3rd EUROYoung Workshop

ESSEC Business School, Cergy, France

5–6 June 2023

Organised by EUROYoung, a Forum of EURO

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Day 1 — Monday, 05 June 2023

09:00 – 09:15	**Opening Session**
09:15 – 10:35	**Contributed Session 1** **09:15.** Cristian Duran. An efficient benders decomposition for the p-median problem. **09:30.** Alice Calamita. A Benders decomposition approach for congested partial set covering the location with uncertain demand. **09:45.** Adrian Göß. Norm-induced Cuts: Optimization with Lipschitzian Black-box Functions. **10:00.** Benedetto Manca. The Ellipsoidal Separation Machine. **10:15.** Charles Medi. Modeling and solving industrial lot-sizing problems.
10:40 – 11:10	**Coffee break**
11:10 – 12:25	**Contributed Session 2** **11:10.** Mariana Oliveira. Informing elective patient inter-hospital transfer using multi-objective optimization. **11:25.** Martina Milat. Scheduling construction projects under uncertain conditions: a multi-objective optimization problem. **11:40.** Giulia Caselli. Exact Algorithms for a Parallel Machine Scheduling Problem with Workforce and Contiguity Constraints. **11:55.** Andrea Mancuso. A Two-Phase Optimization Tool for Efficient Surgery Scheduling. **12:10.** Benedetta Ferrari. Mars Observation Scheduling Problem: optimizing the search for underground water.
12:30 – 14:00	**Lunch**
14:00 – 15:00	**Plenary Talk 1** **Ivana Ljubić**, ESSEC Business School. Benders Adaptive-Cuts Method for Two-Stage Stochastic Programs.
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15:00 – 15:30	**Contributed Session 3** **15:00.** Mohamed El Harrab. Multi-Architecture Microgrid Energy Management System (EMS): A Comparative Study of Deep Reinforcement Learning Algorithms with Population-Based Training for Hyperparameter Optimization. **15:15.** Jan Krause. Pooling with recipes.
15:30 – 19:30	**Social activity** **15:40.** Departure from ESSEC. **16:00.** Boat boarding starts. **16:30.** The boat departs from Pontoise (strict timing). **16:30 – 18:00.** Boat tour of the river Oise. **18:00 – 19:30.** Walking tour of the historical town of Pontoise.
20:00	**Social dinner**

Day 2 — Tuesday, 06 June 2023

09:20 – 10:35	**Contributed Session 4** **09:20.** Valentina Bonomi. Fairness in Home Healthcare: a lexicographic approach to investigate the impact of conflicting stakeholder's goals. **09:35.** Alberto Torrejón Valenzuela. Concerning fairness in Location Analysis. **09:50.** Celia Jiménez-Piqueras. Considering crane availability constraints in the premarshalling problem. **10:05.** Giulia Dotti. A simulation approach to improve buffer storage performance in ceramic tile logistics. **10:20.** Alim Buğra Çınar. The role of individual compensations and acceptance decisions in crowdsourced delivery.
10:40 – 11:10	**Coffee break**
11:10 – 12:25	**Contributed Session 5** **11:10.** Asunción Jiménez Cordero. A Novel Machine Learning Approach For Solving Optimal Transmission Switching. **11:25.** Miren Jasone Ramirez. Ayerbe Group Counterfactual Explanations by means of Mathematical Optimization. **11:40.** Nuria Gómez Vargas. Building uncertainty sets with auxiliary information in Robust Optimization. **11:55.** Manuel Navarro García. Feature selection on high dimensional additive models: a matheuristic approach. **12:10.** Domenico Serra. A Kernel Search algorithm for the Kidney Exchange Problem.
12:30 – 14:00	**Lunch**
14:00 – 15:00	**Plenary Talk 2** **Leo Liberti**, CNRS LIX. Career games with advice in relation to topic detection and community formation.
15:00 – 15:30	**Contributed Session 6** **15:00.** Laura Davila Pena. Metaheuristic approaches for the multi-compartment truck and trailer routing problem. **15:15.** Minakshi Punam Mandal. Tactical Green Fleet-Sizing Decisions for Last-Mile Deliveries.
15:30 – 16:00	**Coffee break**
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16:00 – 17:15	**Contributed Session 7** **16:00.** Marina Leal Palazón. Feature Selection in Hierarchical Clustering: A Mathematical Optimization Approach. **16:15.** Carmine Sorgente. Shortest paths with exclusive-disjunction arc pairs conflicts. **16:30.** Martina Cerulli. Mathematical Programming Formulations for the Collapsed k-Core Problem. **16:45.** Paolo Torrealba. Joint Order Batching and Picker Routing Problem including picker congestion. **17:00.** Vittorio Capocasale. Blockchain in supply chains: a technology-oriented suitability framework.
17:15 – 17:30	**Closing session**
18:00	**Barbecue starts**

Abstracts — Contributed Sessions

Contributed Session 1. Monday, 09:15 – 10:35.

