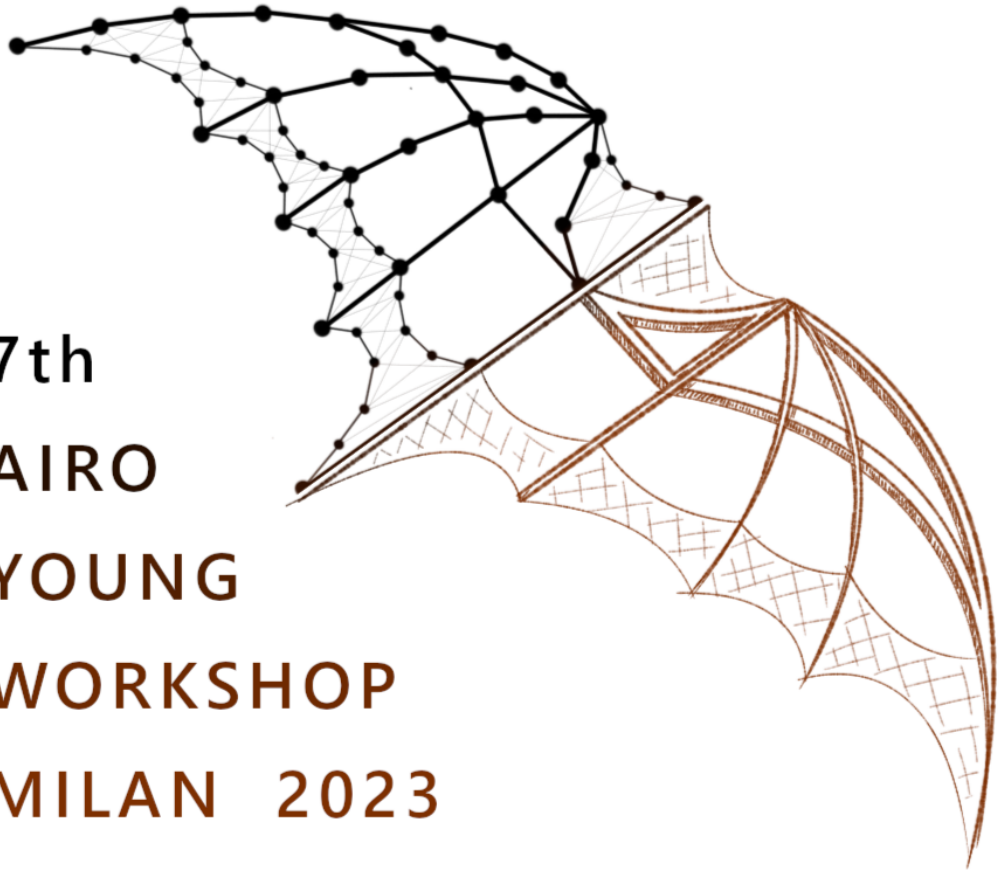


7th AIRO YOUNG WORKSHOP MILAN 2023

"OPERATIONS RESEARCH BEYOND FRONTIERS"

February 15th–17th, 2023

Dept. of Computer Science "Giovanni degli Antoni" – University of Milan

WORKSHOP BOOKLET

AIRO YOUNG

AIRO
ASSOCIAZIONE ITALIANA DI RICERCA OPERATIVA

UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI INFORMATICA

This booklet is based on the AMCOS booklet. The template is available at:
https://github.com/maximelucas/AMCOS_booklet

Contents

About

AIROYoung

AIRO Young Researchers Chapter is part of the Italian Operational Research Society (AIRO). Its aim is to foster collaboration between students and early-career researchers interested in the field of OR, and to provide them with new opportunities to advance their carreer and expand their network. It also strives to connect the demand and the offer in the OR job market, both in academia and in the industry.

The AIROYoung Workshop

The AIROYoung workshop is held each year in an Italian university. The workshop has become a reference for the young operational researchers and practitioners in Italy and abroad. The title of the 7th AIROYoung Workshop is “Operations Research Beyond Frontiers”. The goal is to collect contributions concerning a broad range of applications of the operations research, with an emphasis on applications to computer science and statistical data analysis.

Organizing committee

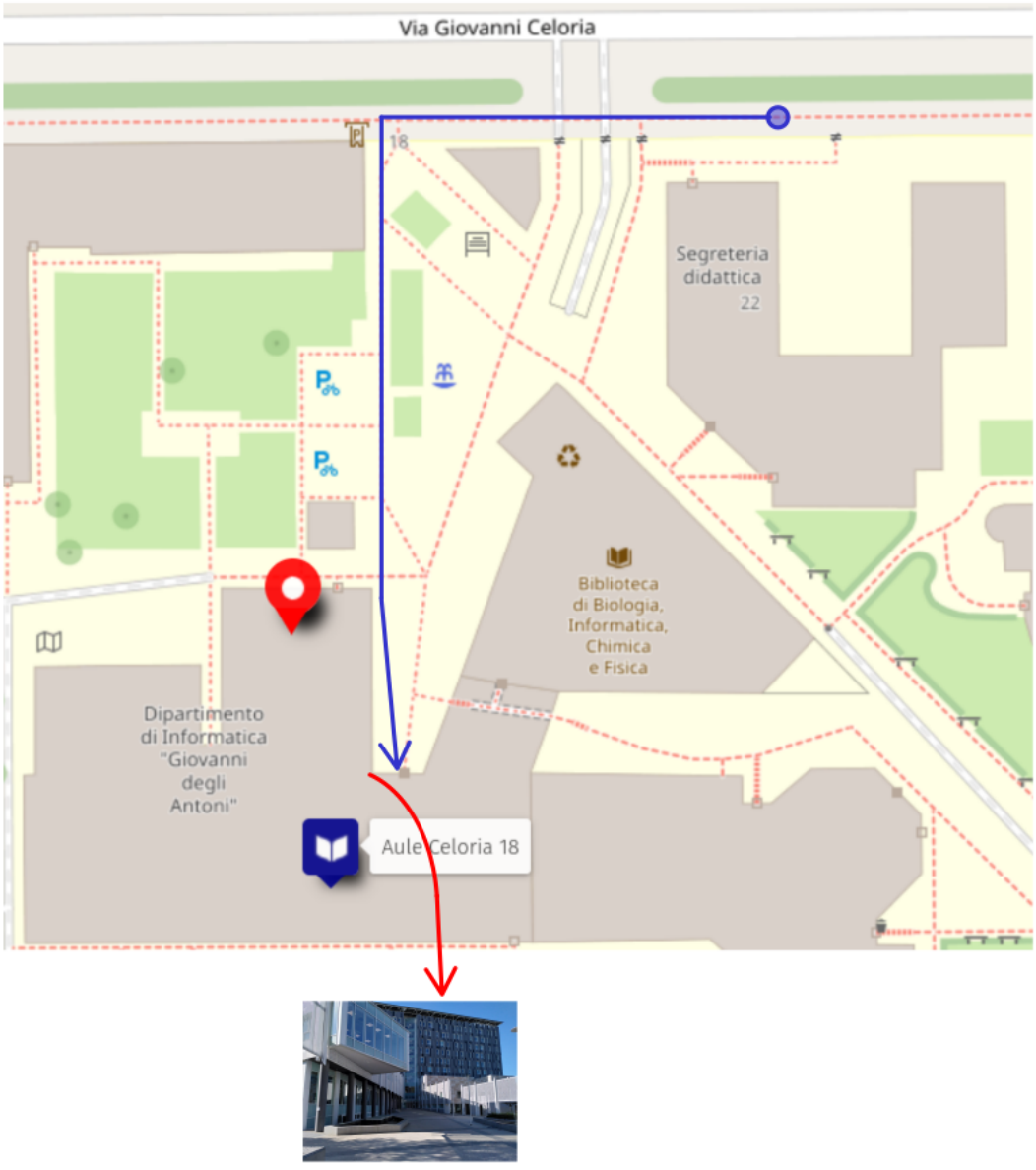
- Michele Barbato
- Alberto Boggio
- Alberto Ceselli
- Rosario Messana
- Cristina Ondei
- Marco Premoli

Venue

The conference venue is the Department of Computer Science of the University of Milan, in Via Celoria 18.

How to reach the workshop venue and the registration desk

All talks will be given in Room "Alberto Bertoni" (Aula Magna) located on the ground floor of the Computer Science Dept. of the University of Milan (Via Celoria 18, 20133 Milano).
To reach the registration desk from Via Celoria, follow the blue path of the picture, and enter the modern tower hosting the Computer Science Department. Once inside the tower, turn on your right and go straight until reaching Aula Epsilon hosting the registration desk.



