Ljubic, Justo Puerto, Francisco Temprano Garcia)

Abstract

The OTSP is to find a Hamiltonian cycle in a network with minimum weighted cost. The costs of the edges of the cycle have to be sorted in decreasing order before multiplying them times the given weights. When all weights are equal and positive, the TSP is obtained as a particular case. When the unique non-null weight (positive) is the first one, the bottleneck TSP is obtained. Positive weights in the first positions and negative weights in the last positions will provide us with balanced cycles. Many other particular cases of interest exist, and the aim of the problem is to study all of them as a whole. In this preliminary work we study and compare different integer programming formulations of reduced size for the OTSP, paying special attention to the sorting part of the models.

The Drone Routing Problem With Pickups, Deliveries And Battery Replacement Stations

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Abstract

With the technology evolving, supply chains experiment with alternative means of transportation to achieve their goals. One novel mean is the unmanned aerial vehicle, commonly known as the drone. In this research a novel drone routing problem is modeled and solved. The objective of the problem is the minimization of the total energy expenditure of the drones. Drones carry out the pickup of the packages, which have predetermined weight, from a set of sellers and they deliver them to a set of corresponding buyers, taking into consideration the capacity and energy constraints. Drones are able to replace their emptied batteries with new ones, by visiting battery replacement stations. For the solution of the problem a hybrid metaheuristic algorithm is implemented, based on the Greedy Randomized Adaptive Search Procedure and the Variable Neighborhood Search. Preliminary results are presented.

Session 12: Miscellaneous

Chair: Paolo Toth

Allocation Problems With Minimal Dissatisfaction On Preference Graphs

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Abstract

We consider the task of allocating indivisible items to agents, when each agent's preferences are captured by means of a directed acyclic graph. The vertices of such a graph represent items and an arc (a,b) means that the respective agent prefers item a over item b. The dissatisfaction of an agent is measured by the number of non-assigned items which are desired by the agent and for which no more preferred item is given to the agent.

Our goal is to allocate the items to the agents in a way that minimizes (i) the total dissatisfaction over all agents (efficiency) or (ii) the maximum dissatisfaction among the agents (fairness).

For both problems we study the status of computational complexity and obtain NP-hardness results as well as polynomial algorithms with respect to different underlying graph structures, such as trees, stars, paths, and matchings. Bounding the number of agents allows some positive parameterized complexity results, but even for only two agents and a bipartite preference graph we can show NP-hardness.

Beside the general problem, where each agent has its own preference graph, we also consider the case of a shared, common preference graph. These two setting exhibit different complexity properties and require quite different solution algorithms.

Models For The Two-Dimensional Variable-Sized Cutting Stock Problem In The Honeycomb Cardboard Industry

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(*joint work with* Antonio Alonso-Ayuso, F. Javier Martin-Campo)

Abstract

In this work we present different novel mathematical optimisation models for the two-dimensional variable-sized cutting stock problem with guillotine cuts. This research is developed in collaboration with a Spanish company in the honeycomb cardboard industry. This company has as its main objective in the medium term to automatise its processes to gain efficiency and effectiveness. Their main business line is to sell the honeycomb cardboard panels used mainly for transportation and items of different sizes made of this material. To help them in their decision-making process we have developed different mathematical optimisation models. The aim is to decide the panels dimensions (width and length) to produce and how to cut them minimising the leftover generated. The panels and the items have rectangular shape so the problem we are dealing with is a two-dimensional cutting stock problem with guillotine cuts. In this case, as the company produces the stock (panels) as part of its production process the stock is considered variable sized. Therefore, the objectives are to decide (1) how many panels produce, (2) their dimensions and (3) how to cut them. Mixed Integer Linear Optimization (MILO) models are presented and validated using real data from the company. The results obtained show that the amount of material produced currently can be drastically reduced, decreasing operating time and economic costs.

