International Conference on

Optimization and Decision Science

Sorrento, Italy, September 4th-7th , 2017

Book of Abstracts of XLVII Annual Meeting
Italian Operations Research Society

International Conference on

Optimization and Decision Science

Hilton Conference Center
Sorrento, Italy, September 4th-7th, 2017

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This book has been edited by Antonio Sforza and Claudio Sterle, Co-Chairs, and Adriano Masone, Organizing Committee Component, of ODS2017, International Conference on Optimization and Decision Science, Hilton Conference Center, Sorrento, Italy, September 4th – 7th , 2017.

The book has been printed with the support of Department of Electrical Engineering and Information Technology (DIETI).

Printed in August 2017

Optimization and Decision Science
(Antonio Sforza, Claudio Sterle, Adriano Masone eds.)

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Dear ODS2017 participants,
on behalf of the entire community of the University of Naples Federico II, I am pleased to welcome you for the ODS2017, International Conference on Optimization and Decision Science.
Our University has a great tradition. It was the first publicly funded university in the world, established in 1224 through an Imperial Charter of Frederick II Hohenstaufen, King of Sicily and Holy Roman Emperor.
Our University is composed by 4 Schools: Medical Sciences, Agriculture and Veterinary Medicine, Human and Social Science, Polytechnic and Basic Sciences. Nowadays it offers courses in a huge number of academic disciplines, leading to 155 graduate level degrees. Current student enrolment nears 97.000 and the academic personnel, at this time, is about 2700.
For all we accepted the challenge of training competent, open-minded professionals, aware of the rapidity changing needs of a modern society. We are pursuing excellence, making every effort to improve our academic and research standards.
Operations Research is active in the Polytechnic School, giving an important contribution in research and teaching activities for the Departments and Courses where it is involved.
We are confident that this Conference will be a valuable research moment and also an occasion to have a nice time in Sorrento and in the surrounding places of the area of Naples.

Gaetano Manfredi
Rector of University Federico II of Naples

Dear ODS2017 participants,

I am pleased to give you the warmest welcome on behalf of the Polytechnic and Basic Sciences School of the University Federico II of Naples established by the Emperor Frederick II in 1224, one of the oldest academic institutions in the world.

The School of Bridges and Roads was founded in 1811by Joachim Murat, King of Naples, with the name. Then it took the names of Royal School of Engineering, Higher Polytechnic School, Faculty of Engineering and now, from 2013, it has become Polytechnic and Basic Sciences School, involving also Architecture and Basic Sciences.

Today the School offers a variety of degree courses, MSc and PhD programmes. Operations Research is mainly present in the Courses of Industrial Engineering, Information Technology and Mathematics. This confirms the transversality of this discipline and in general of the quantitative methods for decision making, which could play also a relevant role for a problem solving based teaching of Mathematics in primary and secondary schools.

This conference is characterized by a great variety of methodological and applicative themes. It represents an important point of contact among researchers, practitioners, private and public companies and policy makers.

I hope you will have a successful meeting and you will enjoy your stay in Sorrento and surrounding places, trying also to find some time to discover the impressive heritage of our region.

Piero Salatino
Dean of Polytechnic and Basic Sciences School
University Federico II of Naples

Dear ODS2017 participants,
as Director of the Department of Electrical Engineering and Information Technology (DIETI) of the University Federico II of Naples, I am glad to welcome you to ODS2017, XLVII Annual Meeting of AIRO, Italian Operations Research Society.
DIETI includes more than 130 professors and researchers, involved in 7 teaching areas, providing cutting-edge research in several fields, such as Automation, Biomedical, Electrical, Electronic, Computer Science, Informatics and Telecommunication Engineering.
In this context Operations Research Group is involved in teaching activity in MSc's and PhD courses with a research activity on methodological and applicative themes with a strong transversal character.
For this reason ODS2017 Conference is a significant moment of the research activity of the OR Group and the Department.
We hope you will appreciate our attempt to make this meeting a successful forum for exchanges of recent experiences and results on the themes of your interest.
We are also confident that you will enjoy your stay in Sorrento and in its beautiful surrounding places.

Giorgio Ventre
Director of Dept. of Electrical Engineering and Information Technology
University of Naples Federico II

Dear ODS2017 participants,
it is a great pleasure for me to welcome you on behalf of AIRO (Italian Association of Operations Research) to its XLVII Annual Meeting, which from this year is called Optimization and Decision Science, ODS2017.
As always, the annual conference will bring together researchers, practitioners and students to discuss the various themes of our discipline and share new problems and innovative solutions. I am very happy to say that, thanks to efforts of the organizers, many members of AIRO and its thematic sections, the participation of international researchers and of practitioners is particularly high and the richness of the conference program will make it a very interesting event for our community.
In a world with increasing complexity, Operations Research methodologies and tools can assist in providing effective solutions to many challenging problems, as witnessed by the large number of success stories we collected from our members. In ODS2017 conference many such issues will be addressed both in the plenary and parallel sessions. I am sure that you will find many papers related to fields of your interest, allowing you to exchange views and ideas with other experts, and you will find also motivation and new challenges in the discussion with practitioners and companies present.
Finally, I would like to express my personal thanks to the members of the Program and Organizing Committees for their hard work in preparation of the Conference and to all the people who contributed to its success by organizing sessions and other initiatives.

Daniele Vigo
President of AIRO

Introduction and presentation of ODS2017

Operations Research is known as the discipline founded on mathematical and quantitative methods aimed at determining optimal or near-optimal solutions to complex decision making problems. The emphasis on the real applications highlights the great versatility and transversality of this discipline. Its solving approaches, methodologies and tools find application in many different fields and areas, notably in industrial and territorial systems. Hence the interplay between researchers, practitioners and policy-makers plays a relevant role which is supported by conferences and workshops.

ODS2017, International Conference on Optimization and Decision Science, is the XLVII annual meeting organized by the Italian Operations Research Society (AIRO) in Sorrento, Italy, September 4th – 7th, 2017, in cooperation with the Department of Electrical Engineering and Information Technology (DIETI) of the University "Federico II" of Naples. The ODS2017 Programme and the Organizing Committee, are composed of researchers from Italy, Europe and North America.

ODS2017 is addressed to the entire Operations Research and related scientific communities working in the wide field of optimization, problem solving and decision-making methods. Its scope is presenting ideas and experiences on cutting-edge research topics, sharing knowledge, discussing challenging issues and results, and creating a point of contact to foster future collaborations among researchers and practitioners from various sectors (applied mathematics, computer science, engineering, economics), private and public companies, industries and policy makers.The Conference has attracted more than 250 researchers and practitioners coming from 23 countries, so confirming its international character.

ODS2017 participants had the possibility either to submit a paper or an abstract on the conference research themes. All the contributions can be found in the conference e-book available at the website: www.airoconference.it/ods2017. In this e-book the reader finds also the abstracts of the invited lectures and of the research papers submitted and accepted for presentation at the conference after a peer-review process, made by experts in operations research and related fields.

The three invited lectures are:

- *Robust Network Control and Disjunctive Programming*, given by Prof. Daniel Bienstock, Department of Industrial Engineering and Operations Research, Columbia University, New York, USA.
- *From Mixed-Integer Linear to Mixed-Integer Bilevel Programming*, given by Prof. Matteo Fischetti, Department of Computer Science, University of Padova, Italy.
- *Data Science meets Optimization*, sponsored by the Association of the European Operations Research Societies, given by Prof. Patrick De Causmaecker, Department of Computer Science, University of Leuven, Belgium.

The submitted research papers and the abstracts span on the methodological and applicative themes proposed in the call for papers: Continuous and Global Optimization; Linear and Non-Linear Programming; Discrete and Combinatorial Optimization; Stochastic and Robust Optimization; Cutting, Packing and Scheduling, Multicriteria and Decision Making, Energy optimization, Health Care, Data Science, Game Theory; Graph Theory and Network Optimization, Location, Routing; Urban Traffic, Freight Transportation; Logistics, Supply Chain Management; Railway and Maritime Systems Optimization; Telecommunication Networks, Critical Infrastructure Protection, Emergency Logistics, Emerging Applications.

The 60 accepted research papers and the 197 abstracts have been organized in 48 sessions, related to the following 28 themes: AIRO Prizes, Cutting and Packing, Cutting and Scheduling, Critical Infrastracture Protection, Data Science, Game Theory, Global Optimization, Health Care, Heuristics and Metaheuristics, Inventory Routing, Recent Advance on Knapsack Problem, Location, Maritime Optimization, Multi-objective Optimization, Non-Linear Optimization and Applications, Optimization and Applications, Optimization Under Uncertainty, Paths and Trees, Railway Optimization, Routing, Scheduling, CORE European Supply Chain Project, OR Spin OFF, Stochastic Progamming, Teaching OR, Mathematics and CS, Transportation Planning, Recent Advances in Transportation, AIRO Young.

All the presentations highlight the impact that Operations Research methodologies and tools have in a society with increasing complexity challenging problems and the cross-fertilization of ideas between theoretical and applicative fields. They exhibit the latest methods and techniques needed in solving a number of existing research problems while provide new open questions for

further research investigations. It is expected that this research volume will be a valuable resource for experienced and young researchers.

As Co-Chairs of ODS2017 the invited lecturers and all the participants. Moreover, we express our sincere gratitude to the 71 researchers from around the world, who spent their valuable time for the review process, so contributing to improve the quality of the presented papers. We also express our thanks to Springer for support and cooperation in publishing the volume of ODS2017 papers in Proceedings in Mathematics and Statistics, which will be available after the Conference.

Finally, as conference chairs of ODS2017, we are thankful to the work team and students of the Department of Electrical Engineering and Information Technology, who actively helped in making the conference a success. We are also thankful to all the institutions, agencies and enterprises that have supported and sponsored the event:

University "Federico II" of Naples
Polytechnic and Base Sciences School of Naples
University of Sannio (Department of Engineering)
University of Salerno
(Dept of Mathematics and Dept of Industrial Engineering)
IASI/CNR - Rome
EURO (Association of the European OR Societies)
IDIS Foundation – Science Center of Naples
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Lottomatica S.p.a.
TecnoSistem S.p.a.
Tekla S.r.l.

Antonio Sforza and Claudio Sterle
ODS2017 Co-Chairs
Dept. of Electrical Engineering and Information Technology
University "Federico II" of Naples

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Plenary Sessions

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PS.1

Robust Network Control and Disjunctive Programming

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Abstract. The problems we consider are motivated by current issues on the safety and stability of power grids; however there are other critical infrastructure settings where very similar paradigms will arise. To explain our approach it is best to very quickly review the three-part mechanism that governs today's power grids. See [1, 2] for background. 1. First we have OPF, or "Optimal Power Flow," a computation performed periodically (roughly every five minutes) and whose main job is to set generator outputs over the next period, using estimates for demands over that period, and so as to minimize generation cost. 2. Demands will deviate from the estimates during the next period, in a noisy fashion, and sometimes indicating a trend. When demands (loads in the language of power engineering) do change, we have a generation vs demand mismatch, and frequency of the AC quantities (voltages in particular) will change in the opposite direction. This change, at the level of physics, guarantees that demands continue to be satisfied. If the change is very large, however, the network will collapse. The frequency change is termed primary response. 3. If a net demand change is somewhat permanent, the frequency shift will be noticed at a central location, and quite rapidly (perhaps in a matter of seconds) fast generators will be commanded to change their output so as to erase the mismatch between generation and loads. This is the secondary response. This three-leg system has proved quite robust and effective in traditional grid operation, but is becoming less effective due to a number of reasons, including the large-scale introduction of renewables, with large real-time variance and complex correlations. Another issue, with increasing interest, is that of adversarial action that causes a large, instantaneous, mismatch and also possibly a correlated interference information flows. In both settings we obtain a variety of problems where fast, and accurate, optimization can play a very important role. We discuss a number of problems and optimization techniques that can be used to address problems described above. In addition to mathematical techniques, modern grid operators will have access to an additional resource: storage (e.g., batteries). Storage gives an operator the ability to very quickly absorbe negative conditions and to react. Scheduling of storage introduces complexity because, for example, the behavior of batteries can be state-dependent and will reflect prior history. We will discuss the use of disjunctive programming in this context.

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[2] D. Bienstock. Electrical Transmission System Cascades and Vulnerability: An Operations Research Viewpoint. SIAM-MOS Series on Optimization (2015).

PS.2

Data Science meets Optimization

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Abstract. Data science and optimization have evolved separately over several decades. The concerns on either side were different as was the background of the community [1,2]. The concern of data science is how to infer knowledge from unstructured data; optimization starts from highly structured models to analyze highly complex solution spaces. Explicit knowledge is the aim of data science, while it is the starting point for optimization. On the other hand, problems in data sci-ence can often be stated as optimization problems and the behavior of algorithms for optimization is highly dependent on the distribution of the problem instances and hence the data entering into the models. The two broad domains have evolved apart while the needs were often similar. This has lead to similar concepts being developed on the two sides and researchers have missed opportunities for cross-fertilization. We discuss and compare some typical examples on both sides. We illustrate how potential cross-fertilization was missed. We discuss recent developments in data science as well as in optimization illustrating that things are actually happening. We identify opportunities for improvement and research questions to be tackled. A related issue is lack of penetration and assimilation by practitioners of highly competitive techniques as they have been developed in the first decades of the 21st century. We argue that in fact, both domains suffer from such a lack of assimilation. The reason for this discrepancy between theory and practice may lie in a missing standardization effort as well as in the lack of expressivity and accessibility of newly developed methodology for non-data science or optimization experts. We argue in favor of some recent efforts along this line [3]. All this was the motivation to create the EWG Data Science meets Optimization. We briefly comment on the activities of this working group [4].

References

[1] Several plenary speakers touched upon these issues at http://www.kuleuvenkulak.be/benelearn/index.html.
[2] The foundational workshop for EWG/DSO: http://set.kuleuven.be/codes/dfofoundationalmeeting.
[3] J. Swan et al. “A Research Agenda for Metaheuristic Standardization”. In: Proceedings of the Eleventh Metaheuristics International Conference (MIC), Agadir, Morocco. 2015. url: https://goo.gl/kC06p5.
[4] The official EWG/DSO websites https://www.euro-online.org/web/ewg/40/ewg-dso-euro-workinggroup-on-data-science-meets-optimizationand http://ds-o.org/.

From Mixed-Integer Linear to Mixed-Integer Bilevel Linear Programming

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Abstract. Bilevel Optimization is a very challenging framework where two players with different objectives compete for the definition of the final solution. Problems of this kind arise in many important practical contexts, including critical infrastructure defense, transportation network design, pricing mechanisms in the energy/airline/telecommunication industry, optimal expansion of gas networks, and machine learning. The exact solution of bilevel optimization problems is a difficult task that received a considerable attention in recent years [2,3]. In this talk we address the solution of a generic Mixed-Integer Bilevel Linear Program (MIBLP), i.e., of a bilevel optimization problem where all constraints and objective functions are linear, and some/all variables are required to take integer values. In doing so, we look for a general-purpose approach applicable to any MIBLP (under appropriate conditions), rather than ad-hoc methods for specific cases. Our approach concentrates on minimal additions required to convert an effective branch-and-cut Mixed-Integer Linear Programming (MILP) code into a valid MIBLP solver, thus automatically inheriting the wide arsenal of MILP tools (cuts, branching rules, heuristics) available in modern MILP solvers. In particular, we outline the method recently proposed in [4,5], where a new class of bilevel-specific Intersection Cuts [1] is introduced and computationally analyzed on a very large class of test cases from the literature.

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Abstracts of Parallel Sessions

(in alphabetical order of sessions)

AIRO Prizes

Chairman: D. Pacciarelli

AIROP.1 *Enhancing Mixed Integer Programming Solvers with Decomposition Methods*
S. Basso

AIROP.2 *An Integrated Algorithm for Shift Scheduling Problems for Local Public Transport Companies*
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C. Gambella , T. Parriani, D. Vigo

AIROP.1

Waste Flow Optimization: An Application in the Italian Context

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Abstract. Given the difficulty of branch-and-cut frameworks to scale well in terms of problem complexity and data size, we explore the viability of using decomposition methods in general purpose solvers for MIPs. First, we assess if good Dantzig-Wolfe decomposition patterns can be consistently found by looking only at static properties of MIP input instances. We adopt a data driven approach by devising a random sampling algorithm and by considering a set of generic MIP base instances, generating a large, balanced and well diversified set of decomposition patterns. Supervised and unsupervised machine learning techniques highlight interesting structures of random decompositions, as well as suggesting (under certain conditions) a positive answer to the initial question and perspectives for future research. Then, we consider a scenario in which a good decomposition has been found and multi-core CPU architectures are available and massive parallelism can be exploited. We propose both a concurrent and a distributed column generation algorithm, that relax the synchronized behavior of classical sequential column generation while providing the same global convergence properties. We present an extensive experimental campaign against a naive parallelization and the cutting planes algorithm implemented in state-of-the-art commercial optimization packages for large scale datasets of a hard packing problem from the literature. Our algorithms turn out to be on average one order of magnitude faster than competitors, attaining almost linear speedups as the number of available CPU cores increases.

An Integrated Algorithm for Shift Scheduling Problems for Local Public Transport Companies

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Abstract. This paper presents an integrated approach to solve two shift scheduling problems for local public bus companies: the first one aims at finding a schedule for vehicles, given a set of rides to do; the second one aims at assigning drivers to vehicle schedules. The first subproblem to be faced is the Multiple Depot Vehicle Scheduling Problem that is known to be NP-hard. Therefore, heuristic algorithms are needed to find feasible solutions for real-life instances. In this work a starting solution for this problem is found by using a greedy algorithm. This solution is then improved by a simulated annealing strategy that exploits several local search techniques. The second problem to deal with is the Crew Scheduling Problem where each trip is assigned to a driver. This problem is still NP-Hard. In this paper an initial solution for the Crew Scheduling Problem is firstly found with a classical sequential approach. This solution is then modified by changing the allocation of trips on vehicles in order to minimize the combined objective function. Both the problems have been modelled taking into account as more real-world constraints as possible. Several constraints take into account the European Union restrictions related to how the driver shifts must be composed. The proposed problem is different from the ones presented in the literature, as the mathematical model, and the related algorithm, are designed based on real world-requirements. Computational results have been carried out on large real-word instances. The results show that the proposed algorithm is able to find quickly good solutions within a limited computational time.

Keywords: Vehicle Scheduling; Crew Scheduling; Simulated Annealing; Local Search

Waste Flow Optimization: An Application in the Italian Context

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Abstract. Over the last few decades, the overall social impact of solid waste management has increased yet further, raising a range of both economic and environmental issues. Waste logistic networks have become complex and challenging as the straightforward source-to-landfill management switched to multi-echelon networks in which waste flows generally go through more than one preliminary treatment before reaching their final destinations. In This paper we propose mixed integer linear formulations, and related resolution methods, as a way of tackling problems arising in waste logistic management, with an application in a real-world case study. In response to the actual needs of a major Italian waste operator, we introduce the modeling of some relevant features of these problems, such as digester facilities, transportation economies of scale and temporary waste storages.

Keywords: Vehicle Scheduling; Crew Scheduling; Simulated Annealing; Local Search

Cutting and Packing

Chairman: J. A. Bennel

C&P.1 *Two-dimensional Bin Packing models with conflict con straints*
S. Mezghani, B. Haddar, H. Chabchoub

C&P.2 *Upper bounds categorization for constrained two-dimensional guillotine cutting*
M. Russo, A. Sforza, C. Sterle

C&P.3 *Efficient local search heuristics for packing irregular shapes in 2-dimensional heterogeneous bins*
A. Martinez-Sykora, R. Abeysooriya, J. A.Bennell

Two-dimensional Bin Packing models with Conflict constraints

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Abstract. Several studies for the classical Bin Packing Problem (BPP) have been proposed in the literature. However, there is a lack of studies which consider realistic constraints that often arise in practice. This paper deals with the BPP with partial and total conflict between objects. We approach the problem by presenting and solving mixed integer linear programming models. We start with the basic model of the two-dimensional Bin Packing Problem (2D-BPP) (Lodi et al. (2002)) that include the essential features of the problem, such as respecting the dimensions of the bin and not exceeding its total capacity. Then, progressively, we add new restrictions to manage the conflicting items. The first constraint means that items in total conflict cannot be packed into the same bin, which extends the well-known 2D-BPP to the 2D-BPP with Total conflicts (2D-BPP-CT) (Khanafer et al. (2012), Muritiba et al. (2010)). The second constraint means that a safety distance must be kept between partially conflicting items in case they are assigned to the same bin. The 2D-BPP is also generalized by introducing partial conflicts between some objects (2D-BPP-CP) (Hamdi-Dhaoui et al. (2012)).The models are solved with the CPLEX 12.5 solver and are tested on the instances of Berkey and Wang (1987). The computational results validate the models and show that they are able to handle problems of a moderate size. These models may be useful in motivating future research and exploring other BPP solution approaches, such as relaxation and heuristics methods.

Keywords: Bin packing Problem, two-dimensional Bin Packing Problem, partial conflict, total conflict, Mathematical Model.

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C&P.2

Upper bounds categorization for constrained two-dimensional guillotine cutting

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Abstract. In the two-dimensional cutting problem, a large rectangular sheet has to be dissected into smaller rectangular desired pieces. If limits exist on the number of extracted pieces, the problem is classified as constrained, with a wide range of applications. Most literature solving methods are based on ad-hoc tree search strategies, with top-down or bottom-up approach. In both cases, lower and upper bounds are exploited, leading to branch and bound algorithms. We present a review of the upper bounds and identify a set of features for their categorization.

Keywords: guillotine cutting, upper bound categorization

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Efficient local search heuristics for packing irregular shapes in 2-dimensional heterogeneous bins

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Abstract. In this work we propose a jostle-based heuristic algorithm to solve the two-dimensional irregular multiple bin-size bin packing problem. The problem consists of placing a set of pieces represented as 2D polygons in rectangular bins with different dimensions such that the total area of bins used is minimized. Most the packing algorithms available in the literature of 2D irregular bin packing consider a unique size for the bins. However, in many industries such as sheet metal, foams and timber sheets the size of the bins is another decision that needs to be made since there are several bin sizes that can be used to satisfy a given demand. This problem extends the problem addressed in Martinez-Sykora et al. (2016), where all the bins are considered to have the same dimensions. Therefore, three decisions should be made simultaneously. First, the well-known placing problem where a feasible position of the pieces in the bins should be found. The second decision is related to the implicit bin packing problem, needed to identify which pieces should be placed in the same bin, and finally, it is important to identify the good selection of bin types. We show that with a jostle-based heuristic algorithm, based on Dowsland and Dowsland (1998), all of these decisions can be addressed simultaneously with low computational effort and obtaining high quality results, improving the results of an adapted Genetic Algorithm proposed in Babu and Babu (2001) to address the bin type selection problem, and also improve the results presented in Martinez-Sykora et al. (2016).

Keywords: Irregular cutting, heterogeneous bin, jostle

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Cutting and Scheduling
PRIN Project Invited Session

Chairman: C. Arbib

C&S.1 *Bin Packing Problems with variable pattern processing times: a proof of concept*
A. Pizzuti, F. Marinelli

C&S.2 *Dynamic programming and filtering to solve a k-stage two-dimensional guillotine knapsack problem*
Q. Viaud, F. Clautiaux, R. Sadykov, F. Vanderbeck

C&S.3 *An archaeological irregular packing problem*
J.A. Bennell, C. Lamas Fernandez, A. Martinez-Sykora, M. Cabo Nodar

C&S.4 *Optimization models for cut sequencing*
C. Arbib, P. Avella, M. Boccia, F. Marinelli, S. Mattia

C&S.1

Bin packing problems with variable pattern processing times: a proof-of-concept

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Abstract. In several real-world applications the time required to accomplish a job generally depends on the number of tasks that compose it. Although the same also holds for packing (or cutting) problems when the processing time of a bin depends by the number of its items, the approaches proposed in the literature usually do not consider variable bin processing times and therefore become inaccurate when time costs are worth more than raw material costs. In this paper we discuss this issue by considering a variant of the one-dimensional bin packing problem in which items are due by given dates and a convex combination of number of used bins and maximum lateness has to be minimized. An integer linear program that takes into account variable pattern processing times is proposed and used as proof-of-concept.

Keywords: one-dimensional bin packing, scheduling, mixed integer programming

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

C&S.2

Dynamic programming and filtering to solve a k-stage two-dimensional guillotine knapsack problem

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Abstract. We compare different exact methods for solving a two-dimensional knapsack problem with guillotine constraints. The problem inputs consist of a large rectangular plate (W,H) and a set of items I (each item i is rectangular (w_i,h_i) and is available d_i times). The objective is to cut a subset of items from the plate such that the sum of their profits is maximized. This problem is standard for glass, metal and wood industries. When the maximum availability of each item is discarded, the set of cutting patterns for the large plate can be represented by a dynamic program (DP). Solving such a DP is equivalent to seeking a max-cost flow in a directed acyclic hyper-graph. Each hyper-graph vertex is a dynamic program state, an hyper-arc is a link between them and represents a cut. In order to reduce the hyper-graph size, we apply dominance rules based on cutting properties. We also use column generation for extended formulation to get tight problem dual bound and combine it with Lagrangian cost filtering to remove hyper-arcs (which cannot belong to any optimal solutions). A direct way to solve our problem is to write the MILP related to the dynamic program and add to it the cardinality constraints corresponding to item availabilities. This MILP formulation is then solved by a commercial solver. A second way uses a label-setting algorithm combined with a state space augmentation strategy. Initially, cardinality constraints are aggregated into a single one. Then at each algorithm iteration, a unique constraint is added and the problem is solved again until a feasible solution is found. An originality of our approach is to generalize Lagrangian filtering method from graphs to hyper-graphs. We compare both methods as well as the impact of Lagrangian cost filtering. Our experiments are realized on real-world problem instances. We also compare our methodology with the best known methods from the literature.

Keywords: Lagrangian cost filtering, Extended formulation, Hyper-graph

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C&S.3

An archaeological irregular packing problem

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Abstract. The paper explores the use of cutting and packing methodologies in a new and innovative way to support archaeological research. Pre-hispanic cultures in Mexico used codices to register different aspects of their everyday life including their lands and crops. Each family register the number of pieces of land that they owned together with some measures of its dimension in a codex. These codices have been deciphered and using the methodologies presented by Williams et al (2008) we have accurate information about the length of each side of the pieces of land and the area they covered. Using the given dimensions, each terrain can be reconstructed as polygons. In addition, the dimensions and location of the settlements are known. This description equates to a two dimensional packing problem with an irregular bin and irregular pieces that can be rotated. While irregular shape packing has been an active research area for many years, the work focuses on packing a single strip for cutting material for manufacturing. However, while the problem at hand is quite different, we draw on the techniques arising from this research area in both geometry and algorithm design; see Bennell and Oliveira (2008, 2009) for reviews. In the presentation we will present the problem and some specific complexities that lead to the solution methodology needing to generate a range of different solutions. We present a formulation of the problem and use some simple heuristics to find a set of solutions.

Keywords: cutting and packing, optimization, heuristic.

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C&S.4

Optimization models for cut sequencing

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Abstract. The paper describes models for scheduling the patterns that form a solution of a cutting stock problem. We highlight the problem of providing the required final products with the necessary items obtained from the cut, choosing which pattern feeds which lot of parts. This problem can be solved prior to schedule cuts, or in an integrated way. We present integer programming models for both approaches.

Keywords: Cutting Stock, Pattern Sequencing, Integer Programming

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Critical Infrastracture Protection

Chairman: R. Setola

CIP.1 *Ansaldo STS: Integrated Security Management Process to protect transportation systems*
I. Lamberti, G. Sorrentino

CIP.2 *The importance to manage Data Protection in the right way: problems and solutions*
H. Mokalled, C. Pragliola, D. Debertol, E.Meda

CIP.3 *Optimization for overvoltage protection of electrical power grid: state of the art and future perspective*
A. Andreotti, A. Sforza, C. Sterle

CIP.4 *Recovery from disruption in a subway network*
E. Tresoldi, F. Malucelli, V. De Maria

CIP.5 *Performance analysis of single and multi-objective approaches for the critical node detection problem*
L. Faramondi, G. Oliva, R. Setola. F. Pascucci, A. Esposito Amideo, M. P.Scaparra

CIP.1

Ansaldo STS: Integrated Security Management Process to protect Transportation Systems

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Abstract. Ansaldo STS is a global leader in Signaling and Transportation Systems both for passenger (Railway/Mass Transit) and Freight, offering state-of-the-art technologies. Critical Infrastructures (CIs) are physical and virtual assets essential for the effective functioning of the Society and the national economy. Transportation systems are CIs: damage/destruction by natural disasters, terrorism and criminal activities may have negative consequences for the security of the entire community. A Transportation System, as Critical Infrastructure, is exposed to the Cyber Attack phenomenon and the main vulnerabilities are: 1) coexistence/interaction between Safety Critical and Non-Safety Critical infrastructures; 2) geographically distributed architectures; 3) human factor management: operators, maintainers, passengers, and so on. For the abovementioned reasons, a Transportation System needs an holistic approach to protect both physical and virtual assets, combining in a unique security framework the multiple aspects of security: minimizing risks related to misuse of data and abuse of confidential information by authorized/unauthorized personnel having malicious intents, exposing passengers and personnel to risk of harm and/or impacting the continuity of operations.
Integration arises from the synergy between the functionalities of the physical infrastructure protection systems (i.e. video surveillance, access control/intrusion detection), and the innovative technology measures for the Cyber Asset protection. In order to monitor and manage the Cyber Risk Level and to achieve the required level of protection, it is necessary to manage security activities in a structured way: ASTS establishes and implements an Information Security Management Systems Process (ISMS) in accordance to the international standards (ISO/IEC 27000: 2016, IEC 62443). The objective is to monitor the Cyber Risk Level during the lifecycle project phases, from Design to Operations, offering an Integrated Security System involving technologies, people, and processes.

Keywords: Confidentiality, Integrity, Availability.

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CIP.2

The importance to manage Data Protection in the right way: problems and solutions

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Abstract. Data has become the most important asset for the companies, and data protection against loss is fundamental for their success. Most of the companies are connected to internet for business reasons and this is potentially risky. Cyberattacks, hacks and security breaches are no longer an exception [1]. They can range from no or limited impact to Distributed Denial of Services (DDoS), stealing/manipulation of data, or even taking over control of systems and harm the physical world [2]. Some companies work on critical projects that contain documentation to be protected and not publicly disclosed. Data leakage or loss could lead to hazardous situations, so data confidentiality, integrity and protection should be conserved. To reach this goal, it is better to adopt an efficient data protection management, i.e. having effective processes and methodologies in place to enable prevention, detection and reaction to any threat that could occur. Companies should give importance to actions, plans, polices, and address the organizational aspect, and be aware and prepared to manage crisis situations, using the best technological solution for each stage of the cybersecurity management. In this paper, we present solutions and key steps to manage data protection inside Ansaldo STS Company from organizational and technological sides, by using an Information Security Management System that implements the cybersecurity strategy of the company through three phases (prevention, detection and reaction, and checks for compliance and improvement) and by adopting a defense-in-depth approach and maturity models to deploy control in a prioritized and effective way.

Keywords: data protection, cybersecurity, ISMS

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The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

CIP.3

Optimization for overvoltage protection of electrical power grid: state of the art and future perspectives

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Abstract. Disturbances in the electrical power supply can originate from natural disasters, technical failures, human errors, labor conflicts, sabotage and acts of war. These events will in turn lead to one or more technical conditions in the electrical power grid (EPG) system that may cause failures/blackouts. Most of the failures occur in local distribution systems, MV and LV EPG and lightning is one of the major cause of their failures. For this reason, various technical solutions have been proposed to reduce failures, in particular: the use of an overhead ground wire (Sato et al., 2014); use of surge arresters (Shariatinasab et al., 2014); combined use of both. The surge arrester location problem has been already tackled by several effective metaheuristic approaches (Perez et al. (2007), Bullich-Massague et al. (2015)), while the complementary use of surge arrester and ground wire has never been investigated before. In this work we will provide the fundamentals on EPG protection and a review of the main optimization approaches proposed in literature for the separated problems. Then we will present the work perspective of *OPT-APP for EPG project* (Optimization Approaches for designing and protecting Electric Power Grid), aimed at: developing an optimization approach to design a reliable EPG network from scratch, using ground wire and surge arresters; developing approaches to identify the most critical elements of an EPG network and to optimally allocate the available protection resources (Cui et al, 2010).