List of Speakers

Suhad Al-Natoor	Eastern Mediterranean University
Saverio Basso	USI-SUPSI
Léo Baty	CERMICS, École des Ponts
Ambrogio Maria Bernardelli	University of Pavia
Lorenzo Bonasera	University of Pavia
Valentina Bonomi	University of Brescia
Martina Cerulli	ESSEC Business School
Emanuele Concas	CERMICS, ENPC
Antonio Consolo	Polytechnical University of Milan
Silvia Anna Cordieri	University of Bologna
Matteo Cosmi	University of Luxembourg
Davide Croci	Polytechnical University of Milan
Francesca Da Ros	University of Udine
Nathalie Frieß	University of Graz
Claudio Gambella	FICO Italy
Katarzyna Gdowska	AGH University of Science and Technology
Riccardo Giusti	Polytechnical University of Turin
Nuria Gómez Vargas	University of Seville
Emiliano Lancini	LAMSADE
Martina Luzzi	University of Calabria
Benedetto Manca	University of Cagliari
Andrea Mancuso	University of Naples
Adriano Masone	University of Naples
Davide Merolla	La Sapienza, University of Rome
Giovanni Micheli	University of Bergamo
Federico Michelotto	University of Bologna
Simone Milanesi	University of Pavia
Veronica Mosca	University of Calabria
Dario Palasgo	University of Padova
Christian Piermarini	La Sapienza, University of Rome
Rafael Praxedes	University of Parma
Francesco Paolo Saccomanno	University of Calabria
Edoardo Scalzo	University of Calabria
Francesco Taverna	University of Udine
Marta Leonina Tessitore	Roma Tre University
Claudio Tomasi	University of Pavia
Christian Truden	University of Klagenfurt
Maria Truvolo	University of Genoa
Chiara Turbian	University of Padova
Eleonora Vercesi	University of Pavia
Dominik Zehetner	University of Klagenfurt

Timetable

Wednesday, 15 of February

9:00–10:00	**Registration**		
10:00–10:30	**Opening session**		
10:30-11:30	**Bin Packing**		
10:30–10:50	CT	**Davide Croci**	A Support Planes Beam Search Algorithm for the Pallet Loading Problem
10:50–11:10	CT	**Riccardo Giusti**	Logistics Capacity Planning with Carrier Selection - A Stochastic Bin Packing Methodology
11:10–11:30	CT	**Chiara Turbian**	Models and Methods for a 2D Bin Packing Problem in the Sheet Metal Industry
11:30-12:10	**Disaster Management**		
11:30–11:50	CT	**Christian Truden**	Allocating temporary blackout supply points within walkable distances
11:50–12:10	CT	**Suhad Al-Natoor**	Temporary Logistic Hubs Prepositioning for Preparedness and Response Disaster Operations
12:10–14:00	**Lunch Break**		
14:00–15:00	**Interactions of Combinatorial Optimization and Machine Learning - 1**		
14:00–14:20	CT	**Simone Milanesi**	The BeMi Stardust: a Structured Ensemble of Binarized Neural Networks
14:20–14:40	CT	**Antonio Consolo**	Randomized regression trees: a model variant and a decomposition training algorithm
14:40–15:00	CT	**Francesco P. Saccomanno**	A Reinforcement Learning approach to solve the bin packing problem
15:00–15:40	**Traveling Salesperson Problem**		
15:00–15:20	CT	**Federico Michelotto**	An Exact and Heuristic Approach for the Traveling Salesman Problem with Drone and Variable Drone Speed Selection
15:20–15:40	CT	**Eleonora Vercesi**	On the generation of Metric TSP instances with a large integrality gap by branch-and-cut
15:40–16:10	**Coffee Break**		
16:10–16:50	**Decomposition Methods**		
16:10–16:30	CT	**Dario Palasgo**	Algorithms for the Pickup and Delivery Problem with Time Windows and Last-in-First-out Loading
16:30–16:50	CT	**Rafael Praxedes**	A unified exact approach for a set of vehicle routing problems with simultaneous pickup and delivery
16:50–17:50	**Manufacturing and Automated Warehouses**		
16:50–17:10	CT	**Katarzyna Gdowska**	Automated Analysis of Shewart Charts in a High Throughput Manufacturing Using Machine Learning Models
17:10–17:30	CT	**Dominik Zehetner**	Towards Large Scale Collaborative Production Planning in Additive Manufacturing
17:30–17:50	CT	**Veronica Mosca**	An adaptive large neighborhood search for the order picking process: the case of a retail distribution company in Italy

CT: Contributed Talk, PL: Plenary Talk, ST: Sponsor Talk.

Thursday, 16 of February

8:40–10:00	**Applications to Finance and Revenue Management**		
8:40-9:00	CT	**Emanuele Concas**	Dynamic Bundles Offer Management in an Airline Context
9:00-9:20	CT	**Martina Luzzi**	Application of auctions mechanisms in restaurant business
9:20–9:40	CT	**Davide Merolla**	A non-parametric model for constrained retail assortment optimization
9:40–10:00	CT	**Claudio Gambella**	FICO Decision Optimizer – Generating causal predictive models
10:00–10:30	**Coffee break**		
10:30–11:30	PL	**Paolo Boldi** Univ. of Milan	Centralities in graphs. The strange case of directedness & monotonicity
11:30–12:30	**Scheduling**		
11:30–11:50	CT	**Emiliano Lancini**	Poly/Mono-chromatic Edge Coloring for Job Scheduling
11:50–12:10	CT	**Adriano Masone**	Minimizing the sum of completion times in the AGV Scheduling Problem with battery constraints
12:10–12:30	CT	**Andrea Mancuso**	An online optimization-based tool for surgery scheduling and re-scheduling
12:30–14:00	**Lunch break**		
14:00-14:30	ST	**Caterina Tamburini** Optit	District Energy Production Management Optimisation: beyond the unit committment problem
14:30-15:00	ST	**Valentina Morandi** Multiprotexion	Optimization problems arising in surveillance companies
15:00–15:40	**Nonlinear Programming**		
15:00–15:20	CT	**Benedetto Manca**	The Ellipsoidal Separation Machine
15:20–15:40	CT	**Christian Piermarini**	Computing Negative Curvature Directions for Large Scale Optimization: exploiting SYMMBK
15:40–16:10	**Coffee break**		
16:10–17:30	**Energy**		
16:10-16:30	CT	**Ambrogio Maria Bernardelli**	A linear approximation for a stochastic optimal power flow problem based on wind energy sources
16:30-16:50	CT	**Silvia Anna Cordieri**	Transactive energy trading using a Solar Organic Rankine Cycle
16:50–17:10	CT	**Nathalie Frieß**	Simulation and Optimization of Renewable Energy Communities
17:10–17:30	CT	**Giovanni Micheli**	Operational Equilibrium of Electricity and Natural Gas Systems with Bi-Directional Energy Flows
17:30–17:45	**AIROYoung meeting**		
18:30–20:15	**Leonardo3 Exhibition**		
21:00–	**Social Dinner at "Casa Lodi" restaurant**		

CT: Contributed Talk, PL: Plenary Talk, ST: Sponsor Talk.