Cristian Duran-Mateluna, Zacharie Ales, Sourour Elloumi.
An efficient benders decomposition for the p-median problem.

The p-median problem is a classic discrete location problem with numerous applications. It aims to open p sites while minimizing the sum of the distances of each client to its nearest open site. We study a Benders decomposition of the most efficient formulation in the literature. We show that the Benders cuts can be separated in linear time. The Benders reformulation leads to a compact formulation for the p-median problem. We implement a two-phase Benders decomposition algorithm that outperforms state-of-the-art methods on benchmark instances by an order of magnitude and allows to exactly solve for the first time several instances among which are large TSP instances and BIRCH instances. We also show that our implementation easily applies to the uncapacitated facility location problem.

Alice Calamita, Ivana Ljubič, Laura Palagi.
A Benders decomposition approach for congested partial set covering location with uncertain demand.

Congestion in facility location problems may result from a sudden increase in the demand of users allocated to a given service facility. Studying congestion is crucial as it directly impacts the performance and efficiency of many communication and service networks. We study the congested facility location problems with partial coverage under the assumption of uncertain customer demand. By seeking a more balanced solution, we can prevent facilities from being overloaded, thereby minimizing diseconomies of scale and ensuring better resource allocation. In the deterministic problem setting, congestion at facilities is typically represented by a convex quadratic term in the objective function, so that the problem is modeled as a mixed-integer convex quadratic program which can be reformulated using perspective constraints. In order to create a reliable and efficient network architecture that is robust against demand changes, we propose to deal with data-uncertainty using the concept of Γ-robustness as introduced in a previous work by Bertsimas and Sim. We first provide a perspective reformulation of the congested facility location with Γ-robustness, which allows us to reformulate the problem as a mixed-integer second-order cone program. We then propose to solve the resulting model using a Benders decomposition approach. Through a series of experiments on (adapted) instances from the existing literature, we highlight the pros and cons of the two proposed approaches.

Adrian Göß.
Norm-induced Cuts: Optimization with Lipschitzian Black-box Functions.

Optimal control problems usually involve constraints which model physical states and their possible transitions. This is represented by ordinary or partial differential equations (ODEs/PDEs) which add an component of infinite dimension to the problem. In recent literature, one method to simulate such ODEs/PDEs are physics-informed neural networks. Typically, neural networks are highly non-linear and even non-differentiable which makes their addition to optimization problems challenging. Hence, we use their often available Lipschitz property on a compact domain. The respective Lipschitz constant L has to be computed only once and is accessible thereafter. We present a method that based on this property iteratively adds cuts, involving the violation of the constraints by the current incumbent and L. Hereby, the "shape" of a cut depends on the norm used. We have proven correctness of the method, discussed termination in the infeasible case, as well as given an analysis of the problem complexity. For the analysis, we show that the lower and upper iteration

bound asymptotically coincide when the relative approximation error goes to zero. Lastly, we can visualize the method on a small example based on a two-dimensional non-convex optimization problem, as well as stress the necessity of having a globally optimal oracle for the sub-problems by another example.

Enrico Gorgone, Benedetto Manca, Antonio Frangioni.
The Ellipsoidal Separation Machine.

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.

Charles Medi.
Modeling and solving industrial lot-sizing problems.

DecisionBrain is a software company that specializes in providing optimization solutions primarily in the fields of workforce management, logistics and production planning. Decision Brain offers modular, custom planning, scheduling and logistics optimization software solutions to solve multi-objective problems with complex constraints. Among production planning problems are lot-sizing problems, that aim at determining a production or distribution plan that satisfies demands over a planning horizon discretized into periods, minimizing the total production, inventory and setup costs. They are very common in manufacturing and logistics and are usually NP-hard. DecisionBrain develops an optimization engine (called the Planning Engine) that uses IBM ILOG CPLEX and that aims at modeling and solving a large variety of lot-sizing problems. In this presentation, we will give insights on issues that might occur when trying to solve industrial lot-sizing problems. We will describe a few of the research topics tackled at Deci- sionBrain, as well as a description of an industrial production planning problem. The first theoretical aspect concerns the end-of-horizon effect. We have shown that when building production plans, this edge effect can affect the quality of the solution obtained and cannot simply be mitigated by considering a larger planning horizon. The second topic discusses the evolution of inventory within periods when solving lot-sizing problems. In many industrial applications the production plan build at a strategic level is used to build an operational schedule. However, we have noticed that not considering the evolution of inventory within each period can lead to schedules of poor quality. Using a discrete model implies inventory constraints to only be ensured at the end of each period. This can raise feasibility issues with regards to inventory levels as a period can last days or weeks, in which production and demand may occur at very different points in time. We will describe an operational use case of lot-sizing problems in the textile industry. In our use case, clothes are produced at plants and then immediately shipped to distribution centers all around the world. The batches that are optimized are then split into the different available sizes in order to satisfy the demands over an horizon of 18 months. The resulting production planning problem is highly complex because production occurs by fixed batch sizes of style- color, which then need to be disaggregated in order to satisfy demands that are defined by sizes.