Keywords: electrical power grid, critical infrastructure protection, reliable network design

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CIP.4

Recovery from Disruption in a Subway Network

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Abstract. Disruptions are unavoidable occurrences in transit systems. Even a minor disruption that implies blocking a section of the network in a subway system has important consequences and usually the recovery time can be very long. In this work the attention is focused on subway transportation systems and a possible approach to recover the correct circulation of trains after a disruption event. The main interest is to restore the regularity of the transportation system in the shortest possible time once the blocking event has been removed. In this process, the crucial aspect is to take into consideration all available resources and limitations in order to keep the operational costs and the inconvenience for the passengers as low as possible. We analyze the problem in the case of Milan subway system, underlining critical methodological and technological aspects that can be improved in order to reduce the recovery time. We present a mathematical formulation for the problem and we describe a solution approach that is able, in a reasonable amount of computational time, to minimize the length of the recovery period considering the scheduling and the requirements of both trains and drivers. A preliminary test phase has been carried out on real instances. We compare our method with the current modus operandi. The results are promising and show the effectiveness of the proposed approach.

Keywords: Disruption Recovery, Local Public Transportation, Real-World Scenarios.

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CIP.5

Performance Analysis of Single and Multi-Objective Approaches for the Critical Node Detection Problem

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Abstract. Critical infrastructures are network-based systems which are prone to various types of threats (e.g., terroristic or cyber-attacks). Therefore, it is paramount to devise modelling frameworks to assess their ability to withstand external disruptions and to develop protection strategies aimed at improving their robustness and security. In this paper, we compare six modelling approaches for identifying the most critical nodes in infrastructure networks. Three are well-established approaches in the literature, while three are recently proposed frameworks. All the approaches take the perspective of an attacker whose ultimate goal is to inflict maximum damage to a network with minimal effort. Specifically, they assume that a saboteur must decide which nodes to disable so as to disrupt network connectivity as much as possible. The formulations differ in terms of the attacker objectives and connectivity metrics (e.g., trade-off between inflicted damage and attack cost, pair-wise connectivity, size and number of disconnected partitions). We apply the six formulations to the IEEE24 Power System and conduct a comparative analysis of the solutions obtained with different parameter settings. Finally, we use frequency analysis to determine the most critical nodes with respect to different attack strategies.

Keywords: Critical Infrastructures, Network Vulnerability, Critical Node Detection Problem

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Data Science 1

Chairman: E. Messina

DS1.1 *A partitioning based heuristic for a variant of the simple pattern minimality problem*
M. Boccia, A. Masone, A. Sforza, C. Sterle

DS1.2 *Supervised and unsupervised learners to detect postural disorders*
L. Palagi, M. Mangone, T. Colombo

DS1.3 *A Graph model for the prediction of epileptic seizures through the analysis of EEG synchronization*
P. Detti, G. Z. Manrique de Lara

DS1.4 *Named entity recognition: resource constrained maximum path*
E. Messina, E. Fersini, F. Guerriero, L. Di Puglia Pugliese, G. Macrina

DS1.1

A partitioning based heuristic for a variant of the simple pattern minimality problem

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Abstract. Logical Analysis of Data deals with the classification of huge data set by boolean formulas and their synthetic representation by ternary string, referred to as patterns. In this context, the simple pattern minimality problem (SPMP) arises. It consists in determining the minimum number of patterns "explaining" an initial data set of binary strings. This problem is equivalent to the minimum disjunctive normal form problem and, hence, it has been widely tackled by set covering based heuristic approaches. In this work, we describe and tackle a particular variant of the SPMP coming from an application arising in the car industry production field. The main difference with respect to SPMP tackled in literature resides in the fact that the determined patterns must be partitions and not covers of the initial binary string data set. The problem is solved by an effective and fast heuristic, tested on several large size instances coming from a real application.

Keywords: simple pattern minimality; minimum disjunctive form; optimal diversity management.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

DS1.1

Supervised and unsupervised learners to detect postural disorders

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Abstract. The aim of the project is developing a new approach to detect postural disorders based on a combination of supervised and unsupervised learning techniques. The posture of a subject is the orientation of the body segments in three-dimensional space as a reaction to the force of gravity. There is still a high methodological variability in the detection of postural diseases, due to lack of evidences and of definition of 'parameters of normality'. Although the possibility to record large amounts of data from patients in the orthopedics field, datasets are still narrow and a method to automatically detect postural disorders in patients is missing. Furthermore, the influence of pathological conditions is unclear. We use data obtained by the Formetric machine which reports spinal column and posture measures and allows to digitally reconstruct the spinal column of a patient. We propose a new approach based on supervised classification and clustering techniques, in order to identify those variables that most count in the identification of postural disorders and that can support an orthopedist in the diagnostic process. To this aim we consider different class of learners to determine whether a patient is affected by a postural disorder is present or not.

Keywords: Postural disease, feature selection, supervised learning

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DS1.3

A Graph model for the prediction of epileptic seizures through the analysis of EEG synchronization

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Abstract. Epilepsy is a neurological disorder, arising from anomalies of the electrical activity in the brain, affecting about 0.5-0.8% of the world populations, with a high social cost. Treatment options for epilepsy are mainly pharmacological and to lesser extent surgical. However, antiepileptic drugs have limitations and fail to control seizures in roughly 20-30% of patients. Historically, epilepsy has been interpreted as a disorder characterized by abnormally enhanced neuronal excitability and synchronization. Several studies investigated the relationship between seizures and brainwave synchronization patterns, highlighting the possibility of distinguishing interictal, preictal and ictal states. In this work, a graph model is introduced to study the presence of synchronization patterns in the electroencephalogram (EEG) signals. In the model, the graph represents the scalp, where nodes are associated to the electrodes sites from which the EEG signals are captured, and an edge between two nodes, with a weight varying over time, measures the synchronization degree of the signals captured by a pair of electrodes. In a first phase, an analysis has been conducted to test different synchronization measures. At this aim, the Phase Lock Value (PLV) (Mormann et al. 2000), the Phase Lag Index (PLI) and its weighted version (WPLI) (Vinck et al., 2011) have been tested. In a second phase, suitable and fast measures on the graph model have been designed able to capture in real-time the dynamic changes of signals' synchronization. Finally, a standard classification technique is used to correctly classify the different states. Computational tests on real data show that simple and computationally fast measures on the graph are able to highlight changes in synchronization during the preictal and ictal states.

Keywords: electroencephalogram signals, graph model, classification.

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DS1.4

Named Entity Recognition: Resource Constrained Maximum Path

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Abstract. The automatic extraction of structured information from unstructured text sources is a challenging process known in the scientific literature as Information Extraction (IE). An interesting field related to the IE is the so-called Named Entity Recognition (NER). The aim of the NER is to identify atomic elements in a given text and to associate them with a predefined category, e.g. names of persons, organizations, locations and so on. The NER is a stochastic process involving both hidden variables (semantic labels) and observed variables (textual cues). In particular, the NER can be formalized as an assignment problem, where a finite sequence of semantic labels is associated with a set of interdependent variables representing text fragments. We consider a model for NER based on Conditional Random Fields (CRFs) where logic rules, defining relations among categories, are included in the decision process. We consider a novel formulation for the inference phase based on dynamic programming paradigm. In particular, the problem is defined as a maximum path problem (MPP) that incorporates the logic rules that can be either extracted from data or defined by domain experts. We model the logic rules as resources, defining proper Resource Extension Functions (REFs) and upper bound on the resource consumptions. The resulting problem is a resource constrained MPP (RCMPP). Labelling algorithm is defined to solve to optimality the problem.

Keywords: Resource Constrained Maximum Path Problem, Named Entity Recognition, Conditional Random Fields

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Data Science 2

Chairman: E. Fersini

DS2.1

Diagnosis for PEM Fuel Cell Systems using Semantic Technologies

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Abstract. The aim of this work is to demonstrate the applicability of semantic web technologies within the early diagnosis and decision support setting. The proposed scheme is applied in the fuel cell paradigm. The commercial success of fuel cell technology is largely dependent on establishing its durability and reliability. A drawback of most of the current fuel cell diagnostic tools is that their functionality is limited to providing warning of impending failures without any explanations, preventing any mitigating action. Data-driven approaches (e.g. [1]) can detect the faults, but they may not further isolate the faults unless enough test data obtained from various faults is available, while model-based methods (e.g. [2]) require the development of the accurate model incorporating different fault effects with mathematical equations, which is usually extremely complex and time-consuming. In this work, we exploit the Ontology Based Data Access (OBDA) [3] technology for robust early diagnosis and decision support for fuel cells. This approach has two main benefits, i.e., it provides the end-user with direct access to the data through the ontology and it allows detection of any forthcoming faults. At the same time the actual sources of the detected faults are indicated. In this way, design of mitigation strategies for system recovery and associated decision making processes are highly optimized. Our system has been validated using real sensor raw data and results of this validation analysis are presented.

Keywords: fuel cell, diagnosis, decision support, ontology based data access

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DS2.2

The Use of Configurational Analysis in the Evaluation of Real Estate Dynamics

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Abstract. The shape of urban space together with the choices that lead to its configuration have been the base of long and multidisciplinary debates taking into account several and heterogeneous factors. In this context, the goal of decision makers is to create and improve the value of a given area and manufactures. In this paper we propose a quantitative approach based on configurational analysis in the domain of real estate. The use of geographic information systems to integrate and analyze data form different data sources shows similarities among social-economics models and spatial approaches which consider completely different parameters.

Keywords: configurational analysis, geographic information systems

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

DS2.3

Approximate Decision Tree-Based Multiple Classifier Systems

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Abstract. Implementing hardware accelerators of multiple classifier systems assures an improving in performance: on one hand, the combination of multiple classifiers outcomes is able to improve classification accuracy, with respect to a single classifier; on the other hand, implementing the prediction algorithm by means of an integrated circuit enables classifier systems with higher throughput and better latency compared with a pure software architecture. Although, this approach requires a very high amount of hardware resources, limiting the adoption of commercial configurable devices, such as Field Programmable Gate Arrays. In this paper, we exploit the application of Approximate Computing to trade classification accuracy off for hardware resources occupation. Specifically, we adopt the bit-width reduction technique on a multiple classifier system based on the Random Forest approach. A case study demonstrates the feasibility of the methodology, showing an area reduction ranging between 8.3% and 72.3%.

Keywords: classifier systems, approximate computing

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

DS2.4

Inverse Reinforcement Learning and Market Surveillance: an optimization approach

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Abstract. Market surveillance solutions aim at supporting investigation, and hopefully prevention, of abusive, manipulative or illegal practices in the financial markets. Development of tools for effective market surveillance is currently one of the biggest challenges and it is now a core request of the new regulations, such as the "Market Abuse Directive" issued at the European Union level. More in detail, the new regulation requires financial intermediaries to develop a methodology to signal to the stock market financial authority (CONSOB in Italy) all the trades suspect of insider trading or manipulation. While insider trading is related to the exploitation of private information, market manipula-tion is not necessarily related to a piece of private information. Thus, an insider trader is likely to act as a price taker while a manipulator acts to affect asset prices. Both macro and micro data can be analyzed to identify anomalies related to possible abusive practices. Macro signals are usually related to public data which can be free (e.g. stock price and volumes provided by services such as Yahoo! Finance) as well for a fee (e.g. anonymized data related to single trades/contracts, best bid and best ask). On the other hand, micro signals are more detailed but more complex: they are usually related to the limit order book config-uration along with anonymized orders and trades. While Reinforcement Learning (RL) proved to be a natural solution to implement function-alities for supporting trading decisions (Shen et al., 2014), just recently RL and Inverse RL have been proposed for market abuse detection, in particular in the high frequency and algo-rithmic trading domains (Martìnez-Miranda et al., 2016 and Yang et al., 2012).
This study present a framework based on RL/IRL and clustering aimed at characterizing trading strategies and then identify those likely driven by abusive practices. Both market manipulation and insider trading have been considered; the framework has been validated through combining a market simulation software and real life market data.

Keywords: Reinforcement Learning, Inverse Reinforcement Learning, market surveillance.

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DS2.5

Word sense disambiguation as a traveling salesman problem

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Abstract. Word sense disambiguation is an early problem in the field of natural language processing. The goal is to identify the sense (or senses) that most likely is associated to a word, or a sequence of words, in a given context. Word sense disambiguation was recently addressed as a combinatorial optimization problem in which the goal is to find a sequence of senses that maximizes the "semantic relatedness" among the target words. For example, in the sentence "I'm going to buy a new mouse for my Apple", the system should be able to select the sense of a computer device for the word "mouse" based on the provided context and similarly the computer company sense for the word "apple". In this talk, we present a formulation of the word sense disambiguation problem as a traveling salesman problem and discuss the computational results obtained by different solution approches.

Keywords: Word Sense Disambiguation, Traveling Salesman Problem, Ant Colony Optimization

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Data Science 3

Chairman: S. Lozano

DS3.1 *Look-Up Tables for Efficient Non-Linear Parameters Estimation*
S. Marrone, G. Piantadosi, M. Sansone, C. Sansone

DS3.2 *On the UTA methods for solving the model selection problem*
V. Minnetti

DS3.3 *Outperforming Image Segmentation by Exploiting Approximate K-means Algorithms*
M. Barbareschi, F. Amato, G. Cozzolino, A. Mazzeo, N. Mazzocca, A. Tammaro

DS3.4 *A Bargaining perspective on DEA*
S. Lozano, M. Á. Hinojosa, A. Mármol

DS3.1

Look-Up Tables for Efficient Non-Linear Parameters Estimation

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Abstract. In the Big-Data era, many engineering tasks have to deal with extracting valuable information from large amount of data. This is supported by different methodologies, many of which strongly relay on curve fitting (both linear and non-linear). One of the most common approach to solve this kind of problems is the use of least squares method, usually by iterative procedures that can cause slowness when applied to problems that require to repeat the fitting procedure many times. In this work we propose a method to speed-up the curve fitting evaluation by means of a Look-up Table (LuT) approach, exploiting problems resilience. The considered case study is the fitting of breast Dynamic Contrast Enhanced-Magnetic Resonance Imaging (DCE-MRI) data to a pharmacokinetic model, that needs to be fast for clinical usage. To validate the proposed approach, we compared our results with those obtained by using the well-known LevenbergMarquardt algorithm (LMA). Results show that the proposed approach and LMA are not statistically different in terms of MSE (with respect to the observed data) and in terms of Sum of Differences in the parameter and in the solution spaces. Considering the computational effort, the proposed LuT approach is an order of magnitude faster than the LMA on the same dataset.

Keywords: Curve Fitting, Least Squares, Levenberg-Marquardt, Look-Up Tables, DCE-MRI, Pharmacokinetic Models, PBPK

Acknowledgements. The authors are grateful to Dr. Antonella Petrillo, Head of Division of Radiology, Department of Diagnostic Imaging, Radiant and Metabolic Therapy, “Istituto Nazionale dei Tumori Fondazione G. Pascale”-IRCCS, Naples, Italy, for providing access to DCEMRI data. Moreover, we would like to thank Roberta Fusco, Ph.D., from the same institution, for the useful discussions.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

DS3.2

On the UTA methods for solving the model selection problem

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Abstract. In this paper, the multiple criteria UTA methods are proposed for solving the problem of model selection. The UTA methods realize a ranking of the models, from the best one to the worst one, by means of the comparisons of their global utility values. These values are computed by means of Linear Programming problems. Two UTA methods are illustrated. An example, that examines the performances of some classification models in the web context, is presented.

Keywords: UTA methods, linear programming, classification models

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

DS3.3

Outperforming Image Segmentation by Exploiting Approximate K-means Algorithms

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Abstract. Recently emerged as an effective approach, Approximate Computing introduces a new design paradigm for trade system overhead off for result quality. Indeed, by relaxing the need for a fully precise outcome, Approximate Computing techniques allow to gain performance parameters, such as computational time or area of integrated circuits, by executing inexact operations. In this work, we propose an approximate version of the K-means algorithm to be used for the image segmentation, with the aim to reduce the area needed to synthesize it on a hardware target. In particular, we detail the methodology to find approximate variants of the k-means and some experimental evidences as a proof-of-concept.

Keywords: Approximate Computing, k-means, Algorithms

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

DS3.4

A Bargaining perspective on DEA

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Abstract. Data Envelopment Analysis (DEA) is a non-parametric methodology for assessing the relative efficiency of similar Decision Making Units (DMU) using the observed data about their input consumption and output production to benchmark them, identifying the efficient DMUs (i.e. those exhibiting the best practices) and those that are inefficient (i.e. dominated in terms of their inputs and outputs). For the inefficient DMUs an efficiency score and a target are computed. The target represents an efficient operating point that dominates the DMU being assessed and the efficiency score measures the distance between the inefficient DMU and its target. There are many DEA models that mainly differ in the way the target is computed and the way the distance to the target is measured. Thus, some DEA models project the DMUs radially, while others use a non-radial projection. Some DEA models use a multiplicative efficiency measure while others use an additive metric. Some DEA models are input- or output-oriented while others are non-oriented, etc. We present a new approach for computing DEA targets from the perspective of bargaining problems, i.e. using cooperative game theory. The players are the inputs and output variables. In the case of the output players their utility is a linear function of the corresponding variable. The input players' utility can be considered as either the inverse of the input variable or as a negative-slope linear transformation of the input variable. The disagreement point corresponds to the utility of inputs and outputs of the observed DMU being assessed. We show how some classical DEA models correspond to certain classical bargaining solution concepts while other bargaining solution concepts lead to new DEA models. The proposed approach can also handle non-discretionary variables and undesirable outputs.

Keywords: DEA, Nash bargaining solution, Kalai-Smorodinsky solution

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Game Theory

Chairman: P. Daniele

GATH.1 *Interdiction Games and Monotonicity*
M. Monaci, M. Fischetti, I. Ljubic, M. Sinnl

GATH.2 *A game-theoretic approach to transportation network analysis*
M. Sanguineti, G. Gnecco, Y. Hadas

GATH.3 *Proximal approach in selection of subgame perfect Nash equilibria*
F. Caruso, M. C. Ceparano, J. Morgan

GATH.4 *A cybersecurity investment supply chain game theory model*
P. Daniele, A. Maugeri, A. Nagurney

GATH.1

Interdiction Games and Monotonicity

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Abstract. Two-person interdiction games represent an important modeling concept for applications in marketing, defending critical infrastructure, stopping nuclear weapons projects or preventing drug smuggling. In this talk, we present an exact branch-and-cut algorithm for interdiction games, under the assumption that feasible solutions of the follower problem satisfy a certain monotonicity property. Prominent examples from literature that fall into this category are knapsack interdiction, matching interdiction, and packing interdiction problems. We also show how practically-relevant interdiction variants of the facility location and prize-collecting problems can be modeled in our setting. Our branch-and-cut algorithm uses a solution scheme akin to Benders decomposition, based on a family of so-called interdiction cuts. We present modified and lifted versions of these cuts along with exact and heuristic procedures for the separation of interdiction cuts, and heuristic separation procedures for the other versions. In addition, we derive further valid inequalities and present a new heuristic procedure. We computationally evaluate the proposed algorithm on a benchmark of 360 knapsack interdiction instances from literature. Our approach is able to solve, within about one minute of computing time, all these instances to proven optimality, including the 27 instances for which the optimal solution was previously unknown.

Keywords: Interdiction Games, Bilevel Optimization, Branch-and-Cut

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GATH.2

A game-theoretic approach to transportation network analysis

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Abstract. A cooperative game-theoretic approach is developed for the analysis of network connectivity, a major aspect of transportation networks. A basic question is: how "important" is each node? An important node might, e.g., highly contribute to short connections between many pairs of nodes, or handle a large amount of the traffic. The concept of "centrality" has been extensively used to quantify the relative importance of nodes, exploiting various so-called "centrality measures" [1]. A common limitation of classical centrality measures is the fact that they evaluate nodes based on individual contributions to the functioning of the network. In this work, taking the hint from [2], an approach to the analysis of network centrality is proposed, based on "transferable utility games" (TU games) [3]. Given a transportation network, a TU game is defined in such a way to take into account the network topology, the weights associated with the arcs, and the demand based on the origin-destination matrix. The nodes are the players, and the well-known solution concept called "Shapley value" is exploited to identify the nodes that play a major role. Using various network structures as test beds, a comparison with classical centrality measures is carried out. The results show the potentialities of the proposed methodology and its advantages over classical approaches, due to the inclusion of transportation networks properties such as travel time and demand.

Keywords: Transportation Networks, TU Games, Shapley Value

Acknowledgements. G. Gnecco and M. Sanguineti are members of GNAMPA-INdAM.

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GATH.3

Proximal approach in selection of subgame perfect Nash equilibria

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Abstract. In one-leader one-follower two-stage games, multiplicity of Subgame Perfect Nash Equilibria (henceforth SPNE) arises when the optimal reaction of the follower to any choice of the leader is not always unique, i.e. when the best reply correspondence of the follower is not a single-valued map. This presentation concerns a new selection method for SPNE which makes use of a sequence of games designed using a proximal point algorithm, well-known optimization technique related to the so-called Moreau-Yosida regularization (Moreau 1965, Martinet 1972, Rockafellar 1976, Parikh and Boyd 2014 and references therein). Any game of the obtained sequence is a classical Stackelberg game (Von Stackelberg 1952), i.e. a one-leader one-follower two-stage game where the best reply correspondence of the follower is single-valued, nothing but a bilevel optimization problem. This mechanism selection is in line with a previous one introduced in Morgan and Patrone (2006) and based on Tikhonov regularization, but using the class of proximal point algorithms has a twofold advantage: on the one hand, it can provide improvements in numerical implementations and, on the other hand, it has a clear interpretation: the follower payoff function is modified subtracting a term that can represent a physical and behavioural cost to move (Attouch and Soubeyran 2009). The constructive method and its effectiveness are illustrated and existence results for the selection are provided under mild assumptions on data, together with connections with other possible selection methods.

Keywords: Stackelberg game, bilevel optimization problem, subgame perfect Nash equilibrium

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GATH.4

A cybersecurity investment supply chain game theory model

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Abstract. We consider a recently introduced cybersecurity investment supply chain game theory model consisting of retailers and consumers at demand markets with the retailers being faced with nonlinear budget constraints on their cybersecurity investments. We construct a novel reformulation of the derived variational inequality formulation of the governing Nash equilibrium conditions. The reformulation then allows us to exploit and analyze the Lagrange multipliers associated with the bounds on the product transactions and the cybersecurity levels associated with the retailers to gain insights into the economic market forces. We also extend the model, assuming that the demands for the product are known and fixed and, hence, the conservation law of each demand market is fulfilled.We provide an analysis of the marginal expected transaction utilities and of the marginal expected cybersecurity investment utilities. We then establish some stability results for the financial damages associated with a cyberattack faced by the retailers.

Keywords: Cybersecurity, Supply Chains, Game Theory

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Global Optimization

Chairman: F. Archetti

GLOP.1 *Global optimization procedure to estimate a starting velocity model for local Full Waveform Inversion*
B. Galuzzi, E. Stucchi, E. Zampieri

GLOP.2 *Markov decision processes and reinforcement learning in the optimization of a black-box function*
I. Giordani, F. Archetti

GLOP.3 *A derivative-free local search algorithm for costly optimization problems with black-box functions*
E. Amaldi, A. Manno, E. Martelli

GLOP.4 *Sequential model based optimization for a pump operation problem*
F. Archetti, A. Candelieri, R. Perego

GLOP.1

Global optimization procedure to estimate a starting velocity model for local Full Waveform Inversion

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Abstract. Finding an efficient procedure to solve a seismic inversion problem, such as Full Waveform Inversion, still remains an open question. This is mainly due to the non linearity of the misfit function, characterized by the presence of multiple local minima, that cause unsuccessful results of local optimization strategies when the starting model is not in the basin of attraction of the global minimum. Therefore, the use of a global optimization strategy in order to estimate a suitable starting velocity model for Full Waveform Inversion is a crucial point. In this work we propose a new method which is based on the application of the Adaptive Simulated Annealing algorithm using a coarse inversion grid, different from the domain modelling one, that allows the reduction of the number of unknowns. Numerical results show that the application of our strategy to an acoustic Full Waveform Inversion provides a good starting model for a local optimization procedure, lying in the basin of attraction of the global minimum.

Keywords: Simulated Annealing. Seismic inversion. Acoustic wave equation

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

GLOP.2

Markov Decision Processes and Reinforcement Learning in the optimization of a black-box function

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Abstract. Markov Decision Processes (MDP) offer a general framework for modelling a sequential decision making process: a MDP consists of a set of states, a set of actions that the Decision Maker (DM) can take in each state, a model of the external environment characterized by action-dependent transition dynamics and a set of state-dependent rewards. The overall aim for the DM is to identify a policy (i.e. a mapping from states to actions) that will result in optimal performance of the system over some time horizon. Dynamic Programming (DP) offers a general mathematical framework for solving MDP and compute optimal policies even if its computational requirements grow exponentially with the number of states. The applications of this general framework have always constrained by this "curse of dimensionality" and a number of approximate strategies have been developed (Bertsekas 2012). Reinforcement Learning (RL) can be regarded as one approximate strategy to solve MDP where knowledge of the environment is incrementally acquired from interaction with the environment (Sutton and Barto, 2017). RL defines how the DM adapts his policy as a result of experience (i.e .rewards collected so far), with the goal to maximize the long run performance or value function. This makes RL naturally suited to online decision making in stochastic environments. In this paper the authors consider a system whose value function is "black-box" (i.e. can only be estimated by simulation) and develop an approximate policy based on the prediction of the reward associated with each action in each stat and its updating by a temporal difference learning. The computational results are related to a water distribution system, where energy cost is minimized given a number of operational constraints and a stochastic demand. The computational results compare favorably with those obtained by mathematical programming methods. Moreover, the RL framework fits naturally into the new technologies of online sensing, data acquisition and preprocessing being deployed in networked infrastructures.

Keywords: Reinforcement learning, Dynamic Programming.

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GLOP.3

A Derivative-Free Local Search Algorithm for Costly Optimization Problems with Black-Box Functions

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Abstract. Many real world problems concern the optimization of expensive black-box characterized by very time-consuming function evaluations. As a typical example, each function evaluation can be the result of the numerical solution of a big differential-algebraic equations system. Although for such applications some effective global optimization algorithms have been proposed in the literature, there is a lack of local search methods. In this work we propose a new local search optimization algorithm for costly black-box functions, which combines direct-search and model-based strategies, and is able to produce good estimates of the solution in a relatively small number of function evaluations. The performance of the proposed algorithm, that has been successfully used for a practical energy application, is compared with some state-of-the-art derivative-free methods to assess its effectiveness and reliability.

Keywords: Derivative-Free, Costly Black-Box Optimization

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GLOP.4

Sequential Model Based Optimization for a pump operation problem

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Abstract. Optimization of operations in Water Distribution Networks (WDN) is a significant research field since many years, characterized by to two areas: water quality and pump operations ([1]). This study proposes a Sequential Model Based Optimization (SMBO) approach to find the optimal pumps operation on a 24 hours horizon. As in other studies, the problem is formulated as a cost optimization problem, where costs are given by the energy needed to supply water multiplied by the associated hourly tariff. Pump operation optimization has been widely studied and many methods, such as dynamic, linear, nonlinear and integer programming have been proposed. Also metaheuristics, such as genetic algorithms and simulated annealing, have been considered, even if they offer a very slow convergence. Pump operation can be defined explicitly by times when pumps operate (i.e. pump scheduling) as well as implicitly by other controls, such as pump flows or pump speeds for variable speed pumps (VSP). These controls are the decision variables of the optimization problem. The evaluation of objective function and the constraints requires the hydraulic simulation of the WDN model: this leads to a "black-box" setting, where every evaluation could be computationally expensive, in particular for large WDNs. SMBO, in this paper combined with EPANET, is based on a metamodel of the objective function: in this case two such models are compared in terms of accuracy and computational time: a Gaussian Process (GP) and a Random Forest (RF). particularly useful to solve expensive black-box optimization. Two rules for the choice of the next point have also been considered: Expected Improvement (EI) and Lower Confidence Bound (LCB). The solution has been validated on a benchmark WDN, comparing results with related recent papers (e.g., [2]). Both explicit (pump scheduling) and implicit (VSP) controls have been considered, by using binary and continuous decision variables, respectively. The toolbox mlrMBO ([3]) has been used to implement the SMBO strategy.

Keywords: sequential model based optimization, pump scheduling, black-box

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Health Care and Optimization 1
Invited Session

Chairman: R. Aringhieri

HEAC1.1 *Offline patient admission scheduling problems*
R. Guido, V. Solina, D.Conforti

HEAC1.2 *Stochastic dynamic programming in hospital resource optimization*
M. Papi, L. Pontecorvi, R. Setola, F. Clemente

HEAC1.3 *Patient–centred objectives as an alternative to maximum utilisation: comparing surgical case solutions*
D. Duma , R. Aringhieri

HEAC1.4 *A hierarchical multi-objective optimisation model for bed levelling and patient priority maximization*
R. Aringhieri, P. Landa, S. Mancini

HEAC1.1

Offline patient admission scheduling problems

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Abstract. Patient admission scheduling problems consist in deciding which patient to admit and at what time. More complex problems address also bed assignment problems at the same time. The complexity of the problem motivates researchers to design suitable approaches to support bed managers in making decisions. The aim of this paper is to define an efficient model formulation for the offline elective patient admission scheduling problem, which defines admission dates and assigns patients to rooms. Due to the multiobjective nature of the problem, we suggest how to set weight values, used to penalise constraint violations. These values are tested on a set of benchmark instances. Improvements in schedule quality are presented.

Keywords: Patient Admission, Scheduling, Combinatorial Optimization

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEAC1.2

Stochastic dynamic programming in hospital resource optimization

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Abstract. The costs associated with the healthcare system have risen dramatically in recent years. Healthcare decision-makers, especially in areas of hospital management, are rarely fortunate enough to have all necessary information made available to them at once. In this work we propose a stochastic model for the dynamics of the number of patients in a hospital department with the objective to improve the allocation of resources. The solution is based on a stochastic dynamic programming approach where the control variable is the number of admissions in the department. We use the dataset provided by one of the biggest Italian Intensive Care Units to test the application of our model. We propose also a comparison between the optimal policy of admissions and an empirical policy which describes the effective medical practice in the department. The method allows also to reduce the variability of the length of stay.

Keywords: stochastic dynamic programming, healthcare resource optimization, hospital management

Acknowledgements. This research is supported in part by San Camillo-Forlanini Hospital in Rome.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEAC1.3

Patient–centred objectives as an alternative to maximum utilisation: comparing surgical case solutions

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Abstract. Operating Room (OR) planning and scheduling is a research topic widely discussed in the literature, in which several performance criteria have been proposed to evaluate the OR planning decisions. Although the OR utilisation is the leading objective, from research experiences, long waiting lists lead to a satisfactory filling of ORs even fixing other objectives. In this paper we analyse the impact on OR utilisation of two patient–centred objectives: the waiting time minimisation and the workload balance. In the former the most commonly used patient–centred criterion is taken into account, while the latter leads to a smooth stay bed occupancies determining a smooth workload in the ward and, by consequence, an improved quality of care provided to patients. To the best of our knowledge, a comparison of the planning determined by these criteria is not yet available in literature.

Keywords: surgery process scheduling, patient–centred, objective functions, comparison

Acknowledgements. The authors would thank the student Rita Iacono for running part of the computational tests. The authors would also thank Greanne Leeftink and Erwin W. Hans for providing the instance generators and the manuscript of their submitted paper [1].