A Mixed 0-1 Linear Optimisation Model For The 1.5-Dimensional Cutting Stock Problem With Slitting Line Allocation

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Abstract

A mathematical optimisation model is presented for the 1.5-dimensional Cutting Stock Problem (CSP) that takes place in a Spanish steel manufacturing company. The company receives orders with certain specifications that have to be fulfilled using coils in stock that are cut into smaller pieces according to the customer's requirements. The orders to be supplied are given in terms of width and weight to be served within certain limits. This variant of CSP is known in the literature as 1.5-dimensional. Furthermore, the mathematical optimisation model determines the slitting machines on which the coils will be processed, assuming that the machines are heterogeneous in terms of speed and specifications of the coils to be processed. The model has been validated by using real-data from the Spanish company and the results improve the company's current operation.

Models And Deterministic Matheuristic Algorithms For The Quadratic Knapsack Problem With Setup

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Abstract

The Quadratic Knapsack Problem (QKP) was presented for the first time by Gallo et al. in 1980, and received a considerable attention since then. As in the classical 0-1 Knapsack Problem (KP), we are given a knapsack with integer capacity, and a set of items characterized by a non-negative integer profit and a non-negative integer weight. The distinctive feature of the QKP, underlying the quadratic nature of the problem, is that each pair of items produces an additional pairwise profit if both are selected. The QKP consists of selecting a subset of items, whose overall weight does not exceed the capacity and the total profit is maximized.

Another relevant generalization of the KP is the Knapsack Problem with Setup (KPS), introduced in 1994 by Chajakis and Guignard and thoroughly investigated in the literature. In the KPS, the items are partitioned into classes, and the items of a class can only be inserted into the knapsack if the corresponding class is activated. Activating a class involves a non-negative integer activation setup cost and a setup reduction of the capacity.

Despite a rich literature on these two problems, their obvious generalization, i.e., the Quadratic Knapsack Problem with Setup (QKPS), was never investigated so far. The purpose of this research is to provide a first study on this problem. We discuss mathematical models, deterministic matheuristic algorithms, and computationally evaluate their performance.

Session 13: Facility location

Chair: Nikolaos Ploskas

Cost Minimizing Planning Of Container Inspection And Repair In Multiple Facilities

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Abstract

A problem of optimal mid-term or long-term planning of inspection and repair of freight containers in multiple facilities is introduced and investigated. The containers are of different types and quality levels, which define their repair costs and workforce requirements. The objective function includes the total holding, inspection, repair, transportation and rejection costs. We propose a deterministic, time-dependent, integer linear min-cost multi-commodity network-flow formulation. The problem is shown to be polynomially solvable if there is a single facility, a single time period and all the containers are repairable and have to be repaired. It is shown to be NP-hard for three important special cases. The computational results of our experiments on randomly generated instances based on real data show that instances of sizes 3 facilities, 4 container types and up to 9 container quality levels can be solved with CPLEX in 5 minutes on a conventional PC, even for 30 periods, with an optimality gap of less than 3%. This is sufficient for medium-term or weekly planning or for short-term recovery planning. However, there are instances of the same magnitude, but with 360 periods of a considerably longer planning horizon, for which an optimality gap of 28% remained even after 10 hours of CPLEX computation.

Exact Solution Methods For The P-Median Problem With Manhattan Distance And A River With Crossings

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(*joint work with* Atsuo Suzuki)

Abstract

Large population densities congregate around large rivers. While humans inhabit around 38

However, in current facility location models, the pivotal influence on travel that a river exerts has not yet been adequately addressed. Despite providing such vital resources to a settlement to this day, rivers are usually impassable but for preconstructed crossings and so present a very real barrier to anyone hoping to travel besides or to the other side of the river.

We propose an exact solution method for the p-median problem with Manhattan distance and a river. This requires the locating of several facilities so as to minimise the total travelling distance from the given demand points to their nearest facility. For any route across the river, a crossing point is chosen from a given set of crossings which minimises the shortest paths where distance is measured using the Manhattan metric (most representative when considering urban applications of facility location).

The objective function is not convex and there are many local minima. A naive solution method is to enumerate all the candidate points and to evaluate the objective function at each. Instead, we construct a Big Triangle Small Triangle algorithm which obtains the exact solution in practical computational time.