Contributed Session 2. Monday, 11:10 – 12:25.

Mariana Oliveira, Daniel Santos, Ana Barbosa-Póvoa.
Informing elective patient inter-hospital transfer using multi-objective optimization.

Patients seeking elective surgical treatments often face long waiting periods in countries with national healthcare systems. This problem arises due to the mismatch between the demand for healthcare services and the available surgical resources in certain hospitals. To address the inability to provide timely care, hospitals may transfer patients to other hospitals with available resources, which can constitute a burden for both the patients and the operating room managers. Additionally, there are associated costs with patient transfers. However, transferring patients can help hospitals increase efficiency and reduce waiting lists and the corresponding waiting times. This research work proposes a multi-objective optimization model that hospitals can use to support decisions on how to collaborate and reduce tardiness and waiting times, while minimizing costs and distance. The model considers hospital capacity and waiting time targets to facilitate easier organization, improved compliance with hospitals' strategic missions, and enhanced fairness and quality of care. The tradeoff of collaborating and non-collaborating hospitals' costs, maximum distance and waiting time before surgery is also assessed. By considering these factors, hospitals can make informed decisions about collaborating with other hospitals to optimize resources and reduce waiting times, thus improving the quality of care for patients.

Martina Milat.
Scheduling construction projects under uncertain conditions: a multi-objective optimization problem.

Construction projects are complex undertakings that are being realized in an uncertain environment. For this reason, a multi-objective optimization problem is developed to simultaneously optimize three conflicting objectives for construction projects. The goal is to obtain minimal makespan, maximal profit from the role of contractor, and also maximize time floats in the baseline plan so the negative impact of uncertainty can be absorbed. The underlying resource-constrained project scheduling problem (RCPSP) is extended with two more objectives so the construction execution can be modeled in greater depth. After the optimization model was set, the metaheuristic algorithm was applied to solve the stated problem efficiently. We have customized a well-known Non-dominated Sorting Genetic Algorithm-II (NSGA-II) in the open-source framework pymoo using the Python programming language. The effect of uncertainty is considered in the following step: the idea is to simulate variation in the duration of risky activities for different baseline schedules obtained as a result of the optimization process. Here we needed to develop an extended Monte-Carlo algorithm so the resource feasibility can be satisfied in the simulation phase. Finally, the optimization-simulation framework was tested on historic data from an existing construction project. Results show that the deviations between planned and realized states can be minimized if makespans are prolonged for a relatively small percentage. It can be stated that this improves the resilience of baseline schedules for construction projects. However, more research is needed to gain a better understanding of this topic. For example, this research can continue by analyzing real data from different construction projects. This was a major obstacle in the study because construction companies prevalently consider project data as confidential information. Moreover, different algorithms can be developed to solve the optimization problem and this can improve the efficiency of the solving algorithms. Last but not least, the underlying model can be extended to alternative execution scenarios. In this manner, the model could represent the real state more thoroughly and with better confidence.

Giulia Caselli, Maxence Delorme, Manuel Iori, Carlo Alberto Magni.
Exact Algorithms for a Parallel Machine Scheduling Problem with Workforce and Contiguity Constraints.

In this work, we consider a real-world scheduling problem where the objective is to allocate a set of tasks to a set of machines and to a set of workers in such a way that the total weighted tardiness is minimized. The constraints that we take into account, namely, precedence, resource, eligibility, and contiguity, have never been studied together in the literature. We present four exact methods to solve the problem: two methods use integer linear programming, one uses constraint programming, and one uses a combinatorial Benders' decomposition in which we first schedule the jobs and then assign the machines and human resources to the jobs. Each of the proposed algorithms uses an innovative strategy to model the contiguity constraints. The efficiency of the methods is proven by computational tests on a heterogeneous dataset composed of real, realistic, and random instances.

Andrea Mancuso, Maurizio Boccia, Adriano Masone, Claudio Sterle.
A Two-Phase Optimization Tool for Efficient Surgery Scheduling.