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The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEAC1.4

A hierarchical multi-objective optimisation model for bed levelling and patient priority maximization

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Abstract. Operating Rooms (ORs) are one of the higher cost drivers of hospital budget and one of the highest source of income. Several performance criteria have been reported to lead and to evaluate the OR planning decisions. Usually, patient priority maximisation and OR utilisation maximisation are the most used objectives in literature. On the contrary, the workload balance criteria, which leads to a smooth stay bed occupancies, seems less used in literature. In this paper we propose a hierarchical multi-objective optimisation model for bed levelling and patient priority maximisation for the combined Master Surgical Scheduling and Surgical Cases Assignment problems. The aim of this work is to develop a methodology for OR planning and scheduling capable to take into account such different performance criteria.

Keywords: operating room planning, elective surgery, multi-objective optimization

Acknowledgements. The authors would thank Greanne Leeftink and ErwinW. Hans for providing the instance generators and the manuscript of their submitted paper [1].

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Health Care and Optimization 2
Invited Session

Chairman: P. Cappanera

HEAC2.1 *Empirical data driven intensive care unit drugs inventory policies*
R. Rossi, P. Cappanera, M. Nonato

HEAC2.2 *Multi Classifier approaches for supporting Clinical Diagnosis*
M. C. Groccia, R. Guido, D. Conforti

HEAC2.3 *Pattern generation policies to cope with robustness in Home Care*
M.G. Scutellà, P. Cappanera

HEAC2.4 *Scheduling team meetings in a rehabilitation center*
F. Rinaldi

HEAC2.1

Empirical Data Driven Intensive Care Unit Drugs Inventory Policies

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Abstract. This work proposes a drugs inventory policy at point-of-use level, tailored for the Intensive Care Unit (ICU) case study and aimed at relieving nurses of the time-wasting task of drugs ordering and refilling. The policy aims at jointly reducing order occurrences and imposing service regularity, while keeping stock value as low as possible. Drugs logistics optimization is crucial in containing steadily increasing health care costs occurring in industrialized countries. Indeed, recent attempts have been made to customize classical inventory policies to account for health care settings. In this study an Integer Linear Programming (ILP) optimization model is proposed and solved on a one-month period real instance and on a set of realistic ones derived from drugs consumption data collection at the ward. It reduces order occurrences, imposes orders regularity, guarantees demand satisfaction and incorporates capacity constraints. In addition, the potentially conflicting priorities of three stakeholders (nurses, administration and clinicians) have been successfully incorporated and their impact on order occurrences and stock value has been analyzed. Computational results suggest that it is possible to optimize the time-consuming order process currently adopted at the ICU case study. This study is part of a more comprehensive project in which the optimization block will be integrated with a demand forecasting tool and deployed in a rolling-horizon framework. Further research also concerns: including urgent orders into the inventory policies, tightening the ILP model formulation, and investigating the mutual relations between stakeholders' perspectives.

Keywords: Supply Chain Management, Replenishment, ICU

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HEAC2.2

Multi Classifier approaches for supporting Clinical Diagnosis

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Abstract. Clinical diagnosis processes can result in many cases very complicated. A misdiagnosis is expensive and potentially life-threatening for patients. Diagnosis problems are mainly in the scope of the classification problems. Multi Classifier approaches can improve accuracy in classification task. In this work, we propose Multi Classifier approaches based on dynamic classifier selection techniques. These approaches have been tested on datasets known in the literature and representative of important diagnostic problems. Experimental results show that a suitable pool of different classifiers increases accuracy in classification task. This suggests that the proposed approaches can improve performance of diagnostic decision support systems.

Keywords: Multi Classifier Systems, Diagnostic Decision Support Systems, Machine Learning

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEAC2.3

Pattern generation policies to cope with robustness in Home Care

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Abstract. We consider the Robust Home Care problem, where caregiver-to-patient assignment, scheduling of patient requests, and caregiver routing, must be taken jointly in a given planning horizon, and patient demand is subject to uncertainty. We propose four alternative policies to fix scheduling decisions and experiment their impact when used as a building block of a decomposition approach. Preliminary experiments on large size instances show that such policies allow to efficiently compute robust solutions of good quality in terms of balancing caregivers' workload and in terms of number of satisfied uncertain requests. Specifically, in this talk we present an extension of the computational tests already presented in a previous work by the same authors.

Keywords: home health care, demand uncertainty, pattern generation

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HEAC2.4

Scheduling team meetings in a rehabilitation center

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Abstract. In recent years, multidisciplinary teams and their meetings occupy a relevant role in health systems management. Here we present a case study regarding the scheduling problem of the team meetings in a center for rehabilitation in developing age. Each patient, in his/her course of treatment, is taken in charge by a team of operators generally composed by a doctor, a psychologist and one or more therapists. At the moment of the diagnosis and during the development of the rehabilitation, the operators of the team need to meet in order to discuss and monitor the progress of the therapies. These meetings take place in particular time slots, three for each day, called synthesis slots. In the weekly schedule of each operator, few of these slots are marked as synthesis slots for the operator and correspond to slots in which the operator does not carry out visits or therapy sessions. When a doctor requires a meeting for a patient, he/she also indicates a date when it would be preferable to schedule it. The high number of meetings and several additional operational constraints not always allow for a complete schedule of the meetings required for a given period. Moreover, several meetings have to be assigned to slots that are not synthesis slots for all the participants. This causes both a loss of service due to the cancellation of some therapy sessions and economic costs for overtime duties. As a consequence, the center has to face with the multi-objective problem to schedule as much as team meetings as possible by maintaining the costs and the quality of the service at a desired level. We designed a procedure for this problem based on an integer linear programming model and applied it in the last year to schedule the team meetings on a monthly basis. The results were quite satisfactory: the method allowed to both strongly reduce the queue of meetings waiting for being planned and decrease the costs of the schedules with respect to the past.

Keywords: Scheduling, Integer Linear Programming, Health care.

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Health Care and Optimization 3

Chairman: M. Gentili

HEAC3.1 *A stepping horizon view on scheduling of working hours of nurses in hospital: The case of the University Hospital in Cagliari*
S. Zanda, C. Seatzu, P. Zuddas

HEAC3.2 *Advances in optimized operating theaterscheduling in Emilia-Romagna, Italy*
P. Tubertini, V. Cacchiani

HEAC3.3 *Rare diseases network: management simulation by a highly parametric model*
G. Romanin-Jacur, A. Liguori

HEAC3.4 *Evaluating the effects of the implementation of variances to the current allocation system on the state of Georgia*
M. Gentili, S. Muthuswamy

HEAC3.1

A stepping horizon view on scheduling of working hours of nurses in hospital: The case of the University Hospital in Cagliari

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Abstract. In this talk we focus on the problem of scheduling working hours of nurses and medical social workers in hospital over a scheduling period, while subject to organizational, legislative and personal constrains. The focus of academic studies on automated personnel rostering is often associated with solving problems containing a single, isolated scheduling horizon rather than on improving the quality of rosters over a long period. This work used the concepts of local and global consistency in constraint evaluation processes and proposes a general methodology to address these challenges in integer programming approaches. The objective is to minimize surplus and shortage of monthly hours for each nurse. The obtained scheduling are compared with those computed by the hospital planner who currently computes them manually. It can be shown that the degrees of freedom are so few that in never cases the resulting scheduling coincides as it often happens in other real world applications. The results demonstrate that the proposed methodology approximates the optimal solution

Keywords: Rostering nurse, Optimisation, Healthcare

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HEAC3.2

Advances in optimized Operating Theater Scheduling in Emilia-Romagna, Italy

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Abstract. In recent years the management of surgical activities has been moving towards resources integration, emphasizing the need of decision support systems for optimizing the utilization of Operating Theaters shared resources such as induction and recovery rooms. Waiting list reduction for elective surgery is a strategic goal for Emilia-Romagna Regional (ERR) administration. On March 2017 the Regional Committee approved a Resolution that defines a roadmap, for each Local Health Authority (AUSL or AOSPU), towards the implementation of Decision Support Systems for Operating Room Planning. In accordance with ERR health organizations we are testing how and to which extent a Perioperative Decision Support System based on quantitative-based methodologies can improve perioperative process performances. The general goal of the project is to design models and algorithms to support the strategic and operational management of pre-operative, intra-operative and post-operative activities at a Regional level, so as to define a common framework that can be easily applied to each regional hospital. We developed a Mixed Integer Programming model and a heuristic algorithm for the weekly scheduling of elective activities and compared the performances of the two approaches on real world instances.

Keywords: Operating Theater, Heuristics, Mixed Integer Programming

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HEAC3.3

Rare diseases network: management simulation by a highly parametric model

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Abstract. Italian ministerial decree 279 of May 2001 provides the establishment of a national network devoted to rare diseases, by means of which preventing action is to be developed, care is to be activated, interventions directed to diagnosis and therapy are to be improved, information and education are to be promoted. Rare Disease Network is made up of all structures and regional system services which contribute, in an integrated way and each one related to its specific competences and functions, to develop and implement all actions provided by the decree. Main nodes of Rare Diseases Network are accredited providers, preferably hospital ones, suitably identified by Regions among those which possess documented experience in diagnosis and care of specific Rare Diseases or Rare Diseases groups, and are equipped with apt support structures and complementary services. Connections between providers, chosen to minimize medium distance to sick people residence places, currently suffer from a fulfilment diversity and still result lacking in many territorial areas. The paper has the objective of carrying out a simulation model, written in language Rockwell Arena, which permits to reproduce the Rare Diseases network actual system and to dynamically analyse its behaviour, to test management criteria, to evaluate critical situations in running queues and in efforts to which each node is called, to suggest and validate planning choices, to compare alternative solutions in short times and with very small expense. Moreover, data processing supplies a database which records all paths covered by every patient among centres both from a medical and from a geographical point of view; such paths may be influenced both by external parameters (managed as system variables) like for instance the appeal of a professional operating in a centre, or by inner parameters like the specific planning which assigns the basin to a node. Such a way we can observe both how patients' population is distributed on the basis of statistical laws, and how patients' population behaves on the basis of strategic decisions. In the model, every newborn,is inserted according to a fixed distribuition. If marked as sick, then all necessary treatments are listed with resources, duration, beginning, etc. All treatments are put in a queue until they are effected: queues are evidenced related to every centre resources and choice policy. All parameters regarding each treatment are stored in a database and can be handled without accessing Arena, thus giving to the model a great flexibility.

Keywords: Rare disease, Assistance network, Simulation

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HEAC3.4

Evaluating the effects of the implementation of variances to the current allocation system on the state of Georgia

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Abstract. The U.S. transplant community has long been concerned about disparities in access to and outcomes of transplantation [1]. While several policies have been introduced to address the discrepancies, transplant researchers still report that a number of key elements that determine equity in transplantation vary significantly depending on the location of a patient. One of the alleged causes of disparity is administratively determined organ allocation boundaries that limit organ sharing across regions. To overcome these issues members of the Organ Procurement Transplant Network (including, transplant hospital, Organ Procurement Organizations, medical/scientific members among others) can propose a modification (i.e., a variance) to the current allocation system to allocate organs differently than the OPTN Policies. Several variances have been proposed and implemented during the years by different members and for different organs. For example, Tennessee and Florida implemented the Statewide Sharing variance to offer kidneys to other donor service areas within the state before releasing them to regional or national allocation. This resulted in a benefit of an average of 7.5 and 5 fewer hours of cold ischemic time, respectively, in the two states while removing in-state geographic disparities [2]. In this study, using optimization and simulation, we investigate how the implementation of a similar variance would affect access to and outcomes of transplantation for the state of Georgia over time.

Keywords: Organ Transplantation, Healthcare, Optimization

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Heuristic and Metaheuristic 1

Chairman: F. Carrabs

HEUR1.1 *A Matheuristic approach for the quickest multicommodity k-splittable flow problem*
A. Melchiori, A., Sgalambro

HEUR1.2 *A heuristic for the integrated storage assignment, order batching and picker routing problem*
D. Cattaruzza, M. Ogier, F. Semet, M. Bué

HEUR1.3 *A heuristic method to solve the challenging sales based integer program for network airlines revenue management*
G. Grani, L. Palagi, G. Leo, M. Piacentini, H. Toyoglu

HEUR1.4 *A tabu search algorithm for the Set Orienteering Problem*
F. Carrabs, R. Cerulli, C. Archetti

HEUR1.1

A Matheuristic approach for the Quickest Multicommodity *k*-splittable Flow Problem

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Abstract. The literature on *k*-splittable flows [1] provides evidence on how controlling the number of used paths enables practical applications of flows optimization in many real-world contexts. Such a modeling feature has never been integrated so far in Quickest Flows, a class of optimization problems suitable to cope with situations such as emergency evacuations, transportation planning and telecommunication systems, where one aims to minimize the makespan, i.e. the overall time needed to complete all the operations [2]. In this talk, in order to bridge this gap, we introduce a novel optimization problem, the Quickest Multicommodity *k*-splittable Flow Problem (QMC*k*SFP). The problem seeks to minimize the makespan of transshipment operations for given demands of multiple commodities, while imposing restrictions on the maximum number of paths for each single commodity. The computational complexity of this problem is analyzed, showing its NP-hardness in the strong sense, and an original mixed-integer programming formulation is detailed. We propose a matheuristic algorithm based on a hybridized Very Large-Scale Neighborhood Search [3] that, utilizing the presented mathematical formulation, explores multiple search spaces to solve efficiently large instances of the QMC*k*SFP. High quality computational results obtained on a set of benchmark instances are presented and discussed, showing how the proposed matheuristic largely outperforms a state-of-the-art heuristic scheme frequently adopted in path-restricted flow problems.

Keywords: Quickest flow, k-splittable flow, Matheuristics

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HEUR1.2

A heuristic for the integrated storage assignment, order batching and picker routing problem

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Abstract. In this abstract we address an integrated warehouse order picking problem. The warehouse is divided in the picking and the storage areas. We focus on the picking area. It contains a set of aisles, each composed by a set of storage positions. For each period of the working day each position contains several pieces of a unique product, defined by its reference. The warehouse is not automated, and the order pickers can prepare up to K parcels in a given picking route. For each period of the working day a set of customer orders has to be prepared. An order is a set of product references, each associated with a quantity, i.e. the number of pieces required. The problem consists in jointly deciding:
(1) the assignment of references to storage positions in the aisles which need to be filled up;
(2) the division of orders into several parcels, respecting weight and size constraints;
(3) the batching of parcels into groups of size K, that implicitly define the routing into the picking area.
The routing is assumed to follow a return policy, i.e. an order picker enters and leaves each aisle from the same end. The objective function is to minimize the total routing cost. In order to deal with industrial instances of large size (considering hundreds of clients, thousands of positions and product references) in a short computation time, a heuristic method based on the split and dynamic programming paradigms is proposed. Experimental results will be presented.

Keywords: Warehouse planning, Logistics, Routing

HEUR1.3

A heuristic method to solve the challenging Sales Based Integer Program for Network Airlines Revenue Management

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Abstract. Revenue Management (RM) has been playing over recent years an increasingly crucial role in both strategic and tactical decisions of Airlines business. Successful RM processes aim to achieve the maximization of revenue by leveraging huge amount of data, upcoming technologies and more sophisticated approaches to measure the RM performances. Multiple phases of RM processes, as well as different components of RM systems, are based on the solution of large integer programming models, like the well-known Sales Based Integer Program (SBIP), whose instances turn out to be challenging, or even not solvable in practice by the state-of-art MIP solvers. SBIP is the discrete version of the Sales Based Linear Program (SBLP) presented in [1]. Our work aims to investigate useful polyhedral properties and introduce a practical heuristic method to find a good solution of hard instances of SBIP. We use a LP-based branch-and-bound paradigm. Firstly, we strengthen the linear relaxations of subproblems by introducing effective Chvátal-Gomory cuts, exploiting the structure of the polytope. Our main contribution consists in the decomposition of the SBIP into two stage MINLP smaller problems. The basic idea is to separate the optimal allocation of the capacity to the markets and then to split it among the different travel options on each market, differently from the traditional leg-based decomposition (see [2]). This leads to the formulation of the market subproblems as piecewise linear problem. We define a concave approximation of the piecewise linear objective function in order to reach a good solution in reasonable time. Decomposition ensures a radical reduction of the dimension of the problem instances, both the number of variables and of constraints, while the concave approximation reduces computational times for the solution of each subproblems. Computational results are reported.

Keywords: Revenue Management, decomposition, mixed-integer programming

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HEUR1.4

A tabu search algorithm for the Set Orienteering Problem

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Abstract. The Set Orienteering Problem (SOP) is a single vehicle routing problem where the customers are grouped in clusters and a profit is associated with each cluster. The profit of a cluster is collected if and only if at least one of its customers is visited in the tour. The profit of each cluster can be collected at most once. The SOP is defined on a complete directed graph in which a cost is associated with each edge. We assume that the costs satisfy the triangle inequality. The cost of a tour is given by the sum of the cost of the edges it traverses. The SOP consists in finding the tour that maximizes the collected profit and such that the associated cost does not exceed a fixed threshold. In this work we propose a tabu search metaheuristic based on two types of neighborhoods and an improvement procedure, based on the Lin-Kernighan traveling salesman heuristic, developed to reduce the solutions costs. The diversification phase is carried out through a MIP model and a classical shake operator. The preliminary results show that the tabu search quickly finds high quality solutions on small instances, where an optimal solution is known.

Keywords: Set Orienteering Problem, Tabu Search

Heuristic and Metaheuristic 2

Chairman: R. Cerulli

HEUR2.1 *Ant colony optimization algorithm for pickup and delivery problem with time windows*
M. NoumbissiTchoupo, A. Yalaoui, L. Amodeo, F. Yalaoui, F. Lutz

HEUR2.2 *A component-based analysis of simulated annealing*
A. Franzin, T. Stützle

HEUR2.3 *An adaptive large neighborhoodsearch approach for the physician scheduling problem*
R. Zanotti, R. Mansini

HEUR2.4 *Automatic design of Hybrid Stochastic Local search algorithms*
F. Pagnozzi, T. Stützle

HEUR2.1

Ant colony optimization algorithm for pickup and delivery problem with time windows

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Abstract. This paper presents an efficient meta-heuristic for the Pickup and Delivery Problem with Time Windows (PDPTW) based on Ant Colony Optimization coupled to dedicated local search algorithms. The objective function is the minimization of the number of vehicles and the minimization of the total distance travelled. In PDPTW, the demands are coupled and every couple is a request which must be satisfy in the same route. Thus, the feasible solution space is tightly constraint and then makes the design of effective heuristics more difficult. Experimental results on 56 instances of 100 customers of Li and Lim's benchmark show that the ACO coupled with PDPTW dedicated local search algorithms outperform existing algorithms. It returns in 98.2% (55/56) of cases a solution better or equal to the best known solution, and find a better solution than the best know in 44.6% (25/56).

Keywords: pickup and delivery problem with time windows, ant colony optimization

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEUR2.2

A Component-Based Analysis of Simulated Annealing

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Abstract. Simulated Annealing (SA) is one of the oldest metaheuristics and it has been successfully applied to many combinatorial optimization problems. Over the years, many authors have proposed both general and problem-specific improvements and variants of SA. In this work, we show how these variants available in the literature can be classified according to their purpose and collected into frameworks as basic algorithmic components. The set of possible, valid combinations of components defines an algorithmic space, that can be used not only to reproduce algorithms already existing in the literature, but also to instantiate new algorithms. In this work, we focus on top-down algorithm instantiation, that is, we aim to choose the best components that fit in the SA structure. In particular, we consider SA as an ensemble of nine components, seven algorithmic-specific ones (that define the behaviour of SA as a metaheuristic), and two problem-specific ones (that vary according to the specific problem to be solved). By combining the use of these frameworks with Automatic Algorithm Configuration techniques, the problem of choosing the best components that build an SA for a given problem becomes an Automatic Algorithm Design problem. We show how to to (i) collect the existing ideas and variants of SA proposed in the literature over the years, (ii) reproduce, study and improve the existing SA implementations, and (iii) exploit the body of knowledge to automatically design better performing SA algorithms. We experimentally demonstrate the potential of this approach.

Keywords: Simulated Annealing, Automatic Algorithm Configuration, Automatic Algorithm Design

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HEUR2.3

An Adaptive Large Neighborhood Search Approach for the Physician Scheduling Problem

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Abstract. The organization of the activities of a large hospital ward is a complex problem that requires taking into account several rules and restrictions, especially when it comes to the physicians and the tasks they are allowed to perform. Over the years, the amount of resources available for the hospitals has significantly decreased, while the number of patients requiring health care services has reached new heights. The lack of resources has highlighted the need for good quality solutions for the scheduling of the physicians' activities within the hospital. In our work, we study this problem, known in the literature as the Physician Scheduling Problem ([2]), where we consider all the possible activities (e.g. surgeries, ambulatories, guards, administrative duties) that have to be carried out each day in a hospital ward. The objective is to assign each task that has to be performed to one or more physicians and to a time slot, while minimizing the number of physicians' working hours required. The study of this problem is further motivated by the real case of a local hospital that is dealing with new regulations recently introduced by the Italian government. We propose two Mixed-Integer Linear Programming formulations for the PSP. Then, we present an Adaptive Large Neighborhood Search (originally introduced in ([1])) solution approach for the problem. Our ALNS approach considers several constructive and destructive heuristics to efficiently explore the feasible region and to avoid getting stuck into local minima. We introduce several parameters that are used to fine tune the behavior of the algorithm. Since the proposed ALNS needs a starting solution, we also present a heuristic procedure that is able to identify a feasible solution within a reasonable amount of time. To test our approach, we generated several classes of instances, some of which are extremely challenging. We first test, using Gurobi 6.5.1, the two proposed formulations on these instances to determine which one to use in our ALNS. Then, we verify the performance of our initial solution heuristic and finally proceed to compare our ALNS approach (with a 20 minutes time limit) to the results obtained by the MILP solver (with a 60 minutes time limit). We show that our approach is able to obtain better solutions than Gurobi in most cases, despite the shorter time limit.

Keywords: Scheduling, Physicians, Task assignment

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HEUR2.4

Automatic design of Hybrid Stochastic Local search algorithms

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Abstract. Stochastic local search methods such as Iterated Local Search, Iterated Greedy, Tabu Search, GRASP or Simulated Annealing have reached high performance for many NP-hard optimization problems and, in particular, they are among the best methods for tackling permutation flowshop (PFSP) problems. As recently shown, using automated algorithm design techniques and flexible templates for developing hybrid stochastic local search methods can produce automatically new high-performance heuristics and even new state-of-the-art algorithms. In this paper, we present an improved system for the automatic design of hybrid stochastic local search algorithms by combining different algorithm components following a specific set of rules for combining them. The system uses (i) a new framework, EMILI, that we developed to implement the algorithm-specific and problem-specific building blocks; (ii) a grammar to define the rules for composing algorithms and (iii) an automatic configuration tool, irace, to combine building blocks according to the given rules. We used this system to design new hybrid stochastic local search algorithms for permutation flowshop problems under the three most studied objectives: Makespan, total completion time or flowtime and total tardiness. Our experimental results show that the algorithms generated by this system are the new state of the art for these three objectives, in part by a substantial margin considering the large research effort these problems have received.

Keywords: Automatic Algorithm Configuration, Metaheuristics, Combinatorial Optimization

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Heuristic and Metaheuristic 3

Chairman: I. Vasyliev

HEUR3.1 *Efficient solutions for the Max Cut-Clique Problem*
T. Pastore, D. Ferone, P. Festa, A. Napoletano, D. Marino

HEUR3.2 *Column generation embedding Carousel Greedy for the maximum network lifetime problem with interference constraints*
F. Carrabs, C. D'Ambrosio, A. Raiconi, C. Cerrone

HEUR3.3 *A heuristic for multi-attribute vehicle routing problems in express freight transportation*
L. De Giovanni, N. Gastaldon, I. Lauriola, F. Sottovia

HEUR3.4 *A shared memory parallel heuristic algorithm for the large-scale p-median problem*
I. Vasilyev, A. Ushakov

HEUR3.1

Efficient solutions for the Max Cut-Clique Problem

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Abstract. The Max Clique Problem (MCP) is one of the most renowned problems in combinatorial optimization literature. This problem belongs to Karp's 21 NP-complete problems and finds a wide variety of applications in a very heterogeneous set of contexts, ranging from pattern recognition in communication networks to computational biology. In this presentation, we will focus on a more recent, strictly related problem: the Max Cut-Clique Problem. Given an undirected graph G = (V, E) and a clique C of G, the cut-clique is the set of arcs [i, j] of E with i in C and j in V\C. The aim of the Max Cut-Clique Problem (MCCP) is to find a clique C* of G whose cut-clique has maximum cardinality. MCCP was proposed in [Martins 2012, Martins et al. 2015] and given its recent definition, the problem is yet to be exhaustively explored. In our work, a new hybrid meta-heuristic based on the integration of GRASP and a Phased Local Search was devised to tackle the problem. Our proposal positively compares with the current state-of-the-art.

Keywords: Hybrid Meta-heuristic, Max Cut-Clique, Combinatorial Optimization.

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HEUR3.2

Column Generation embedding Carousel Greedy for the Maximum Network Lifetime Problem with Interference Constraints

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Abstract. We aim to maximize the operational time of a network of sensors, which are used to monitor a predefined set of target locations. The classical approach proposed in the literature consists in individuating subsets of sensors (covers) that can individually monitor the targets, and in assigning appropriate activation times to each cover. Indeed, since sensors may belong to multiple covers, it is important to make sure that their overall battery capacities are not violated. We consider additional constraints that prohibit certain sensors to appear in the same cover, since they would interfere with each other. We propose a Column Generation approach, in which the pricing subproblem is solved either exactly or heuristically by means of a recently introduced technique to enhance basic greedy algorithms, known as Carousel Greedy. Our experiments show the effectiveness of this approach.

Keywords: Column Generation, Carousel Greedy, Maximum Lifetime Problem

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEUR3.3

A heuristic for multi-attribute vehicle routing problems in express freight transportation

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Abstract. We consider a multi-attribute vehicle routing problem arising in a freight transportation company owning a fleet of heterogeneous trucks with different capacities, loading facilities and operational costs. The company receives short- and medium-haul transportation orders consisting of pick-up and delivery with soft or hard time windows falling in the same day or in two consecutive days. Vehicle routes are planned on a daily basis taking into account constraints and preferences on capacities, maximum duration, number of consecutive driving hours and compulsory drivers rest periods, route termination points, order aggregation. The objective is to maximize the difference between the revenue from satisfied orders and the operational costs. We propose a two-levels local search heuristic: at the first level, a variable neighborhood stochastic tabu search determines the order-to-vehicle assignment, the second level deals with intra-route optimization. The algorithm provides the core of a decision support tool used at the planning and operational stages, and computational results validated on the field attest for an estimated 9% profit improvement with respect to the current policy based on human expertise.

Keywords: Multi-attribute VRP, Tabu Search, Express Freight Transportation

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

HEUR3.4

A shared memory parallel heuristic algorithm for the large-scale p-median problem

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Abstract. We develop a modified hybrid sequential Lagrangean heuristic for the p-median problem and its shared memory parallel implementation using the OpenMP interface. The algorithm is based on finding the sequences of lower and upper bounds for the optimal value by use of a Lagrangean relaxation method with a subgradient column generation and a core selection approach in combination with a simulated annealing. The parallel algorithm is implemented using the shared memory (OpenMP) technology. The algorithm is then tested and compared with the most effective modern methods on a set of test instances taken from the literature.

Keywords: p-median problem, parallel computing, OpenMP

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Inventory Routing
Invited Session

Chairman: D. Laganà

IROUT.1 *A combination of Monte-Carlo simulation and a VNS meta-heuristic algorithm for solving the stochastic inventory routing problem with time windows*
P. Lappas, M. Kritikos, G. Ioannou, A. Bournetas

IROUT.2 *Inventory routing with pickups and deliveries*
C. Archetti, M. G. Speranza, M. Christiansen

IROUT.3 *Efficient routes in a periodic inventory routing problem*
R.Paradiso, D. Laganà, L. Bertazzi, G. Chua

IROUT.4 *The impact of a clustering approach on solving the multi-depot IRP*
A. De Maio, L. Bertazzi, D. Laganà

IROUT.1

A combination of Monte-Carlo simulation and a VNS meta-heuristic algorithm for solving the Stochastic Inventory Routing Problem with Time Windows

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Abstract. The main objective of this work is to propose a hybrid algorithm for solving the Stochastic Inventory Routing Problem with Time Windows (SIRPTW), which has not been excessively researched in the literature. The SIRPTW arises from the application of the Vendor Managed Inventory (VMI) concept, where the supplier has to make inventory and routing decisions simultaneously for a given planning horizon. The SIRPTW is a generalization of the standard Inventory Routing Problem (IRP) involving the added complexity that every customer should be served within a given time window, while the supplier knows customer demand only in a probabilistic sense. Due to the NP-hard nature of the SIRPTW, it is very difficult to develop an exact algorithm that can solve large-scale problems within a reasonable computation time. As an alternative, a hybrid algorithm combining the Monte Carlo Simulation and the Variable Neighborhood Search (VNS) meta-heuristic algorithm is presented to handle the SIRPTW. Namely, the Monte Carlo Simulation is related to the planning phase, while the VNS algorithm is associated with the routing phase. Both solution approaches are dealt with in an iterative way to define a re-optimization phase. Testing instances with different properties are established to investigate algorithmic performance, and the computational results are then reported. The computational study underscores the importance of integrating the inventory and vehicle routing decisions. Graphical presentation formats are provided to convey meaningful insights into the problem.

Keywords: Stochastic Inventory Routing Problem with Time Windows, Monte Carlo Simulation, Variable Neighborhood Search Algorithm

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IROUT.2

Inventory routing with pickups and deliveries

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Abstract. This paper introduces a class of problems which integrate pickup and delivery vehicle routing problems (PDPs) and inventory management, and we call them inventory routing problems with pickups and deliveries (IRP-PD). We consider a specific problem of this class, where a commodity is made available at several origins and demanded by several destinations. Time is discretized and transportation is performed by a single vehicle. A mathematical programming model is proposed together with several classes of valid inequalities. The model is solved through a branch-and-cut method. Computational tests are performed to show the effectiveness of the valid inequalities on instances generated from benchmark instances for the inventory routing problem. Results show that the branch-and-cut algorithm is able to solve to optimality 345 over 400 instances with up to 50 customers over 3 periods, and 142 over 240 instances with up to 30 customers and 6 periods. In addition, computational tests are made to test the effect of parameter values on the difficulty on solving the problem and on the solution value. Finally, we perform a computational study to compare the integrated policy related to the IRP-PD versus a decentralized policy where delivery customers decide the replenishment policy on their own. The study shows that the average cost of a non-integrated policy is more than 35% higher than the cost of an integrated policy.

Keywords: Inventory Routing, Pickup-and-Delivery, Branch-and-Cut.

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IROUT.3

Efficient routes in a Periodic Inventory Routing Problem

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Abstract. In this work, a mixed-integer linear programming formulation for a Periodic Inventory Routing Problem, based on routes variables, is presented. In particular, a product has to be shipped from a supplier to a set of customers over a finite time horizon. Given the plan periodicity, the problem is to determine a periodic shipping policy that minimizes the sum of transportation and inventory costs at the supplier and at the customers per time unit. Due to the difficulty to solve a formulation with all the possible feasible routes, the aim of this work is to find the minimal set of routes that allows to have the best possible worst-case performance ratio, allowing to solve the problem with a lower number of integer variables ensuring the quality of the solution over a threshold.

Keywords: Inventory Routing, Worst-case analysis, Periodic policy

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IROUT.4

The impact of a clustering approach on solving the Multi-Depot IRP

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Abstract. We study the Multi-Depot Inventory Routing Problem (MDIRP) with homogeneous vehicle fleet and deterministic demand. We implement a branch-and-cut algorithm for this problem. Then, we design a matheuristic in which we first optimally solve a modified version of the Capacitated Concentrator Location Problem (CCLP) to generate a cluster of customers for each depot and, then, we exactly solve the problem based on these clusters with a branch-and-cut algorithm. Computational results are presented to compare the performance of the matheuristic with respect to the branch-and-cut, in order to analyze the value of the clustering approach in solving this problem.