Hybrid Grasp And Vns Methods For Continuous Facility Location And Transportation Mode Selection In The Supply Chain

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Abstract

The purpose of this study is to understand the challenges faced when determining the location of a facility and selecting the mode of transportation within a supply chain network while considering carbon emissions. In this study, we aim to (i) locate facilities (such as distribution centers) in continuous space, taking capacity limitations and opening costs into account, and (ii) reduce carbon emissions by choosing transportation mode. The problem is formulated as a mixed-integer linear programming. This study hybridised a greedy randomised adaptive search (GRASP) and variable neighborhood search (VNS) to deal with the problem. In order to assess the performance of the proposed method, well-known datasets from the literature are utilized and adapted. In addition, the study emphasizes some research avenues for future study based on a computational analysis of the proposed hybrid method.

Integer Programming Formulations For Facility Location Problems With Distance Constraints

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Abstract

Facility location problems have attracted much attention in the last decades since they appear in various real-world problems. However, facility location problems with distance constraints have received relatively little attention in OR and related areas. In this work, we study two variants of facility location problems, the p-median and the p-dispersion problems, where minimum distance constraints exist. The problems with distance constraints can be utilized in cases where the facilities to be located are semi-obnoxious, e.g., filling gas stations. We have selected two representative facility location problems to experiment with; the p-median problem deals with locating p facilities so that the sum of distances between the demand points and their nearest facility is minimized, while the p-dispersion problem concerns the location of p facilities so that the minimum separation distance between any pair of open facilities is maximized. We also consider both the problem of locating homogeneous and the one of locating heterogeneous facilities on the plane and we propose various integer linear programming models to solve these problems. Gurobi Optimizer is used to compare these integer linear programming models on a large dataset of problems and useful conclusions are drawn.

Session 14: Miscellaneous

Chair: Juan José Salazar González

Counting How Weightedness Is A Simple Game Restricted To Their Weighted Players

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(*joint work with* Josep Freixas, Salvador Roura)

Abstract

In voting theory and social choice theory, decision systems can be represented as simple games, i.e., cooperative games defined through their players and the set of winning coalitions. The weighted voting games are a strict subclass of simple games, where each player has a voting weight so that a coalition wins if the sum of weights of their members exceeds a given quota. The number of winning coalitions can be exponential with the number of players. However, simple games can be represented as an intersection or an union of weighted voting games. This representation is much more compact than from the set of winning coalitions.

There exists different concepts that can characterize how weighted a simple game is. For instance, the dimension (codimension) of a given simple game is the minimum number of weighted voting games such that their intersection (union) gives us the simple game. So, we can define the weightedness of a simple game according to its dimension (codimension). On the other hand, we also can define the weightedness of a simple game according to its trade robustness. In general, we say that a simple game is m-trade robustness if the players of m winning coalitions can be interchanged to obtain m losing coalitions. There also exists other related studies such as the invariant-trade robustness or the α-roughly weightedness. In this work, we establish a new statement of weightedness: Given a simple game with N players (not necessarily weighted), we compute the maximum number of players N' such that the new restricted simple game to N' players is a weighted voting game. In that direction, we classify all simple games up to N=7 players. We also analyze and give some properties related to these games. Finally, we present experimental results to compare different characterizations of weightedness using combinatorial techniques in programming.

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Solving The Flexible Job-Shop Scheduling Problem With Transportation Resources

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(*joint work with* Stéphane Dauzere-Peres, Claude Yugma)

Abstract

Many extensions of the job-shop scheduling problems have been studied in the literature. This work considers the combination of two of these extensions: The flexible job-shop scheduling problem (FJSP), where multiple machines can perform the same production operation, and the job-shop scheduling problem with transportation resources, where a fleet of vehicles must perform transportation tasks between machines. The flexible job-shop problem with transportation resources (FJSPT) involves the assignment of production, resp. transportation, operations to machines, resp. vehicles, the scheduling of production operations on machines and the routing of vehicles. We consider a disjunctive graph model to quickly evaluate every possible move in a local search algorithm. The problem is composed of a set of jobs, where each job requires a sequence of multiple consecutive operations (route) to be completed, a set of machines and a set of vehicles with unit capacity. As the FJSPT is an extension of the FJSP, each production operation has a set of machines on which it can be processed. The processing times of the production operations are machine dependent, i.e. machines are different, while vehicle travel times are not vehicle dependent, i.e. vehicles are identical. The objective is to determine an assignment of production operations to machines and an assignment of transportation operations to vehicles, to schedule the production operations on machines and to route vehicles in order to minimize the makespan (time of completion of all jobs). We extend the disjunctive graph model to this problem and exploit it in a tabu search framework with quick a priori moves evaluations. Computational results on existing and new benchmark instances will be presented.