The effective management of operating rooms is a challenging but crucial element in ensuring the proper functioning of hospitals. One of the most critical aspects of hospital operations is surgery scheduling. A surgery schedule must take into account the contrasting goals of maximizing the utilization of operating rooms while being able to cope with unforeseeable events. The principal causes of unpredictability are linked to possible deviations in surgery duration and the unpredictable arrival of emergencies. The Surgical Scheduling Problem (SSP) arises in this context. It involves optimizing the utilization of resources such as operating rooms and medical staff while considering various operational issues and constraints, including surgery duration, patient priority, availability of surgeons and equipment, and possible variations in conditions. This complex problem involves two key aspects. The first is ex-ante management, which entails scheduling surgeries by assigning a specific day, operating room, and start time for each procedure. The second aspect is in-itinere management, which involves dealing with unforeseeable events that may require modifications to the initial plan. To address these challenges, this work presents a two-phase optimization approach for the SSP. Phase I focuses on designing an efficient and proactive surgery schedule, considering the potential arrival of emergencies, with the aim of maximizing operating room utilization and minimizing postponed surgeries. Phase II reacts to changes in conditions to ensure the schedule remains efficient and responsive throughout the planning period, minimizing deviations from the schedule established in Phase I. Both phases are formulated using integer linear programming (ILP) and have been integrated into an optimization tool. The effectiveness and performance of the proposed optimization tool are validated using real data from a hospital in Naples. The results show that the tool could be a valuable resource for supporting surgery department executives in managing operating rooms efficiently and effectively.

Benedetta Ferrari, Maxence Delorme, Manuel Iori, Marco Lippi, Roberto Orosei.
Mars Observation Scheduling Problem: optimizing the search for underground water.

In recent years, the exploration of space beyond Earth has received increasing attention from governmental and private space agencies. The exploration is carried out through space missions, which require a a continuous operative effort during their execution. Within this field, our research focuses on MARS EXPRESS, a mission that started in 2003 by the launch of a satellite that since then is orbiting around Mars. The satellite is equipped with several instruments, among which the radar MARSIS, managed by the Italian National Institute of Astrophysics (INAF), which has the purpose of observing Mars subsurface in order to map the presence of underground water. Our role in this framework is to optimize and automate the generation of feasible schedules for MARSIS observations, with the aim to reach a coverage of maximal quality of the South Pole of Mars by

considering both environmental conditions and instrumental constraints. The resulting optimization problem, called Mars Observation Scheduling Problem (MOSP), is of high difficulty and has been only manually solved until now. To the best of our knowledge, observation scheduling problems in outer space have been faced only by Paterna et al. A large number of studies has been produced for Earth Observation Satellites, but these are not directly applicable to outer space missions because they have different operational constraints. In this work, we model MOSP as an Integer Linear Program. Besides, we solve it by means of three constructive heuristics and a matheuristic. We also adopt Machine Learning algorithms to predict the quality of the future observations. The algorithms have been tested on the real data set from INAF, and a combination of matheuristic and gradient boosting obtained the best performance. Different scenarios have been analysed by attempting several operating configurations of the radar, proving the flexibility and efficiency of the combined algorithm.

Contributed Session 3. Monday, 15:00 – 15:30.

Mohamed El Harrab.

Multi-Architecture Microgrid Energy Management System (EMS): A Comparative Study of Deep Reinforcement Learning Algorithms with Population-Based Training for Hyperparameter Optimization.

Microgrids are small-scale power systems that integrate various energy resources including renewable sources and energy storage systems to deliver reliable, secure and cost-effective power to local loads. The expansion of distributed energy resources (DERs) along with the increasing complexity of energy management have made efficient optimization of microgrid operations a relevant and critical research topic. In this sense, traditional optimization methods may face challenges when attempting to address the complex, non-linear, and uncertain characteristics of microgrid systems. Machine learning (ML) techniques, particularly Deep Reinforcement Learning (DRL), have emerged as powerful tools for addressing the challenges of microgrid optimization. The core concept of DRL revolves around the agent interacting with his environment to learn the optimal control policies by trial and error, becoming suitable tools for complex and dynamic issues. DRL algorithms and advanced optimization techniques enable the conception of innovative EMS that optimizes energy generation, consumption, and storage, improving microgrid performance and resilience. In this paper, we present a comprehensive study on the design and implementation of a multi-architecture microgrid Energy Management System (EMS) for On-Grid, Off-Grid, and Weak-Grid topologies. The proposed EMS employs DRL techniques to optimize energy dispatch and consumption, maximizing the benefits of available renewable resources through self-consumption. We systematically compare the performance of various state-of-the-art DRL algorithms, namely Proximal Policy Optimization (PPO), Rainbow DQN, Dueling DQN, Double DQN, and Twin Delayed DDPG (TD3), to identify the most suitable algorithm for our microgrid EMS. We use Population-Based Training (PBT) for hyperparameter optimization (HPO) to enhance DRL algorithms' performance. PBT adapts hyperparameters during training, allowing efficient exploration of the hyperparameter space. By evaluating the EMS and analyzing results, we identify the most effective DRL algorithm and its optimal hyperparameters. Our findings reveal the potential of DRL algorithms for managing multi-architecture microgrids and the effectiveness of PBT in optimization, offering valuable insights for developing efficient, robust EMSs and sustainable, resilient energy systems.