Keywords: Inventory routing, branch-and-cut, clustering

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Recent Advances on Knapsack Problem
Invited Session

Chairman: M. Monaci

KNAD.1 *An effective dynamic programming algorithm for the minimum-cost maximal knapsack packing problem*
F. Furini, I. Ljubic, M.Sinnl

KNAD.2 *Fractional Knapsack Problem with penalties: models and algorithms*
P. Paronuzzi, E. Malaguti, M. Monaci, U. Pferschy

KNAD.3 *Approximation results for the Incremental Knapsack Problem*
R. Scatamacchia, F. Della Croce, U. Pferschy

KNAD.4 *MILP formulations for the Multiple Knapsack Problem: a comparative study*
M. Delorme, S. Martello, M. Dell'Amico, M. Iori

KNAD.1

An effective dynamic programming algorithm for the minimum-cost maximal knapsack packing problem

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Abstract. Given a set of items with profits and weights and a knapsack capacity, we study the problem of finding a maximal knapsack packing that minimizes the profit of the selected items. We propose an effective dynamic programming (DP) algorithm which has a pseudo-polynomial time complexity. We demonstrate the equivalence between this problem and the problem of finding a minimal knapsack cover that maximizes the profit of the selected items. In an extensive computational study on a large and diverse set of benchmark instances, we demonstrate that the new DP algorithm outperforms a state-of-the-art commercial mixed-integer programming (MIP) solver applied to the two best performing MIP models from the literature.

Keywords: Maximal knapsack packing, Minimal knapsack cover, Dynamic programming

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KNAD.2

Fractional Knapsack Problem with Penalties: models and algorithms

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Abstract. Given a set of items, each one having positive profit and weight, and a knapsack of fixed capacity, the objective of the classical 01 Knapsack Problem is to select the subset of maximum profit that does not exceed the knapsack capacity. If items can be fractionated, the problem can be easily solved through the well-known algorithm of Dantzig. In this talk we consider the case in which items can be fractionated at cost of a penalty, so that a given fraction of an item brings a smaller fraction of profit. The problem is denoted as Fractional Knapsack Problem with Penalties (FKPP). We show that, when the penalty for fractionated items is described by a concave function, there exists an optimal solution for the FKPP that has at most one fractional item. We present alternative mathematical models for the problem and describe a solution algorithm based on Dynamic Programming for the case of concave penalty functions. All models and algorithms are compared through computational experiments on instances derived from the literature.

Keywords: Knapsack Problem, Penalties, Dynamic Programming.

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KNAD.3

Approximation results for the Incremental Knapsack Problem

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Abstract. We consider the 0-1 Incremental Knapsack Problem (IKP). In this generalization of the classical Knapsack Problem, the capacity grows over time periods and if an item is placed in the knapsack in a certain period, it cannot be removed afterwards. The problem calls for maximizing the sum of the profits over the whole time horizon. We provide approximation results for IKP and its restricted variants. Interestingly, in our contribution we also rely on Linear Programming to study the worst case performance of different algorithms for deriving approximation bounds. We first manage to prove the tightness of some approximation ratios of a general purpose algorithm currently available in the literature. We also devise a Polynomial Time Approximation Scheme (PTAS) when the input value associated with the periods is considered as a constant. Then, we give further insights into the problem under the mild assumption that each item can be packed in the first time period. For this reasonable variant, we study the performance of approximation algorithms suited for any number of time periods and provide algorithms with a constant approximation factor of 6/7 for the case with two periods and of 30/37 for the variant with three periods.

Keywords: Incremental Knapsack problem, Approximation schemes, Linear Programming

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KNAD.4

MILP formulations for the Multiple Knapsack Problem: a comparative study

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Abstract. Given a set of n items and a set of m knapsacks ($m \leq n$), with p_j = profit of item j, w_j = weight of item j, c_i = capacity of knapsack i, the *Multiple Knapsack Problem* (MKP), consists in selecting m disjoint subsets of items so that the total profit of the selected items is a maximum, and each subset can be assigned to a different knapsack whose capacity is no less than the total weight of items in the subset (see [1]). The problem has been extensively studied in the literature, and several exact approaches based on branch-and-bound and dynamic programming were proposed (see [2]). In this work, we are interested in the Mixed Integer Linear Programming (MILP) formulations for the MKP: the textbook formulation whose variables assign an item to a knapsack, and two alternative formulations that assign an item to a partial filling of a knapsack, as it was shown to be effective for the Bin Packing Problem (see [3]). After a detailed description of the three formulations, we compare their efficiency through extensive computational experiments and outline some specific cases in which a formulation is better than the others.

Keywords: Knapsack problem, MILP formulation, Computational experiments

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Delorme M., Iori M., Martello S.: Bin packing and cutting stock problems: mathematical models and exact algorithms, European Journal of Operational Research, 255, 1–20, (2016).

Location 1

Chairman: J.W. Owsiński

LOC1.1 *A districting model to support the redesign process of Italian Provinces*
G. Bruno, A. Diglio, A. Melisi, C. Piccolo

LOC1.2 *A model and an algorithm to construct Mexican district maps*
C. Peláez, D. Romero

LOC1.3 *Facility location with item storage and delivery*
S. Coniglio, J. Fliege, R. Walton

LOC1.4 *Optimal content distribution and multi-resource allocation in software defined virtual CDNs*
A. M. Tulino, J. Llorca, A. Sforza, C. Sterle

LOC1.5 *Selecting candidate Park-and-Ride nodes for a transport system of an agglomeration*
J. W. Owsiński, J. Stańczak, K. Sęp, A. Barski

LOC1.1

A districting model to support the redesign process of Italian Provinces

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Abstract. In the general context of welfare reforms in western economies, many actions concerning the rationalization of local administrative structures have been undertaken. In particular, in Italy, a recent debate has been addressed about the reduction of the overall number of provinces and the rearrangement of their borders. As provinces are responsible of providing some essential services to the population within their boundaries, any possible scenario should combine the need for more efficient territorial configurations with the safeguard of the services' accessibility. From a methodological point of view, such problem involves aspects from both facility location and districting problems. In this work, we formulate a mathematical model to support the decision making process and we compare scenarios provided on four benchmark problems, built on the real data associated to the most representative Italian regions.

Keywords: districting problems, facility-location models, territorial re-organization

Acknowledgements. This research was partially supported by the project "Promoting Sustainable Freight Transport in Urban Contexts: Policy and Decision-Making Approaches (ProSFeT)", funded by the H2020-MSCA-RISE-2016 programme (Grant Number: 734909).

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

LOC1.2

A model and an algorithm to construct Mexican district maps

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Abstract. The construction of political district maps is a highly complex task generally involving the participation of people coming from different backgrounds: Cartography, operations research, demography, political and computer science, ethnography, etc. Many mathematical models and algorithms have been studied to help along the districting process across the world, see references below. In this talk we focus on the Mexican case, pointing out its peculiarities, where the challenge of subjective considerations has been officially recognized, then agreeing to give as much emphasis as possible to the objectivity that mathematical approaches can provide. In this background we propose both a combinatorial optimization model and a heuristic procedure to purvey scientific support to political districting in Mexico. The objective function of our model incorporates desired properties for districts: population balance, compact form, and conformity to existing administrative boundaries. Our heuristic procedure consists of first strategically partitioning the territory, then applying in each part a local search procedure for the sole maximization of population balance and geometric compactness. The results yielded by a computer implementation of our approach are very satisfactory.

Keywords: Political districting, combinatorial optimization, local search procedure

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LOC1.3

Facility location with item storage and delivery

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Abstract. We discuss part of an ongoing research activity involving the University of Southampton and the Royal British National Lifeboat Institution (RNLI), aimed at improving the RNLI's warehousing and logistics operations. In particular, we consider a facility location problem to determine the optimal number and location of warehouses and which items are to be stored in each of them, minimising the costs of storage and transportation. We propose a mixed-integer non-linear programming formulation for the problem, which we then linearise in two different ways and solve to optimality with CPLEX. Computational results are reported and illustrated.

Keywords: Facility location, warehousing, mixed-integer linear programming

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

LOC1.4

Optimal Content Distribution and Multi-Resource Allocation in Software Defined Virtual CDNs

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Abstract. A software defined virtual content delivery network (SDvCDN) is a virtual cache network deployed fully in software over a programmable cloud network infrastructure that can be elastically consumed and optimized using global information about network conditions and service requirements. We formulate the joint content-resource allocation problem for the design of SDvCDNs, as a minimum cost mixed-cast flow problem with resource activation decisions. Our solution optimizes the placement and routing of content objects along with the allocation of the required virtual storage, compute, and transport resources, capturing activation and operational costs, content popularity, unicast and multicast delivery, as well as capacity and latency constraints. Numerical experiments confirm the benefit of elastically optimizing the SDvCDNs configuration, compared to the dedicated provisioning of traditional CDNs.

Keywords: softwared defined virtual CDN; flow-location-routing problem

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

LOC1.5

Selecting candidate Park-and-Ride nodes for a transport system of an agglomeration

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Abstract. A methodology is outlined, developed to rationalize transport graphs, applied to the case of the P+R system of an agglomeration, with presentation of examples of results. It is assumed that the original graph of connections (here: municipal public transport with stops and lines) is transformed into either the hub-and-spoke (see, e.g., O'Kelly, 1987) or the kernel-and-shell structure, corresponding to the functioning of the system with inclusion of the P+R facilities. The example pertains to Warsaw agglomeration, with altogether roughly 3 000 aggregate nodes and several hundred transport lines. The methodology employed is composed of two stages. In the first stage, a set of candidate nodes (hubs) is generated, while in the second one – the proper P+R locations are found with reference to the candidate nodes. In the first stage we employ, alternately, two approaches: the evolutionary algorithms (Stańczak, 2003; Potrzebowski, Stańczak and Sęp, 2005), and finding of the hypergraph transversal (see Berge, 1989, and, for the very first idea of such an approach: Johnson, 1974). In the second stage either exhaustive search is performed, or, for bigger problems, the evolutionary algorithm is applied again. The relation to the explicit – or, indeed, implicit – multiple criteria of choice (various kinds of costs to various parties, time consumed, environmental considerations,…) is addressed in the context of both stages of the procedure. We outline the technical side of both approaches used, the implications of their use, and the exemplary results. The possibility of performing a broader analysis, involving not just traffic-related objectives, is discussed.

Keywords: Park+Ride, hub-and-spoke, kernel-and-shell, hypergraphs, genetic algorithms.

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Location 2

Chairman: C. Sterle

LOC2.1 *A partitioning-based heuristic for large scale p-median problems*
A. Masone, A. Sforza, C. Sterle, I. Vasilyev

LOC2.2 *A model and algorithm for solving the landfill siting problem in large areas*
M. Gallo

LOC2.3 *A stochastic maximal covering formulation for a bike sharing system*
C. Ciancio, G. Ambrogio, D. Laganà

LOC2.4 *The hub location problem in the cold food chain*
G. Stecca, F. Condello

LOC2.1

A partitioning-based heuristic for large scale p-median problems

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Abstract. The p-median problem is one of the basic models in discrete location theory. In many interesting applications we have to solve very large scale p-median problems. For this kind of problems, we integrate the methods proposed by Avella et al. [2005] and Avella et al. [2012] developing a heuristic based on the decomposition of the problem into p-median subproblems that are solved independently. The decomposition is obtained partitioning the network into disconnected components through a clustering algorithm. In each component the p-median problem is solved for a suitable range of *p* [1]. by a Lagrangean based algorithm [2]. The solution of the whole problem is obtained combining all the p-median solutions through a knapsack-assignment model using a MILP solver. The heuristic is tested and compared with the most effective methods present in literature on a wide set of test bed instances.

Keywords: Large scale p-median, Graph Clustering

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LOC2.2

A model and algorithm for solving the landfill siting problem in large areas

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Abstract. In this paper we study the problem of siting landfills over large geographical areas. An optimisation problem is formulated and solved with a heuristic algorithm. The formulation of the problem explicitly considers economic compensation for the population of areas affected by the landfill. The approach is used to solve the problem in the real-scale case of the southern Italian region of Campania, with 551 possible sites. The proposed methodology is able to solve the problem with acceptable computing times.

Keywords: landfills, location problems, waste management

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

LOC2.3

A Stochastic Maximal Covering Formulation for a Bike Sharing System

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Abstract. This paper discusses a maximal covering approach for bike sharing systems under deterministic and stochastic demand. Bike sharing is constantly becoming a more popular and sustainable alternative transportation system. One of the most important elements for the design of a successful bike sharing system is given by the location of stations and bikes. The demands in each zone for each period is however uncertain and can only be estimated. Therefore, it is necessary to address this problem by taking into account the stochastic features of the problem. The proposed model determines the optimal location of bike stations, and the number of bikes located initially in each station, considering an initial investment lower than a given predetermined budget. The objective of the model is to maximize the percentage of covered demand. Moreover, during the time horizon, it is possible to relocate a certain amount of bikes in different stations with a cost proportional to the traveled distance. Both deterministic and stochastic models are formulated as mixed integer linear programs.

Keywords: Bike Sharing System; Stochastic Model

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

LOC2.4

The hub location problem in the cold food chain

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Abstract. The distribution of frozen goods require tight integration of production, stocking, and transportation in order specialized logistic operators can efficiently run distribution processes while maintaining high service levels and food quality (Hsiao et al., 2017). In this settings a key problem is the optimal location of distribution hubs which are equipped with refrigerated warehouses able to maintain food quality. Optimal location is effected by dynamism in frozen goods market which lead to a frequent relocation of hubs. In this work we present a real case of hub location problem for a logistic operator of the cold chain in Italy. Hub Location Problem (HLP) can be considered a variant of location problems (Mirchandani and Francis, 1990). In HLP, demands are defined on a digraph where nodes are decomposed on client C and hub H nodes respectively. Customer demands are identified as transfer orders (i,j) from origins i to destinations j. Arcs connecting hubs are in general associated with a discount and hub activation have a fixed cost. The HLP consider the minimization of the total traveling and fixed hub activation costs and can be solved with similar approaches developed in classical facility location problems (Ernst and Krishnamoorthy, 1999). In this work we present a variant of the HLP in which direct shipment and specific delivery constraints are considered as requirements of the industry of distribution of frozen food. The problem is formulated as a mixed integer linear programming model (MILP). Experimental studies on real case instances revealed complexities in the problem with medium size instances. Bounds are provided and management insights on test results shown potential benefits of the proposed optimization together with issues on cost parameter measurement.

Keywords: Hub Location Problem, Supply Chain Management, Frozen Food

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Maritime Optimization
PRIN SPORT Project Invited Session

Chairman: M. Di Francesco

MAROPT.1 *A truck-and-container routing problem with heterogeneous services*
F. Bomboi, M. Di Francesco, E. Gorgone, P. Zuddas

MAROPT.2 *A multi-period VRP set-covering formulation with heterogeneous trucks*
A. Ghezelsoflu, M. Di Francesco, P. Zuddas, A. Frangioni

MAROPT.3 *The role of inland ports within freight logistic networks. Impact of the externality costs on the modal split*
D. Ambrosino, A. Sciomachen

MAROPT.4 *City Logistics planning in a maritime urban area*
M. Di Francesco, E. Gorgone, P. Zuddas, T. G. Crainic

MAROPT.1

A truck-and-container routing problem with heterogeneous services

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Abstract. This study investigates a truck-and-container routing problem, motivated by drayage operations of large carriers in the hinterland of seaports. Customers demand pickup and delivery orders of 20 ft container loads with time windows restrictions. Some customers require "stay with" services, in which drivers must wait for containers during packing and unpacking operations. Other customers require "drop & pick" services, where drivers leave and pick up containers at customer locations. Trucks carry up to two 20 ft containers, but some customers need to ship or receive heavy container loads that must be served by vehicles carrying one container at a time. All feasible routes are enumerated and a Set Covering model is proposed. Possible solution methods will be discussed during the talk. Preliminary computational experiments will be presented.

Keywords: Vehicle Routing Problem, Set Covering.

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MAROPT.2

A multi-period VRP set-covering formulation with heterogeneous trucks

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Abstract. This work addresses a drayage problem, which is motivated by the case study of a real carrier. Its trucks carry one or two containers from a port to importers, from importers to exporters or the port, and from exporters to importers or the port. We propose a set covering formulation where all possible routes are enumerated in a single-day planning horizon. We show that realistic instances can be optimally solved by MIP solver. Next, we extend our problem setting to the case of a planning horizon of several days and assume that the demand of customers could be split among these days, depending on the flexibility of customers. We present a set covering-based formulation and we discuss possible decomposition methods. Preliminary computational experiments will be provided.

Keywords: Drayage, multi-period VRP, Set-Covering

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MAROPT.3

The role of inland ports within freight logistic networks. Impact of the externality costs on the modal split

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Abstract. This work focuses on the containerized flow from maritime terminals via road and rail; key elements are the location of the inland ports in terms of effectiveness of the logistics corridors and the impact of external costs. In particular, an analysis aimed at choosing the best investments in seaports for improving the rail split modality when transferring goods from ports to final destinations is presented considering different scenarios. The problem is modelled on a capacitated weighted multimodal network. The logistic networks originating from the Ligurian ports (Italy) is the test bed. Starting from a current network infrastructure, already optimized according to previously studies, we show that it is possible to obtain a new rail capacity able to increase the modal split thanks to possible alternative investments. First, a Mixed Integer Linear Programming (MILP) model is proposed; then, a set of possible financial interventions is examined in such a way to obtain a desired rail share for the import-containerized flows. The objective function of the proposed model aims at minimizing the costs of the adopted investments and the overall logistic costs, given by transportation, facility and external components. Externalities include pollutant, noise and congestion factors.

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MAROPT.4

City Logistics planning in a maritime urban area

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Abstract. In a port a fleet of inbound containers is filled with pallets, which must be delivered to their final destinations in the landside. Freight distribution is organized in a two-tiered structure: in the first tier, containers are moved from the port to satellites, where pallets are transshipped into different vehicles, which move pallets to their final destinations in the second tier. In this study, each container is allowed to be unpacked at a satellite only. The planning of operations involves selecting satellites and vehicles, which must be used to determine routes in order to allocate containers in the first tier and pallets in the second. We present and compare several mathematical formulations for this problem. We illustrate and discuss related solution methods. Preliminary computational tests are presented.

Keywords: City logistics, Two-echelon Vehicle Routing, Facility location

References

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Mathematical Programming

Chairman: L. Liberti

MATHPRO.1 *Quadratic form with fixed rank can be maximized in polynomial time over hypercube*
M. Rada, M. Hladík

MATHPRO.2 *Robust trading mechanisms over 0/1 polytopes*
M. C. Pinar

MATHPRO.3 *An ILP-based proof that 1-tough 4-regular graphs of at most 17 nodes are Hamiltonian*
G. Lancia, E. Pippia, F. Rinaldi

MATHPRO.4 *Benders in a nutshell*
M. Fischetti, I. Ljubic, M. Sinnl

MATHPRO.5 *Mathematical programming bounds for kissing numbers*
L. Liberti

Quadratic form with fixed rank can be maximized in polynomial time over hypercube

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Abstract. We contribute to the problem of maximization of a quadratic form over a hypercube. The problem is NP-hard in the general setting; for example, the problem of finding weighted maximal cut in a graph is a special case of our problem. On other hand, there are several "easy" cases. In particular, it is known that if the quadratic form is positive semidefinite with fixed rank, the maximum can be found in polynomial time using Cholesky decomposition of the quadratic form, followed by a geometric transformation of the problem resulting in a reduction in dimension. The transformed problem is then solved by enumeration of vertices of the feasible set, which is a zonotope. The important property of this result is that it is valid also for the discrete version of the problem, i.e. for maximization of a positive semidefinite quadratic form over vertices of a hypercube. The main message of this contribution is that the problem can be solved in polynomial time even if the quadratic form doesn't have to be positive semidefinite. The assumption on fixed rank turns out to be sufficient. A similar geometric transformation of the problem can be used. However, the enumeration of vertices is not sufficient, one must enumerate faces of all dimensions. Similarly as in the positive semidefinite case, the number of such faces can is exponential only in the rank of the original quadratic form. Unfortunately, this approach cannot be used for the discrete version of the problem.

Keywords: Zonotope, Quadratic maximization, Fixed rank.

Acknowledgements:
The work was supported by Czech Science Foundation project No. 17-13068S.

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MATHPRO.2

Robust Trading Mechanisms over 0/1 Polytopes

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Abstract. The problem of designing a trade mechanism (for an indivisible good) between a seller and a buyer is studied in the setting of discrete valuations of both parties using tools of finite-dimensional optimization departing from the continuous valuations setting of Hagerty and Rogerson 1987. A robust tradedesign is defined as one which allows both traders a dominant strategy implementation independent of other traders' valuations with participation incentive and no intermediary (i.e., under budget balance). The design problem which is initially formulated as a mixed-integer non-linear non-convex feasibility problem is transformed into a linear integer feasibilityproblem by duality arguments, and its explicit solution corresponding to posted price optimal mechanisms is derived along with full characterization of the convex hull of integer solutions. A further robustness concept is then introduced for a central planner unsure about the buyer or seller valuation distribution, a corresponding worst-case design problem over a set of possible distributions is formulated as an integer linear programming problem, and a polynomial solution procedure is given. When budget balance requirement is relaxed to feasibility only, i.e., when one allows an intermediary maximizing the expected surplus from trade, a characterization of the optimal robust trade as the solution of a simple linear program is given. A modified VCG mechanism studied in Kos and Manea 2009, turns out to be optimal.

Keywords: Mechanism design, robustness, integer programming

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An ILP-based proof that 1-tough 4-regular graphs of at most 17 nodes are Hamiltonian

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Abstract. The study of t-tough graphs was started by Chvatal in the 70's, who hypotesized that every 2-tough graph is Hamiltonian (which was later proved to be false). In this work, we have used an ILP approach to attack and solve a relatively minor but still challenging conjecture by Bauer, Broesma and Veldman stating that: "Every 4-regular, 1-tough graph with at most 17 nodes is Hamiltonian". Prior to our work it was known that the statement held for graphs of at most 15 nodes, and also that it is false for 18 nodes. We have modeled the set of counterexamples to Bauer et al.'s conjecture as a polytope with variables associated to the edges of a complete graph of 16 and 17 nodes. The non-existence of a Hamiltonian cycle is guaranteed by a set of inequalities which are separated via a reduction to the TSP problem. We have addressed the more difficult separation of the 1-tough constraints through a division into cases based on a preliminary analysis (still by means of a simple ILP model) which shows that there are only a small number of 4-regular, 2-connected but non-1-tough graphs. The high level of symmetry of the model has been reduced by the adoption of the Orbital Branching approach. The proposed method has allowed to prove in few days of computations on a standard PC that the conjecture is true.

Keywords: t-tough graphs**,** Integer Linear Programming, Orbital branching.

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MATHPRO.4

Benders in a nutshell

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Abstract. Benders decomposition is one of the most famous tools for Mathematical Optimization. The original method from the '60s exploits two distinct ingredients for solving a Mixed-Integer Linear Program (MILP): 1) a *search strategy* where a relaxed (but still NP-hard) MILP defined on a suitable variable subspace is solved exactly (i.e., to integrality) by a black-box solver, and then is iteratively tightened by means of additional linear inequalities called "Benders cuts"; 2) the *technicality* of how to actually compute the Benders cut coefficients by using LP duality. Later developments in the '70s modified the original search strategy by proposing to "open" the black-box MILP solver to be able to generate Benders cuts within a single enumeration tree, and/or to use Benders cuts to exclude fractional solutions as well. Nowadays, everything can be framed very naturally in the Branch-and-Cut (B&C) framework proposed by Padberg and Rinaldi in the '90s, making the Benders approach very natural and easy to implement. In this talk we aim at presenting the Benders theory from a modern viewpoint where Benders cuts are yet another family of cutting planes to be used within the B&C framework. To make the approach even more appealing and simpler to implement, we present a straightforward formula to compute the Benders cut coefficients for generic convex problems, that only requires the computation of reduced costs. We also address some "implementation details" that are instrumental for the practical success of the method, including the role of the cut-loop scheme applied at the B&C root node, and we briefly report computational results on linear and quadratic facility location problems.
Keywords: Benders Decomposition, Mixed-Integer Convex Programming, Branch and Cut.

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MATHPRO.5

Mathematical programming bounds for kissing numbers

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Abstract. We give a short review of existing mathematical programming based bounds for kissing numbers. The kissing number in K dimensions is the maximum number of unit balls arranged around a central unit ball in such a way that the intersection of the interiors of any pair of balls in the configuration is empty. It is a cornerstone of the theory of spherical codes, a good way to find n equally spaced points on the surface of a hypersphere, and the object of a diatribe between Isaac Newton and David Gregory.

Keywords: Semidefinite Programming, Linear Programming, Delsarte bound, spherical code

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Multi-Objective Optimization 1

Chairman: M. Hladik

MOPT1.1 *Multiobjective optimization model for pricing and seat allocation problem in non profit performing arts organization*
A. Baldin, D.Favaretto, A. Ellero, T. Bille

MOPT1.2 *Stable matching with multi-objectives: agoal programming approach*
M. Gharote, S. Lodha, N. Phuke, R. Patil

MOPT1.3 *A multiobjective approach for sparse mean-variance portfolios through a concave approximation*
G. Cocchi, T. Levato, M. Sciandrone, G. Liuzzi

MOPT1.4 *Evaluation of financial market returns by optimized clustering algorithm*
S. Barak

MOPT1.5 *On relation of possibly efficiency and robust counterparts in interval multiobjective linear programming*
M. Hladík

MOPT1.1

Multiobjective optimization model for pricing and seat allocation problem in non profit performing arts organization

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Abstract. The implementation of Revenue Management (RM) techniques in non profit performing arts organizations presents new challenges compared to other sectors, such as transportion or hospitality industries, in which these techniques are more consolidated. Indeed, performing arts organizations are characterized by a multi-objective function that is not solely limited to revenue. On the one hand, theatres aim to increase revenue from box office as a consequence of the systematic reduction of public funds; on the other hand they pursue the objective to increase its attendance. A common practice by theatres is to incentive the customers to discriminate among themselves according to their reservation price, offering a schedule of different prices corresponding to different seats in the venue. In this context, price and allocation of the theatre seating area are decision variables that allow theatre managers to manage these two conflicting goals pursued. In this paper we introduce a multi-objective optimization model that jointly considers pricing and seat allocation. The framework proposed integrates a choice model estimated by multinomial logit model and the demand forecast, taking into account the impact of heterogeneity among customer categories in both choice and demand. The proposed model is validated with booking data referring to the Royal Danish Theatre during the period 2010-2015.

Keywords: Multi-objective optimization, Pricing, Seat allocation

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MOPT1.2

Stable Matching with Multi-Objectives: A Goal Programming Approach

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Abstract. Stability in matching has been well studied in the literature. In practice, there are many matching applications where along with stability, other measures such as equity, welfare, costs, etc. are also important. We propose a goal programming based approach for finding a Stable Matching (SM) solution with multi-objectives such as equity and welfare. The goal values are obtained by solving the linear assignment models. On the comparison with prior art, the results of our experiment shows comparable and in many cases significant improvement in the solution quality.

Keywords: Stable Matching; multi-objective; optimization; goal programming

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

MOPT1.3

A multiobjective approach for sparse mean-variance portfolios through a concave approximation

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Abstract. In this work, we propose a multiobjective optimization problem to deal with the construction of efficient portfolios with respect to expected return, volatility and cardinality. Considering the cardinality function as an objective allows the investors to analyze the tradeoff between the quality of the portfolio and the number of asset investments. In order to optimize our formulation with the multiobjective steepest descent algorithm, we handle the cardinality objective function through concave approximation. Equivalence properties with respect to the original problem are stated. The obtained computational results and the comparison with some existing approaches show the effectiveness of our formulation in terms of the Pareto front.

Keywords: portfolio selection, multiobjective optimization, cardinality

MOPT1.4

Evaluation of financial market returns by optimized clustering algorithm

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Abstract. Following the globalization of the economy and the increasing significance of international trade investments, linkages among economic variables of different countries are becoming strikingly evident. In Management, it could be interesting to identify similarities in financial assets for investment and risk management purposes. In Finance, we may be interested in identifying correlations in financial market returns for portfolio diversification, and there is a keen interest among researchers to capture presence and extent of such negative or positive correlations. In Economics, an application would be the cluster analysis of some countries by looking at the leading macroeconomic time series indicators. In this paper, we embark a two-level methodology to identify the correlated market by a modified clustering procedure and verify the relationship between clusters with multi-criteria decision making (MCDM) algorithms. In the first level, the proposed methodology mainly works with the k-means clustering method in which its performance is improved using particle swarm optimization algorithm (PSO). The integration of these methods aims at finding the best number of clusters (k) within the dataset with a distance-based index to achieve the most relevant stock market assigned to each cluster. After clustering the stock market return of some countries and optimized the number of countries in each cluster, in the second level, the MCDM algorithms are developed to consider the relationship between the countries within each cluster and between the clusters. This step plays a verification role to justify the accuracy in the first step clustering procedure, as well as, find out the real intensity of the relationship between the stock market of different countries. The result shows that it is useful to create a diversified portfolio while their components are not very correlated and decrease the amount of investment risk. As a case study, an experiment on daily and monthly stock market returns of 50 counties has been implemented.

Keywords: Clustering, Particle swarm optimization, MCDM

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MOPT1.5

On relation of possibly efficiency and robust counterparts in interval multiobjective linear programming

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Abstract. We investigate multiobjective linear programming with uncertain cost coefficients.We assume that lower and upper bounds for uncertain values are known, no other assumption on uncertain costs is needed. We focus on the so called possibly efficiency, which is defined as efficiency of at least one realization of interval coefficients. We show many favourable properties including existence, low computational performance of determining possibly efficient solutions, convexity of the dominance cone or connectedness or the efficiency set. In the second part, we discuss robust optimization approach for dealing with uncertain costs. We show that the corresponding robust counterpart is closely related to possible efficiency.

Keywords: Interval linear programming; multiobjective linear programming; robust Optimization

Acknowledgements. The author was supported by the Czech Science Foundation Grant P402/13-10660S.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Multi-Objective Optimization 2

Chairman: P. Dell'Olmo

MOPT2.1 *A numerical study on Rank Reversal in AHP: the role of some influencing factors*
M. Fedrizzi, N. Predella

MOPT2.2 *Sustainable manufacturing: an application in the food industry*
M. E. Nenni, R. Micillo

MOPT2.3 *Robust plasma vertical stabilization in Tokamak devices via multi-objective optimization*
G. De Tommasi, A. Mele, A. Pironti

MOPT2.4 *Sparse analytic hierarchy process networks*
P. Dell'Olmo, G. Oliva, R. Setola, A. Scala

MOPT2.1

A numerical study on Rank Reversal in AHP: the role of some influencing factors

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Abstract. We study, by numerical simulations, how rank reversal phenomenon in the Analytic Hierarchy Process is influenced by two different factors in the case of consistent judgements. We consider a three level hierarchy, where the alternatives constitute the lowest layer and the (k) criteria the layer immediately above. First, we focus on the distribution of the normalized criteria weights $(v_1, \dots, v_k)$. It is known that no rank reversal occur if all the criteria weights but one are zero, for instance, if $(v_1, \dots, v_k) = (1,0, \dots ,0)$. In fact, this case corresponds to the single criterion case, which is rank reversal free if the judgements are consistent. By drifting away from this polarized case, rank reversal can arise. We assume that the entropy is a suitable quantity to describe how far the distribution of criteria weights is from the extreme case described above. Indeed, the maximum entropy case is the uniform case $(v_1, \dots, v_k) = (1/k\,, 1/k\,, \dots, 1/k)$. We obtained an interesting monotone behavior, that is, the probability of rank reversal increases when the entropy of $(v_1, \dots, v_k)$ increases. We obtained a similar result by substituting the entropy with the standard deviation. Clearly, in this latter case the estimated probability of rank reversal decreases as the standard deviation increases. The second part of our study focuses on the method used for the aggregation of the local weight vectors. It is known that, if the weighted geometric mean is used, then rank reversal cannot occur. Conversely, by using the weighted arithmetic mean, as AHP suggests, rank reversal can occur. Therefore, we used the more general aggregation method of the weighted power mean. The weighted arithmetic mean and the weighted geometric mean are particular cases of the weighted power mean. More precisely, they are obtained by setting the power parameter p to the values $p = 1$ and $p \to 0$ respectively. We studied the estimated probability of rank reversal as a function of p. In this case too, we obtain a regular monotone behavior. As expected, the estimated probability of rank reversal is zero for $p \to 0$ and it increases in the interval [0,1]. For each study, we randomly generated 500.000 consistent pairwise comparison matrices.