Optimization And Simulation Of Renewable Energy Communities

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Abstract

Renewable energy communities (RECs) are a key tool to support citizen participation in the transformation of energy systems. Individual entities such as households, municipalities, or businesses can join together in non-profit-oriented communities and generate, store, consume and sell renewable energy. The daily implementation of these actions involves a large number of different decisions. Electricity produced by an individual household can be consumed or stored by the household itself, used to charge an electric vehicle or other time-flexible electrical loads, or can be distributed to the community. Similarly, electricity available in a community can be conceded to other community members, stored in a community battery, or sold to the power grid. Clearly, there is a strong interdependence between the members' demand profiles and consumption decisions. Therefore, a central optimization model is developed to determine a system-wide optimum for the community based on short-term production and consumption forecasts. As the actual conditions may well deviate from initial forecasts, not all intended actions can be carried out as planned. Therefore, a simulation model is used to update the input of the optimization model with up-to-date values in a rolling time horizon. The outcomes of these calculations are used to demonstrate the benefits of coordinated decision-making and to evaluate the realistic performance of RECs.

Solving A Combinatorial Problem To Find Another Planet To Live On

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Abstract

Recent events are remarking that we need another planet to live on. Astronomers are investigating the sky looking for planets where humans could live on. Using spectroscopy, they have detected more than 4000 planets so far, and there are many areas of the sky still waiting to be explored. Spectroscopy splits the light from a distant celestial object into its component colours by passing it through a dispersive element (grism). As planets orbit a star, they cause it to wobble ever so slightly. By observing the star's spectrum, scientists can detect a slight shift in the location of the elemental absorption lines, compared to where they should be, thus indicating that a planet was making the star wobble. In addition, spectroscopy also informs us about the age, temperature, mass and surface gravity of objects. The infrared spectrum provides invaluable information about the Universe's warm dust and gas phase. Micron-sized particles such as silicates, silicon carbide, carbon, coals, aluminium oxides or polycyclic aromatic hydrocarbon molecules are significant contributors to thermal-infrared emission.

Requests of observations submitted to modern telescopes by scientists are carried out in queue-scheduled service mode. Not surprisingly, spectroscopes are in high demand, and observing time is a limited resource leading to an important optimization problem in Astronomy. Modern spectroscopes can observe dozens of objects simultaneously, but still, not all desired observations can be granted. Astronomers submit proposals with objects to observe and priorities. Each proposal should be partitioned into masks for the spectrograph. A mask is a group of objects that can fit in the same field of view of the spectrograph to be observed simultaneously, and therefore should conform to a set of technical requirements. The list of masks related to a proposal should arrive at the telescope sorted according to the sum of their objects' priorities. The masks with the highest sum of priorities are loaded and executed sequentially a night while sky conditions and awarded time allow. Typically around 5 to 10 masks from each awarded applicant will be completed by the instrument, so the complete partition of all the objects in the proposal (catalogue) is unnecessary. The applicant is responsible for creating the list of masks once informed by the committee about his/her awarded time. The necessity is for an automatic procedure to design the best-possible mask from a given catalogue. Designing a mask means selecting the centre where the spectrograph must point, selecting the rotation of the field of view, and selecting the objects satisfying the technical requirements. It is called the Mask Design Problem (MDP) and the aim of this talk is to describe an approach to solve it in practice.