Friday, 17 of February

9:00–10:00	**Public and Multimodal Transportation**		
9:00–9:20	CT	**Claudio Tomasi**	Evaluating Public Transport by Multimodal Schedule-based Routing
9:20–9:40	CT	**Maria Truvolo**	A MILP model for multimodal logistics cooperation
9:40–10:00	CT	**Marta L. Tessitore**	On the Fragility of a Train Timetable
10:00–10:30	**Coffee Break**		
10:30-11:30	PL	**Claudia D'Ambrosio** École Polytechnique (Paris)	Mathematical optimization to guarantee safety in Urban Air Mobility
11:30–12:30	**Multiobjective Optimization and Bilevel Programming**		
11:30-11:50	CT	**Valentina Bonomi**	Fairness in Home Healthcare: a lexicographic approach to investigate the impact of conflicting stakeholder's goals
11:50-12:10	CT	**Matteo Cosmi**	Mathematical programming for managing the profitability-sustainability trade-off in complex chemical value chains
12:10–12:30	CT	**Martina Cerulli**	A bilevel pricing and routing problem
12:30–14:00	**Lunch break**		
14:00–15:00	**Interactions of Combinatorial Optimization and Machine Learning - 2**		
14:00–14:20	CT	**Léo Baty**	Winning Approach for the EURO-NeurIPS Dynamic Vehicle Routing Competition
14:20–14:40	CT	**Nuria Gómez Vargas**	Explainability in predict-and-optimize
14:40–15:00	CT	**Lorenzo Bonasera**	Optimal Shapelets Tree for Time Series Interpretable Classification
15:00-15:30	ST	**Andrea Mosconi** Target Reply	Ship Certifications: Operational search with Genetic Algorithms
15:30-16:00	ST	**Nicholas Draghetti** LAIFE Reply	From data to smart optimization science: a real case study in the healthcare sector
16:00–16:40	**Software**		
16:00–16:20	CT	**Saverio Basso**	PathWise: an open-source library for the Resource Constrained Shortest Path
16:20–16:40	CT	**Francesca Da Ros**	JuLeS: A Julia Framework for White-box Metaheuristic Design
16:40–17:20	**Electric Vehicles**		
16:40–17:00	CT	**Francesco Taverna**	Waste collection with EVs: a MILP formulation
17:00–17:20	CT	**Edoardo Scalzo**	A GRASP for a Green Location Problem
17:20-17:30	**Closing session**		

CT: Contributed Talk, PL: Plenary Talk, ST: Sponsor Talk.

List of Abstracts – Plenary Talks

Thursday 16th

Centralities in graphs. The strange case of directedness & monotonicity

P. Boldi

Dept. of Computer Science, University of Milan, Italy

Is it always beneficial to create a new relationship (have a new follower/friend) in a social network? This question can be formally stated as a property of the centrality measure that defines the importance of the actors of the network. In this lecture, we will explain the role of centrality, introduce the most important centrality scores, and discuss some notions of monotonicity. In particular, we will present some recent results about the effect of directedness.

Friday 17th

Mathematical optimization to guarantee safety in Urban Air Mobility

C. D'Ambrosio

École Polytechnique of Paris, France

Urban air mobility (UAM) represents a new era for public transportation. For example, passengers' transportation via eVTOLs, i.e., electric flying vehicles, will allow exploiting the sky to help smooth ground traffic in densely populated areas. Clearly, one of the biggest challenges in UAM is to ensure safety. We present how mathematical optimization can be applied in this context to solve the tactical deconfliction (TD) problem. TD is an online problem aimed at identifying and fixing potential conflict between each pair of aircraft passing through the same air space. While TD is a well-known problem in air traffic management, its specialization to the urban air mobility case has some peculiarities. Our mathematical model is one of the first attempts to fully formalize such a problem and to propose a solution to it. We test our method on three different scenarios, where the following sources of conflict are generated: $i.$ standard conflicts due to delay w.r.t. the original planning; $ii.$ a priority flight that has to be integrated into the original planning; $iii.$ an intruder flight. In the computational study, we, thus, compare our approach against a variant considering only pairwise conflicts, on three sets of realistic instances.

List of Abstracts – Sponsor Talks

Thursday 16th

District Energy Production Management Optimisation: beyond the unit committment problem

Caterina Tamburini

Optit

As decarbonization becomes a global priority, there is a need to increase the efficiency of energy production. Combined Heat and Power (CHP) is an energy efficient technology that generates electricity and captures the heat that would be wasted otherwise, in order to provide thermal energy, often used to feed district heating networks. Unit Commitment (UC) is a key problem in this context. The goal in UC is to determine a schedule for the machines that maximize the operative margin, satisfying a forecasted heat demand coming from a district heating network as well as functional and regulatory constraints deriving from system composition and placement. This gives rise to UC problems. In this work, we present some key features of the UC problem and our approach to perform the optimization of real world CHP systems, in both short and long term cases. Along with more classic and Operations Research based perspectives, we show how machine learning and data driven models can support and integrate the optimization process. We formulate and solve a Mixed Integer Linear Problem for the short-term optimization problem. Since the ability to predict the heat demand of the network is a relevant factor for the accuracy of the energy production plan, we developed a forecasting module that, given a series of historical data, automatically builds accurate prediction models. Further, we present a metaheuristic algorithm for the long-term case, founded on a time-based decomposition of the problem, that leverage on a clustering module and on the above mentioned MILP for the short-term optimization. Moreover we show how the MILP for the short-term optimization can play a central role in the automatization of some complex processes, such as trading in power market sessions and managing plants where machines are operated in series. In the first case, we have a portfolio of plants and we use the optimization model to assess cost-opportunity of alternative scenarios in order to maximize the revenues obtained trading electric power across several market sessions. In the latter case, operating temperature and water flows become important decision variables, introducing some nonlinear and nonconvex relations that make the optimization problem very hard to be solved.

Optimization problems arising in surveillance companies

Valentina Morandi

Multiprotexion

Multiprotexion is a company that deals with the surveillance of international transport vehicles and facilities with a telematics escort option for vehicles/companies with a high monetary value of transported goods. The company provides multiple services including the 24/7 operational centre to manage the alarms received from the drivers and the assisted fleet route guidance for fuel savings. We will illustrate how Operations Research has been and will be effective in evaluating and decision-making in provided services, and which optimization techniques have been effectively used. Many of the problems arising in Multiprotexion, and possibly in many companies doing remote surveillance, can be solved through optimization and machine learning approaches. Many have been already identified and will be faced in the next years. Some promising research and business areas will be proposed and discussed during the talk.

Friday 17th

Ship Certifications: Operational search with Genetic Algorithms

Andrea Mosconi

Target Reply

The client is a world leader in ship certification, classification, verification of conformity and testing. Ships need continuous checkings, different controls require different qualifications for the surveyors that perform them. Every day, hundreds of ships approach some of the hundreds of ports where the client has an office. How to choose which is the best suitable surveyor for each of the ships?
In this session we will show how to:

- Use Open Data: Vesseltracker (for ship fleet scheduling) and OpenStreet for georeferentiation of ports and offices
- Manage a scalable big-data ready architecture based on MongoDB
- Define a “best match” function to rank surveyors
- choose the best surveyor for each ship by mean of Genetic Algorithm based operational search

From data to smart optimization science: a real case study in the healthcare sector

Nicholas Draghetti

LAIFE Reply

The problem of scarcity of resources to cope with an increasing number of demands is a problem that is assuming great prominence in every sector, not least the health sector. This issue came to the forefront during the Covid 19 pandemic where, faced with an increasing number of requests, an increasingly optimized approach to the use of available resources was required. During the talk, the approach put in place to identify and subsequently solve a specific "business critical" problem in healthcare management will be presented. Specifically, it will be shown how the joint use of data and optimization models is the key element in decision support within a real-world context. In particular, by exploding the pipeline set up, the data-driven approach (based on the proprietary hegos solution) adopted in order to identify the “business-critical” issue under study will be presented in the first instance. Next, the mathematical modeling approach of the identified problem (set covering problem) will be shown through the comparison of 2 heuristic algorithms (greedy algorithm vs hunt-colony optimization) showing strengths and weaknesses of the heuristics considered with respect to the specific case study.

A Support Planes Beam Search Algorithm for the Pallet Loading Problem

Davide Croci, Ola Jabali, Federico Malucelli
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Abstract. We consider the Pallet Loading Problem (PLP), a variant of the three-dimensional bin packing problem which includes practical constraints related to the loading of boxes on pallets. In particular, we consider constraints on item rotations, static stability, load bearing and weight limit. We develop a new constructive heuristic for the PLP called Support Planes (SP), where a set of highly heterogeneous boxes is loaded on one or more pallets by solving a series of two-dimensional bin packing problems on planes created by placed boxes. We use SP as a component for developing an efficient beam search algorithm for the PLP called the Support Planes Beam Search (SPBS). The proposed algorithm is evaluated on test instances from the literature, where it outperforms the current state-of-the-art algorithms both in terms of the quality of solutions and in in terms of time efficiency. After demonstrating the effectiveness of the developed algorithm, we test it on a series of large instances obtained from our industrial partner.