Keywords: Rank Reversal, AHP, numerical simulations.

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MOPT2.2

Sustainable manufacturing: an application in the food industry

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Abstract. This paper aims at providing an enhancement to the decision support systems for sustainable manufacturing. We thus propose a hierarchical multi-level model to evaluate the sustainability of the production process. Our work tries to fill the gap in literature as it takes in account all the sustainability dimensions (economic, environmental and social one as well). Moreover, it is an effective decision support system as it can evaluate the impact of improvements to optimize the sustainability. We applied the model in a company operating in the food industry, by running the Analytic Hierarchy Process (AHP) method followed by a sensitivity analysis to test the model robustness.

Keywords: Sustainable operations, triple-bottom-line, Analytic Hierarchy Process (AHP)

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

MOPT2.3

Robust Plasma Vertical Stabilization in Tokamak Devices via Multi-objective Optimization

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Abstract. In this paper we present a robust design procedure for plasma vertical stabilization systems in tokamak fusion devices. The proposed approach is based on the solution of a multi-objective optimization problem, whose solution is aimed at obtaining the desired stability margins under different plasma operative scenarios. The effectiveness of the proposed approach is shown by applying it to the ITER-like vertical stabilization system recently tested on the EAST tokamak.

Keywords: Control theory, robust control, multi-objective optimization, control in nuclear fusion devices

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

MOPT2.4

Sparse Analytic Hierarchy Process Networks

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Abstract. In this talk we develop a new sparse and distributed approach to the AHP methodology. We show that, in the ideal case, it is still possible to compute the values even if the available information is sparse (i.e., a limited number of ratios is known), under the assumption that the information at hand corresponds to a connected undirected graph. When the available information is distorted and, in general, does not correspond to transitive preferences, we provide a condition and a metric to quantify the degree of consistency of the available data, extending Saaty's results in the sparse case. Finally, we show that our approach can be easily implemented also in a distributed way. In this distributed setting, we consider *n* agents, interacting via a connected undirected graph. Each agent is associated to an unknown value that describes its utility or relevance. We assume that each agent has distorted information regarding its relative utility with respect to its neighbors. Our objective is to let each agent asymptotically compute its own utility in a distributed way. At the same time, we want the agents to compute the overall degree of consistency of the sparse data. To this end, we develop a distributed algorithm that lets the agents compute, at the same time, the dominant eigenvalue and the *i-th* component of the corresponding eigenvector of the sparse AHP matrix, that is, a matrix collecting the relative information at hand. Our sparse setting is the basis for the implementation of decision making techniques having a large number of alternatives and featuring several decision makers, each with a limited perspective, e.g., in a social network context.

Keywords: Distributed Decision Processes, Analytic Hierarchy Process, Sparse Information**.**

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Non-Linear Optimization and Applications 1
Invited Session

Chairman: M. Roma

NLOA1.1 *A new grey-box approach to solve the workforce scheduling problem in complex manufacturing and logistic contexts*
L. Maccarrone, S. Lucidi

NLOA1.2 *Modelling for multi-horizon prediction of time-series*
A. De Santis, T. Colombo, S. Lucidi

NLOA1.3 *Quasi-Newton based preconditioning techniques for Nonlinear Conjugate Gradient Methods, in large scale unconstrained optimization*
A. Caliciotti, M. Roma, G. Fasano

NLOA1.4 *Exploiting damped techniques in preconditioned nonlinear conjugate gradient methods*
M. Roma, A. Caliciotti, M. Al-Baali, G. Fasano

NLOA1.1

A new grey-box approach to solve the workforce scheduling problem in complex manufacturing and logistic contexts

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Abstract. We present a new approach to solve the workforce scheduling problem in complex applicative contexts such as manufacturing and logistic processes. We consider systems where one or more workloads require to be sequentially processed in different areas by different types of operators exclusively characterized by their skills. We assume the request of such skills is not fixed and may be varied in order to match the time/cost objectives of the organization. Furthermore, due to the complexity of the considered processes, we suppose it is not possible to derive an analytic expression linking the number of resources of different types working on an activity to the time to complete it. For this reason, a set of ad hoc simulators are employed and their outputs are used as parameters for the scheduling formulation. Typical issues arising in workforce management applications are related to the need of minimizing the labor cost while meeting deadlines and industrial plans. These resource/time trade-offs are even more complex under our assumptions due to the presence of simulators which natively split the problem into two sequential sub-problems. Our strategy addresses these difficulties through a decomposition approach which allows to model the problem as a grey-box optimization problem combining a bin packing-scheduling formulation with the simulation of some complex manufacturing and logistic processes.

Keywords: Workforce scheduling, Grey-box optimization, Simulation.

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NLOA1.2

Modelling for multi-horizon prediction of time-series

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Abstract. Multi-horizon time series prediction has a growing interest. In many diverse fields of applications (Energy market, logistics, pricing of goods, services …) the management needs to know the amount of resources to allocate for satisfying the demand many periods ahead the time of their use. It is a common experience that iterating simple one-step-ahead algorithms, either linear or nonlinear, leads to disappointing results as the iteration progresses. Therefore there is a need to model explicitly the dependency of the time series future values on multiple time steps ahead of the current time, on the time series past history. Even though linear models can still be technically devised, in this context it is clear that the basic assumption that makes them efficient is lacking, since they should describe the time series behavior over a non-short time interval. The generally nonlinear mapping between the future values to be predicted and the past values of the time series is better represented by Neural Networks, availing also of the variety of structures and the large supply of learning algorithms, in open source software. Nevertheless the blind use of such computational structures can make the learning algorithm clumsy and lacking of reliability. It is therefore important to understand which kind of information contained in the past data affects more the future values, depending on the value of the prediction horizon. This would provide more efficient and reliable training data.

Keywords: forecast, machine-learning

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NLOA1.3

Quasi-Newton based preconditioning techniques for Nonlinear Conjugate Gradient Methods, in large scale unconstrained optimization

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Abstract. In this work we describe new preconditioning strategies for Nonlinear Conjugate Gradient (NCG) methods, for large scale unconstrained optimization (see [1] and [2]). They are based on quasi-Newton updates and have a twofold purpose: on one hand, drawing inspiration from the class of Approximate Inverse preconditioners, they collect information from the NCG iterations, in order to generate an approximate inverse Hessian. On the other hand, they also try to convey information by means of quasi-Newton (secant) equation [3]. We tackle general large scale nonconvex problems and we use information gained from a prefixed number of previous NCG iterations, in order to limit the storage. This implies that a careful use of the latter information is sought. In particular, at any NCG iteration we construct a preconditioner based on new low-rank quasi-Newton symmetric updating formulae, obtained as by-product of some previous NCG iterations. We also investigate the role of each component of our preconditioners, which contributes to define our proposal. An extensive numerical experience is performed on a large selection of CUTEst test set, showing that our proposal is reliable and effective.

Keywords: Preconditioned Nonlinear Conjugate Gradient, Large Scale nonconvex optimization, Quasi-Newton updates

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NLOA1.4

Exploiting damped techniques in preconditioned nonlinear conjugate gradient methods

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Abstract. In this work we investigate the use of damped techniques within Preconditioned Nonlinear Conjugate Gradient (PNCG) methods for large scale unconstrained optimization. Damped techniques were introduced by Powell for SQP Lagrangian BFGS methods [i] and recently extended by Al-Baali to quasi-Newton methods [ii]. We consider their use for possibly improving the efficiency and the robustness of Nonlinear Conjugate Gradient (NCG) methods in tackling difficult problems. In particular, we propose the use of damped techniques for a twofold aim: for obtaining modified NCG/PNCG methods and for modifying the construction of the preconditioners based on quasi-Newton updates used in the PNCG schemes. In the first case, we obtain a novel NCG/PNCG method, hence the necessity of ensuring its global convergence. In the second case, a new general framework for defining new preconditioning techniques for PNCG methods is obtained, by combining the preconditioners based on quasi-Newton update recently proposed in [iii] and some novel damped strategies. An extensive numerical experience confirms the effectiveness of the proposed approach.

Keywords: Preconditioned Nonlinear Conjugate Gradient, Damped techniques, Quasi-Newton updates

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Non-Linear Optimization and Applications 2
Invited Session

Chairman: S. Lucidi

NLOA2.1 *A Lagrangean relaxation technique for multiple instance learning*
A. Astorino, A. Fuduli, M. Gaudioso

NLOA2.2 *Sequential equilibrium programming for computing quasi-equilibria*
M. Passacantando, G. Bigi

NLOA2.3 *New active-set Frank-Wolfe variants for minimization over the simplex and the l1-ball*
A. Cristofari, M. De Santis, S. Lucidi, F. Rinaldi

NLOA2.4 *A derivative-free model-based method for unconstrained Nonsmooth optimization*
S. Lucidi, G. Liuzzi, F. Rinaldi, L. N. Vicente

NLOA2.1

A Lagrangean relaxation technique for multiple instance learning

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Abstract. The objective of a Multiple Instance Learning (MIL) problem [1] is to categorize bags of points: such points are called instances. The main characteristic of the problem is that only bag labels are known, while those of the instances are unknown. Examples of real world applications are in drug prediction, image recognition and text classification. In particular we focus on the binary case, where the objective is to discriminate between positive and negative bags constituted by two classes of instances. Since a bag is considered negative if all its instances are negative and positive whenever at least one instance is positive, then only the labels of the instances of the positive bags are to be predicted. Our method stems from the nonlinear integer programming model presented in [2] and it is based on the well-established Support Vector Machine (SVM) approach. It consists in recovering a solution to the MIL problem by minimizing a biconvex objective function, obtained by applying a Lagrangean relaxation technique to the original model. Then the optimization process is done by means of an Alternate Convex Search algorithm. We also provide some numerical results on benchmark datasets.

Keywords: Multiple Instance Learning, Mixed integer nonlinear optimization, Lagrangean relaxation

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NLOA2.2

Sequential equilibrium programming for computing quasi-equilibria

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Abstract. An algorithm for solving quasi-equilibrium problems (QEPs) is proposed relying on the sequential inexact resolution of equilibrium problems. First, we reformulate QEP as the fixed point problem of a set-valued map and analyse its Lipschitz continuity under monotonicity assumptions. Then, a few classes of QEPs satisfying these assumptions are identified. Finally, we devise an algorithm that computes an inexact solution of an equilibrium problem at each iteration and we prove its global convergence to a solution of QEP.

Keywords: Quasi-equilibrium problem, equilibrium problem, monotonicity, inexact solution.

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NLOA2.3

New active-set Frank-Wolfe variants for minimization over the simplex and the l1-ball

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Abstract. An active-set algorithmic framework is proposed for minimizing a continuously differentiable function over the unit simplex. It combines an active-set estimate [1] (to identify the variables equal to zero at the stationary point) with Frank-Wolfe-type directions [2]. In particular, two steps are performed at each iteration: in the first step, a sufficient decrease in the objective function is obtained by setting the estimated active variables to zero and suitably updating one estimated non-active variable; in the second step, a search direction is computed in the subspace of the estimated non-active variables and the new iterate is then computed by means of the Armijo line search. In particular, three variants of the Frank-Wolfe direction are considered: the standard Frank-Wolfe direction [3], the away-step Frank-Wolfe direction [4] and the pairwise Frank-Wolfe direction [5]. Global convergence of the method is proved and a linear convergence rate is guaranteed under additional assumptions. By properly adjusting the active-set estimate, the algorithm is then extended to solve minimization problems over the l1-ball. Numerical results show the effectiveness of the proposed approach.

Keywords: Active-set methods, Frank-Wolfe algorithm, Unit simplex.

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NLOA2.4

A Derivative-Free Model-Based Method for Unconstrained Nonsmooth Optimization

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Abstract. We consider the unconstrained optimization of a nonsmooth function, where first-order information is unavailable or impractical to obtain. Such optimization problems arise in many real-world problems in different fields. For example, in many problems of computational mathematics, physics, and the values of the objective,e functions are computed by means of complex simulation programs or are obtained by measurements. Such classes of optimization problem present both the difficulty that the functions are typically of the black-box type so that first-order information is unavailable and the difficulty that the functions present a certain level of nonsmoothness. The derivative free methods previously proposed in literature for nonsmooth function are based on the idea of sampling the objective function on an asymptotic dense set of search directions, see [1] and [2]. In this work, we propose a new algorithm approach based on approximating models of the objective function that explicitly takes into account its non-smoothness. A theoretical analysis concerning the global convergence of the approach is carried out. Furthermore, some results related to a preliminary numerical experience are reported.

Keywords: derivative free methods, nonsmooth optimization, nonlinerar programming methods

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Non-Linear Optimization and Applications 3
Invited Session

Chairman: M. Gaudioso

NLOA3.1 *Using a two-phase gradient projection method in IRN minimization for Poisson image restoration*
M. Viola, D. Di Serafino, G. Landi

NLOA3.2 *Recurrent neural networks: why do LSTM networks perform so well in time series prediction?*
T. Colombo, A. De Santis, S. Lucidi

NLOA3.3 *First-order optimization methods for imaging problems*
L. Zanni, V. Ruggiero

NLOA3.4 *Piecewise linear models for some classes of nonsmooth and nonconvex optimization problems*
M. Gaudioso, G. Giallombardo, G. Miglionico

NLOA3.1

Using a two-phase gradient projection method in IRN minimization for Poisson image restoration

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Abstract. We are interested in the solution of image restoration problems from Poisson data. We consider restoration problems modeled as constrained optimization problems where the objective function consists of the generalized Kullback-Leibler divergence plus a Total Variation regularization term. A single linear constraint, representing photon flux conservation, and non-negativity constraints are imposed. We propose a solution procedure based on an Iterative Reweighted Norm (IRN) approach [1], where the least-squares problem arising at each iteration is solved using a recently proposed two-phase gradient projection method, named P2GP [2]. Inspired by the GPCG method by Moré and Toraldo [3], P2GP alternates between an identification phase, which performs gradient projection iterations to determine a promising active set, and an unconstrained minimization phase, where the conjugate gradient method or suitable spectral gradient methods are applied to reduce the objective function in a subspace defined by the identification phase. The termination of the minimization phase is driven by a criterion based on a comparison between a measure of optimality in the reduced space and a measure of bindingness of the active variables, which yields efficiency and robustness. Experiments on some restoration problems show the effectiveness of the proposed approach.

Keywords: Poisson image restoration, Iterative Reweighted Norm approach, Gradient Projection method.

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NLOA3.2

Recurrent Neural Networks: why do LSTM networks perform so well in time series prediction?

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Abstract. We present an application of deep learning to time series forecasting and perform a theoretical analysis of Long Short-Term Memory (LSTM) networks, a broadly-used and very well-known variant of Recurrent Neural Networks. Deep learning has been revolutionary in many fields for the last two decades (e.g., image recognition, natural language processing, ...) thanks to the continuous increase in computing speed and capacity. To train deep learning machines, one needs to solve complex, highly nonlinear and large-scale optimization problems, but this notwithstanding few authors studied the theoretical properties of such problems. We here present an application of the so-called LSTM network to time series forecasting and a comparison with a "simple" fully-connected deep neural network with a similar number of parameters, with the aim of showing that these types of networks benefit from a design specifically targeted at the forecasting problem under consideration. Empirical tests have been carried out on the task of multi-step-ahead forecasting on an Italian energy dataset.

Keywords: Deep Learning, Nonlinear Optimization, Time Series Forecasting.

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NLOA3.3

First-order optimization methods for imaging problems

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Abstract. Many variational formulations of real-life image reconstruction problems involve the solution of large-scale optimization problems. Due to the size of these problems, first-order optimization approaches exploiting only the objective gradient are often the most suitable choice. For these reasons, the strategies for accelerating first-order methods play a crucial role in designing real-time image reconstruction systems. In this talk we describe the main acceleration ideas that have been successfully exploited in the last years for designing effective first-order imaging algorithms. Within the general framework of the forward-backward approaches, we discuss recent advances on the use of adaptive step-length selection rules, extrapolation/inertial steps and problem-dependent variable metric techniques. Numerical evidence of the effectiveness of these strategies are shown on some imaging problems arising in Astronomy and Computed Tomography.

Keywords: Imaging problems, First-order methods, Forward-backward methods

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NLOA3.4

Piecewise linear models for some classes of nonsmooth and nonconvex optimization problems

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Abstract. Nonsmooth problems arise in many areas where optimization models are adopted to support decision making. We mention here industrial design, machine learning, game theory, variational inequalities, equilibrium problems and mixed integer programming problems, whenever Lagrangian relaxation approaches are used. As far as convexity of the objective function is assumed, a large variety of well established methods is currently available, starting from classic subgradient method and its recent variants. Bundle methods, equipped either with subgradient aggregation or limited memory techniques, have proved effective even in large scale applications. Treatment of nonconvexity takes place either by introducing local convexification of the objective function or by constructing piecewise affine models, more complex than standard cutting plane. Of course such methods are aimed at finding local minima, whereas nonconvexity typically implies multi-extremality. We focus on the minimization of nonconvex nonsmooth functions of the following types:
- DC (Difference of Convex) functions;
- Pointwise maximum of a finite number of concave functions.

For each type of function we state first a local (parsimonious) optimization method based on the construction of a piecewise affine model of the objective function. Several ideas coming from the bundle methods are in action. After the local minimization has been performed, appropriate techniques to escape from a local minimum are devised. Termination properties of the proposed algorithms are given and the results of several numerical tests are reported.

Keywords: Nonsmooth Optimization, DC Programming, Bundle methods.

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Optimization and Applications 1

Chairman: R. Albanese

OPTAP1.1 *Influence maximization in social networks*
M. E. Keskin

OPTAP1.2 *Line feeding with variable space constraints for mixed-model assembly lines*
N. A. Schmid, V. Limère

OPTAP1.3 *Comparison of IP and CNF models for control of automated valet parking systems*
A. Makkeh, D. O. Theis

OPTAP1.4 *Optimization of the PF coil system in axisymmetric fusion devices*
R. Albanese, A. Castaldo, V.P. Loschiavo, R. Ambrosino

OPTAP1.1

Influence maximization in social networks

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Abstract. There is a growing interest in influence maximization in social networks especially after observing that the effects of social events of Arab spring, Gezi event of Turkey, uprising in Ukraine etc. have been built by the help of social networks. Consequently, political parties, commercial firms are willing to spread their messages throughout the network. Although there are many studies about influence maximization in social networks, all of them but one (Guney, 2017) consider the issue as a simulation instance and do not intend to construct mathematical models or optimal strategies. Guney et al. provide a mathematical model for budgeted influence maximization under cascade diffusion model. In this work, we extend the study of Guney in two different dimensions. First of all, we provide mathematical models that works under threshold diffusion model (See Shakarian et al. for diffusion models). Secondly, we extend the model for searching for the strategies to cope with the situation in which there is also an enemy party spreading black propaganda in the social network.

Keywords: Influence maximization, Threshold diffusion model, Mathematical programming

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OPTAP1.2

Line feeding with variable space constraints for mixed-model assembly lines

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Abstract. Nowadays, assembly systems are used for the assembly of an increasing amount of models, which are often mass-customized to meet customers' demands. This results in a rising number of parts used for assembly and, consequently, space scarcity at the line. Therefore, parts must not only be fed to the line cost-efficiently, but also meet space constraints (Limère et al., 2015). The assembly line feeding problem (ALFP) deals with the assignment of parts to line feeding policies in order to reduce costs and obtain a feasible solution. Within this paper, we examine all distinct line feeding policies at the same time, namely line stocking, kanban, sequencing and kitting (stationary and traveling kits). There is, to the best of our knowledge, no research conducted, including more than three line feeding policies in a single model (cf. Sali and Sahin, 2016). Furthermore, we assume space at the border of line (BoL) being variable. For this reason, space is not constrained per individual station, but we assume one overall space constraint for the entire line (Hua and Johnson, 2010). The main focus of this work is on accurately modeling the problem. This includes a representation of all line feeding processes, being storage, preparation, transportation, line side presentation and usage. By incorporating the variable space constraints at the BoL, we provide a decision model reducing the overall costs for line feeding in assembly systems, since rigid space constraints at the BoL usually lead to more expensive line feeding policies. In contrast, variable space constraints enable balancing unequal space usage of different stations, allowing cheaper line feeding policies to be selected. Some preliminary results on the cost impact of variable versus fixed space constraints will be discussed.

Keywords: Logistics, Decision support system, Material supply

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OPTAP1.3

Comparison of IP and CNF Models for Control of Automated Valet Parking Systems

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Abstract. In automated valet parking system, a central computer controls a number of robots which have the capability to move in two directions, under cars, lift a car up, carry it to another parking slot, and drop it. We study the theoretical throughput limitations of these systems: Given a car park layout, an initial configuration of a car park (location of cars, robots), into a desired, terminal configuration, what is the optimal set of control instructions for the robots to reorganize the initial into the terminal configuration. We propose a discretization and compare an Integer Programming model and a CNF-model on real-world and random test data.

Keywords: Discrete optimization and control, emerging applications, logistics

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTAP1.4

Optimization of the PF coil system in axisymmetric fusion devices

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Abstract. Nuclear fusion is one of the most promising way of obtaining energy supply in a clean and in principle inexhaustible way. The most advanced devices for hot nuclear fusion are tokamaks, toroidal axisymmetric structures where the plasma is magnetically confined due to the interaction with magnetic fields produced by the currents flowing in suitable coils placed around the chamber. The main projects in this field are ITER [1], an experimental reactor that is under construction in France, and DEMO [2], the first reactor producing net electricity for the grid. The magnet system of a tokamak device is mainly composed by a Toroidal Field (TF) coils, Central Solenoid (CS) and Poloidal Field (PF) coils set. To minimize the Joule losses in the coil windings, all magnets of future generation tokamaks will be made by superconducting wires. The TF coils set produces a magnetic field strength within the toroidal volume bounded by its coils. The CS and PF coils sets generate a magnetic field that, on the contrary, permeates the whole space and it is designed to shape the plasma and to drive inductively its current. The design of the CS/PF coil system is a complex problem due to the nonlinear relation between the plasma shape variation and the currents in the CS/PF coils. Moreover, a set of linear and nonlinear constraints on the maximum current density, vertical forces and magnetic fields on the coils has to be satisfied. The previous considerations make the optimization of the number, position and dimension of the PF coils a challenging task in the design of the next generation fusion reactors. In this paper, an optimization procedure of the PF/CS coil system is proposed, which is able to optimize PF coils number, position and dimension keeping the reference plasma magneto hydro dynamic (MHD) equilibrium fixed. This approach is an extension of the procedure used for the optimization of the PF coil currents in existing devices. It is based on the linearization of the Grad-Shafranov equation around the desired plasma equilibrium; then an iterative quadratic optimization problem with linear and quadratic constraints is solved. The proposed solution, which dramatically simplifies the nonlinear computations needed for tokamak design, is currently being exploited for the definition of the PF coil system in next generation tokamaks such as DEMO and DTT [3].
Keywords: nuclear fusion, quadratic programming with quadratic constraints

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Optimization and Applications 2

Chairman: M. F. Norese

OPTAP2.1 *Optimization of target coverage and network lifetime in wireless sensor networks through Lagrangian relaxation*
G. Miglionico, M. Gaudioso, A. Astorino

OPTAP2.2 *Initialization of optimization methods in parameter tuning for computer vision algorithms*
A. Bessi, D. Vigo, V. Boffa, F. Regoli

OPTAP2.3 *From reactive monitoring to prevention; how science and new big data solutions help Lottomatica, in optimizing operations and business processes*
R. Saracino

OPTAP2.4 *Models and methods for the social innovation*
M. F. Norese, L. Corazza, L. Sacco

OPTAP2.1

Optimization of target coverage and network lifetime in wireless sensor networks through Lagrangian relaxation

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Abstract. Wireless sensor network optimization has received intense attention in the last few years since sensor application fields are wide and diversified and include, among the others, security, healthcare and environment. We apply a Langrangian relaxation approach to two of the most studied network sensor problems, i.e. the Sensor Coverage Problem (SCP) and the Network Lifetime Problem (NLP). Given a certain area to be monitored, the SCP problem aims at activating the minimum number of devices so that each point of the area is sensed by at least one sensor. In particular we address the Directional Sensor Coverage Problem (DSCCP), where sensors are supposed to be directional and hence characterized by a discrete set of possible radii and aperture angles. The objective is to obtain the minimum cost coverage while setting the orientation radius and the aperture angle of each sensor. As for NLP, the objective is to define an appropriate scheduling and setting of the sensors to maximize the time when they are able to cover all targets. We propose a mixed binary formulation which is alternative to the most commonly adopted column generation-based models. We propose Lagrangian Relaxation approaches to tackle both the problems. We design ad hoc dual ascent procedures, equipped by Lagrangian heuristics. The results obtained by implementing our methods are also presented.

Keywords: Sensor coverage problem, Network lifetime, Lagrangian relaxation

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OPTAP2.2

Initialization of Optimization Methods in Parameter Tuning for Computer Vision Algorithms

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Abstract. Computer Vision Algorithms (CVA) are widely used in several applications ranging from security to industrial processes monitoring. In recent years, an interesting emerging application of CVAs is related to the automatic defect detection in some production processes for which quality control is typically performed manually, thus increasing speed and reducing the risk for the operators. The main drawback of using CVAs is represented by their dependence on numerous parameters, making the tuning to obtain the best performance of the CVAs a difficult and extremely time-consuming activity. In addition, the performance evaluation of a specific parameter setting is obtained through the application of the CVA to a test set of images thus requiring a long computing time. Therefore, the problem falls into the category of expensive Black-Box functions optimization. We describe a simple approximate optimization approach to define the best parameter setting for a CVA used to determine defects in a real-life industrial process. The algorithm computationally proved to obtain good selections of parameters in relatively short computing times when compared to the manually determined parameter values.

Keywords: Parameter Tuning, Black Box Optimization

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTAP2.3

From reactive monitoring to prevention; how science and new big data solutions help Lottomatica, in optimizing operations and business processes

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OPTAP2.4

Models and methods for the social innovation

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Abstract. When the Municipality of Turin decided to invest in social innovation, involved some public and private incubators and organizations of the social economy and non-profit contexts. A public program and a network of the partners were created, Turin Social Innovation (TSI), and a procedure supporting social innovation start-ups was applied for the first time in 2014. Several projects of social entrepreneurs have been funded when the Municipality activated a monitoring process. The Chamber of Commerce and its Office of Social Economy (OSE), a member of TSI, were asked to participate in the process and, specifically, to evaluate the social impact of the funded start-ups. The invitation to evaluate the social impact was denied, above all because some months of project implementation cannot produce social impact. A proposal to evaluate the propensity to produce social innovation, in the first steps of project implementation, was accepted and a team, which involved SEO, University of Turin and Politecnico di Torino, was created to develop the study. Two methodological approaches, actor network analysis and multicriteria analysis, were combined to analyze the start-up behaviors and to evaluate if they could address social needs, in their specific fields, and develop business projects for an inclusive and sustainable economy. A logical graph was created to synthesize and visualize the results of each start-up analysis ([1]; [2]; [3]). A multicriteria model was then elaborate, to evaluate the propensity of each start-up to produce social innovation, starting from the graph analysis. The results of this study were proposed and discussed with a TSI committee, in relation to the Municipality monitoring and decision processes. The adopted multi-methodology will be presented, together with its results, as a proposal of new models, metrics and methods for the social economy.

Keywords: Social innovation, Multiple criteria decision aiding, Soft OR

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Optimization under Uncertainty 1

Chairman: P. Beraldi

OPTU1.1 *A polyhedral study of the robust capacitated edge activation problem*
S. Mattia

OPTU1.2 *From revenue management to profit management: a dynamic stochastic framework for multiple-resource capacity control*
G. Giallombardo, F. Guerriero, G. Miglionico

OPTU1.3 *Using market sentiment to enhance second order stochastic dominance trading models*
G. Mitra, C. Erlwein-Sayer, C. Arbex Valle, X. Yu

OPTU1.4 *Enhanced indexation via probabilistic constraints*
P. Beraldi, M.E. Bruni

OPTU1.1

A polyhedral study of the Robust Capacitated Edge Activation Problem

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Abstract. Given a capacitated network, the Capacitated Edge Activation problem consists of activating a minimum cost set of edges in order to serve some traffic demands. If the demands are subject to uncertainty, we speak of the Robust Capacitated Edge Activation problem. We consider the capacity formulation of the robust problem and study the corresponding polyhedron to generalize to the robust problem the results that are known for the problem without uncertainty.

Keywords: Polyhedral study, capacity formulation, robustness

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTU1.2

From revenue management to profit management: a dynamic stochastic framework for multiple-resource capacity control

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Abstract. The quantity-based revenue management decision in the framework of multiple-resource capacity control is about accepting/rejecting the product request issued at the current period, given the residual capacity of each resource and the random demand of each product. The problem can be formulated as a dynamic stochastic program, whose aim is to maximize the expected future revenue subject to capacity constraints. An underlying assumption of such approach is that all the resources are already available, and that no extra cost is associated to the accept/reject decision. In fact, since the service under consideration will be operated anyway, independent of the sale levels, then the operational costs can be assumed as essentially fixed. In several applications the assumption of fixed operational costs may result over-restrictive and unrealistic. This is the case when, upon acceptance of a product request, service providers have to bear non-negligible additional operational costs, or they want to catch the opportunity of rearranging operations with the aim of reducing marginal operational costs. Rather than dealing with revenue maximization, in such cases it would be more appropriate to deal with a profit maximization problem. We introduce a dynamic stochastic optimization framework to formulate multiple-resource capacity control problems that can handle profits rather than revenues only. We study the asymptotic properties of deterministic approximations for the proposed model, and provide some examples to show the practical relevance of the proposed approach.

Keywords: revenue management, dynamic stochastic optimization, deterministic approximation

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OPTU1.3

Using Market Sentiment to Enhance Second Order Stochastic Dominance Trading Models.

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Abstract. This We describe a method for generating daily trading signals to construct trade portfolios of exchange traded securities. Our model uses Second Order Stochastic Dominance (SSD) as the choice criterion for both long and short positions. We control dynamic risk of 'draw down' by applying money management. The asset choice for long and short positions are influenced by market sentiment; the market sentiments are in turn acquired from news wires and microblogs. The solution method is challenging as it requires processing stochastic integer programming (SIP) models as well as computing the impact of market sentiment. The computation of SSD portfolios are well known to be computationally hard as this involves processing of large discrete MIP problems. The solution approach is based on our well-established solver system FortSP which uses CPLEX as its embedded solver engine to process SIP models.

OPTU1.4

Enhanced Indexation via Probabilistic Constraints

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Abstract. Index tracking is an investment strategy targeted to replicate the performance of a specific financial index, the so-called benchmark. This strategy has been gaining in popularity in the last years, as witness by the flourishing scientific literature (see, for example, [1],[2] and the references therein). In this talk, we focus of the Enhanced Index Tracking (EIT) problem, aimed at creating a portfolio that outperforms the benchmark, while bearing a limited additional risk. The EIT is clearly an optimization problem under uncertainty since the performance of the securities to include in the tracker portfolio are unknown when investment decisions have to be taken. We deal with this challenging problem by adopting the stochastic programming framework, and, in particular, the paradigm of chance constraints [3]. The idea is to create a portfolio of assets that outperforms the benchmark most of the time. This is accomplished by mathematically imposing that the probability that the random portfolio return is higher than the random benchmark return is at least α, where higher values of □ are chosen to accomplish with higher levels of risk aversion. In addition to the traditional form of chance constraint, we also consider an integrated formulation. In this second case, we quantify the deviation from the benchmark and we limit the corresponding expected value to be lower than a given bound, properly chosen. Extensive computational experiments have been carried to evaluate the performance of the proposed approaches on instances taken from the scientific literature. Comparison of the out-of-sample performance with other investment strategies are presented and discussed.