Part of this talk is published in https://doi.org/10.1016/j.omega.2021.102392

Session 15: Bioinformatics

Chair: Marta Szachniuk

Analysis Of K-Mer Characteristics For The Reference Genome In The Genomic Map Of Poland Project

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Abstract

The first draft of the human reference genome was published more than two decades ago. Due to the technological limitations, it was full of gaps, especially in highly repetitive regions of centromeres and telomeres. It was updated and corrected several times and for many years the newest version of the genome was GRCH38. Last year Telomere To Telomere (T2T) consortium published a new release of the haploid human reference genome, called CHM13, that filled over 200 Mbp of gaps in repetitive regions. DNA sequencing has become much cheaper in the last few years, moreover, new technologies allow to read longer DNA fragments with decent quality. However, people noticed that one reference genome, although well-annotated, cannot represent a given population with its most common variants. Several attempts were made in this area, and a few reference genomes were already published (e.g. Korea, China, Japan).

We used a pipeline for constructing a diploid human genome within the Genomic Map of Poland project. The genome is assembled de novo based on a trio: mother, father, and child. In the pipeline, we used several technologies short reads, long high-quality reads (PacBio HIFI), artificial long reads (stLFR), long-distance contact reads (Hi-C), and ultralong reads (Nanopore). The resulting scaffolds, spanning the whole chromosome, were compared with the GRCH38 and CHM13 reference genomes. We evaluated the quality of our reference genome assembly by analyzing k-mers that appear in input genomic short sequences vs k-mers from the reference genome. Also k-mers specific to only one of the parents (mother or father) were checked if they exist in a copy of chromosome inherited from a single parent (each copy of chromosome contains small variances in the sequence, specific to an individual). Different k-mers characteristics show the high quality of the assembled genome.

Genomic Map Of Poland - Computational And Machine Learning Challenges

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Abstract

The Genomic Map of Poland (GMP) project consist of the development and implementation of innovative bioinformatics tools for the analysis and processing of genomic data corresponding to the reference polish genome and map of genetic variability of Polish population. The reference genome is assembled in a multistage process which includes incorporation and standardization of heterogenous data. Within the project databases correspond to the connections between the phenotype and the genotype are created, based on sequencing, analysis of phenotype data, results of basic clinical research and information concerning the state of health as well as bioinformatics tools for the analysis of the genetic variation of ethnic minorities are developed. The research objective of GMP is to create a detailed catalog of genetic variation in the Polish population and to develop bioinformatics tools for multidimensional genomic and genetic analysis. GMP has been built in the form of computationally processed databases and a set of bioinformatics analytical tools serves both scientists conducting basic research on the genetic determinants of various types of diseases, and researchers developing medical tests used in prevention, diagnosis and therapy. The use of widely understood machine learning approaches gives the ability to create a connection between genomic and clinical data being able to explore and support medicine almost in all its aspects. During the project various tools and computational ideas have been developed and explored trying to identify how to extract the most relevant elements from large heterogeneous and often fragmented data sets and then integrate them in such a way that they form a single coherent picture. The project opens the way to research, related to genetic risk factors for various types of diseases and the introduction of personalized predictive and precision medicine, including analysis of genetic defects inheritance and pharmacogenomics.

Rnapdbee 3: An Rna Structure Multitool With Optimum Pseudoknot Order Assignment

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Abstract

RNA molecules are essential actors in the viral and living organisms' lifecycles. As with other molecules, it is the 3D structure that enables these functions to work right. Yet, understanding RNA 3D structure is challenging. We store RNA structure in various file formats - often not interchangeable easily, sometimes outdated, and usually with some quirks and exceptions. We have external tools that look into the RNA structure data, but each works differently and extracts pieces of information. RNApdbee is a web server that combines support for different formats and external applications in a unified venture. Doing so also solves the Pseudoknot Order Assignment (POA) problem. A pseudoknot is an RNA motif in which nucleotides separated by a base-paired segment form a base pair too. Naturally, in a pseudoknot motif, some base pairs must develop first (the core structure) for the others to appear next (we call these the pseudoknots). Analyzing all base pairs in larger RNA structures often shows an intricate network of interleaved nucleotide interactions. The POA problem is about deciding which are the core structure and which are pseudoknots. We model the situation as an undirected graph with vertices for nucleotides and edges for interleaves. Solving POA resembles vertex-coloring the graph with additional constraints on colors or finding a maximum independent set and treating it as the core structure. Here we present several algorithms and a MILP model to solve the POA problem.