Keywords: pallet loading, 3d bin packing, beam search;

Logistics Capacity Planning with Carrier Selection - A Stochastic Bin Packing Methodology

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Abstract. We address the tactical-planning problem of a shipper that needs to contract carriers to secure transport capacity for the next operation season (e.g., six, twelve months). The planning is made some time before operations start and must account for an uncertain environment in which the actual demand for each operation period (e.g., a day) may vary from the expected value [1]. Moreover, the shipper must account for carrier unreliability factors, i.e., the possibility that carriers do not provide the contracted capacity at each operation period due to disruptions or low-quality management practices. Variations in expected demand and the possible capacity loss during operations require calling on the spot market for ad-hoc capacity at a high cost. This problem, up to our knowledge, has not been addressed in the literature. We define a variant of the Bin Packing model, namely the *Stochastic Bin Packing Problem with Unreliable Bin-Supplier Selection*, and propose a two-stage stochastic model to represent it. The first-stage decisions regard the selection of contracts to ensure transport capacity. The second-stage decisions address the recourses to secure the required ad-hoc capacity during operations. We propose a new solution method based on a Greedy Randomized Adaptive Search Procedure (GRASP) metaheuristic [2]. We finally report the results of computational experiments to evaluate the efficiency of our solution method compared to that of a commercial solver and derive managerial insights for this new problem.

Keywords: Logistics capacity planning, Stochastic programming, GRASP metaheuristic

References

[1] Crainic, T. G. , Gobbato, L. , Perboli, G. , & Rei, W. (2016). Logistics capacity planning: A stochastic bin packing formulation and a progressive hedging meta-heuristic. European Journal of Operational Research, 253 (2), 404–417.

[2] Feo, T.A., Resende, M.G.C. (1995). Greedy Randomized Adaptive Search Procedures. Journal of Global Optimization, 6, 109–133.

Models and Methods for a 2D Bin Packing Problem in the Sheet Metal Industry

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Abstract. We consider an optimization problem arising in Salvagnini Italia, a multinational corporation in the sheet metal industry. The problem aims at determining efficient cutting layouts by minimizing the waste material and by keeping into account several technological constraints involving, in particular, hard and soft precedence relations among groups of items. This problem falls into the well-known area of Two-Dimensional Bin Packing Problems (2DBPP) [2] and considers additional precedence constraints [1]. Nevertheless, the specific set of practical attributes, to the best of our knowledge, has never been considered yet. We devise exact and heuristic approaches to solve the problem, both based on solving Mixed Integer Linear Programming (MILP) models and a post process optimization. Computational tests on instances of practical relevance have been preformed, and preliminary results will be presented.

Keywords: 2D-Bin Packing; Sheet Metal Industry; Mixed Integer Linear Programming; Precedence Constraints.

References

[1] M. Dell'Amico, J. C. Diaz, M. Iori, *The Bin Packing Problem with Precedence Constraints*, Operations Research 60:6, 1491-1504 (2012).

[2] D. Pisinger, M. Sigurd, *The Two-Dimensional Bin Packing Problem with Variable Bin Sizes and Costs*, Discrete Optimization 2, 154-167 (2005).

Allocating temporary blackout supply points within walkable distances

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Abstract.

A large-scale power outage, commonly known as a blackout, is caused by natural disasters, cyber attacks, technical failure, or human errors, and can lead to a variety of severe consequences. The far-reaching dynamics of blackouts can even result in the collapse of critical public service infrastructure reliant on electricity (e.g., communication, water supply, medical services, public safety). Particularly, the loss of information and communication infrastructure essential to reporting medical emergencies, and the collapse of the drinking water supply are two critical stressors for the population to cope with. One attempt to tackle this situation is to install temporary supply points into existing infrastructure. These can be approached by the population to communicate with medical personnel and to receive drinking water. Different types of professional personnel, which is a limited resource, are required to run such locations. Our study introduces this tactical decision problem. We formulate it as a mixed-integer linear program for the optimal spatial allocation of these supply points, such that multiple types of human resources that are required for operating such locations can be efficiently assigned. A comprehensive numerical study, based on data of the City of Vienna, demonstrates how to reduce the walking distance of inhabitants while increasing the efficiency of resource allocation.

Keywords: p-median problem; mixed-integer programming ; GIS-data; numerical study

TEMPORARY LOGISTIC HUBS PREPOSITIONING FOR PREPAREDNESS AND RESPONSE DISASTER OPERATIONS

Suhad Rebhi Al-Natoor, Bela Vizvari
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Abstract. Large-scale natural disasters have catastrophic consequences for human life. In order to save more lives, humanitarian logistic planning should be performed in preparedness and response stages. The number and the location of the temporary logistic hubs should be prepositioned in the best spatial places in both reachable and isolated areas. The purpose of this study is to develop a robust methodology using a modified version of the maximal coverage location problem to determine the optimal number and location of the temporary logistic hubs. In order to develop accurate and actual methodology, this study employs the concept of the risk of facility status aftermath of the disaster and it uses two types of factors: crime rate that considers as pre-disaster factor and damage degree that considers as post-disaster factor. The objective function of this study is to maximize the total number of demand points that are served within the specified reachable and isolated coverage area. The transportation of the relief items in response stage in both reachable and isolated area will be served by using truck-drone system.

Keywords: Natural disaster; temporary logistic hubs; maximal coverage location problem; risk of facilities; crime rate.

The BeMi Stardust: a Structured Ensemble of Binarized Neural Networks

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Abstract. Binarized Neural Networks (BNNs) are receiving increasing attention due to their lightweight architecture and ability to run on low-power devices. The Mixed-Integer Programming (MIP) approach achieves the state of the art for training classification BNNs when limited data are available [1] . In this work, we propose the BeMi ensemble, a structured architecture of BNNs introduced in [2], and based on training a single BNN for each possible pair of classes and applying a Condorcet-inspired majority voting scheme to predict the final output. The training of each BNN is achieved with a MIP model that optimizes a lexicographic multi-objective function, representing the principles of robustness and simplicity. We computationally validate our model using the MNIST and Fashion-MNIST datasets. The BeMi ensemble outperforms both BNNs trained by stochastic gradient descent and state-of-the-art MIP-based techniques: while the previous approaches achieve an average accuracy of 51.1% on the MNIST dataset, the BeMi ensemble achieves an average accuracy of 61.7% when trained with 10 images per class and 76.4% when trained with 40 images per class.

Keywords: Binarized neural networks; MILP; Structured ensemble of neural networks.

References

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Randomized regression trees: a model variant and a decomposition training algorithm

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Abstract. Decision trees are widely used for classification and regression tasks arising in a variety of application fields. Recently in [1], the authors proposed a novel continuous nonlinear optimization formulation to train multivariate randomized regression trees (MRRTs) which may account for sparsity and fairness. For any given input vector, the prediction is a weighted combination of the leaf nodes outputs, where the weight is the probability that the vector falls in the corresponding leaf node. In this work, we investigate a variant of the above MRRT model where, for every input vector and for every leaf node, the prediction is expressed as a linear regression of the input variables. For any data point the prediction is given by the leaf node reached by following from the root the branches with highest probability. The associated formulation is well-suited not only to decomposition but also to induce fairness measures. After investigating the universal approximation property of such MRRTs, we present a decomposition training algorithm including a specific initialization strategy and a heuristic for the reassignment of the input vectors along the branching nodes of the tree. Under mild assumptions, we also establish asymptotic convergence guarantees. The results obtained on 15 datasets from the UCI and KEEL repositories indicate that our model variant and decomposition algorithm yield promising results in terms of accuracy compared with the original formulation, and significant speed-up in training time and similar accuracy compared with the MILP-based approach described in [2, 3].

Keywords: Machine Learning; randomized regression trees; decomposition methods; nonlinear programming

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A Reinforcement Learning approach to solve the bin packing problem

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Abstract. The bin packing problem (BPP, for short) is a combinatorial optimization problem, which consists in filling containers of the same size, with a series of items of different weights, in such a way to not exceed the bins maximum capacity and to minimize the number of bins used. Given its practical importance, the BPL has received much attention among researchers and several exact and heuristic approaches have been proposed for its solutin. In this work, we propose a reinforcement learning strategy to address the BPP. Unlike exact and heuristic approaches, reinforcement learning techniques try to find a solution, using an agent, which learns to behave in an interactive environment, based on its own actions and experiences. In the proposed approach, the agent was trained by imitating a classic bin packing heuristic, that is the "best fit" strategy, which fills the containers by choosing the one that has the minimum space necessary to contain the item to be packed. An extensive computational study has been carried out to assess the behaviour of the proposed approach. The collected computational results have shown that the agent is able to learn and overcome the reference heuristic in all cases tested.