Keywords: Enhanced Index Tracking Problem, Probabilistic Constraints

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Optimization under Uncertainty 2

Chairman: N. Zufferey

OPTU2.1 *A queueing networks-based model for supply systems*
L.Rarità, M. De Falco, N. Mastrandrea

OPTU2.2 *Efficiency measures for traffic networks with random demand and cost*
F. Raciti, B. Jadamba, M. Pappalardo

OPTU2.3 *Capital asset pricing model - a structured robust approach*
R. J. Fonseca

OPTU2.4 *On the properties of interval linear programs with a fixed coefficient matrix*
E. Garajová, M. Hladìk, M. Rada

OPTU2.5 *A push shipping-dispatching approach for high-value items: from modeling to managerial insights*
N. Zufferey, J. Respen

OPTU2.1

A queueing networks-based model for supply systems

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Abstract. In this paper, a stochastic model, based on queueing networks, is analyzed in order to model a supply system, whose nodes are working stations. Unfinished goods and control electrical signals arrive, following Poisson processes, at the nodes. When the working processes at nodes end, according to fixed probabilities, goods can leave the network or move to other nodes as either parts to process or control signals. On the other hand, control signals are activated during a random exponentially distributed time and they act on unfinished parts: precisely, with assigned probabilities, control impulses can move goods between nodes, or destroy them. For the just described queueing network, the stationary state probabilities are found in product form. A numerical algorithm allows to study the steady state probabilities, the mean number of unfinished goods and the stability of the whole network

Keywords: queueing networks, supply systems, product–form solution.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTU2.2

Efficiency measures for traffic networks with random demand and cost

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Abstract. In this note we combine two theories that have been proposed in the last decade: the theory which describes the vulnerability and efficiency of a congested network, and the theory of stochastic variational inequalities. As a result, we propose a model which can describe the performance and vulnerability of a congested network with random traffic demands and where the travel time can be affected by uncertainty. For a given network, where the traffic demand and cost are known through their probability densities, we give a computational procedure to evaluate its average efficiency and the importance of its components. We illustrate our methodology with the help of the famous Braess' network.

Keywords: Network vulnerability, stochastic variational inequalities, Braess' paradox

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OPTU2.3

Capital Asset Pricing Model - a structured robust approach

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Abstract. We present an alternative robust formulation to the determination of the Capital Asset Pricing Model. We consider that both the asset and the market returns are uncertain and subject to some structured perturbations, and calculate a robust beta. The resulting structured robust model can be easily solved using semidefinite programming and is subsequently tested with data from the portuguese stock market. Numerical results have shown that the robust beta is, not only greater than the traditional least squares beta, but also that it tends to increase with a growing number of perturbation matrices, thus yielding a higher level of systematic risk.

Keywords: robust optimization, capital asset pricing model, linear regression

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTU2.4

On the Properties of Interval Linear Programs with a Fixed Coefficient Matrix

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Abstract. Interval programming is a modern tool for dealing with uncertainty in practical optimization problems. In this paper, we consider a special class of interval linear programs with interval coefficients occurring only in the objective function and the right-hand-side vector, i.e. programs with a fixed (real) coefficient matrix. The main focus of the paper is on the complexity-theoretic properties of interval linear programs. We study the problems of testing weak and strong feasibility, unboundedness and optimality of an interval linear program with a fixed coefficient matrix. While some of these hard decision problems become solvable in polynomial time, many remain (co-)NP-hard even in this special case. Namely, we prove that testing strong feasibility, unboundedness and optimality remains co-NP-hard for programs described by equations with non-negative variables, while all of the weak properties are easy to decide. For inequality-constrained programs, the (co-)NPhardness results hold for the problems of testing weak unboundedness and strong optimality. However, if we also require all variables of the inequality-constrained program to be non-negative, all of the discussed problems are easy to decide.

Keywords: Interval linear programming, Computational complexity

Acknowledgements. The first two authors were supported by the Czech Science Foundation under the project P402/13-10660S and by the Charles University, project GA UK No. 156317. The work of the first author was also supported by the grant SVV-2017-260452. The work of the third author was supported by the Czech Science Foundation Project no. 17-13086S.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTU2.5

A Push Shipping-Dispatching Approach for High-Value Items: from Modeling to Managerial Insights

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Abstract. A real shipping-dispatching problem is considered in a three-level supply chain (plant, wholesalers, shops). Along the way, different perturbations are expected (when manufacturing, when forecasting the demand, and when dispatching the inventory from the wholesalers level), and accurate reactions must be taken. An integer linear program is proposed and some managerial insights are given.

Keywords: inventory management, shipping, dispatching, simulation

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Optimization under Uncertainty 3

Chairman: A. Violi

OPTU3.1 *Performance evaluation of a push merge system with multiple suppliers, an intermediate buffer and a distribution center with parallel channels: The Erlang case*
S. Koukoumialos, N. Despoina, M. Vidalis, A. Diamantidis

OPTU3.2 *Newsvendor problems with unreliable suppliers and capacity reservation*
D. G. Pandelis, I. Papachristos

OPTU3.3 *Supplier selection under uncertainty in the presence of total quantity discounts*
D. Manerba, G. Perboli, R. Mansini

OPTU3.4 *The optimal energy procurement problem: astochastic programming approach*
A. Violi, P. Beraldi, M. E. Bruni, G. Carrozzino

OPTU3.1

Performance Evaluation of a push merge system with multiple suppliers, an intermediate buffer and a distribution center with parallel channels: The Erlang case

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Abstract. In this paper, the most important performance measures of a two stage, push merge system are estimated. More specifically, S non identical and reliable suppliers send material to a distribution center (DC) of one product type. The DC has N possible parallel identical reliable machines. Between the suppliers and the DC a buffer with unlimited capacity, is located in order the material flow to be controlled. All stations processing and replenishment times are assumed stochastic and follow the Erlang distribution. The considered model is developed as Markov Process with discrete states where the Matrix Analytic method is used to calculate the system stationary probabilities and performance measures.

Keywords: Merge production systems, Markovian analysis, Matrix analytic method

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

OPTU3.2

Newsvendor problems with unreliable suppliers and capacity reservation

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Abstract. We develop and analyze newsvendor models with two suppliers. At first the retailer places an order to a primary unreliable supplier and reserves the capacity of a backup reliable supplier. Then, the retailer may exercise the option to buy any amount up to the reserved capacity after the delivered quantity from the primary supplier becomes known. In related work, Saghafian and Van Oyen (2012) have analyzed a two-product model where the primary supplier is subject to random disruptions. Guo et al. (2016) have provided numerical results for the problem with the primary supplier being simultaneously subject to random disruptions and random yield. In our work we analyze appropriate optimization models for several versions of the problem. We consider primary suppliers that are subject to random yield or random capacity and the cases when the option to buy from the backup supplier is exercised before or after the demand becomes known. We derive conditions on the reservation price that make the use of the backup supplier profitable and obtain properties of the optimal order and reservation quantities. We also study the effect of the various parameters of the problem through numerical experiments.

Keywords: Newsvendor, Supply uncertainty, Backup supplier

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OPTU3.3

Supplier Selection under Uncertainty in the presence of Total Quantity Discounts

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Abstract. We study a multi-product multi-supplier procurement problem including supplier selection, total quantity discounts policies, restricted availabilities of products at the suppliers and business activation costs (Capacitated Total Quantity Discount problem with Activation Costs, CTQD-AC). Since in the medium/long-term several of the problem's parameters may be unknown a priori, we propose a two-stage stochastic programming (SP) formulation with recourse to cope with different sources of uncertainty, highlighting the strategic and the operational decisions involved. In particular, we focus on the cases in which only the products price or only the products demand are stochastic, adapting the general model and the recourse actions for these special cases. The resulting modeling approaches are validated (also in terms of stability) on a large set of instances, considering different discount and activation costs characteristics, as well as different scenario tree generation rules based on several parameters and probability distributions. Due to the computational burden of solving SP problems through state-of-the-art MIP solvers, we also develop a branch-and-cut framework based on valid inequalities and other accelerating mechanisms. The experiments show the convenience of having in place models explicitly considering fluctuations (with respect to using expected values for approximating it) and give rise to interesting managerial insights concerning the importance of activating total quantity discounts to mitigate the curse of the uncertainty.

Keywords: Procurement logistics, Total Quantity Discount, Stochastic Programming.

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OPTU3.4

The Optimal Energy Procurement Problem: A Stochastic Programming Approach

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Abstract. The paper analyzes the problem of the optimal procurement plan at a strategic level for a set of prosumers aggregated within a coalition. Electric energy needs can be covered through bilateral contracts, self-production and the pool. Signing bilateral contracts reduces the risk associated with the volatility of pool prices usually incurring higher average prices. Self-producing also reduces the risk related to pool prices. On the other hand, relying mostly on the pool might result in an unacceptable volatility of procurement cost. The problem of defining the right mix among the different sources is complicated by the high uncertainty affecting the parameters involved in the decision process (future market prices, energy demand, self-production from renewable sources).We address this more challenging problem by adopting the stochastic programming framework. The resulting model belongs to the class of two-stage model with recourse. The computational results carried out by considering a real case study shows the validity of the proposed approach.

Keywords: Energy procurement; Stochastic Programming; Risk Management

Acknowledgements. This work has been partially supported by Italian Minister of University and Research with the grant for research project PON03PE 00050 2 “DOMUS ENERGIA - Sistemi Domotici per il Servizio di Brokeraggio Energetico”.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Paths and Trees

Chairman: P. Festa

PATH.1 *On the forward shortest path tour problem*
F. Laureana, F. Carrabs, R. Cerulli, P. Festa

PATH.2 *A dual-based approach for the re-optimization shortest path tree problem*
A. Napoletano, P. Festa, F. Guerriero

PATH.3 *Optimization-based solution approaches for shortest path problems under uncertainty*
C. Gambella, G. Russo, M. Mevissen

PATH.4 *Exact and approximate solutions for the constrained shortest path tour problem*
P. Festa, D. Ferone, F. Guerriero

PATH.1

On the Forward Shortest Path Tour Problem

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Abstract. This paper addresses the Forward Shortest Path Tour Problem (FSPTP). Given a weighted directed graph, whose nodes are partitioned into clusters, the FSPTP consists of finding a shortest path from a source node to a destination node and which crosses all the clusters in a fixed order. We propose a polynomial time algorithm to solve the problem and show that our algorithm can be easily adapted to solve the shortest path tour problem, a slightly different variant of the FSPTP. Moreover, we carried out some preliminary computational tests to verify how the performance of the algorithm is affected by parameters of the instances

Keywords: Shortest Path Tour, polynomial algorithm, electric *vehicles*

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

PATH.2

A Dual-Based Approach for the Re-optimization Shortest Path Tree Problem

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Abstract. The re-optimization shortest path problem consists in solving a sequence of shortest path problems, where the kth problem is slightly different from the $(k-1)^{th}$ one, because a root change may have occurred, the cost of a subset of arcs may have been changed, or some arcs/nodes may have been removed from the graph. Each problem could be solved simply from scratch, ignoring the solution previously computed, or, alternatively, in a clever way by using an ad-hoc algorithm that efficiently re-use the information obtained from previous computation. A large part of the strategies proposed in literature were often inspired by one of the most iconic algorithm, in the field of combinatorial optimization, which is based on a labeling method proposed by Dijkstra in 1959. In this talk, we will present an exact algorithm for the re-optimization shortest path tree problem, when a root change occurred, based on a dual approach, and which adopts a strongly polynomial auction scheme in order to establish how to extend the under construction solution. A first in-depth phase of experimentation has allowed us to establish that the proposed strategy is able to compete and outperform Dijkstra-like approaches.

Keywords: Re-optimization, Shortest Path, Auction Algorithm

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PATH.3

Optimization-based solution approaches for shortest path problems under uncertainty

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Abstract. Connected vehicles adopt several technologies to communicate with the driver, other cars on the road (vehicle-to-vehicle), roadside infrastructure (vehicle-to-infrastructure), and with a cloud platform. The big amount of information they deal with can be exploited to improve vehicle safety and efficiency, and reduce commute times. In this context, methods that enable to filter and parse only the information relevant to the journey and pass those to the driver are momentous ([1]). Applications of those methods can be found in decision support systems or travel companion systems ([2]). Furthermore, mobility in urban environments has an important impact on pollutant emissions and increase of travel times (see, e.g., [3], [4]). Both emissions and travel times are affected by uncertainty, because traffic congestion and events such as accidents and adverse weather conditions affect the possible speed values in the urban area. In this work, we aim to determine shortest paths between a given origin and a destination for a vehicle driver in a road network under uncertainty, by taking into account several sources of risk associated with the journey. The total cost of the path comprehends the travelled distance, the travel time and pollutant emissions. The minimization problem is formulated on a graph representing the road network. We propose an optimization-based solution approach, which considers a statistical estimation of the travel speeds, in order to associate a value of risk with each driver's historical path. A shortest path problem with uncertain parameters is then solved on a risk-filtered solution space. Finally, we compare solutions obtained in a stochastic/robust environment with solutions given by deterministic approximations.

Keywords: Risk mitigation, Transportation, Shortest Path.

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PATH.4

Exact and approximate solutions for the Constrained Shortest Path Tour Problem

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Abstract. The Constrained Shortest Path Tour Problem (CSPTP) consists in finding a single-origin single-destination shortest path in a directed graph such that a given set of constraints is satisfied. In particular, in addition to the restrictions imposed in the simple shortest path tour problem (see Bertsekas (2005), Festa (2012), and Festa et al. (2013)), requiring that the path needs to cross a sequence of node subsets that are given in a fixed order, in the CSPTP it is imposed that the path does not include repeated arcs. In this talk, the computational complexity of the problem will be theoretically briefly investigated proving that the CSPTP belongs to the NP-complete class. A Branch & Bound method to exactly solve it will be described. Furthermore, given the problem hardness, a Greedy Randomized Adaptive Search Procedure will be also presented to find near-optimal solutions for medium to large scale instances. The computational results show that the Greedy Randomized Adaptive Search Procedure is effective in finding optimal or near optimal solutions in very limited computational time.

Keywords: Shortest Path Problems, Network Flow Problems, Combinatorial Optimization, Shortest Path Tour Problem

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Railway Optimization
Invited Session

Chairman: A. D'Ariano

ROPT.1 *A conflict solution algorithm for the train rescheduling problem*
A. Bettinelli, M. Pozzi, A. M. Santini, D. Vigo, M. Rosti, D. Nucci, A. Di Carmine

ROPT.2 *A MILP algorithm for the minimization of train delay and energy consumption*
T. Montrone, P. Pellegrini, P. Nobili

ROPT.3 *A MILP reformulation for train routing and scheduling in case of perturbation*
P. Pellegrini, G. Marliére, J. Rodriguez, R. Pesenti

ROPT.4 *Exact and heuristic algorithms for the real-time train scheduling and routing problem*
M. Samà, A. D'Ariano, D. Pacciarelli, M. Pranzo

ROPT.1

A Conflict Solution Algorithm for the Train Rescheduling Problem

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Abstract. We consider the real-time resolution of conflicts arising in real-world train management applications ([1]; [2]; [3]; [4]). Given a nominal timetable for a set of trains and a set of modifications due to delays or other resources unavailability, we are aiming at defining a set of actions which must be implemented to avoid potential conflicts such as train collisions or headway violations, and restore quality by reducing the delays. To be compatible with real-time management, the required actions must be determined in a few seconds, hence specialized fast heuristics must be used. We propose a fast and effective parallel algorithm that is based on an iterated greedy scheduling of trains on a time-space network. The algorithm uses several sortings to define the initial train dispatching rule and different shaking methods, and is enhanced by sparsification methods for the time-space network. The resulting heuristic obtained excellent solution quality within just two seconds of computing time, for instances involving up to 151 trains and two hours of planning time horizon.

Keywords: Railway Optimization, Train Rescheduling, Real-time Algorithm

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ROPT.2

A MILP Algorithm for the Minimization of Train Delay and Energy Consumption

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Abstract. A new timetable must be calculated in real-time when train operations are perturbed. The energy consumption is becoming a central issue both from the environmental and economic perspective but it is usually neglected in the timetable recalculation. In this paper, we formalize the real-time Energy Consumption Minimization Problem (rtECMP). The rtECMP is the real-time optimization problem of finding the driving regime combination for each train that minimizes the energy consumption, respecting given routing and precedences between trains. We model the trade-off between minimizing the energy consumption and the total delay by considering as objective their weighted sum. We propose an algorithm to solve the rtECMP, based on the solution of a mixed-integer linear programming (MILP) model. We test this algorithm on the Pierrefitte-Gonesse control area, which is a critical area in France with dense mixed traffic. In particular, we consider a onehour traffic perturbation. In this situation, we take into account different routing and precedence possibilities and we solve the corresponding rtECMP. This experimental analysis shows the influence on the solution of the weights associated with energy consumption and delay in the objective function. The results show that the problem is too difficult to be solved to optimality in real time, but is indeed tractable.

Keywords: Railway Traffic Management; Energy Consumption; Mixed-Integer Linear Programming

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROPT.3

A MILP reformulation for train routing and scheduling in case of perturbation

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Abstract. In this paper we propose a reformulation of RECIFE-MILP aimed at boosting the algorithm performance. RECIFE-MILP is a mixed integer linear programming based heuristic for the real-time railway traffic management problem, that is, the problem of re-routing and rescheduling trains in case of perturbation in order to minimize the delay propagation. The reformulation which we propose exploits the topology of the railway infrastructure. Specifically, it capitalizes on the implicit relations between routing and scheduling decisions to reduce the number of binary variables of the formulation. In an experimental analysis based on realistic instances representing traffic in the French Pierrefitte-Gonesse junction, we show the performance improvement achievable through the reformulation.

Keywords: Real-time railway traffic management problem, train re-routing and rescheduling, mixed-integer linear programming

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROPT.4

Exact and heuristic algorithms for the real-time train scheduling and routing problem

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Abstract. This talk deals with the real-time train scheduling and routing problem [1]. The problem is NP-hard and finding a good quality solution in a short computation time for practical size instances is a very difficult task [2]. In this work we model the problem via an alternative graph formulation [3] and solve it by using a new methodology based on the relaxation of train routing constraints. We assign a nominal routing to each train, formed by common and alternative operations. We call a common operation the traversing of a block section by the train which takes place independently from the actual path chosen. An alternative operation is the shortest path between two common operations and represents alternative portions of a path in the network traversable by the train. Using a so built alternative graph allows to quickly compute good quality lower bounds. This is achieved by solving the corresponding train scheduling problem. Such a lower bound is then used as a first step toward the development of a branch-and-bound algorithm for the overall problem. The decisions taken during the branch-and-bound algorithm refer to selecting the routing of trains and solving the train sequencing and timing decisions generated by these selections. Computational experiments are performed on several networks and disturbed traffic situations.

Keywords: real-time Railway Traffic Optimization, Disjunctive Programming.

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Routing 1
Invited Session

Chairman: E. Manni

ROUT1.1 *The vehicle routing problem with occasional drivers and time windows*
G. Macrina, L. Di Puglia Pugliese, F. Guerriero, D. Laganà

ROUT1.2 *Including complex operational constraints in territory design for vehicle routing problems*
F. Bertoli, P. Kilby, T. Urli

ROUT1.3 *An exact algorithm for the vehicle routing problem with private fleet and common carrier*
S. Dabia, D. Lai, D. Vigo

ROUT1.4 *Scalable anticipatory policies for real-time vehicle routing*
E. Manni, G. Ghiani, A. Romano

ROUT1.1

The Vehicle Routing Problem with Occasional Drivers and TimeWindows

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Abstract. In this paper, we study a variant of the Vehicle Routing Problem with Time Windows in which the crowd-shipping is considered. We suppose that the transportation company can make the deliveries by using its own fleet composed of capacitated vehicles and also some occasional drivers. The latter can use their own vehicle to make either a single delivery or multiple deliveries, for a small compensation. We introduce two innovative and realistic aspects: the first one is that we consider the time windows for both the customers and the occasional drivers; the second one is the possibility for the occasional driver to make multiple deliveries. We consider two different scenarios, in particular, in the first one multiple deliveries are allowed for each occasional driver, in the second one the split delivery policy is introduced. We propose and validate two different mathematical models to describe this interesting new setting, by considering several realistic scenarios. The results show that the transportation company can achieve important advantages by employing the occasional drivers, which become more significant if the multiple delivery and the split delivery policy are both considered.

Keywords: Vehicle Routing Problem, Crowd-shipping, Occasional Drivers

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROUT1.2

Including Complex Operational Constraints in Territory Design for Vehicle Routing Problems.

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Abstract. Territory-based routing approaches aim to achieve high consistency in service or to balance some measure of workload through the design of clusters, called territories, of customers that will be served by the same driver over a given horizon of time. The drawback is a loss in routing flexibility. In the literature, the typical approach is to estimate a tour's length (or time) in order to create balanced territories. A major limitation of this approach is the difficulty in considering complex operational constraints such as time windows. A different approach is to directly consider the routing decisions while designing the territories. Two examples are (Cortinhal et al. (2016), Schneider et al. (2014)) for arc and node routing respectively. In particular, in (Schneider et al. (2014)) the authors study the influence of time windows on the problem. To the best of our knowledge, the latter is the only work trying to estimate the influence of a non-trivial operational constraint on the design of territories. In this work we aim to generalise their work by proposing a general method to tackle territory design problems in the presence of operational constraints. Our method separates the districting and routing problems by means of a Benders Decomposition. The major advantage is that we can now use standard heuristics for the routing problem, which makes us able to consider complex operational constraints. We investigate the effectiveness of our method and compare it to the result obtained without decomposing the problem. Moreover we study the impact of different operational constraints on the design of territories.

Keywords: Territory Design, Decomposition, Routing Consistency.

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ROUT1.3

An exact algorithm for the vehicle routing problem with private fleet and common carrier

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Abstract. In this talk, we will present an exact approach based on a branch-and-cut-and-price algorithm for the Vehicle Routing Problem with Private Fleet and Common Carrier (VRPPC). The VRPPC is a generalization of the classical Vehicle Routing Problem where the owner of a private fleet can either visit a customer with one of his vehicles or assign the customer to a common carrier. The latter case occurs if the demand exceeds the total capacity of the private fleet or if it is more economical to do so. The owner's objective is to minimize the variable and fixed costs for operating his fleet plus the total costs charged by the common carrier. we will present the more general and practical case where the cost charged by the external common carrier is based on cost structures inspired from practice. The problem at hand is solved by means of a branch-and–cut-and-price based on two set partitioning formulations. Furthermore, we introduce tailored subset row inequalities, and develop efficient dominance criteria to deal with the additional complexity in the pricing problem. In a extensive numerical study, we show interesting insights and demonstrate the value of the proposed algorithm.

ROUT1.4

Scalable anticipatory policies for real-time vehicle routing

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Abstract. In this paper, we deal with the dynamic and stochastic Pickup and Delivery Problem, which falls under the broad category of real-time fleet management ([1], [2]). Here, we consider a fleet of vehicles that must service a set of pickup and delivery customers' requests, characterized by a priority class. The goal is to maximize the overall customer service level or, equivalently, to minimize customer inconvenience. The problem is dynamic in that customers' requests are disclosed during the planning horizon, whereas it is stochastic because we assume that the requests arrive according to a known stochastic process. For this class of problems two kinds of policies are common in the literature: (i) reactive policies which manage new requests only once they have occurred (neglecting any available stochastic information) characterized by extremely fast running times obtained at the expenses of solution quality; (ii) anticipatory algorithms which exploit the stochastic characterization of future demand in an attempt of anticipating it, and generally achieve better results than reactive algorithms, but longer running times. Here, we propose two dispatching policies that share a twofold goal. First, trading off between the two previous extremes, the aim is to match the quality of anticipatory algorithms with a computational effort comparable to reactive approaches. The second goal is to achieve scalable performances. The basic idea of the first policy is to reserve a fraction of the fleet capacity to service the requests belonging to the top-prioritized classes. As an additional dispatching rule, when evaluating the different alternatives we allow an insertion if the delivery instants of the requests of each class already allocated on a route are not delayed more than a given value. To take advantage of the stochastic knowledge of the problem, the values of the parameters characterizing the policy are determined by solving off-line a training problem on a sample that is representative of the instances to be solved. Moreover, under certain circumstances it could be beneficial to relax the capacity-restriction constraint. In particular, when inserting a new request, if the increase in the objective function using the capacity-reserve policy is greater than the increase when no capacity-restriction is considered (multiplied for a constant greater than 1), then the constraint is relaxed. In the second policy the characteristics of the previous policy are combined with a strategy to reposition idle vehicles to a number of home positions. Computational results show that our policies are able to achieve the two goals previously described.

Keywords: real-time vehicle routing, dispatching policies, anticipatory routing

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Routing 2

Chairman: E. Fernández

ROUT2.1 *A flow formulation for the close-enough arc routing problem*
R. Pentangelo, C. Cerrone, R. Cerulli, B. Golden

ROUT2.2 *Last-mile deliveries by using drones and classical vehicles*
L.Di Puglia Pugliese, F. Guerriero

ROUT2.3 *Traveling Salesman Problem with drone: computational approaches*
S. Poikonen, B. Golden

ROUT2.4 *Target-visitation arc-routing problems*
E. Fernández, J. Rodríguez-Pereira, G. Reinelt

ROUT2.1

A flow formulation for the close-enough arc routing problem

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Abstract. The close-enough arc routing problem is a generalization of the classic arc routing problem and it has many interesting real-life applications. In this paper, we propose some techniques to reduce the size of the input graph and a new effective mixed integer programming formulation for the problem. Our experiments on directed graphs show the effectiveness of our reduction techniques. Computational results obtained by comparing our MIP model with the existing exact methods show that our algorithm is really effective in practice.

Keywords: close enough arc routing problem, MIP model, vertex cover

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROUT2.2

Last-mile deliveries by using drones and classical vehicles

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Abstract. We address the problem of managing a drone-based delivery process. We consider the specific situation of a delivery company, that uses a set of trucks equipped with a given number of drones. In particular, items of a limited weight and size could be delivered by using drones. A vehicle, during its trip, can launch a drone when serving a customer, the drone performs a delivery for exactly one customer and returns to the vehicle, possibly at a different customer location. Each drone can be launched several times during the vehicle's route. It is imposed a limit on the maximum distance that each drone can travel and synchronization requirements between vehicle and drone should be ensured. In particular, it is assumed that a vehicle waits for a drone for a maximum period of time. The aim is to serve all customers within their time window. The problem is modeled as a variant of the vehicle routing problem with time windows. The aim of this work is to analyze the delivery process with drones, by taking into account the total transportation cost and highlighting strategical issues, related to the use of drones. The numerical results, collected on instances generated to be very close to reality, show that the use of drones is not economically convenient in the classical terms. However, when considering negative externalities related to the use of classical vehicles and quality of service requirements, the benefit of using drones becomes relevant.

Keywords: Vehicle routing problem, time windows, drone, last-mile delivery

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROUT2.3

Traveling Salesman Problem with Drone: Computational Approaches

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Abstract. The traveling salesman problem with a drone (TSPD) is a hybrid delivery model using both a truck and a drone. The truck can make a delivery directly, or a drone can launch from the top of the truck to make a delivery then return to the truck. The objective is to deliver all packages and minimize the time until the truck and drone return to the origin depot. The truck and drone may utilize different distance metrics. While the drone is in flight, the truck may continue making deliveries. The drone may deliver only one package while in the air, before it must return to the truck. The drone may remain in the air for a finite amount of time before it must return to the truck. However, the drone is able to instantly swap batteries after returning to the truck. Each package may be marked as "truck only delivery," if drone delivery is infeasible due to legal restrictions, obstacles around the delivery site, high package weight, etc. We also assume that all drone launches or landings must occur at a customer location. We may also specify some overhead time for each drone launch. Past exact computational methods have been intractable for problem sizes of more than 10 packages. Our method is capable of solving the TSPD exactly for instances up to 40 packages in a reasonable time. If we add one small heuristic assumption to our method, computational speed increases very significantly. Testing on many small instances indicates our heuristic produces objective values that are very near the exact solution method, thus, our heuristic solutions are very near optimal. Computational results for various parameters (drone speed, battery life, number of packages, etc.) will be presented. Finally, we note that with some minor modification, this method may be extended to other problems including the traveling repairman problem with a drone, which minimizes the sum of waiting times, and a variant of TSPD which allows for drone releases and landings anywhere along the truck's path (not restricted to only customer locations).

Keywords: UAV, Traveling Salesman, Vehicle Routing

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ROUT2.4

Target-visitation arc-routing problems

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Abstract. Target Visitation Problems (TVPs) (see, for instance, Grundel, and Jeffcoat, 2004 and Hildenbrandt and Reinelt, 2015), combine routing and linear ordering problems (Martí and Reinelt, 2011). Feasible solutions are tours that visit a given set of targets. The objective aims at balancing two different criteria: the preferences for the order in which the targets are visited and the routing costs of the tours. In this work we introduce Target-Visitation Arc-Routing Problems (TV-ARPs), in which the targets are some of the arcs of a given network. To the best of our knowledge TVPs have not yet been addressed in the context of arc-routing. We discuss potential applications for this type of problems and propose two alternative models with different modeling hypothesis. In the first one it is imposed that all the targets in the same connected component are visited consecutively, whereas in the second model the sequence defining the order in which targets are visited may alternate among targets in different components. Mathematical programming formulations are presented for each case together with families of valid inequalities that reinforce their Linear Programming Relaxation. Numerical results from preliminary computational experiments are presented and analyzed.

Keywords: Target Visitation, Linear Ordering, Arc Routing

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Routing 3

Chairman: G. Hasle

ROUT3.1

A mesoscopic approach to model route choice in emergency conditions

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Abstract In this paper, a dynamic approach to simulate users' behaviour when a hazardous event occurs in a transport network is proposed. Particularly, a route choice model within a mesoscopic dynamic traffic assignment framework is described, assuming that users can acquire information on the network status in real time. The effects of the event are taken into consideration by introducing a risk factor in arc cost function in order to allow en-route changes in users' path choice decisions. The proposed approach is tested on a trial network, highlighting the evolution of changes in path choice caused by a hazardous event that modifies supply conditions.

Keywords: Path choice, Evacuation, Dynamic Traffic Assignment

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROUT3.2

A Scenario Planning Approach for Shelter Location and Evacuation Routing

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Abstract. Emergency planning operations are one of the key aspects of Disaster Operations Management (DOM) [1]. This work presents a scenario-based location-allocation-routing model to optimize evacuation planning decisions, including where to establish shelter sites and which routes to arrange to reach them, across different network disruption scenarios. The model considers both supported-evacuation and self-evacuation. The objective is to minimize the duration of the supported-evacuation while guaranteeing that the routes of self-evacuees do not exceed a given traveling time threshold. Both shelter location and routing decisions are optimized so as to identify solutions which perform well across different disruption scenarios. A mathematical formulation of this model is provided, which can be solved through a general-purpose solver optimization package for modest size instances. Some computational results are reported.

Keywords: Disaster Management, Evacuation Planning, Shelter Location

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The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROUT3.3

A solution approach for the green vehicle routing problem

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Abstract. In response to the noxious impact of climate change, green vehicle routing has emerged as an active area of research that is concerned with the development and analysis of distribution activities of alternative energy powered vehicles, with an emphasis on eco-friendly objectives. In this context, we propose a practical solution approach for the Green Vehicle Routing Problem (GVRP). This problem requires designing a set of routes for a homogeneous fleet of environment-friendly vehicles, such as plug-in hybrid electric, electric and alternative-fuel powered vehicles. Toward this end, we propose to solve the GVRP using a mixed-integer linear programming formulation together with a preprocessing reduction procedure. The newly derived formulation offers two significant advantages. First, it includes a polynomial number of variables and constraints and can thereby be directly solved using a general-purpose solver. Second, it is flexible and can accommodate many variants of green vehicle routing problems. We provide empirical evidence that attests to the efficacy of the proposed formulation for solving medium-sized instances, and we show that it consistently outperforms a state-of-the-art branch-and-cut algorithm. Hence, the proposed exact approach constitutes an appealing, simple, and practical alternative for optimally solving medium-sized green vehicle routing problems.