Jan Krause.

Pooling with recipes.

The pooling problem is a well-known $\mathcal{NP}$-hard optimization problem that was introduced by C. A. Haverly

in 1978. It originates from the modelling of refinery processes in the petroleum industry where one seeks to find the minimum cost way of mixing raw materials of varying quality in intermediate tanks (pools) so as to produce multiple final blends. This is to be performed such that certain quality requirements are satisfied for the outputs. We adapt this model to apply it in food industry where besides the quality constraints also recipes for the final products needs to be taken into account. These recipes specify proportions of different raw materials which should be contained in a certain output. We refer to this variant as pooling problem with recipes. In a recent working paper we consider a slight extension of this problem where the recipes are not fixed anymore, but instead only need to be 'almost' satisfied. The talk presents polyhedral studies for the solution spaces for both of the cases of fixed and flexible recipes. In particular, valid and facet-defining inequalities are presented that might be beneficial when used as cutting planes in a Branch & Cut framework.

Contributed Session 4. Tuesday, 09:20 – 10:35.

Valentina Bonomi, Renata Mansini, Roberto Zanotti.
Fairness in Home Healthcare: a lexicographic approach to investigate the impact of conflicting stakeholder's goals.

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. 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 previous work 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.

Ivana Ljubic, Miguel Pozo, Justo Puerto, Alberto Torrejón Valenzuela.
Concerning fairness in Location Analysis.

Effectiveness and efficiency are concepts that have been successfully included in optimization context. However, a third relevant concept to guarantee acceptable decisions is the principle of fairness, of equity, a complicated concept to model. Ordered optimization can be used as a framework for analyzing fairness measures in optimization problems. In the case of location problems, the Discrete Ordered Median Problem (DOMP) allows the generalization of different location problems such median or center, and in particular can be used to create a framework for the analysis of the concept of equity in location problems. In this talk we will present the recent work on discrete ordered location problems, reviewing the latest enhancements in algorithmic efficiency by embedding the state-of-the-art formulation into a Benders decomposition, how to include system connection by means of a tree modelization between facilities and giving some insights on how we can use DOMP to create fairer solutions in location problems.

Celia Jiménez-Piqueras.
Considering crane availability constraints in the premarshalling problem.

The container premarshalling is a port terminal optimization problem that has been widely studied in the literature. However, the original version of this problem considers several assumptions that hamper its implementation in practice. We propose a novel version that deals with the limited availability of the crane, a fact that is neglected in the classical formulation. The original problem looks for the minimum number of crane movements to reorder a set of container stacks so that each container is accessible by the crane at its retrieval time without performing any additional relocation. The version we propose measures the time the crane uses instead of the number of movements and aims to find a partial premarshalling that can be performed within a given time limit. The definition of the quality of the partial premarshalling solutions is not straightforward. We tackle this question and study different approaches to solve the novel problem using constraint programming.

Giulia Dotti, Marco Taccini, Manuel Iori, Anand Subramanian.
A simulation approach to improve buffer storage performance in ceramic tile logistics.

This study aims to enhance the warehouse logistics performance of an international ceramic tile company headquartered in Italy by identifying an efficient storage policy for the buffer area between the production plant and the logistics department. Considering the lack of homogeneity of the ceramic production process and the requests for uniform-tile orders, the storage policy must divide the products into homogeneous categories and store them accordingly. The current policy adopted by the company classifies tiles based on their technical properties, whereas the newly devised policy classifies them based on their downstream destination. A discrete event simulation was developed using Salabim, a recently developed Python-based open-source software that offers a range of attractive features, including comprehensive documentation, object-oriented architecture, and animations. The simulation was run multiple times to gather the values of four performance indicators, and statistical comparative analyses demonstrated that the proposed policy outperformed the current one on all different indicators. Additionally, a sensitivity analysis was conducted to assess the effectiveness of the policies under different scenarios by increasing the production quantity, coherently with the positive market trends observed in the sector. The results revealed that, regardless of the increase in production, the devised policy consistently outperformed the current policy in all scenarios. As a result, the company decided to implement the proposed storage policy, estimating to reduce the costs related to the buffer area emptying process by 17%. Overall, this research contributes to the literature on simulation-based decision-making in material management and this approach can be implemented in different contexts to enhance warehouse performance. Finally, this work provides a functional case study that illustrates the achievable results of Salabim for modelling complex systems.

Alim Buğra Çınar, Wout Dullaert, Markus Leitner, Rosario Paradiso, Stefan Waldherr.
The role of individual compensations and acceptance decisions in crowdsourced delivery.