Keywords: Bin Packing, Reinforcement Learning;

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PathWise: an open-source library for the Resource Constrained Shortest Path

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Abstract. In this work, we consider the Resource Constrained Shortest Path Problem (RCSPP), a fundamental and hard combinatorial problem, and propose *PathWise*, a flexible, open-source library for its resolution.

More in detail, we developed a platform capable of modeling and solving a variety of standardRCSPPs with an off-the-shelf implementation of state-of-the-art algorithms. We designed PathWise with the final user in mind and included easy-to-use interfaces for both beginners and experts: beginners can either use the library standalone or from their favourite programming language, whilst experts can define and implement, due to clear and well-defined hook points, custom solutions to extend the algorithms and functionalities of the library. Finally, we planned and devised components that will allow PathWise to become a platform ready for data-driven and process-driven methodologies.

We provide computational experiments for two classes of instances from the literature that present a single resource constraint, namely the RCSPP on cyclic networks and the RCSPP on large acyclic networks. Furthermore, we also consider the RCSPP when facing ad-hoc cyclic networks with multiple resource constraints. We detail every result for PathWise, when using multiple techniques and under different configurations, and sketch a comparison with state-of-the-art specialized algorithms. We show that our library is packed off-the-shelf with methods capable of tackling all classes of problems.

This study represents the first step along the journey of devising and implementing a comprehensive open-source library for a large variety of RCSPPs.

JuLeS: A Julia Framework for White-box Metaheuristic Design

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Abstract. In the last decades, metaheuristics have been used to solve a wide range of combinatorial optimization problems successfully. Despite these outcomes, the field presents a series of challenges concerning duplication of effort as users and practitioners tend to re-implement these algorithms from scratch, impeding their replicability, reproducibility, and comparability [3]. To address these challenges, we propose JuLeS, a white-box framework in Julia that implements the most common local search metaheuristics (i.e., hill climbing, simulated annealing, steepest descent, and tabu search). The template is based on the inverse control mechanism allowing for a highly extensible, modular, and reusable code. Specifically, users define the information on the problem but do not control the search structures and processes, which are instead dealt with by the framework. Preliminary results on a benchmark problem (i.e., k-GraphColoring problem with DSJC graphs [2]) show that the overhead with respect to its ancestor in C++ (i.e., EasyLocal++ [1]) is moderate. An advantage of the Julia encoding of the solver is that it results in a more succinct local search model (i.e., considering the lines of code). Future extensions of this work include a visualization module (i.e., representation of search trajectories to allow comparison of different algorithms) and the addition of other metaheuristics (e.g., population-based techniques).

Keywords: Metaheuristic design; Metaheuristic replicability; White-box framework.

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Algorithms for the Pickup and Delivery Problem with Time Windows and Last-in-First-out Loading

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Abstract. The *Pickup and Delivery Problem with Time Windows and Last-in-First-out Loading* (PDPTWL) is an important problem arising in transportation. Its goal is to minimize the costs to serve a set of customers, consisting of a pickup and a delivery location, using a fleet of vehicles and handling their loads with a LIFO policy.

The state-of-the-art exact method for the PDPTWL is owed to [1]. [1] use a relaxed network-flow model with side constraints where each variable corresponds to a *fragment*, which is a sequence of pickup and delivery requests starting and ending with an empty vehicle.

In this talk, we propose algorithms to find good dual bounds to the PDPTWL by solving the continuous relaxation of a set partitioning formulation of the problem, where variables correspond to (non-necessarily elementary) tours obtained as sequence of fragments. This set partitioning model is solved with column generation. These dual bounds are then used to find an optimal PDPTWL solution through variable enumeration/fixing and branching. Preliminary results are promising and show that the proposed method is competitive with the state-of-the-art solution method.

Keywords: pickup and delivery; column generation; dynamic programming;

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A unified exact approach for a set of vehicle routing problems with simultaneous pickup and delivery

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Abstract. One problem that belongs to pickup and delivery problems class is the vehicle routing problem (VRP) with simultaneous pickup and delivery (VRPSPD), in which each customer has delivery and pickup demands to be attended at the same time. Proposed by [1], the VRPSPD has become a very studied problem [2] and many variants were proposed over these years, incorporating characteristics as heterogeneous fleet, time windows for customer service, multiple depot, and others. However, we were not able to find a generic exact algorithm capable of addressing multiple VRPSPD variants at the same time. Therefore, we developed a mathematical formulation for the VRP including simultaneous/mixed pickup and delivery, heterogeneous fleet, time windows, route duration, multiple depot, facilities location and asymmetric costs in a unified problem, denoted as heterogeneous location routing problem with simultaneous pickup and delivery and time windows (HLRPSPDTW). Moreover, we propose a branch-cut-and-price (BCP) algorithm with a view of obtaining new optimal solutions or improve known lower bounds of benchmark instances of ten VRPSPD variants.

Keywords: vehicle routing; simultaneous pickup and delivery; unified approach.

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Winning Approach for the EURO-NeurIPS Dynamic Vehicle Routing Competition

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Abstract. The *EURO meets NeurIPS 2022 Vehicle Routing Competition*[1] focuses on the usual static *Capacitated Vehicle Routing Problem with Time Windows* (VRPTW), as well as a dynamic variation. The static VRPTW has been extensively studied in the literature, including exact approaches, as well as heuristic ones, among which the hybrid genetic search [2]. Our contribution is a policy for the dynamic VRPTW, which ranked first of the competition. It relies on a Deep Learning pipeline with a prize collecting VRPTW combinatorial optimization layer [1]. This pipeline requires a subroutine for solving the prize collecting VRPTW, for which we introduce the prize collecting hybrid genetic search, a variant of the hybrid genetic search adapted for the prize collecting VRPTW.

Keywords: machine learning; combinatorial optimization; vehicle routing; multi-stage optimization; hybrid genetic search; EURO-NeurIPS challenge

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Explainability in predict-and-optimize

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Abstract. In real-world applications, the presence of uncertainty in the multiple parameters that model decision problems is a standard. We focus on Operations Research models that are associated in some way with a prediction problem. Such an example is a supply chain problem, which cannot be solved without predicting demands that depend on prices, trends or user click history. For these contextual stochastic optimization problems, we propose a predict-and-optimize approach that focuses on guiding the training of Machine Learning models by their performance on the downstream optimization problem but also on enhancing sparsity in the feature space to tackle the explainabilty of the decisions.

Keywords: contextual stochastic optimization; explainability; predict-and-optimize; prescriptive analytics; sparsity

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Optimal Shapelets Tree for Time Series Interpretable Classification

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Abstract. Time series shapelets are a state-of-the-art data mining technique that is applied to time series supervised classification tasks. Shapelets are defined as subsequences that retain the most discriminating power contained in time series [1]. The main advantage of shapelet-based methods consists of their great interpretability. Indeed, shapelets can provide the end-user with very helpful insights about the most interesting subsequences. In this work, we propose a novel mixed-integer programming model to optimize shapelets discovery based on optimal binary decision trees [2]. Our formulation provides a flexible and adaptable classification framework that is interpretable with respect to both the mathematical model and the final output. Computational results for a large class of datasets show that our approach achieves performance comparable with state-of-the-art shapelet-based classification methods.

Keywords: Time series classification; Explainable Artificial Intelligence; Interpretable machine learning; Optimal decision tree; Shapelets

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Fairness in Home Healthcare: a lexicographic approach to investigate the impact of conflicting stakeholder's goals

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Abstract. When dealing with Home Healthcare applications, the main goal is often based on economical aspects such as the minimization of costs or the maximization of profits. These formulations prioritize the hospital's interests neglecting the needs of the other stakeholders. In fact, an efficient Home Healthcare system relies on the satisfaction of all the actors involved (from the hospital to the patients and the professional caregivers) and is able to guarantee that their often conflicting perspectives are included in the decision process [2]. The concept of *fairness* allows to include in the optimization both employee and customer centered measures and compare them with the hospital ones. We consider the fairness measures presented in [1]with the addition of two new measures regarding the hospital, the total tardiness and the time of last visit. In this paper, we propose a lexicographic approach to solve a Multi-Objective mathematical formulation with three objective functions, one for each stakeholder. The interaction among different measures is evaluated on small size instances while a metaheuristic approach including a parallel implementation of an Adaptive Large Neighborhood Search is applied to help the resolution real-life instances.