Keywords: Green Vehicle routing problem, Reformulation-Linearization-Technique, preprocessing procedures.

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ROUT3.4

Optimal paths for dual propulsion vehicles on real street network graphs

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Abstract. There are several examples of dual propulsion vehicles: hybrid cars, bifuel vehicles, electric bikes. Compute a path from a starting point to a destination for these typologies of vehicles requires evaluation of many alternatives. In this paper we develop a mathematical model, able to compute paths for dual propulsion vehicles, that takes in account the power consumption of the two propulsors, the different types of charging, the exchange of energy and, last but not least, the total cost of the path. We focus our attention on electric bikes and we perform several experiments on real street network graph. In our tests we took into account the slope of roads, the recharge in downhill streets and the effort of the cyclist. To validate the model we performed computational tests on properly generated instances set. This set of instances is composed of graphs representing real cities of all around the world. The computational tests show the effectiveness of our approach and its applicability on a real street network.

Keywords: graphs, shortest path, mathematical model, bi-fuel vehicles,electric bikes

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

ROUT3.5

Assessing the carbon emission effects of consolidating shipments

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Abstract. This paper studies the effect on carbon emissions of consolidation of shipments on trucks. By utilizing existing vehicle capacity better, one can reduce distance and thereby carbon emission reductions. Our analysis determines the emission savings obtained by a transport provider that receives customer orders for outbound deliveries as well as pickup orders from supply locations. The transport provider can improve the utilization of vehicles by performing the pickups and deliveries jointly instead of using separate trucks. We compare a basic setup, in which pickups and deliveries are segregated and performed with separate vehicles, with two consolidation setups: backhauling and mixing. We assume that the transport provider minimizes costs by use of a vehicle routing tool, and use a set of test instances derived from a standard VRP benchmark and an industrial solver to generate routing plans for the three setups. To compare carbon emissions, we use a carbon assessment method that uses the distance driven and the average load factor. We find that emission savings are relatively large in case of small vehicles and for delivery and pickup locations that are relatively far from the depot. However, if a truck visits many demand and supply locations before returning to the depot, we observe negligible carbon emission decreases or even emission increases for consolidation setups, meaning that in such cases investing in consolidation through combining pickups and deliveries may not be effective.

Keywords: Pickup and Delivery, Consolidation, Carbon emissions

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Routing 4
Invited Session

Chairman: E. Guerriero

ROUT4.1 *Vehicle assignment in site-dependent vehicle routing problems with split deliveries*
M. Batsyn

ROUT4.2 *Exact and heuristic algorithms for the Traveling Salesman Problem with time-dependent service times*
C. Contreras-Bolton, V. Cacchiani, P. Toth

ROUT4.3 *A GRASP with set partitioning for time dependent vehicle routing problems*
S. Mancini

ROUT4.4 *A Branch-and-Bound algorithm for the time-dependent Chinese postman problem*
E. Guerriero, T. Calogiuri, G. Ghiani, R. Mansini

ROUT4.1

Vehicle Assignment in Site-Dependent Vehicle Routing Problems with Split Deliveries

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Abstract. In this talk we consider the problem of vehicle assignment in heterogeneous fleet site-dependent Vehicle Routing Problems (VRP) with split deliveries. In such VRP problems vehicles can have different capacities, fixed and travel costs, and site-dependent constraints limit for every customer a set of vehicles, which can serve it. The Vehicle Assignment Problem (VAP) arises in heuristic and exact algorithms, when a vehicle is selected for the current route or vehicles are assigned to all currently constructed routes. The VAP objective is to minimize the total assignment cost while the cost of assigning a certain vehicle to a certain customer or a certain route is computed in some heuristic way. Without split deliveries, when a delivery to a customer cannot be split between two vehicles or more, the VAP problem is equivalent to the variable cost and size Bin Packing Problem with additional constraints determining for every item a set of bins to which it can be placed. We show that allowing split deliveries make the VAP problem polynomial, because in this case it can be reduced to the Transportation Problem. We also consider a special case, which is not rare in practice, when customers could be partitioned into classes, such that all customers in a class has the same set of vehicles, which can serve them, and these vehicle sets for different customer classes form a sequence of nested sets. We show that in this case if the cost per demand unit of assigning a vehicle to a customer depends only on the vehicle and does not depend on the customer, then the VAP problem can be solved by a linear algorithm.

Keywords: Vehicle assignment, Site-dependent, Split deliveries

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ROUT4.2

Exact and heuristic algorithms for the Traveling Salesman Problem with Time-dependent Service Times

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Abstract. We consider the Traveling Salesman Problem with time-dependent Service Times (TSPST), a variant of the classical Asymmetric TSP (ATSP) (Roberti and Toth, 2012). As in the ATSP, we are given a directed complete graph, and each arc is assigned a cost representing the corresponding travel time. In the TSPST, each customer also requires a service time, whose duration depends on the time at which the customer is visited. The TSPST calls for finding a Hamiltonian circuit such that the total duration of the circuit (i.e. the sum of the travel times and of the service times) is minimized. The TSPST is a generalization of the ATSP (arising when the services times of the customers have constant values) hence it is NP-hard. In Taş et al., (2016), "compact" Mixed Integer Programming (MIP) formulations, using a polynomial number of constraints, are proposed. We strengthen the MIP models by considering exponential-size formulations that explicitly incorporate subtour elimination constraints and by introducing additional valid inequalities. An exact branch-and-cut algorithm and a metaheuristic are also proposed. Extensive computational experiments on benchmark TSPST instances are reported, showing the effectiveness of the proposed algorithms.

Keywords: TSP, branch and cut algorithm, metaheuristic

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ROUT4.3

A GRASP with Set Partitioning for Time Dependent Vehicle Routing Problems

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Abstract. Vehicle Routing Problems (VRP) have been broadly addressed in literature but the largest part of the works consider constant travel times. This strong simplification does not allow to properly represent real world problems. In fact, nowadays, travel times sensibly change across the day, due to traffic congestion. Hence, to actually represent the reality, it is necessary to consider time dependent travel times. In this work, a GRASP with Set Partitioning to solve Time Dependent Vehicle Routing Problems, (TDVRPs), is proposed. This metaheuristic is composed by two phases. In the first one, A Greedy Randomized Adaptive Search Procedure, (GRASP), in which congestion level impact on travel times is considered, is exploited to generate several solutions. The routes belonging to the solutions generated in the first phase are then used, in the second phase, as columns in a Set Partitioning formulation. The main advantage of this method is its extreme versatility and portability. In fact, it can be adopted to address several extensions of the TDVRP, such as TDVRP with Time Windows, Multi Depot TDVRP, TDVRP with route duration constraints, and, more generally, all problems dealing with time dependent travel times. Computational results, carried out on the TDVRP with maximum route duration constraint, show the efficiency of the effectiveness of the proposed. A comparison with results obtained applying the same metaheuristics, but discarding the travel times time dependency, has been carried out to put in evidence the importance of considering travel time fluctuations when planning the vehicle routing and scheduling.

Keywords: Time-Dependent Vehicle Routing, GRASP, Set Partitioning

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ROUT4.4

A Branch-and-Bound Algorithm for the Time-Dependent Chinese Postman Problem

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Abstract. Given a graph whose arc traversal times vary over time, the Time-Dependent Chinese Postman Problem consists in finding a tour traversing each arc at least once such that the total travel time is minimized. In the literature, the conventional Chinese Postman Problems defined on the Euler graph are polynomially solvable. However, the Chinese Postman Problem defined on the time dependent network is NP-Hard even if it verifies the Eulerian and First-In-First-Out properties. In this paper we exploit some properties of the problem and develop a branch-and-bound algorithm. We demonstrate the efficiency and applicability of the proposed approach by solving instances of increasing complexity.

Keywords: chinese postman problem, time dependence, branch-and-bound

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Scheduling 1

Chairman: M. Dell'Amico

SCHED1.1 *Developing an integrated timetabling and vehicle scheduling algorithm in urban public transport*
S. Carosi, L. Girardi, B. Pratelli, G. Vallese, A. Frangioni

SCHED1.2 *A simultaneous slot allocation on a network of airports*
L. Castelli, T. Bolić, P. Pellegrini, Raffaele Pesenti

SCHED1.3 *Decomposition and feasibility restoration for cascaded reservoir management*
C. D'Ambrosio, W. van Ackooij, R. Taktak

SCHED1.4 *Enhanced arc-flow formulations to minimize weighted completion time on identical parallel machines*
M. Dell'Amico, A. Kramer, M. Iori

SCHED1.1

Developing an Integrated Timetabling and Vehicle Scheduling Algorithm in Urban Public Transport

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Abstract. In the last few years, M.A.I.O.R. has developed, with the aid of the Computer Science Department of the University of Pisa, a Time Table Design algorithm that allows a public transport company to ensure the desired regularity of service and to minimize the required number of vehicles, at the same time. The corresponding mathematical model shows two clearly distinct components, the Timetable and the Vehicle Scheduling, with linking constraints ensuring compatibility between the two aspects. Hence, a natural solution approach is to perform a Lagrangian relaxation of the linking constraints and to iteratively construct the integer solution by alternating the solution of the corresponding Lagrangian Dual (in particular, with a method from the Bundle family) and fixing variables. To increase the applicability of the approach in practice, the base model has been recently extended to consider specific structures of the vehicle blocks, such as

- having one or more service breaks in specific time intervals to allow drivers to have meals;
- having the vehicle pass at a specific location at defined intervals to allow drivers exchange.

Those changes have significantly increased the complexity of the model, requiring significant improvements in the solution approach. We describe several strategies that have been explored, among which new ways to choose the variables to fix, improvements to the Bundle method used to solve the Lagrangian Dual, and use of alternative continuous solvers like simplex and barrier methods, as well as their overall impact on the efficiency and effectiveness of the approach.

Keywords: Time table design, Bundle methods, Scheduling

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SCHED1.2

A simultaneous slot allocation on a network of airports

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Abstract. This work shows the benefits of optimally coordinating the capacity management of airports by simultaneously allocating slots in all the European coordinated and schedule facilitated airports. This is achieved through SOSTA, an integer linear programming formulation that reproduces the current regulations and best practices, and minimizes the number of missed allocations and the total schedule displacement cost, in lexicographic order. It could be used to partially replace and shorten the current (lengthy) slot allocation process. We present the results using SOSTA to allocate the slots requested for the busiest day of year 2013 in 186 European airports. The model comprises about 145000 binary variables and 243000 constraints, and exploits real data both for airport capacities and airspace users' slot requests. First, we validate the model by comparing SOSTA's with the currently implemented allocation: the difference is only 6 slots out of the 32665 slots requested in the test day. Second, we test SOSTA's behavior when a significant imbalance between demand and capacity exists to assess the impact of possible regulation changes. Specifically, we compare SOSTA's and the optimal allocation under the current rules assuming a uniform 20% reduction of airport capacity across Europe. Results show that the simultaneous slot allocation at all airports significantly outperforms the current allocation process: the number of missed allocations decreases by 67% and the total displacement cost remains almost unchanged.

Keywords: Airport slot allocation; air transport; capacity-demand imbalances

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SCHED1.3

Decomposition and feasibility restoration for cascaded reservoir management

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Abstract. We consider the Unit Commitment subproblem dedicated to hydro valley management, also known as Hydro Unit Commitment Problem (HUCP). The problem consists in finding an optimal hydro schedule for hydro valleys composed of head-dependent reservoirs for a short term period in which the electricity prices and the inflows are forecasted. We propose a Mixed Integer Linear Programming (MILP) formulation for the problem. Then, we solve it using a Lagrangian relaxation based decomposition combined with local branching used to restore feasibility. Preliminary computations show promising results.

Keywords: Hydro unit commitment, decomposition, local branching

Acknowledgements. This research benefited from the support of the FMJH Program Gaspard Monge in optimization and operation research and from the support to this program from EdF.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

SCHED1.4

Enhanced arc-flow formulations to minimize weighted completion time on identical parallel machines

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Abstract. We are given a set $J = \{1, \ldots, n\}$ of n jobs to be scheduled without preemption on a set $M = \{1, \ldots, m\}$ of m identical parallel machines. Each job j in J has a processing time p_j and a penalty weight w_j . Let C_j define the completion time of job j in a schedule. Our goal is to find a schedule for which the total weighted completion time, $\Sigma_{j=1,\ldots,n} w_j C$, is a minimum. Following the well known three-field classification, this problem is denoted as $P||\Sigma w_j C_j$ and was proven to be *NP*-hard. Despite being a classical production scheduling problem, with many real-world applications, the $P||\Sigma w_j C_j$ has not received much attention in the last years and cannot be considered a well solved problem. To the best of our knowledge, the main exact methods proposed in the literature for the $P||\Sigma w_j C_j$ are the branch-and-bound algorithms developed by [1], [2] and [5], where the last two works made use of column generation techniques. Aside from these works, the *mixed integer linear programming* (MILP) formulation proposed originally for single machine scheduling problems by [4] and the *convex integer quadratic programming* (CIQP) formulation proposed by [3] for the case of unrelated parallel machines ($R||\Sigma w_j C_j$) can be adapted to handle the $P||\Sigma w_j C_j$. In this paper, we solve exactly large-size instances of the $P||\Sigma w_j C_j$, by focusing on the development of enhanced *Arc-flow* (AF) formulations. These formulations represent the problem as a capacitated network with side constraints, and make use of a MILP model with a pseudo-polynomial number of variables and constraints.

Keywords: parallel machines, arc-flow formulation, production scheduling.

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Scheduling 2

Chairman: F. Rossi

SCHED2.1 *Practical solution to parallel machine scheduling problems*
E. Parra

SCHED2.2 *An optimization model for the outbound truck scheduling problem at cross-docking platforms*
A. Diglio, C. Piccolo, A. Genovese

SCHED2.3 *Minimizing total completion time in the two-machine no-idle no-wait flow shop problem*
F. Salassa, F. Della Croce, A. Grosso

SCHED2.4 *Shift scheduling with breaks: the cost of agents self-organization*
F. Rossi, S. Smriglio, S. Mattia, M. Servilio

SCHED2.1

Practical solution to parallel machine scheduling problems

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Abstract. Parallel machine scheduling problems, even medium-sized ones, are very time consuming. The time taken to find a solution is very often more important than the exact solution itself. Different objective optimization functions depend on the specific situation. This paper presents a mathematical model and the software to implement it. The model allows users to switch between different objective functions and select the accuracy of the solution: from the fastest solution to the most exact one. It can be used with equal or different processing times for each job in different machines.

Keywords: scheduling, parallel machines, optimization models

Acknowledgements. I would like to thank the anonymous reviewers for their valuable recommendations, which that have been considered in the final version and to Ms. Prudence Brooke-Turner for her revision of the English manuscript.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

SCHED2.2

An optimization model for the outbound truck scheduling problem at cross-docking platforms

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Abstract. A cross-dock is a facility where arriving materials are sorted, grouped and delivered to destinations, with very limited storage times, with the overall objective of optimizing the total management costs. The operational efficiency of a cross-docking system strongly depends on how the logistic activities are organized. For this reason, optimization models and methods can be very useful to improve the system performances. In this paper, we propose a mathematical model to describe the so-called truck scheduling problem at a cross-docking platform. The model considers most of the actual constraints occurring in real problems; therefore, it can be viewed as an interesting basis to define a decision support system for this kind of problems. Some preliminary results show that the model can be efficiently solved in limited computational times.

Keywords: supply chain, cross-docking, truck scheduling

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

SCHED2.3

Minimizing total completion time in the two-machine no-idle no-wait flow shop problem

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Abstract. We consider the two-machine no-idle, no-wait flow shop problem with total completion time as performance measure, namely problem F2 | no-idle, no-wait | $\sum C_j$ according to the standard three-field notation. In this problem, n jobs are available at time zero. Each job j must be processed non-preemptively on two continuously available machines M_1, M_2 with integer processing times $p_{1,j}$, $p_{2,j}$, respectively. The processing order is M_1 - M_2 for all jobs. Each machine is subject to the so-called no-idle constraint, that is it processes continuously one job at a time and operations of each job cannot overlap. Also, each job is subject to the so-called no-wait constraint, that is it must start on M_2 immediately after the completion on M_1. The objective is the minimization of the sum of completion times on the second machine. As for the relevant literature, in [1], it is mentioned that both problems F2 | no-idle | $\sum C_j$ and F2 | no-wait | $\sum C_j$ are NP-hard in the strong sense by exploiting the fact that the NP-hardness proof of problem F2 | | $\sum C_j$ in [2] was given by constructing a flow shop instance that happened to be both no-idle and no-wait. Similar consideration holds for problem F2 | no-idle, no-wait | $\sum C_j$. In [3], it is shown that minimizing the number of interruptions on the last machine is solvable in $O(n^2)$ time on two machines while it is NP-hard on three machines or more. A recent work [4] indicates that problem Fm | no-idle, no-wait | C_{max} is polynomially solvable, while problems J2 | no-idle, no-wait | C_{max} and O2 | no-idle, no-wait | C_{max} are NP-hard in the strong sense. We point out that the no-idle, no-wait constraint is very strong as it forces consecutive jobs to share common processing times, namely, any feasible solution for problem F2 | no-idle | $\sum C_j$, requires that for all j in 1,…,n-1, $p_{2,j} = p_{1,j+1}$. Correspondingly, the sum of completion times on M_2 is equal to the sum of completion times on M_1 plus a constant. We discuss several solution approaches exploiting specific properties of the problem and compare it to an exact algorithm based on a positional completion times integer programming formulation. Detailed results will be presented at the Conference.

Keywords: Two-machine flow shop, no-idle / no-wait, total completion time

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SCHED2.4

Shift scheduling with breaks: the cost of agents self-organization

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Abstract. We study the problem of including breaks in shift plans, guaranteeing to cover the required staffing levels and minimizing personnel and understaffing costs. This problem is known in the literature as the *shift scheduling problem with breaks assignm*ent. It has been addressed by considering two types of models: explicit [1, 2] and implicit models [3, 4]. Both explicit and implicit models share the same decision-making point of view: a decision maker (a manager) chooses both the plans and the breaks, whereas the agents play a little or no role in the decision process. In this talk we investigate what happens when the agents are involved in the decision process, allowing them to autonomously choose their breaks. The aim is to measure the extra cost, if any, related to the autonomous decisions of the agents. Hence, we compare two models: a manager model, where the manager assigns to the agents both a plan and a set of breaks inside the plan, and an agent model, where the manager chooses the plan, but the breaks are autonomously decided by the agents. To represent agents decisions, we consider the actual number of agents on duty in a given time slot as subjected to uncertainty, leading to a robust optimization problem. A computational experience based on real-world instances from an Italian customer care center shows that under certain conditions agents can choose their breaks time without significantly affecting the overall costs.

Keywords: Shift Scheduling, Integer Programming, Robust Optimization

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Scheduling 3

Chairman: A. Agnetis

SCHED3.1 *Preemptive scheduling of a single machine with finite states to minimize energy costs*
M. M. Aghelinejad, Y. Ouazene, A. Yalaoui

SCHED3.2 *Resource constrained scheduling for an automated picking machine*
M. Salani, L. Cerè, L. M. Gambardella

SCHED3.3 *Min-Max regret scheduling to minimize the total weight of late jobs with interval uncertainty*
M. Drwal

SCHED3.4 *The price of fairness in single machine scheduling*
A. Agnetis, B. Chen, G. Nicosia, A. Pacifici

SCHED3.1

Preemptive scheduling of a single machine with finite states to minimize energy costs

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Abstract. This paper addresses a single machine scheduling problem in which the system may switch among three different states, namely ON (needed for processing the jobs), OFF or Idle. Each state, as well as switching among the different states, consume energy. The objective is schedule n preemptive jobs to minimize the total energy costs. Time varied electricity price are considered. The complexity of this problem is investigated using a new dynamic programming approach. In this approach, a finite graph is used to model the proposed problem. The dimension (number of vertices and edges) of this graph is dependent on the total processing times and the total number of periods. Then, the optimal solution of the problem is provided by calculating the shortest path between the first node and last node representing respectively the first and the last periods. Based on the Dijkstra's algorithm complexity, we prove that the complexity of this problem, is polynomial of degree 3.

Keywords: Preemption scheduling problem, Time-dependent energy costs, Dynamic programming, Dijkstra's algorithm

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

SCHED3.2

Resource Constrained Scheduling for an Automated Picking Machine

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Abstract. We consider the planning problems related to an Automated Picking Machine (APM) as a component of a manufacturing system equipped with 2D laser or plasma cutting devices. The APM is composed of pairs of arms, equipped with picking tools (magnetic or vacuum), spanning the operating zone used to unload cut parts. Picking tools can be changed during operations. An APM features multiple and interrelated decision problems:
• Tool selection: for each part, the problem is to select the most appropriate picking tools and the optimal lifting points. We remark that each part can be picked with one or more picking tools.
• Cutting pattern sequencing: the problem asks to define the sequence of execution of each cutting pattern depending on the availability of the storage zone
• Storage planning: cut parts are stacked onto pallets or put into boxes. The problem is to define the final position of each part and the number of necessary storage elements (pallets and boxes) so that all cut parts can be stored.
• Parts sorting: the sequence of parts pickup and release is to be decided so that the overall time span in minimized.
There are two objectives: minimize the occupied storage resources and minimize the overall completion time. These two objectives are contrasting: more packed solutions save space but restrict parallel moves slowing down the overall process. We present alternative heuristic approaches to tackle the combination of such decision problems and discuss the difficulties of bringing such solutions to a market product. The problem arise from a collaboration between IDSIA and Astes4 in the context of a project financed by the swiss commission for technology and innovation (KTI - 17340.1 PFES-ES).

Keywords: Resource Constrained Scheduling, 2D Packing

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SCHED3.3

Min-Max Regret Scheduling To Minimize the Total Weight of Late Jobs With Interval Uncertainty

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Abstract. We study the single machine scheduling problem with the objective to minimize the total weight of late jobs. It is assumed that the processing times of jobs are not exactly known at the time when a complete schedule must be dispatched. Instead, only interval bounds for these parameters are given. In contrast to the stochastic optimization approach, we consider the problem of finding a robust schedule, which minimizes the maximum regret of a solution. Heuristic algorithm based on mixed-integer linear programming is presented and examined through computational experiments.

Keywords: robust optimization, mixed integer programming, uncertainty

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

SCHED3.4

The Price of Fairness in Single Machine Scheduling

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Abstract. The notion of *fairness* has been introduced to compare the utility for one agent to the others' utilities in a multi-agent (multi-decider) allocation problem. Fairness issues arise in several real-world contexts and are investigated in different research areas of mathematics, game theory and operations research. We consider this concept in a scheduling setting in which two agents share a common processing resource. Agent 1 pursues the minimisation of the sum of its jobs' completion times while Agent 2 is interested in minimising the makespan of its own jobs. We assume that every schedule implies a certain "benefit" for the agents: to this purpose, associated with a certain schedule, we formalize a measure of the *utility* for each of the two agents. We adopt the sum of the agents' utilities as an index of collective satisfaction (*system utility*) and refer to any solution maximizing the system utility as a *system optimum*. Depending on the specific problem setting and also on the agent perception of what a fair solution is, assorted definitions of fair solution can be found in the scientific literature. In this work we consider different types of fair solutions and aim at characterizing the so-called *price of fairness* (PoF). PoF is a standard indicator of the system efficiency loss when a fair solution is implemented and it is given by the relative loss of utility of a fair solution compared to the system optimum, in a worst-case sense.

Keywords: Multi-Agent Scheduling, Price of Fairness.

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CORE European Supply Chain Project
Invited Session

Chairman: C. Mannino

SCPRO.1 *Integrated planning for multimodal networks with stochastic demand and customer service requirements*
J. Wagenaar, I. Fragkos, R. Zuidwijk

SCPRO.2 *Integrating railway timetabling with locomotive assignment and routing*
J. Elomari, M. Bohlin, M. Joborn

SCPRO.3 *A heuristic approach supporting automated train ordering and re-scheduling*
C. Becker

SCPRO.4 *Real-time train dispatching on the iron ore line*
L. Bach, O. Kloster, C. Mannino

SCPRO.1

Integrated planning for multimodal networks with stochastic demand and customer service requirements

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Abstract. Multimodal networks utilize multiple modes of transportation to carry freight from its origin to its destination. Although such networks are more cost efficient than their single-mode counterparts, planning their operations is far more challenging: resource requirements have to be requested in advance and to be coordinated across several modes of transport. Motivated by the planning operations of a rail transport provider in the Netherlands, we formulate the integrated planning operations of multimodal systems, having rail as the main mode of transport, taking into account customer service level requirements. We integrate strategic, tactical and operational decisions to a single framework, which, on its original form, is intractable. By utilizing a careful reformulation, we devise three custom decomposition heuristics and lower bounding procedures. Our computational experiments demonstrate that good solutions for realistic, large-scale instances can be obtained within reasonable time limits.

SCPRO.2

Integrating Railway Timetabling with Locomotive Assignment and Routing

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Abstract. In railway tactical planning, several problems are often solved sequentially where the solution of one problem serves as an input to another, for example: timetabling, platform assignment, locomotive assignment, and locomotive routing. Often so, a solution of an upstream problem may cause a downstream problem to become infeasible, in which case the planner iteratively revisits both problems to find a feasible compromise. Integrating the problems into a single mathematical model helps overcome such situations, but it is challenging due to the model size; for example, Caprara et al. (2006) considered timetabling with a simplified version of station capacity of a real-life Italian railways case; a constraint that is usually discarded. Optimal solutions were hard to obtain, but feasible ones were found heuristically and satisfied the capacity requirements. More importantly, such solutions showed a decrease of 9% in profit and an increase of 15% in service cancelation, compared to the model that assumed infinite capacity (i.e. solutions were more realistic to apply). Motivated by a real-life case in the iron ore corridor along Sweden and Norway, we propose integrating the locomotive assignment and routing problems with timetabling under station capacity restrictions. Within our scope, locomotive assignment is the determination of engine profiles required to transport cargo from one point to the other, and station capacity is the number of tracks available and their lengths. We will use binary-encoding to reduce the number of binary variables needed to model disjunctive constraints in the integrated model; hence, enabling standard solvers to find high quality solutions for larger instances, without having to customize, or redesign, the search algorithm.

Keywords: Railway timetabling, locomotive scheduling, optimization

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SCPRO.3

A heuristic approach supporting automated train ordering and re-scheduling

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Abstract. One of the main features of HaCon's software product TPS, is to provide train planners with the means to efficiently build a timetable. One corner stone is the tool FindSlot. Bane NOR (Norway) is already using FindSlot to fit a train into an existing timetable. Other trains, temporary infrastructure restrictions and station or line closing hours might complicate this task. Traditionally, a planner would analyze the train, i.e. by looking into a train graph and tweaking the train. Now, the tweaking can be replaced by running FindSlot. Thus, the planner can concentrate on choosing the best of several potential solutions. Currently, we are also adapting FindSlot to simplify the ordering process for new trains. In this scenario, that we are developing for Trafikverket (Sweden), FindSlot is reviewing orders fully automatically to reject orders that have no chance of success without any planner interaction. The ordering user is provided with information to improve the request. In our presentation we will give an overview about the work flows FindSlot is part of and the challenges that result from that. Finally we will take a look into the techniques used by FindSlot to meet these challenges and we will demonstrate FindSlot's capabilities with real world examples and give an outlook over future challenges.

Keywords: train planning, ordering, decision support systems, re-scheduling

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SCPRO.4

Real-Time Train Dispatching on the Iron Ore line

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Abstract. On a congested critical railway corridor, the iron Ore line between Narvik (Norway) and Lluleå (Sweden), we investigate if optimized train dispatching can increase the capacity of the corridor such that more trains can be operated while reducing delays. This is achieved by applying an exact mathematical model as real-time decision support to the dispatchers, given a railway infrastructure and its status, a set of trains and their current position, we find a route for every train from its current position to the destination and a disposition timetable to minimize the cost function. The (exact) solution algorithm is based on logic Benders' decomposition, and resembles the behaviour of human dispatchers. The system is expected to provide several important benefits, in terms of greater punctuality, increased capacity, and better coordination between the different "shores" of the line, in Sweden and Norway.

Keywords: Train Scheduling, Benders' decomposition, Integer Programming.

OR Spin Off Session
Invited Session

Chairman: L. Palagi

SPIN.1 *Operations Research startup experiences from Florence University*
G. Cocchi, F. Schoen

SPIN.2 *M.A.I.O.R.: Optimization algorithms for public transport*
L. Girardi, S. Carosi, B. Pratelli, A. Frangioni

SPIN.3 *Optit srl, spin-off from the University of Bologna*
M. Pozzi, C. Caremi, D. Vigo

SPIN.4 *ACTOR srl, Spinoff of Sapienza University of Rome*
G. Di Pillo

SPIN.1

Operations Research startup experiences from Florence University

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Abstract. In this talk I will present some recent experiences in innovative startup initiatives born from the Global Optimization Laboratory at the University of Florence. The first startup specialized in the solution of vehicle routing problems; it has now become part of one of the largest companies in the world devoted to ICT. The second, more recent one, has just started its activity in the field of demand planning. In this talk I will briefly outline some of the key factors behind the success of the first startup, and which, hopefully, will lead to an analogous success the new one too.

SPIN.2

M.A.I.O.R.: Optimization algorithms for Public Transport

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Abstract. M.A.I.O.R. (Management, Artificial Intelligence & Operations Research) was established in 1989, stemming from the Operations Research Group of the University of Pisa. M.A.I.O.R. mission is to provide services and advanced software systems to satisfy the different needs of Public Transport Authorities and Operators for regulating, designing, managing and operating Public Transport Systems. M.A.I.O.R. business model was grounded in the belief that significant improvements in efficiency and service quality were possible by applying the right mix of tools from Computer Science and Operations Research, exploiting advanced algorithmic techniques and a detailed knowledge of the specific systems to be optimized. This was considered not particularly urgent by the publicly owned Public Transport Operators of the time, but it has been proven the right approach over time, and the only way to achieve the necessary service quality that is the essential driver for the competitiveness of public local transport companies in today's economically challenging scenario. M.A.I.O.R. now offers an integrated software system, covering from design of the service network to drafting of timetables, from optimization of vehicle-blocks and driver-duties up to rosters. Operations Research algorithms are deeply embedded inside the software suite, and represent one of the most relevant line of investments. A software house like M.A.I.O.R. has to keep aligned with the state of art of technology, which requires constant and structured cooperation with academic research; our next goal is dealing with real-time service disruptions and subsequent re-optimization. As a result of the labor and enthusiasm of its employees, M.A.I.O.R. is today the Italian market leader in its segment, and actively expanding abroad.

Keywords: Public Transport, Integrated System, Real-time Optimization

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SPIN.3

Optit srl, spin-off from the University of Bologna

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Abstract. Optit srl is an accredited spin-off company of the Operations Research Group of the Alma Mater Università di Bologna. Founded in 2007 by Prof. Daniele Vigo, the company has gradually evolved its business model, from "product company" in the waste logistics sector, to providing a large range of predictive and prescriptive analytics services and solutions in various industries like Energy & Utilities, Logistics and Transportation, and Services. Revisiting the key steps of this process, we intend to highlight the key factors that have allowed Optit to survive the initial start-up phase (that coincided with one of the most serious economic crisis of the Western world) and set the basis for a well-recognized offering, providing stable employment to more than 20 employees (growing steadily) and a promising international outlook. Some flagship projects will also be presented shortly, to highlight how state-of-the-art OR methodologies have been applied to real life business environments, improving our customer's decision making processes at strategic, tactical and daily operations level.