High demand, rising customer expectations, and governmental regulations require companies to increase the efficiency and sustainability of urban (last-mile) distribution. Consequently, several new delivery concepts have been suggested that increase the flexibility for customers and other stakeholders. One of these innovations is crowdsourced delivery, where deliveries are made by occasional drivers who want to utilize their excess resources (unused transportation capacity) by performing deliveries in exchange for some compensation. Next to a decrease in delivery costs, potential advantages of crowdsourced delivery include better utilization of transportation capacity, reduction of total traffic, and increased flexibility (by scaling the delivery capacity up and down when necessary). Nevertheless, utilizing occasional drivers presents new challenges since (in contrast to traditional couriers) neither their availability nor behavior in accepting the delivery offers is certain.

The relation between compensation offered to occasional drivers and the probability that they are willing to perform a task has been largely neglected in the scientific literature. Therefore, we consider a setting in which compensation-dependent acceptance probabilities are explicitly considered in the process of assigning delivery tasks to occasional drivers. We propose a mixed-integer non-linear model minimizing the expected delivery costs while identifying optimal assignments of tasks to a mix of traditional and occasional drivers and their compensations. We propose exact linearization schemes for two practically relevant probability functions and an approximate linearization scheme for the general case. The results of our computational study show clear benefits of our new approach over previously existing ones.

Contributed Session 5. Tuesday, 11:10 – 12:25.

Salvador Pineda, Juan Miguel Morales, Asunción Jiménez-Cordero.
A Novel Machine Learning Approach For Solving Optimal Transmission Switching.

The design of new strategies that exploit methods from Machine Learning to facilitate the resolution of challenging and large-scale mathematical optimization problems has recently become an avenue of prolific and promising research. In this paper, we propose a novel learning procedure to assist in the solution of a well-known computationally difficult optimization problem in power systems: The Direct Current Optimal Transmission Switching (DC-OTS). This model consists in finding the configuration of the power network that results in the cheapest dispatch of the power generating units. For this, the model includes a set of binaries that determine the on/off status of the switchable transmission lines. Therefore, the DC-OTS problem takes the form of a mixed-integer program, which is NP-hard in general. Its solution has been approached by way of exact and heuristic methods. The former employ techniques from mixed-integer programming to solve the problem to certified global optimality, while the latter seek to identify good solutions quickly. While the heuristic methods tend to be comparatively much faster, they may suggest suboptimal or even infeasible networks topologies. The proposed approach in this paper leverages known solutions to past instances of the DC-OTS problem to speed up the mixed-integer optimization of a new unseen model. Although it does not offer optimality guarantees, a series of numerical experiments run on a real-life power system dataset show that it features a very high success rate in identifying the optimal grid topology (especially when compared to alternative competing heuristics), while rendering remarkable speed-up factors.

Miren Jasone Ramirez Ayerbe.
Group Counterfactual Explanations by means of Mathematical Optimization.

Counterfactual analysis has been shown to be a powerful tool in the growing field of Explainable Artificial Intelligence. In Supervised Classification, the aim is to associate with each record a counterfactual explanation: an instance that is close to the record and whose probability of being classified in the positive class by a given classifier is high. Finding counterfactual explanations is equivalent to solving an optimization model, the structure of which will depend on several ingredients. This talk will illustrate several such models for group counterfactual analysis.

Rafael Blanquero, Emilio Carrizosa and Nuria Gómez-Varga.
Building uncertainty sets with auxiliary information in Robust Optimization.

In real-world decision problems, the presence of uncertainty in the multiple parameters that model either the

objective function to be optimized (e.g., minimizing travel times) or some of the constraints that must be satisfied (e.g., demands) is the usual scenario. In Robust Optimization, we deal with a collection of problems of a common structure but with the parameters of the model varying in some uncertainty set. We study an approach to build these uncertainty sets by leveraging the contextual information provided by a set of covariates (e.g., weather or traffic congestion). Specifically, we design ellipsoidal uncertainty sets that are defined by the maximum likelihood estimated parameters of the assumed Gaussian distribution resulting from conditioning the uncertain parameters to the given values of the covariates, and provide both theoretical and empirical guarantees for the coverage provided. Finally, we implement our approach on synthetic data to demonstrate the value of exploiting contextual information in Robust Optimization.

Manuel Navarro-García, Vanesa Guerrero, María Durban, Arturo del Cerro.
Feature selection on high dimensional additive models: a matheuristic approach.