Keywords: Vehicle Routing Problem; Healthcare; Fairness; Multi-Objective problem; parallel ALNS;

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A bilevel pricing and routing problem

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Abstract. The Profitable Tour Problem (PTP) belongs to the class of Vehicle Routing Problems with profits. In PTP, a vehicle, starting from a central depot, can visit a subset of the available customers, collecting a specific revenue whenever a customer is visited. The objective of the problem is the maximization of the net profit, i.e., the total collected revenue minus the total route cost. Most of the literature in this field considers only one decision maker. However, in several real-world routing applications, and in particular in the last-mile delivery, there are different involved agents with conflicting goals. If the decisions are made in a hierarchical order, this problem can be modeled with bilevel programming, with the PTP at the lower level.

In this talk, we consider a company, which acts as a "leader" and offers disjoint subsets of a given set of items to a set K of drivers. At the lower level, each driver solves a PTP communicating to the company the items she accepts to serve. Both the company and the drivers aim at maximizing their net profit, which is calculated differently in the two levels. We propose a bilevel formulation that models this interaction and allows the leader not only to anticipate the best followers' response, but also to find the optimal pricing scheme for each carrier. We find exact solutions to this model using a branch and cut approach.

Keywords: Pricing; Routing; Profitable Tour Problem; Bilevel Programming.

Mathematical programming for managing the profitability-sustainability trade-off in complex chemical value chains

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Abstract. Limiting the effects of global warming and climate change is one of the main objectives that the international community has set for the next decades. Therefore, several countries approved laws legally binding them to achieve net-zero targets within the next 25-30 years. One of the major greenhouse gases emitted by human activity is the carbon dioxide (CO2) which accounts for more than 75% of the global greenhouse gas emissions. Industry and transport sectors account for more than 35% of the global emissions and there is an increasing pressure over industry to pledge net-zero emissions. To remain competitive in their markets while reducing their emissions, companies need to re-optimize their entire supply chain focusing not only on traditional costs, related to manufacturing and transport, but also on those related with greenhouse gas emissions. In this work we propose a linear programming model to optimize a deterministic multi-objective supply-chain problem aimed at minimizing CO2 emissions and their related costs. This model has been developed in collaboration with a leading international chemicals manufacturer. We perform an extensive campaign of tests on real data to analyze the differences with the former supply chain structure when costs related with emissions were not a primary consideration.

Keywords: value chain; sustainable supply chain; multi-objective optimization;

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A linear approximation for a stochastic optimal power flow problem based on wind energy sources

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Abstract. In recent years, alternating current-optimal power flow (AC-OPF) has become one of the most widely studied optimization problems in energy management: it deals with determining the best-operating levels for electric power plants to meet the given demand. It is a non-convex and generally NP-Hard problem with nonlinear equality and inequality constraints [2]. In addition, the increasing use of renewable energy sources (RES) has led to the need to formulate AC-OPF problems in a stochastic setting, since the generation from RES can be variable and uncertain. We then talk about stochastic AC-OPF problems. In this work, we present a stochastic mixed integer linear programming (S-MILP) model for the solution of an approximated stochastic AC-OPF problem. The AC-OPF model is based on the formulation of [1]. We implement sample average approximation techniques and other scenario-generation techniques to deal with different stochasticity aspects of the problem. We show the preliminary results of our method applied to real-world data from our industrial partner.

Keywords: Optimal Power Flow; Stochastic Optimization; Renewable Energy Sources

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Transactive energy trading using a Solar Organic Rankine Cycle

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Abstract. Solar Organic Rankine Cycles (ORC) are power production plants where thermal power is supplied to the cycle using solar irradiation. Given the significant compatibility between the operating temperatures of solar irradiation based technologies and the temperature needs of the cycle, they can be a promising renewable technology. Moreover, their higher performance compared to steam Rankine cycles in small size applications, makes them interesting within the communities and microgrids context. In this study, we inspect the impact that this technology can have in the peer-to-peer trading application in renewable based community microgrids. Here the consumer becomes a prosumer (functioning as both energy producer and consumer), and engage actively in automated market trade with other prosumers at the distribution system level. Specifically, we concentrate on a microgrid where the solar ORC is combined with a storage system, to fullfill the final consumer's demand. In fact, the combination of these plants with storage systems, is fundamental to increase their predictability and competitiveness with conventional plants, but it is quite challenging from a management perspective. Thus, we develop a methodology based on operations research techniques to use this system at its optimal point. Moreover, we investigate how different technological parameters of the solar ORC may affect the final solution. Finally, we study the value of the solar ORC in the transactive energy trading context under different configurations and scenarios.

Keywords: Solar organic Rankine cycles, peer-to-peer energy trading, transactive energy trading, storage systems, microgrids, operations research;

Simulation and Optimization of Renewable Energy Communities

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Abstract. Renewable energy communities (RECs) are a key tool to support active participation in the transformation of energy systems. Individual entities such as households, municipalities, or small and medium-sized enterprises 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. The ultimate goal of a REC is the intelligent and efficient management of locally produced electricity. Load shifting, i.e., shifting a household's electricity consumption from one time period to another, can support the direct use of locally produced energy and thereby increase a community's self-consumption. Clearly, there is a strong interdependence between the member's demand profiles and 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. In practice, actual conditions may well deviate from initial forecasts and not all intended actions will be executed as planned. Therefore, a simulation model representing the real-world production and consumption values is used to update the input of the optimization model in 15-minute intervals. The outcomes of these calculations are used to demonstrate the benefits of coordinated decision-making and to develop a pricing scheme that induces individual members to follow the system-optimal behavior.

Keywords: linear programming, optimization model, simulation model, energy communities

Towards Large Scale Collaborative Production Planning in Additive Manufacturing

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Abstract. CMfg is seen as a key enabler of collaborative production (CP) systems, especially in combination with Additive Manufacturing (AM). Recent studies have shown that CP can reduce costs in an AM operation significantly. However, existing solution methods are limited to medium size instances. Nevertheless, such an environment usually leads to large-scale instances as many participants must be matched and scheduled. This study aims to close this research gap by proposing a hybrid Mixed Integer Linear Programming (MILP) - Machine Learning (ML) framework. This approach is inspired by an auction-based framework widely researched in logistics and consists of five steps. In the first step, machines autonomously select jobs from the existing production plan to forward them the CMFg platform. Then the platform creates promising bundles of the transferred parts. In the bidding step, manufacturing machines autonomously report the marginal costs of the packages. The winner of the bundles is determined via a combinatorial reverse auction, and the costs of the reallocated bundles are shared. In the bidding step, the marginal costs are determined by solving a production planning problem for every bundle, and hence is the most time-demanding step. Our MLenriched framework eases this problem by splitting this step into two sub-steps. In the first one, the costs of the bundles are estimated via a supervised ML model. The estimated costs are reported to the auctioneer, requesting an accurate report to the most promising bidders in the second sub-step. In our experiments, we investigate several ML models and demonstrate the most effective one for cost estimation. We also show that our enhanced approach reduces computational time significantly.

Keywords: Collaborative Production Planning; Supervised Machine Learning; Mixed Integer Linear Programming; Decentralized Planning

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FICO Decision Optimizer – Generating causal predictive models

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Abstract. The FICO Decision Optimizer (DO) application [1] is an optimization software to perform optimal assignment of treatments to a portfolio of customers. DO leverages various optimization algorithms with the goal to empower non-OR professionals with a tool that creates and solves Generalized Assignment Problems. DO considers different kinds of constraints (budget, ratio, . . .) and allows users to generate highly interpretable decision trees.
The DO optimization models depend on structural inputs (values known with certainty, like the composition of the portfolio or customer attributes) and uncertain inputs (predictable target values, such as the impact of treatments on customers). While the DO interface makes it possible to use and edit the predictive models required to produce the uncertain data, developing these Predictive Causal Models [2] usually requires additional tools and knowledge for the Business Analyst. Furthermore, there is inherent historical data bias, because the historical actions are likely to be targeted on certain segments, consequently there may be significant data gaps for some actions.
To simplify the user experience, we developed a 2-step Action Effect (AE) approach to predict the impact of the treatment assignment on every customer of the portfolio. We will present the logics behind the quadratic programming models that are solved to create the predictive models. We conclude our presentation with a discussion about the modelling implications on bounding target scores.

Keywords: Finance; Predictive Causal Models; Regression Models; NLP.

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Automated Analysis of Shewart Charts in a High Throughput Manufacturing Using Machine Learning Models

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Abstract. In the traditional approach, an experienced worker plays an important role in analyzing Shewart chart records. Human perception is a significant limitation on the number of features analyzed and the sampling frequency of measurements. In production processes with low product variability and a long time to refine the measurement apparatus, the traditional approach is satisfactory. However, in small-series production processes with a throughput of several thousand pieces per hour, the traditional approach is unreliable, as errors are detected too late.