Knot Hunters In The Molecule World

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Abstract

In the late 1970s, researchers began to predict that knots could form in organic biological molecules. Soon after, the first knot was found in DNA [1] and a knotted molecule was synthesized [2]. In the following years, studies of entangled topologies in protein structures were conducted in an attempt to find out what their biological significance might be. The recent decade brought an interest in RNA knots [3]. The first work reported on the absence of knots in organic RNA molecules. However, recently a lasso-type entanglement has been found in the structure of the SARS-Cov-2 virus genome. Also, algorithms that predict the 3D structure of RNA molecules from sequence occasionally generate entangled topologies. Thus, it is necessary to identify and describe them, as is the case with protein knots. Recently, computational methods have been developed to detect tangles in molecule structures and classify them into various topological groups [4][5]. During the lecture, the problem of molecular knots will be presented along with the classification of entangled topologies. The algorithms for knot identification will be shown and compared. The audience will also learn about the results of knot-focused scanning of the datasets containing organic, experimentally solved and predicted structures.

References [

References:

[1] L. F. Liu, L. Perkocha, R. Calendar, and J. C. Wang, Knotted DNA from bacteriophage capsids, *Proceedings of the National Academy of Sciences*, **78**:9, (1981) 5498-5502. [2] Dietrich-Buchecker, O. Christiane, and J-P Sauvage, A synthetic molecular trefoil knot, *Angewandte Chemie International Edition in English* **28**:2 (1989) 189-192. [3] A. S. Burton, M. Di Stefano, N. Lehman, H. Orland, and C. Micheletti, The elusive quest for RNA knots. *RNA biology*, 13:2, (2016) 134-139. [4] A. I. Jarmolinska, A. Gambin, and J. I. Sulkowska, Knot_pull—python package for biopolymer smoothing and knot detection. *Bioinformatics*, **36**:3 (2020) 953-955. [5] K. Luwanski, V. Hlushchenko, M. Popenda, T. Zok, J. Sarzynska, D. Martsich, and M. Antczak, . RNAspider: A webserver to analyze entanglements in RNA 3D structures. *Nucleic Acids Research*, **50**:W1, (2022) W663-W669.

Session 16: Miscellaneous

Chair: Maciej Drozdowski

Introduction To The Satellite Image Mosaic Combination Problem

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Abstract

Governments and military forces are no longer solely occupying the space industry market, which continues to grow rapidly.

According to a recent European Union Space Program Agency report, the Global Satellite Navigation and Earth Observation (EO) market reached revenues of around 200 billion euros in 2022 and is expected to reach 500 billion euros by 2031. As access to space has become cheaper, more private companies have entered the space business. Some companies even use space data without owning any space assets, thanks to services such as satellite-as-a-service.

Thanks to advances in satellite design and high-resolution remote sensors, the EO sector has experienced significant growth in recent years. In 2021, the number of satellites dedicated to EO was more effective than the number of launches from 2012-2016. In 2020, more than 100 terabytes of satellite images were generated per day.

This research focuses on the combinatorial optimization problem of selecting a set of satellite images that form a mosaic covering the interested area. The goal is to recommend a collection of images that meet the user's criteria by optimizing specific parameters, for example, the total cost of the images or the image resolution. The main contribution of this abstract is the presentation and modeling of the problem, which we call the Satellite Image Mosaic Combination Problem (SIMCOP).

At higher levels of abstraction, some similarities can be found between SIMCOP and the Cloud Brokering Problem, especially for the bundled version. Another problem that can be somehow related to SIMCOP is the Internet Shopping Optimization Problem in various variations, where a customer plans to buy products from online stores.