Sparse feature selection has become a recurring research topic in modern regression analysis, which strives to build interpretable models without sacrificing accuracy. An essential problem in this field of study is the best subset selection problem with subset size k, which has the goal of identifying the k covariates that give the best fit in terms of an empirical loss function. The cardinality constraint makes this problem non-convex, prompting numerous researchers to suggest alternate strategies to get around the computational challenges that such a decision problem entails. To increase the sparsity in the prediction model most of the approaches developed in this context either assume linearity on the predictors or employ convex penalties. However, this first assumption may be an inaccurate approximation of reality, while the second may lead to selecting a large number of non-informative features. In this work, we address the best subset selection problem in a general setting where the variables may enter the model as linear and/or non-linear. To do so, we developed a matheuristic approach based on the Akaike Information Criterion of the smooth components. Additive models are employed to model non-linear relationships in the data, where each smooth term in the model is decomposed into a linear and a non-linear term. The usage of smooth functions instead of linear predictors generates a group structure on the parameters to be estimated, and the resulting best group subset selection problem is stated as a mixed integer quadratic optimization (MIQP) problem. In addition, we introduced a general framework based on the group lasso algorithm that provide solutions which significantly improve the performance of the MIQP model in terms of the sizes of the problems to be handled. Our approach is compared with other state-of-the-art methodologies in feature selection on high dimensional additive models, and we prove to be competitive in terms of predictive power both in synthetic and real-world data sets.

Domenico Serra, Raffaele Cerulli, Monica Gentili, Carmine Sorgente.
A Kernel Search algorithm for the Kidney Exchange Problem.

The Kidney Exchange Problem (KEP) is a combinatorial optimization problem, born from the need to provide support to hospitals in identifying a compatible living kidney donor for each patient who requests one. Kidney exchange programs aim to match patients with end-stage renal disease who have available but incompatible kidney donors with other compatible ones. Such programs include pools of incompatible patient-donor pairs, that can be mapped on the nodes of a graph; whenever the donor of the i-th pair is compatible with the patient of the j-th pair, we insert an arc oriented from node i to node j. Each arc is associated with a weight that indicates the degree of compatibility between the donor of node i and the patient of node j (or the probability of success of the transplant). KEP consists in the identification of cycles or chains of limited length on a given directed graph. We address this problem using a tailored Kernel Search algorithm, which is a matheuristic framework that iteratively solves a restricted version of the problem. We test our approach using a set of instances randomly generated.

Contributed Session 6. Tuesday, 15:00 – 15:30.

Laura Davila Pena, David Penas, Balbina Casas Méndez, Maria Antónia Caravilla, José Fernando Oliveira.
Metaheuristic approaches for the multi-compartment truck and trailer routing problem.

Vehicle routing problems admit different variants depending on the customers' needs. One of them is the truck and trailer routing problem (TTRP), where a fleet of trucks and trailers serves a set of customers such that when the trailer is not able to reach a customer, they are attended to only by the truck. Motivated by the needs of a Spanish agricultural cooperative that produces and distributes cattle feed, this work proposes a novel approach to combine the TTRP with product compartmentalization, which we call the multi-compartment truck and trailer routing problem (MC-TTRP). We present two metaheuristic algorithms for the MC-TTRP: an iterated tabu search (ITS) and an adaptive large neighborhood search (ALNS). Both proposals have been integrated as the second phase of two-stage heuristic algorithms, whose first phase coincides and iteratively builds an initial solution based on the savings method of Clarke and Wright. We carried out a computational study on 21 new test problems adapted from those in preexisting literature, obtaining results that prove the effectiveness of our proposals. In particular, the ITS outperforms previous approaches for some TTRP instances, and both the ITS and ALNS achieve a reduction in the cost of the initial solution. Furthermore, an application of the proposed model and heuristics is demonstrated in the field of agricultural logistics by comparing the results attained in small-sized instances.

Minakshi Punam Mandal.
Tactical Green Fleet-Sizing Decisions for Last-Mile Deliveries.

We study a Last-Mile Delivery (LMD) problem that deals with the fleet sizing decisions of a company. While existing studies primarily focus on the day-to-day operational aspect of the LMD systems, we aim to explore the problem at a tactical level where the number of freighters to be hired by the company is fixed for a long period of time (e.g., 4 months). We study deliveries in real cities that are usually divided into areas, and packages first reach Local Distribution Centres located within each area, from where they need to be delivered to the end customers using green delivery modes. This study is particularly aimed at complementing innovative LMD strategies where the use of delivery trucks is limited. We intend to estimate the number of freighters that need to be hired by the company in each area to serve the demand during different periods of the day. If the number of freighters recruited is insufficient to serve all the demand, then it must be outsourced to a third-party logistics provider, which is typically more expensive. Our objective is to minimize the total cost of hiring and outsourcing over the planning horizon. We propose mixed integer programming techniques to study a stochastic version of the problem. We use an approximation algorithm to capture the operational requirements of the system and embed it into our model. We provide computational studies to support the viability of our studies.

Contributed Session 7. Tuesday, 16:00 – 17:10.

Marina Leal Palazón.
Feature Selection in Hierarchical Clustering: A Mathematical Optimization Approach.