Keywords: Business Model, Optimization, OR Practitioner

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SPIN.4

ACTOR srl, Spinoff of Sapienza University of Rome

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Abstract. ACTOR (Analytics, Control Technologies and Operations Research) is a R&D boutique company which supplies services based on models, methods and algorithms of control, optimization, forecasting and simulation for the design and management of complex systems. ACTOR is born as the integration of an academic component (DIAG – Sapienza) and an industrial component (ACT Solutions srl) with the aim to develop advanced applications of Operations Research. It addresses decision makers of firms and organizations with the aim to propose integrated software solutions able to attain an optimal usage of resources, greater effectiveness, reduction of costs and limitation of risks. A side activity is the development of tutorial modules based on real data sets and case studies, as support for a training not only theoretical in firms and universities. ACTOR is operating in Europe and USA. In particular at present it develops solutions of Optimal Design in Engineering, of Optimal Management in Transportation and of Optimal Forecasting in Marketing.

Keywords: academic spinoff.

Stochastic Programming
Invited Session

Chairman: F. Maggioni

STOCH.1 *Stochastic gradient method for energy and supply optimization in water systems*
J. Napolitano, G. M. Sechi, A. A. Gaivoronski

STOCH.2 *The Football Team Composition Problem: a stochastic programming approach*
G. Pantuso

STOCH.3 *A column generation-based algorithm for an inventory routing problem with stochastic demands*
D. Laganà, C. Ciancio, R. Paradiso, A. Violi

STOCH.4 *Bounding multistage stochastic programs: a scenario tree based approach*
F. Maggioni, E. Allevi

STOCH.1

Stochastic Gradient Method for Energy and Supply Optimization in Water Systems

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Abstract. In water scarcity conditions, energy saving in operation of water pumping plants and the minimization of water deficit are contrasting requirements, which should be considered when optimizing a complex water supply system. Undoubtedly, a high uncertainty level due to hydrologic input variability and water demand behavior characterizes these problems. In this paper, we provide a decision support to the water system authorities, in order to achieve a robust decision policy, minimizing the risk of wrong future decisions. Herein, it has been done through the optimization of emergency water transfer activation schedules. Hence, a *cost-risk balancing problem* has been modelled to manage this problem, balancing the damages in terms of water shortage occurrences and energy and cost requirements for emergency transfers. In Napolitano et al. (2016), we dealt with this problem using a traditional Scenario Analysis approach with a two stages stochastic programming model. The obtained results were appreciable considering a limited number of scenarios characterized by a short time horizon. Nevertheless, if we had to increase the number of considered scenarios, taking into account the effect of climate and hydrological changes, computational problems arise. Therefore, to solve this kind of difficulties, it is necessary to apply a specialized approach for the cost-risk balancing optimization under uncertainty, such as the *stochastic gradient methods* [1]. We developed a mixed simulation-optimization modelling approach using the stochastic gradient method, applying this methodology to a real multi-reservoirs and multi-users water supply system in a drought-prone area in south-Sardinia (Italy).

Keywords: Stochastic Gradient Methods, Water Pumping Schedules Optimization, Cost-Risk Balancing Problem

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STOCH.2

The Football Team Composition Problem: a Stochastic Programming Approach

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Abstract. Sports are big businesses (Fry and Ohlmann, 2012) with a market size double the size of the automotive market (DeSarbo and Madrigal, 2012). As such, sports analytics is growing in popularity. Particularly, most professional football clubs are nowadays well structured businesses and the cumulative revenue of the top 20 football clubs is estimated in Euro 6.6 billion for season 2014/15 (Deloitte, 2016). Therefore, besides the competitiveness of football teams on the field of play, the financial performance of investments in football players becomes crucial. However, the career development of football players is uncertain and influenced by many elements such as injuries, motivations, and luck. Therefore, a football club can be seen as the owner of a portfolio of risky assets. We present a mathematical model for the decision problem of investing in football players. The objective of the model is that of maximizing the expected value of the team in a given planning horizon while ensuring that the team has the required mix of skills, that competitions regulations are met, and that budged limits are respected. Tests on a case study based on the English Premier League show that the model ensures a steady growth of the value of the team, potentially improving current decisions. Furthermore, the problem includes elements of decisions-dependent uncertainty. Therefore, we introduce a new scenario tree structure for the problem which accommodates different probability distributions as well as a new formulation for the problem.

Keywords: Team Composition, Stochastic Programming, Football

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STOCH.3

A column generation-based algorithm for an inventory routing problem with stochastic demands

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Abstract. In this paper, we propose a a multistage stochastic linear program for an inventory--distribution problem in the context of the Agri-food Supply Chain management. Given a set of retailers, the problem consists of determining the amount of product to send to each retailer in each period and combine these decisions into feasible routes, considering a maximum number of available vehicles, that allow minimizing both inventory and routing costs. Fresh products can be acquired from different production plants for which a maximum production capacity and purchase price is defined. We assume that the products are affected by a high perishability that is tackled through age-dependent inventory levels of the products. The demand of each retailer is unknown and it varies according to a given probability distribution. The problem is addressed by using a branch-price-and-cut algorithm. Preliminary computational results are presented on medium size instances of the problem.

Keywords: Inventory Routing, Stochastic Programming, Column Generation

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STOCH.4

Bounding Multistage Stochastic Programs: a Scenario Tree Based Approach

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Abstract. Multistage mixed-integer stochastic programs are among the most challenging optimization problems combining stochastic programs and discrete optimization problems. Approximation techniques which provide lower and upper bounds to the optimal value are very useful in practice. In this paper we present a critic summary of the results in [1] and in [2] where we consider bounds based on the assumption that a sufficiently large discretized scenario tree describing the problem uncertainty is given but is unsolvable. Bounds based on group subproblems, quality of the deterministic solution and rolling-horizon approximation will be then discussed and compared.

Keywords: Ship-berth link, Discrete Event Simulation, Demurrage Cost

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The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

Teaching OR, Mathematics and CS
Invited Session

Chairman: F. Malucelli

TEACH.1 *Learning greedy strategies at secondary schools: an active approach*
V. Lonati, D. Malchiodi, M. Monga, A. Morpurgo

TEACH.2 *From Minosse's maze to the orienteering problem*
P. Cappanera

TEACH.3 *A teaching strategy for mathematics based on problem solving and optimization. The institutional experiences made in Campania Region*
A. Sforza

TEACH.4 *Intuition and creativity: the power of game*
F. Malucelli, M. Fantinati, M. Fornasiero

TEACH.1

Learning greedy strategies at secondary schools: an active approach

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Abstract. We describe an extra-curricular learning unit for students of upper secondary schools, focused on the discovery of greedy strategies. The activity, based on the constructivistic methodology, starts by analyzing the procedure naturally arising when we aim at minimizing the total number of bills and coins used for giving change. This procedure is used as a prototype of greedy algorithms, whose strategies are formalized and subsequently applied to a more general scheduling problem with the support of an ad hoc developed software.

Keywords: CS teaching, active teaching, greedy algorithms

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

TEACH.2

From Minosse's maze to the orienteering problem

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Abstract. In this talk we report an educational experience focused on problem-solving performed in a primary school with two groups of 10-years old pupils. Once, during a philosophy for children class, their teacher asked them: "Suppose you are leaving just now to the moon. Which objects would you bring with you?" Unintentionally, the teacher posed them a knapsack problem. Thus, when one of his student (incidentally, my son!) told me the story, the idea of involve teachers and students in a puzzle-based learning project straightforwardly arose. We started to play with knapsack, assignment and orienteering problems. For this latter problem, indeed we really enjoyed ourselves with wool threads, wool balls and scissors to describe a tour acting as Teseo and Arianna in Minosse's maze!

Keywords: educational, problem-solving.

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TEACH.3

A teaching strategy for mathematics based on problem solving and optimization. The institutional experiences made in Campania Region

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Abstract. In the last years some institutions of Campania Region carried out several initiatives aimed at preparing Campania students to sustain OCSE-PISA mathematics trials [1], based on the concept of "problem solving", which is not traditionally present in Mathematics teaching. In this context the Instruction Department of Campania Region promoted two courses, the first one in 2008/09 and the second one in 2010 [2] on the logical-mathematical learning. The scope was to train mathematics teachers of Secondary School, within a deal between Public Education Ministry and Campania Region, which establishes initiatives aimed at "supporting the education of mathematics, science and technology in the school and to favor the didactic innovation". School teachers who successfully attended the course performed a final presentation on a theme related to the logical-mathematical learning and received an attendance certificate by Campania Region. More recently, in 2013, the Regional Office of Education Ministry carried out another initiative devoted to develop a project named Objective 500, with the aim to increase proficiency of the fifteen years old students of Campania in OCSE PISA test to reach the score 500. 80 schools participated to the initiative. Furthermore, the Science Center of Naples promoted the National Project LogicaMente [3], a project whose aim is to support the improvement of scientific, logic and mathematical skills of the Italian students and to help the didactic innovation, promoting and supporting the collaboration between education, science and society. Finally the University Federico II of Naples constituted a Group named "Federico II in the School" to strengthen the link between Secondary School and University.
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Keywords: Mathematics, Teaching, problem solving.

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TEACH.4

Intuition and creativity: the power of game

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Abstract. The approach to mathematics by the students of schools at all levels is often critical and may end up to hostile or passive behaviors. This is often due to initial negative experiences causing prejudices with respect to this discipline that are hard to recover. In this paper we report on several experiences that we carried out from elementary schools and to high schools in Italy. During these experiences we introduced a series of games during the classes of Mathematics, and in certain cases also of Italian literature, with the intent of stimulating the creativity and empower the students. We have used simple materials to stimulate the observation and to trigger the intuition and the creative process, and applied the *Puzzle Based Learning* technique. Some of these ideas have been applied also to the basic course of Operations Research at the Politecnico of Milan, despite the limited time available. Although the experience carried out in the schools has been quite restricted in time, the outcomes have been extremely positive both from the qualitative and quantitative point of view.

Keywords: Teaching, creativity, intuition.

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Transportation Planning 1
PRIN SPORT Project Invited Session

Chairman: W. Ukovich

TP1.1 *Towards the physical internet paradigm: a model for transportation planning in complex intermodal networks with empty returns optimization*
M. Paolucci, C. Caballini, S.Sacone

TP1.2 *Scheduling ships and tugs within a harbour: the Port of Venice*
R. Pesenti, G. di Tollo, P. Pellegrini

TP1.3 *A flexible platform for intermodal transportation and integrated logistics*
M. P. Fanti, G. Iacobellis, A. M. Mangini, I. Precchiazzi, S. Mininel, G. Stecco, W. Ukovich

TP1.4 *Recent topics in cooperative logistics*
W. Ukovich, S. Carciotti, M. Cipriano, K. Ivanic, S. Leiter, S. Mininel, M. Nolich, G. Stecco, M. P. Fanti, G. Iacobellis, A. M. Mangini

TP1.1

Towards the Physical Internet Paradigm: a model for transportation planning in complex intermodal networks with empty returns optimization

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Abstract. The idea of Physical Internet (PI) is envisioned to completely change the way of producing and transporting goods around the planet. PI would mimic the way information is packaged, distributed and stored in the virtual world to improve real world logistics. Accordingly, representing the virtual data transmission, freight travels from hub to hub in an open network rather than from origin to destination directly. Cargo is routed automatically and, at each segment, is bundled for efficiency. This indeed requires the building of a new network topology and assessment of the benefits it could generate in terms of carbon footprint, throughput times, cost reductions, including the socio-economic aspects. In this paper an intermodal transportation network devoted to the PI paradigm is designed, modeled and implemented. More specifically, the problem deals with groupage transportation, including consolidation and deconsolidation centers in the network nodes where goods are loaded/unloaded in/out from containers. The first and last mile transport (i.e. local transport) to/from consolidation/deconsolidation centers is performed with small trucks, while the distance between consolidation centers may be covered in three different ways: (i) by using long distance road transport, (ii) by adopting short-distance trucks that exchange containers in specific road transit nodes, and (iii) by using an intermodal transport composed of a rail and a road segment. Transportation activities are planned by managing in different ways the capacities of the various transportation modes involved: the local and short-distance transport are characterized by a capacity in a certain time period; the long-distance road transport is managed by also considering the return of trucks to their starting nodes, so to minimize the number of empty trips. Finally, the capacity of rail transport is provided by train schedules. A mixed integer programming (MIP) model for a transportation network which includes the above mentioned characteristics is presented; such model can be the basis for a rolling horizon planning approach aiming at introducing the fundamental concepts of resilience and vulnerability in the arcs and nodes of the network. The results obtained by a preliminary experimental analysis with the proposed MIP model will be presented and discussed.

Keywords: Physical Internet, Intermodal Network, Empty return, MIP optimization

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TP1.2

Scheduling ships and tugs within a harbour: the Port of Venice

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Abstract. In this work we consider the problem of scheduling both ships' and tugs' movements in a congested canal harbour. This work is motivated by the new mobile gates at the inlets of the Venice lagoon and the new previous environmental laws issued in response of the Costa Concordia wreckage in 2012 that have forced the Port Authority of Venice to rethink the harbour activities. We initially introduce the problem and we present its commonalities and differences with train scheduling and timetabling problems along single-track networks. Then, we present an integer linear programming formulation, inspired on the RECIFE-MILP algorithm for train scheduling, that reproduces the current regulations and best practices, and minimizes the total schedule displacement and the tugs' movement costs in lexicographic order. Finally, we discuss the issues arising in the practical application of the model. In particular, we first deal with the use of AIS data transmitted by the vessel for the model validation. Then, we deal with the problem of automatically updating the model to respond to the continuous change of the navigation rules fixed by the Harbour Portmaster due to the changes in the infrastructure of the harbour, of the weather and marine conditions or the occurrence of particular activities.

Keywords: Ship scheduling; Port management; RECIFE-MILP

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TP1.3

A Flexible Platform for Intermodal Transportation and Integrated Logistics

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Abstract. Intermodal transportation and integrated logistics are characterized by the use of different transportation modes carrying goods in the same loading unit or vehicle. Today, new technological solutions are creating a new business reality for Intermodal Transport Network (ITN): the actors create, use, and interact with multiple types of content, data, and digital resources via Web (Fanti et al. 2014, Fanti et al 2017). In the industrial world, the diffusion of ICT allows radically re-organizing the supply chain production in an integrated way: design, job organization, product control, marketing and sales, customer relationship and the next maintenance can be managed and monitored in real time through clusters for Internet of Things (IoT). In addition, the implementation of IoT in logistic services is needed for increasing competitiveness leading to the establishment of the so-called "smart logistic transport" by passive and active RFID, personal communication, Wireless Bus, Wi-fi, RMLP, PLC, cellular networks (Prasse et al.2014).This contribution focuses on the design of a new ICT platform, able to achieve a cloud based cooperative logistics ecosystem. More in detail, the platform is proposed as a user-configurable and secure intelligent dashboard, where information flows, which are provided by multiple sources, can be collected, organized, connected, manipulated and used depending on the role of the logistics and supply chain actors. Through the intelligent dashboard, each actor in the supply chain can easily deliver its information to existing and potential customers and obtain the needed information. The platform is designed in the framework of the H2020 project AEOLIX -Architecture for EurOpean Logistics Information Exchange (Programme available at https://aeolix.eu/).

Keywords: Intermodal Transportation Systems, ICT, Logistic Platform.

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TP1.4

Recent topics in cooperative logistics

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Abstract. This contribution presents an updated review of the projects on cooperative logistics in which the Operations Research Group (ORTS) of the University of Trieste (UNITS) was involved. CO-GISTICS is the first European project fully dedicated to the development of Intelligent Transport Systems (C-ITS) focused on logistic. Five cooperative services are deployed in seven European logistics hubs; Aran, Bordeaux, Bilbao, Frankfurt, Thessaloniki, Trieste and Vigo. The Trieste pilot site addresses stakeholders` requirements by promoting the development of ICT system enabling information exchange and decision-making support. AEOLIX provides a comprehensive architecture for a digitally secure and regulated logistics services and information sharing platform. The AEOLIX Platform represents a critical step forward for supply chain visibility and interoperability through the decentralisation of information sharing. Trieste is one of the eleven Living Labs in AEOLIX.
ASMARA develops an ICT system (DSS) to deal with the flows management (vehicles and people) in the port areas. ASMARA aim is to connect port and city including data from different systems and logistics ITC platforms. The objective of SPORT is to devise innovative and smart methodologies to design, im-plement, test and assess on the field an integrated and modular set of software elements able to provide a concrete support to the port logistics operators for the management of the intermodal activities.

Keywords: logistics, intermodality, port management

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Transportation Planning 2
PRIN SPORT Project Invited Session

Chairman: E. Gorgone

TP2.1 *Best and worst values of the optimal cost of the interval transportation problem*
R. Cerulli, C. D'Ambrosio, M. Gentili

TP2.2 *Some complexity results for the minimum blocking items problem*
T. Bacci, S. Mattia, P. Ventura

TP2.3 *The forwarder planning problem in a two-echelon network*
E. Gorgone, M. Di Francesco, P. Zuddas, M. Gaudioso

TP2.1

Best and Worst Values of the Optimal Cost of the Interval Transportation Problem

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Abstract. We address the Interval Transportation Problem (ITP), that is, the transportation problem where supply and demand are uncertain and vary over given ranges. We are interested in determining the best and worst values of the optimal cost of the ITP among all the realizations of the uncertain parameters. While finding the best optimum value is an easy task, determining the worst optimum value is NP-hard and becomes polynomially solvable if the sum of the lower bounds for all the supplies is no less than the sum of the upper bounds of the demand [1]. In this paper, we prove some general properties of the best and worst optimum values from which the existing results derive as a special case. Additionally, we propose an Iterated Local Search algorithm to find a lower bound on the worst optimum value. Our algorithm is competitive compared to the existing approaches in terms of quality of the solution and in terms of computational time.

Keywords: Transportation Problem, Uncertainty, Interval Optimization

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The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

TP2.2

Some complexity results for the Minimum Blocking Items Problem

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Abstract. In this paper, we study the Minimum Blocking Items Problem (MBIP) as a generalization of the Bounded Coloring Problem for Permutation Graphs and we motivate our interest by discussing some practical applications of MBIP to the context of minimizing reshuffle operations in a container yard. Then we present some results on the computational complexity of MBIP.

Keywords: Bounded Coloring Problem, Block Relocation Problem, Complexity

Acknowledgements. This work has been partially supported byMinistry of Instruction University and Research (MIUR) with the program PRIN 2015, project “SPORT - Smart PORt Terminals”, code 2015XAPRKF, and project “Nonlinear and Combinatorial Aspects of Complex Networks”, code 2015B5F27W.

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

TP.3

The forwarder planning problem in a two-echelon network

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Abstract. This study investigates a problem faced by a forwarder in a two echelon network, where a seaport is linked to several dry ports, which are in turn connected to customers. In the seaport the loads of several customers are grouped into inbound containers. In this context, the forwarder deals with the assignment of inbound containers to satellites, and, in turn, of their loads to the vehicles used for the distribution from the selected satellites to consignees. We present a mathematical model for this problem to minimize assignment costs, while accounting for distribution costs and a balanced workload among all carriers involved in this distribution scheme. We discuss the tailored implementation of the model in a specific case study and present a heuristic based on two-stage optimization approach as a solution method to solve realistic-sized instances arising in the terminal containers of Cagliari Port. Our computational experiments confirm the viability of this method for large scale instances.

Keywords: Maritime Logistics, Combinatorial Optimization

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Recent Advances in Transportation
Invited Session

Chairman: V. Cacchiani

TRAD.1 *Boosting the resource conflict graph approach to train rescheduling with column-and-row generation*
A. Toletti, V. De Martinis, F. Corman, U. Weidmann

TRAD.2 *Optimal design and operation of an electric car sharing system*
E. Malaguti, F. Masini, D. Vigo, G. Brandstätter, M. Leitner, M. Ruthmair

TRAD.3 *System optimal routing of traffic flows with user constraints using linear programming*
M.G. Speranza, E. Angelelli, V. Morandi, M. Savelsbergh

TRAD.4 *Train timetabling and stop planning*
V. Cacchiani, P. Toth, F. Jiang

TRAD.1

Boosting the Resource Conflict Graph approach to train rescheduling with column-and-row generation

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Abstract. Previous applications of the Resource Conflict Graph formulation to train rescheduling problems proved its suitability to represent various dispatching decisions (rerouting, rescheduling, wait-depart for connecting trains, Caimi et al., 2012) as well as its flexibility with respect to the optimization's objectives (train delay, customer delay, energy efficiency, Toletti et al., 2017). The main drawback of time indexed formulations like the resource conflict graph is the dimension. To obtain satisfactory results a large number of alternative route-schedule combinations have to be modelled explicitly using binary decision variables, which dramatically increases the size of the model and, consequently, the processing time to build and solve it (cfr. results by Caimi et al., 2012). The current work presents a column-and-row generation approach which enables exploiting all dispatching degrees of freedom given by the resource conflict graph formulation and controls the model size to deliver satisfactory train rescheduling results within short times. The main idea is to start with a small subset of alternative schedules on the planned routes and iteratively add further routes, departure slots, and speed targets until a predefined stop criterion is reached. Numerical experiments on a partition of the Swiss railway infrastructure using the actual timetable and realistic delay scenarios show that the new approach is able to deliver results near to optimality in much shorter computing times than the monolithic approach (i.e. building and solving a unique huge model).

Keywords: decision support, railway traffic, train rescheduling

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TRAD.2

Optimal Design and Operation of an Electric Car Sharing System

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Abstract. We consider a car sharing system operated by electric vehicles with limited battery capacity. The vehicles are made available at renting stations, where they are also charged, and can be returned to any station in the system (two ways system). We assume that customer requests are known in advance, and hence relocation of unused vehicles can be used to satisfy the users demand by providing charged vehicles where and when needed. System design, i.e., finding optimal locations and sizes for charging stations, and day-by-day operations are modeled on a time-space network. We present compact and extended Mixed-Integer Linear Programming formulations for the problem of maximizing the value of the satisfied customers requests, given a budget constraint. The linear relaxation of the extended model is solved through column generation, and near-optimal integer solutions are obtained by fixing generated variables. Extensive computational experiments on realistic instances obtained from taxi services in Vienna are reported.

Keywords: Car-sharing, time-space network, Mixed-Integer Linear Program formulation.

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TRAD.3

System optimal routing of traffic flows with user constraints using linear programming

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Abstract. Road congestion is one of the most pressing problems in urban areas. Many vehicles, nowadays, are equipped with navigational devices that can compute a shortest route (based on user preferences) from an origin to a destination. The latest versions of these devices can also display current traffic conditions and use current traffic data on shortest route computations. Unfortunately, these devices do not consider the potential impact of the directions provided to a driver on the traffic system. As a consequence, the same route may be suggested to many users, which, if the recommended routes are followed by the users, may simply result in congestion occurring in other parts of the road network rather than a reduction in system-wide congestion or in avoiding an increase in system-wide congestion. Coordinating route guidance across the users of the system is needed to reduce congestion or, even better, to avoid congestion. In the (near) future, with the introduction of self-driving vehicles, this may become a reality. Route choice, or traffic assignment, concerns the selection of routes (alternatively called paths) between origins and destinations in transportation networks. For static traffic assignment problems, it is well-known that (1) the total travel time in a user-equilibrium solution can be substantially higher than the total travel time in a system-optimum solution, and (2) the user-experienced travel time in a system-optimum solution can be substantially higher that the user-experienced travel time in a user-equilibrium solution. By seeking system optimal traffic flows subject to user constraints, a compromise solution can be obtained that balances system and user objectives. We propose a linear programming based approach to efficiently obtain a solution that effectively balances system and user objectives. A computational study reveals that solutions with near-optimal total travel times can be found in which most users experience travel times that are better than user equilibrium travel times and few users experience travel times that are slightly worse than user-equilibrium travel times.

Keywords: Route guidance, congestion, linear programming models.

TRAD.4

Train Timetabling and Stop Planning

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Abstract. We focus on a real-world application arising in the high-speed JingHu double-track line between Beijing and Shanghai, where in 2014 more than one hundred million of passengers travelled. In this work, we study the problem of scheduling additional passenger trains to meet the increasing passenger demand. When planning the new train schedule, the existing timetable can be changed by increasing the dwelling time of some trains at some stations, stopping them at some additional stations and even skipping a few stops. The studied problem consists of a combination of Train Timetabling and Stop Planning, i.e. we have to decide the schedule of the trains as well as the stations where they will stop. This problem has been recently studied in Niu et al. (2015), Yang et al. (2016) and Yue et al. (2016), although different goals and constraints where taken into account. In particular, we explicitly consider acceleration and deceleration times instead of simply adding them to the train travel times. To solve the problem we extend a Lagrangian-based heuristic algorithm proposed in Cacchiani et al. (2010) in order to take into account stop skipping and acceleration and deceleration times. The proposed method is tested on a real-world instance of the JingHu line with more than 300 trains scheduled between 6 a.m. and midnight. The obtained results show that several additional trains can be scheduled with a small impact on the existing timetable.

Keywords: Train Timetabling, Skip-stop planning, Heuristic algorithm

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AIRO Young Session
Invited Session

Chairman: A. Santini

YOUNG.1 *Exploring the pareto optimal frontier of a bi-criteria optimization problem on 5G networks*
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YOUNG.2 *A heuristic algorithm for solving the multi-objective trajectory optimization problem in air traffic flow management*
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YOUNG.3 *Using OR + AI to predict the optimal production of offshore wind parks: a preliminary study*
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YOUNG.4 *Modelling service network design with quality targets and stochastic travel times*
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YOUNG.1

Exploring the Pareto Optimal Frontier of a Bi-Criteria Optimization Problem on 5G Networks

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Abstract. In this talk, we make a first step in a new class of network optimization problem for mobile services and in particular for forthcoming generation of 5G networks. In this context several initiatives are currently devoted to the design of 5G networks [1], which are expected to turn into reality by 2020. One of these is the definition of a *superfluid approach*, meaning that network functions and services are decomposed into reusable components, denoted as Reusable Functional Blocks (RFBs), which are deployed on top of physical nodes. By means of the RFBs it is possible to design 5G networks having key features, such as high flexibility and high performance. The problem to efficiently manage a 5G superfluid network based on RFBs also leads to mathematical programming models considering different KPIs (see [2]). Besides the technical aspects which characterize these networks, the new management issues imposes to consider two aspects simultaneously: one is related to the quality of the service: i.e. the maximization of the network flows to the customer (Throughput); the other is related to the cost of the service i.e. the number of the network nodes activated. As usually it happens in service systems, objective functions go to opposite directions, and it is hard for the service manager to find out, a priori, an adequate balance of these two criteria and the most appropriate solution depends on the parameters of the specific instance. For the above reason, it is crucial, rather than having a single efficient solution by means of scalarization techniques, to explore completely the Pareto optimal frontier of the problem. In the talk, we will present exploration techniques for generating the complete set of non-dominated solutions (see [3]) of this bi-objective mixed integer linear programming model.

Keywords: Bi-objective combinatorial optimization, 5G networks

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YOUNG.2

A heuristic algorithm for solving the multi-objective Trajectory Optimization Problem in Air Traffic Flow Management

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Abstract. The Trajectory Based Operation (TBO) concept is a cornerstone concept of the SESAR Research and Innovation Programme [1], [2]. During the pre-tactical (operational planning) and the tactical phases (flight operations), i.e. during the last 24 hours before flight departure, Trajectory Based Operations will ensure coherency between all Air Traffic Management (ATM) components. TBO will synchronize trajectories' prediction and will ensure consistency between the trajectory and constraints that originate from the various ATM components, ATM exogenous factors - e.g., constraints of geographic nature that shape the trajectory - or both. This ATFM problem has been formulated as a multi-objective integer problem with four objective functions [3]. The preferences of airspace users, in terms of alternative trajectories, and priorities for flights of the same airline are also incorporated. The several objectives of the program represent different Key Performance Indicators of interest of the stakeholders. Due to the large scale nature of the problem, the size of the formulation can be extremely large of the order of millions. Hence, we present a heuristic algorithm based on a local search routine: the algorithm finds Pareto optimal initial solutions and, by exploring the space of objectives, designs a 4D trajectory for each considered flight to obtain an approximation of the Pareto front. To achieve this, simple rerouting routines are combined with the solution of bi-objective integer problems.

Keywords: Air Traffic Flow Management, heuristic algorithm, multiobjective programming

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YOUNG.3

Using OR + AI to predict the optimal production of offshore wind parks: a preliminary study

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Abstract. In this paper we propose a new use of Machine Learning together with Mathematical Optimization. We investigate the question of whether a machine, trained on a large number of optimized solutions, can accurately estimate the value of the optimized solution for new instances. We focus on instances of a specific problem, namely, the offshore wind farm layout optimization problem. In this problem an offshore site is given, together with the wind statistics and the characteristics of the turbines that need to be built. The optimization wants to determine the optimal allocation of turbines to maximize the park power production, taking the mutual interference between turbines into account. Mixed Integer Programming models and other state-of-the-art optimization techniques, have been developed to solve this problem. Starting with a dataset of 2000+ optimized layouts found by the optimizer, we used supervised learning to estimate the production of new wind parks. Our results show that Machine Learning is able to well estimate the optimal value of offshore wind farm layout problems.

Keywords: Machine Learning, Mixed Integer Linear Programming, Wind Energy

The short paper related to this contribution will be published in ODS2017 Conference Proceedings as a special volume of the Springer series PROMS (Proceedings in Mathematics and Statistics).

YOUNG.4

Modelling Service Network Design with Quality Targets and Stochastic Travel Times

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Abstract. Service network design (SND) is one of the fundamental problems that carriers face at tactical level when planning a consolidation-based service network. Its scope is to define a transportation plan (selection and scheduling of services and determination of routing policies of freight) which satisfies an estimated demand and achieves economic and quality targets chosen by the carrier. The presence of uncertainty in the network (demand, cost, travel time, lead-time) is a critical issue to consider in the decision process to achieve the carrier's goals. We propose a stochastic - in terms of travel times – formulation for this problem. The goal is to define a cost-efficient transportation plan such that the selected services and freight arrival times at destinations adhere to, respectively, the scheduled arrival times at stops and the agreed upon time of deliveries as much as possible over time. Design and routing decisions are made before any travel time realization. We, thus, propose a two-stage stochastic linear mixed-integer programming formulation. Design and routing make up the first stage, the given targets are accounted in the second stage through a set of penalties, once travel time realizations become known (simple recourse). We present results of experiments performed on moderate-sized problem instances with the scope of investigating the characteristics and structural differences between stochastic and deterministic solutions, that is, when stochastic parameters are replaced by fixed values.

Keywords: Service Network Design, Stochastic Travel Time, 2-Stage Formulation

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YOUNG.5

Exact and Heuristic Algorithms for the Partition Colouring Problem

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Abstract. We study the Partition Colouring Problem (PCP), a generalisation of the Vertex Colouring Problem, where the vertex set is partitioned. The PCP asks to select one vertex for each cluster of the partition, in such a way that the chromatic number of the induced graph is minimum. We propose a new Integer Linear Programming formulation with an exponential number of variables. To solve this formulation to optimality, we design an effective Branch-and-Price algorithm, where new columns are generated by solving a Maximum Weight Stable Set Problem. Integer solutions are produced applying two hierarchical branching rules that assigns colours to clusters and vertices. We propose and compare several heuristic algorithms based on meta-heuristics, capable of finding excellent quality solutions in short computing time. Extensive computational experiments on a benchmark test of instances from the literature show that our Branch-and-Price algorithm, combined with the new heuristic algorithms, is able to outperform the state-of-the-art exact approaches for the PCP.

Keywords: Vertex Colouring, Partition Colouring, Selective Colouring

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Plenary Sessions

ODS2017 Parallel Sessions

This e-book contains the abstracts of the presentations at ODS2017, International Conference on Optimization and Decision Science, XLVII Annual Meeting of the Italian Operations Society, held at Hilton Conference Center, Sorrento, Italy, 4th-7th September 2017.

It provides a wide set of contribution in the wide field of optimization and decision science models and methods, and their application in the industrial and territorial system.