An Efficient Tour Construction Heuristic For Candidate Set Generation Of The Large Traveling Salesman Problem

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Abstract

A key point for solving large TSP instances efficiently is to take into account only a subset of edges connecting the nodes. The well-known techniques don't work well; they are missing many edges from the optimal or best-known solutions (like Nearest Neighbor heuristic) or have high time complexity (like candidate sets [1]). In this work we present an efficient, near-linear tour construction heuristic for generating candidate sets. Our approach first creates fuzzy clusters (our experiments showed that fuzzy clustering results in higher-quality candidate sets than the traditional ones), then solves the subproblems with a variant of the Lin-Kernighan heuristic [1], finally the subtours are connected into a valid solution improving further with the Lin-Kernighan heuristic [1]. The performance of our heuristic was evaluated by testing it on world and Euclidean benchmark instances up to 1 million nodes. Its time complexity is nearly linear, which makes it applicable even for large-scale problems. Similar to the POPMUSIC heuristic [2] the union of the tours generated with our heuristic contains almost all edges of the optimal or best-known solutions. Furthermore, the size of the candidates set generated with our approach is smaller compared with the POPMUSIC, which ensures faster execution of the tour improvement methods (Helsgaun's Lin-Kernighan heuristic [1], evolutionary algorithms [3] etc.).

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References: [1] K. Helsgaun, An effective implementation of the Lin-Kernighan traveling salesman heuristic, *European Journal of Operational Research*, **126**, (2000) 106–130.

[2] E.D. Taillard, K. Helsgaun, POPMUSIC for the travelling salesman problem, *European Journal of Operational Research*, **272**:2, (2019) 420–429.

[3] L.T. Kóczy, P. Földesi, B. Tüű-Szabó, Enhanced discrete bacterial memetic evolutionary algorithm- An efficacious metaheuristic for the traveling salesman optimization, *Information Sciences*, **460–461**, (2018) 389–400.

Cyclic Scheduling For The Single Track Railway Problem

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Abstract

The cyclic version of the single track railway scheduling problem (C-STRSP) is an extension of the classic single track railway scheduling problem, where trains move continuously in a closed loop without the need for end stations or turnarounds. The C-STRSP is a complex optimization problem that involves scheduling trains on a cyclic railway network while minimizing both travel time and waiting time, while also avoiding conflicts and collisions. The problem is challenging because trains may have different travel times around the loop, requiring an optimal schedule that minimizes the overall travel time. This problem has applications in various areas, including urban transit systems, freight transportation, and industrial logistics. Several approaches, including mathematical programming and metaheuristic algorithms, have been proposed to solve the C-STRSP. In this abstract, we review the problem and its variants, the methods used to solve it, and recent advances in the field. We also highlight some practical applications of the C-STRSP and discuss future research directions in this area.

The Structure Of Mean-Variance And Max Entropy Frontiers In Portfolio Optimization

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Abstract

The traditional Markowitz Mean–Variance method for optimizing a portfolio is based on risk (variance) minimization. The combinations of portfolio assets lead to the associated Mean-Variance frontier. The Max Entropy approach is based on maximizing entropy as a way to measure portfolio differentiation. Geometrically the structure of the Max Entropy frontier is similar to that of the Mean-Variation frontier. Both frontiers are the answer to a specific optimization problem with certain constrains. The cases of 2, 5, and 10 assets portfolios are used to show the similarities and differences of the two frontiers. The implications for portfolio managers are discussed using a new index for the Max Entropy frontier that is comparable to the Sharpe index of the Mean-Variance method.

Quay Partitioning Problem

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(*joint work with* Jakub Wawrzyniak, Eric Sanlaville, Yoann Pigné, Frédéric Guinand)

Abstract

Quay partitioning problem consists in partitioning quay length into berths for minimum ship waiting time. This problem arises when designing a layout of container terminal. Two schemes of quay layout are considered: with at most one ship in a berth and with at most two ships in a berth. Ship arrival times, service times, lengths and weights are given. The two versions of QPP are formulated as mixed integer linear programs. Scalability of solving quay partitioning problem via mixed linear programming is studied. We investigate, analytically and by computational experiments, phenomena arising in the quay partitioning problem solutions such as: (1) changes in solution quality when one long berth length is used vs choosing various berth lengths flexibly, (2) what lengths of berths are chosen under changing ship lengths mixture and (3) under ship traffic congestion, (4) how much the above quay layout schemes differ in ship quality of service.