This paper demonstrates that applying an artificial intelligence model to quality control of a manufacturing process enables monitoring any number of features as well as significantly increasing the sampling frequency of measurements. As result, it is possible to analyze a far larger number of samples in real-time. This is of colossal importance for production lines with high productivity and short production batches. The contribution of this article is an analysis of selected Machine Learning models (including Linear Regression, Support Vector Machine, Decision Forest, and Deep Neural Network) implemented in Python for automated Shewart charts analysis for large-sized sets of features. The models were tested on data from real production processes with high productivity. The results were analyzed and standardized, and the most effective Machine Learning model for this problem was identified.

Keywords: Machine Learning; Statistical Process Control; assessment automation; Artificial Intelligence; manufacturing process;

Poly/Mono-chromatic Edge Coloring for Job Scheduling

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Abstract. In the present work, we introduce the *Poly/Mono-chromatic Edge Coloring* (PMCEC) on undirected graphs. The problem is inspired by a variant of the open shop scheduling problem, where one must schedule a set of jobs on parallel heterogeneous machines, in such a way that each job is completed in a single time slot and each machine processes at most one job at a time. In graph-theoretic terms, such a problem asks to find an edge coloring of a bipartite graph which must be proper on the vertices of one shore and homogeneous on the vertices of the other shore. We show that such problem on bipartite graphs is equivalent to the vertex coloring problem on general graphs. In addition, we study a generalization of PMCEC to non-bipartite graphs. We conclude by studying the relation between PCMEC and graph coloring problems, and we show several equivalences for some particular cases.

Keywords: Graph Coloring; Scheduling; Edge Coloring;

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Minimizing the sum of completion times in the AGV Scheduling Problem with battery constraints

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Abstract. Automated Guided Vehicles (AGVs) are driverless vehicles used to move goods and materials around various locations, such as shipping and receiving areas, storage areas, and workstations. These vehicles have become increasingly popular because they can improve efficiency, utilize space effectively, protect products, and be easily integrated with computer systems. When implementing AGV systems, various tactical (e.g., determining the size of the fleet and designing the flow paths) and operational (e.g., dispatching, routing, and scheduling) decisions need to be made. In this study, we focus on a scheduling problem faced by a manufacturing company that uses AGVs with battery constraints to move materials horizontally. This problem, known in the literature as the AGV Scheduling Problem with battery constraints, involves minimizing the overall transfer process. In this study, we will address a new variant of the problem involving the minimization of the sum of transfer operation times. We propose a Mixed Integer Linear Programming Model and a three-step heuristic approach combined with a local search to solve this problem. Our methods have been tested on simulated and real-world instances provided by a manufacturing company, and the results show their effectiveness and scalability.

Keywords: Scheduling; AGV; MILP; Matheuristics;

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An online optimization-based tool for surgery scheduling and re-scheduling

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Abstract. Considering unforeseeable events within the organization of an operating block is a key issue that hospital executives must take into account to ensure an adequate service level. Within an operating block, the major causes of unpredictability are related to deviations from expected of surgery duration and sudden emergency arrivals. In this context, it is fundamental to design a reliable and resilient weekly surgery plan. Reliability can be measured in terms of actual operating room usage and number of surgeries performed without postponements. Resiliency is related to reaction time, or in other words, the capacity of the system in timely managing unforeseen events.

In this context, this paper addresses the surgery scheduling problem by a two phases optimization approach. Phase I is related to elective patients. It is devoted to designing a surgery plan, maximizing the number of surgeries to be performed, incorporating patient severity and emergency reaction time. Phase II is devoted to the management of exogenous and endogenous variations, guaranteeing the system efficiency and responsiveness during the whole planning horizon, minimizing the deviation from the schedule defined in phase I. Both phases are developed in an ILP-based fashion and have been integrated in an optimization tool.

The effectiveness of the proposed optimization tool is validated by a broad experimentation based on real data provided by a local hospital in Naples.

Keywords: Surgery scheduling; online optimization; emergency management;

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An Exact and Heuristic Approach for the Traveling Salesman Problem with Drone and Variable Drone Speed Selection

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Abstract. In this work, we propose an exact and heuristic method for the *Flying Sidekick Traveling Salesman Problem with Variable Drone Speeds Selection* (FSTSP-VDS), an extension of the *Flying Sidekick Traveling Salesman Problem* (FSTSP) in which a truck is combined with a drone that can fly at variable speeds and the drone energy consumption is defined by a nonlinear model. We present the first exact method for the FSTSP-VDS based on a compact *Mixed Integer Linear Programming* (MILP) formulation, and we show that this approach allows to solve instances with up to 25 customers. Furthermore, we propose a genetic-based heuristic that allows to obtain an average improvement of 6% with respect to the state of the art FSTSP-VDS heuristic, and an average optimality gap of 0.30% when tested on 227 optimally solved FSTSP instances with up to 39 customers.

Keywords: Traveling salesman problem; Drone; Variable drone speeds

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An adaptive large neighborhood search for the order picking process: the case of a retail distribution company in Italy.

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Abstract. Among the key activities involved in the warehouse management, order picking is crucial to make order management more efficient and to speed up warehouse operations. The order picking problem consists in the retrieval of the products ordered by a customer in the warehouse. In particular, we study the order picking activities of an existent warehouse of PAC 2000A CONAD. We first modelled the problem as a variant of the Vehicle Routing Problem - *VRP*, in which the items to be withdrawn can be viewed as customers to be visited, each one characterised by an items demand, while trolleys handled by operators can be seen as vehicles. Since customers order may contain a huge number of products, solving this problem thought exact methods is very difficult. Hence, we propose a metaheuristic, namely Adaptive Large Neighbourhood Search - *ALNS* to handle it. ALNS is used to conduct a computational study on real-based instances, containing different numbers of product. The results show the effectiveness and efficiency of the proposed algorithm.

Keywords: Adaptive Large Neighbourhood Search; Order picking; Vehicle Routing Problem; Warehouse Optimisation.

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A GRASP for a Green Location Problem

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Abstract. In this work we address a capacitated charging stations location problem in a middle-mile scenario, in which a tour is eligible for an electric vehicle (EV) if there is at least one charging station within a certain distance from the origin point of the tour. The goal is to maximize the number of EV-eligible tours, minimize the number of charging stations installed and the total distance between the charging stations and the origin point of the tours. We propose a Greedy Randomized Adaptive Search Procedure (GRASP) with a mixed path-relinking and a restart strategy to solve the location problem. We performed a comparison between the proposed approach and a Goal Programming Optimization (GO) on instances of different sizes. Experimental results show the efficacy of the GRASP proposed compared to GO.

Keywords: Green location problem; Greedy randomized adaptive search procedures; Path-relinking; Restart strategy.

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Dynamic Bundles Offer Management in an Airline Context

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Abstract. Nowadays, in the era of online purchasing, it is crucial to offer relevant products to customers. This is notably the case in the airline context. The selling process is commonly divided into two subsequent stages: in the former, a customer buys the ticket, and in the latter, she buys some ancillaries. Ancillaries are non-core products, such as in-flight Wi-Fi, snacks or additional baggage. It is particularly important to make use of offer management, since if ancillaries are not sold, all the value is lost after the flight departure. Ancillaries can be combined in a single utility called a bundle, which are then sold for a single price.

We propose a novel approach in which tickets are sold with bundles. Differently from the usual approach, in the first stage, we sell the bundle with the ticket, where the bundle could be empty. In the second one, when the bundle has been purchased, and we are getting closer to the departure date, we allow customers to upgrade. They can add ancillaries that were not originally included in the bundle. This later stage catches the difference in price sensitivity that customers have in between the beginning of the selling period and the check-in time, which allows to increase the revenue.

The bundle assortment poses practical challenges. The difficulties arise from the problem structure, since for practical purposes we can't propose all the possible bundles combinations, and we need to offer a limited set that brings the optimal revenue.