Hierarchical clustering is a grouping method that builds a hierarchy of clusters. The order in which the objects/individuals are linked is determined by using a measure of dissimilarity between sets of observations and by using a linkage criterion. There exist several types of linkage that lead to different clusterings and dendrograms. Dendrograms are the output of the hierarchical cluster analysis. They are a representation of the two-dimensional cluster similarity matrix. Dendrograms are useful in a wide variety of fields such as medicine, biology, anthropology, and sociology among others. Feature selection is common in data mining for managing large databases. Since dendrograms represent groupings of large databases, they are also likely to the use of feature selection. The construction of dendrograms is commonly approached by using algorithms. In this work, we introduce mathematical optimization models for feature selection in hierarchical clustering with different linkage criteria.

Carmine Sorgente, Raffaele Cerulli, Francesca Guerriero, Edoardo Scalzo.
Shortest paths with exclusive-disjunction arc pairs conflicts.

Shortest paths with exclusive-disjunction arc pairs conflicts Shortest path problems have been frequently employed, in the literature, to assist the automatic generation of test paths for programs. The addressed scenarios involve, inter alia, specific subsets of forced vertices and forbidden vertex pairs. In this talk, we consider exclusive-disjunction conflicts among arcs, each of which is violated if either none or both the arcs in conflict are traversed. For each violation, a given penalty has to be paid, while the main goal is to minimize the overall cost of the solution, i.e., the sum of the costs of the traversed arcs and the penalties associated with the violated conflicts. This setting models web application testing scenarios, where paths represent sequences of web pages and hyperlinks. Firstly, we present two mathematical formulations of the problem, both relying on binary arc decision variables, but differing in how conflict violations and penalties are modeled. Then, we describe a two-stage matheuristic algorithm and we compare the performances of the proposed approaches, in terms of efficiency and effectiveness, on several sets of instances, characterized by different network topologies. Finally, we discuss how network size and conflict density variations affect the hardness of the problem.

Martina Cerulli.
Identifying the most critical users, in terms of network engagement, is a compelling topic in social networks analysis. Users who leave a community potentially affect the cardinality of its k-core, i.e., the maximal induced subgraph of the network with minimum degree at least k. We focus on the Collapsed k-Core Problem, which seeks to find a subset of b users, namely the most critical users of the network, the removal of which results in the smallest possible k-core. On the one hand, we model the Collapsed k-Core Problem as a natural deletion-round-indexed Integer Linear formulation. On the other hand, we provide two bilevel formulations for the problem, which differ in the way in which the k-core identification problem is formulated at the lower level. The performance of the proposed formulations is compared on a set of benchmarking instances with the existing state-of-the-art solver for mixed-integer bilevel problems proposed by Fischetti et al.

Paolo Torrealba.
Joint Order Batching and Picker Routing Problem including picker congestion.

Order picking is one of the most important processes in warehouse operations. Although some activities in warehouses are becoming more automated, picking activities are still mainly performed by human operators. This work considers a human-operated warehouse in which pickers deal with the simultaneous preparation of different customer orders. In this context, two main decisions must be taken: (1) grouping the orders that must be collected together into a batch, and (2) determining the route that each picker will follow to retrieve the items of the orders to be collected. The Joint Order Batching and Picker Routing Problem (JOBPRP)

integrates both decisions into a single mathematical model, minimizing the total distance or time. However, this assumes that the pickers operate without any congestion produced by other pickers, which is not realistic when there are many pickers working in the same warehouse, especially given that product localization policies often tend to concentrate high turnover products. In practice, congestion causes inefficiency, increases costs, reduces performance, and leads to accidents. Congestion occurs when multiple pickers use the same space simultaneously, resulting in a delay in normal picker operations. To estimate the congestion level, the planning horizon is divided into homogeneous time intervals, and timing variables are introduced. If two or more pickers are in the same sub-aisle during the same time interval, a delay in the nominal travel time is imposed. To solve the JOBPRP, including the effect of picker congestion, an extended mathematical formulation is presented in which variables or columns represent a picker route. Each column defines the orders that the picker is collecting, the exact path that will be followed, and the congestion level in each time period for the visited spaces. A heuristic solving approach is proposed based on the solving of the linear relaxation of the formulation by an exact column generation procedure. The main components of the algorithm and several experiments will be presented.

Vittorio Capocasale.
Blockchain in supply chains: a technology-oriented suitability framework.

Blockchain and distributed ledger technologies are attracting the interest of institutions, companies, and the academy. Nonetheless, assessing the suitability of blockchain technology is not straightforward, as the standard way of addressing problems needs to be reshaped and addressed from a decentralized perspective. Thus, decision-makers adopt blockchain technology for the wrong reasons or prefer it to more suitable ones. We present a suitability framework to help decision-makers understand whether blockchain is applicable, valuable, and preferable to other technologies. In particular, the decision framework comprises a small set of questions that can be answered from a managerial standpoint without requiring a deep technical knowledge of blockchain-related topics. The framework focuses on the technological perspective and does not consider other economic, legal, or human-related factors. An application of the framework to a logistic use case is also discussed.