Session 17: Graphs

Chair: Hadrien Mélot

Improving Local Search Heuristics For The Cluster Editing Problem

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Abstract

In the Cluster Editing Problem (CEP) we are given an undirected simple graph G = (V,E) and the goal is to find the smallest possible subset S of V x V, such that the graph G = (V, E') is a union of cliques, where E' denotes the symmetric difference of sets E and S. It has been shown that CEP is NP-complete and it is therefore unlikely to find an efficient algorithm to solve it optimally. Hence, in order to tackle CEP in practice, various heuristics are used. In one of the approaches a local search method is applied, where transitions between states are performed by iteratively moving nodes between different clusters. In this work we present a structural representation of a graph that enables us to both improve existing local search moves and design new ones as well. Created algorithms are based on changing cluster-membership of subsets of nodes instead of single nodes only, which makes them much less prone to getting stuck in a local optimum. Adoption of new graph representation makes it also easier to apply algorithms whose implementation would otherwise be much more complicated. By carefully implementing designed algorithms we are able to quickly obtain high-quality cluster editing sets, even for very large graphs.

On Struction In K-Partite Graphs

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(*joint work with* Sandor Szabo)

Abstract

A notion on a graph transformation with special properties arose in 1984 [2,3]. The so called struction transformation allows a transformation of any simple unweighted graph such that its stability number (or clique number) reduced by one. Of course from the NP-completness of the question follows that the new graph in many cases will increase in size. Some special cases, where the new graph guaranteed to decrease in size resulted several specialized transformation algorithms [1], and laid path for kernelization and Fixed Parameter Tractable (FTP) algorithm design for different problems such as Vertex Cover. Highly efficient algorithms for weighted case were also developed [4].

In their previous work the authors were investigating the problem of finding a k-clique in k-partite graphs [5]. They showed that the struction transformation is a much stronger tool in this case. In the present work they extend this results, when several simultaneous k-colorings of the graph are given. Graphs representing several problems, such as graph isomorphism, Keller's conjecture or Costas arrays have this property, and the new struction promises much stronger preconditioning in these cases.

References:

[1] T Akiba, Y. Iwata, Branch-and-reduce exponential/fpt algorithms in practice: A case study of vertex cover. *Theoretical* Computer Science, **609**, (2016) 211–225.

[2] G. Alexe, P.L. Hammer, V.V. Lozin, D. de Werra, Struction revisited, *Discrete applied mathematics*, **132**, (2003) 27–46.

[3] C. Ebenegger, P.L. Hammer, D. de Werra, Pseudo-Boolean Functions and Stability of Graphs,N*orth-Holland mathematics studies*, **95**, (1984) 83–97.

[4] A. Gellner, S. Lamm, Ch. Schulz, D. Strash, B. Zavalnij, Boosting Data Reduction for the Maximum Weight Independent Set Problem Using Increasing Transformations, In: 2021 Proceedings of the Workshop on Algorithm Engineering and Experiments (ALENEX), *Society for Industrial and Applied Mathematics* (2021) 128–142.

[5] S. Szabo, B. Zavalnij, Clique search in graphs of special class and job shop scheduling. *Mathematics*, **10**:5, 697.

Extremal Properties Of The Arithmetic Geometric Index

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(*joint work with* Alain Hertz, Hadrien Mélot, Gauvain Devillez, Pierre Hauweele)

Abstract

The arithmetic geometric index, noted AG, is a graph invariant defined in 2015 by V. Shegehalli and R. Kanabur. AG is a topological index designed to improve the prediction capacity of the well known Randic index QSPR/QSAR studies. However, the two have different extremal properties. Despite its objective of improving the Randic index, AG has not been widely studied in extremal graph theory.

We present results on the extremal properties of AG as well as the theoretical and practical methods we developed to work with invariants defined as sums of weights on the edges.

Exploring Extremal Properties Of Graphs Using Phoeg

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Abstract

PHOEG is an acronym for PHOEG Helps to Obtain Extremal Graphs. This discovery system is based on a large database of small graphs, invariant values and graph transformation effects. It uses a geometric approach to discover inequalities between graph invariants and hints for proofs by transformation. PHOEG provided tight bounds for several graph invariants, including the number and average number of non-equivalent colorings and the eccentric connectivity index. In this talk, we present a new web interface that allows graph theorists to query PHOEG and manipulate and visualize the outputs, without the need for programming. Also, we will give examples of results and open problems that were obtained with the help of PHOEG.