Keywords: dynamic pricing; bundles; ancillaries; airlines; revenue management; customer-choice model

Application of auctions mechanisms in restaurant business

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Abstract. In this study we focus on the application of auction mechanism, through a web platform, to the restaurant business. In particular, we propose several optimization models and strategies, aimed at winners determination and revenue maximization. We model the problem with a combinatorial auction mechanism, considering different auction peculiarities such as first price auctions, second price auctions and dynamic auctions. We consider bundles characterized by tables of different sizes and different types of menus. Furthermore, the possibility to choose a particular turn with a different level of flexibility is allowed, hence, the tables are considered as a renewable resource, and the customer's satisfaction is also taken into account. Moreover, we give some directions to address the bid generation problem in terms of calcutation of the offers price (e.g. bids) proposed by the bidders. Preliminary computational results have shown that the application of auction strategies to restaurant business is an effective way to achieve revenues.

Keywords: Auction · Winner determination · Restaurant Revenue Management;

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A non-parametric model for constrained retail assortment optimization

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Abstract. This research considers a constrained assortment optimization problem where retailers define a set of products organized in different multi-level categories, and set their related inventory levels to maximize profits. We develop a non-parametric model in which consumers' behavior is described through simple statistical measures rather than classical choice models. In particular, we make use of average sales to represent consumer familiarity with a product, and we compute correlation coefficients between sales series of different items to individuate substitution/complementarity effects among them. These aspects characterize the customer demand for a product. Retailers can decide, according to their objective, to introduce deviations from the observed customers behavior by easily calibrating the model parameters. A preliminary campaign of computational experiments conducted on both artificial and realistic case studies shows promising results on the effectiveness of the proposed approach.

Keywords: assortment optimization; non-parametric models; substitution; complementarity.

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Evaluating Public Transport by Multimodal Schedule-based Routing

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Abstract. One of the main EU policy priorities under the European Green Deal is to achieve climate neutrality by 2050, and transport is a key sector in this effort due to its significant contribution to greenhouse gas emissions. To monitor the performance of public transport in the EU, the European Commission uses comprehensive data to compute accessibility-to-opportunities measures related to public transport. These measures are based on various Operations Research challenges, such as the schedule-based time-dependent all-pairs scheduling problem of calculating accessibility measures across Europe. While previous methods have considered multiple modes of transport for this problem, they have not been able to effectively handle large instances, such as entire European countries. We propose a new method, based on the RAPTOR algorithm [1], that addresses this limitation by considering multiple modes of transport for large instances. Our tool aims to support the design and implementation of policies promoting equitable access to public transport, and we apply it to a specific set of European countries with varying characteristics in terms of public transport coverage and population density. The goal is to assess the number of relevant opportunities, or essential services, that are accessible through the transport network.

Keywords: public transport; multimodality; routing transport; accessibility; routing algorithms

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Waste collection with EVs: a MILP formulation

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Abstract. The rising carbon emissions made clear that achieving sustainable mobility can no longer be delayed. To this aim, we required emission-free heavy-duty urban trucks, as they impact significantly on carbon emissions despite their small overall quantity. In this work, we focus on garbage collection with an electric fleet, namely, on optimizing the collection routes of electric trucks. Starting from [1] , we propose a MILP formulation for the electric vehicle routing problem with non-linear charging functions (E-VRP-NL [2]), which considers the effect of load on energy consumption. The model describes the recharging process without using binary decision variables, which represents a novelty in the literature to the best of our knowledge. In most cases, the tests on Montoya's small instances, up to 40 bins, resulted in better routes with higher charging time utilizations than those found by the meta-heuristics. The former results are obtained within 30 minutes of computational time. This study aims at filling the lack of research into exact algorithms [3] for the E-VRP-NL.

Keywords: E-VRP-NL; Waste collection; MILP; Smart cities.

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A MILP model for multimodal logistics cooperation

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Abstract. The aim of the proposed research project is to develop an integrated framework to be used in the novel paradigm of cooperative logistics that provides support to supply chains moving towards the Sustainable Development Goals expressed by the United Nations 2030 Agenda [1]. The work proposes an efficient mathematical programming models to answers to the current lack of cooperation among shippers and logistics service providers to reach effective freight movements through the optimal use of transportation modes by increasing the performance, cargo consolidation and asset sharing. The design of the method is based on the finding of a shortest route in a multimodal freight transportation [2] environment with multiple possible minimisation goals. Instances of case studies are translated and parameterised for a Mixed Integer Linear Programming Model (MILP) and thus served to a solver, the results of which are thoroughly discussed to highlight the advantages and the correctness of the method.

Keywords: Sustainability; Multimodality Freight Transport; Cooperative Logistics; Mixed Integer Linear Programming Model.

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On the generation of Metric TSP instances with a large integrality gap by branch-and-cut

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Abstract. In this talk we introduce a computational method for generating metric Travelling Salesman Problem (TSP) instances having a large integrality gap. The method is based on the solution of an integer programming problem, called IH-OPT, that takes as input a fractional solution of the Subtour Elimination Problem (SEP) on a TSP instance and computes a TSP instance having an integrality gap larger than or equal to the integrality gap of the first instance. The decision variables of IH-OPT are the entries of the TSP cost matrix, and the constraints are defined by the intersection of the metric cone with an exponential number of inequalities, one for each possible TSP tour. Given the very large number of constraints, we have implemented a branch-and-cut algorithm for solving IH-OPT. Then, by sampling cost vectors over the metric polytope and by solving the corresponding SEP, we can generate random fractional vertices of the SEP polytope. If we solve the IH-OPT problem for every sampled vertex using our branch-and-cut algorithm, we can select the generated TSP instance (i.e., cost vector), yielding the longest runtime for Concorde, the state-of-the-art TSP solver. Our computational results show that our method is very effective in producing challenging instances.

Keywords: Integer Programming ; Integrality gap analysis ; Branch-and-cut ; Metric Traveling Salesman Problem

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The Ellipsoidal Separation Machine

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Abstract. We build on the general proposal of Grzybowski et al. that defines the concept of separation of two finite point sets X and Y by means of a convex set S. We chose S as, roughly speaking, the minimum volume ellipsoid that intersects the convex combinations of all pairs of points of different class. The corresponding fitting problem is non-convex, hence we solve it heuristically via an iterative algorithm of the block-Gauss-Seidel type solving alternatively an SDP program and a quadratically constrained (convex) program. The thusly computed separating ellipsoid is used to classify new points by means of a newly defined score based on the relative fraction of the original points that are properly separated from them. This necessarily leads to being unable to classify points inside the ellipsoid, making ours inherently a classifier with reject, as opposed with most proposals in the literature where a reject function is bolted upon a standard classifier. This feature can be relevant in cases where an incorrect classification may be more damaging than explicitly refusing to assign a label, indicating uncertainty. We will provide numerical experiments comparing the quality of the ellipsoidal classifier with that of standard approaches endowed with a rejection function

Keywords: Supervised classification with rejection; Non-convex optimization; SDP programming

Computing Negative Curvature Directions for Large Scale Optimization: exploiting SYMMBK

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Abstract.e consider the issue of computing negative curvature directions, for nonconvex functions, in large scale optimization. This issue has been widely investigated in the literature, so that a number of different approaches have attracted the attention of the scientific community. We focus on the well known SYMMBK method for solving large scale symmetric linear systems, and show how to exploit it to yield an effective negative curvature direction. Moreover, a distinguishing peculiarity of our proposal is given by the fact that, under reasonable assumptions, the computation of our negative curvature direction can be iteratively carried out, without storing no more than a couple of additional vectors.

Keywords: Nonlinear Programming, Negative Curvature Directions, Newton's Equation, SYMMBK, Conjugacy

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Operational Equilibrium of Electricity and Natural Gas Systems with Bi-Directional Energy Flows

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Abstract. The operations of electricity and gas systems are highly interrelated because of the bi-directional energy conversion allowed by modern energy systems. Indeed, natural gas can be converted to electricity by gas-fired power plants, while electricity can be transformed to gas by the Power-to-Gas (PtG) technology. Despite the strong interrelation, the electricity and the gas systems are usually operated independently. In this work, we capture the coupling between the electricity and the gas systems by deriving a market equilibrium for the day-ahead operations of the two systems. Two different linear models are formulated to represent the operations of the electricity system and the gas system. Such models are interdependent as: (i) the dispatch of the power system impacts the natural gas demand; (ii) the electricity consumption of PtG plants impacts the electricity demand; (iii) the price of natural gas impacts the operational cost of gas-fueled thermal power plants; and (iv) the price of electricity impacts the operational cost of PtG plants. The Karush-Kuhn-Tucker conditions of the two problems are then gathered and solved jointly to find a market equilibrium.

Keywords: Integrated systems; Power-to-Gas; Complementarity modeling

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