1^{st} EUROYoung Workshop

IMUS, University of Seville, $2^{nd} - 3^{rd}$ May 2019

Book of Abstracts

Sevilla, May 2-3

1st EUROYoung Workshop

The Organizing Committee

Lavinia Amorosi, Sapienza University of Rome, Italy

Martina Fischetti, Vattenfall, Denmark

Marina Leal, University of Seville, Spain

Moisés Rodríguez, University of Seville, Spain

Alberto Santini, Pompeu Fabra University, Spain

Plenary speakers

Ana Viana, 2OR $\vee$ $\sim$2OR? (that's the question)

Federico Perea, Exact methods for hard problems

2OR $\vee$ $\sim$2OR? (that's the question)

Ana Viana
Department of Technology and Science Associate Laboratory (INESC TEC), University of Porto;
aviana@inesctec.pt

Having been asked to give an "inspirational" talk to young researchers, and having faced this challenge as a NP-hard problem, I decided to share with the audience a couple of combinatorial optimisation problems that were/are inspirational to me and that make me definitely answer "2OR". Both problems, one in the area of healthcare and the other in logistics, address social concerns, a potential source of inspiration for many of us. In this talk (that I expect to be as interactive with the audience as possible), I will present the problems and their mathematical models, as well as problem variants. Open research avenues will also be emphasized. At the end of the talk I hope there are no shifts from "2OR" to "$\sim$2OR" within any element in the audience!

Exact methods for hard problems

Federico Perea Rojas-Marcos
Universidad Politécnica de Valencia, España;
perea@eio.upv.es

The non-polynomial complexity of some combinatorial optimization problems have provoked a great success of the research in approximate methods. Among these methods, heuristics and metaheuristics are very popular, since (if well calibrated) they are able to yield near-optimal solutions to hard problems in a reasonable amount of time. On the other hand, exact methods guarantee the optimal solution, if enough computational time is allowed. The main drawback of these methods is that the time allowed is not always enough, even to find a feasible solution! Despite this, even for hard problems, efforts in designing good exact methods should not be neglected by default. Refinements in mathematical formulations, improvements in solvers and technology, make it possible for us to find optimal solutions to problems that could not be addressed in the past. In such case: why using an approximation method, if you can guarantee the optimal solution in a short time? In this talk, we will show how standard combinatorial optimization techniques allow us to solve realistic instances of a NP-hard problem.

Tutorial sessions

Lavinia Amorosi, A practical introduction to Polyscip for multicriteria linear optimization

Mercedes Pelegrín, Symmetry Breaking in Integer Programming

A practical introduction to Polyscip for multicriteria linear optimization

Lavinia Amorosi
Department of Statistical Sciences, Sapienza University of Rome;
lavinia.amorosi@uniroma1.it

In this tutorial the main functionalities of PolySCIP ([1] and [2]) for multicriteria linear optimization are presented. After a short introduction to the mathematical formalization and to the main preliminary concepts of multiobjective linear programming problems, the tutorial focuses on the PolySCIP free solver for multiobjective (integer) linear programming problems. This is able to generate the Pareto frontier for multiobjective linear and for bi and three-objectives integer linear programs. Its main options and the .mop input file format are introduced and tested by means of some examples.

[1] Schenker S, Strunk T (2016) *Polyscip*. URL http://polyscip.zib.de.

[2] S. Maher and al. *The scip optimization suite 4.0*. ZIB Technical Report, 2017.

Symmetry Breaking in Integer Programming

Mercedes Pelegrín
Universidad de Murcia; mariamercedes.pelegrin@um.es

An integer programming formulation presents symmetries if permutations of some variables in a feasible solution produce a new feasible solution with the same objective value. Symmetric integer programs arise in many applications, ranging from job scheduling in identical machines to frequency channel assignment. Symmetries are an obstacle for traditional branch and bound solving procedures due to the unnecessarily large search tree and the poor LP bounds usually featured by these models. Here, we review some general strategies to cope with symmetric integer programs.

Parallel seminars session A1: Pricing and Trading Problems

Alba V. Olivares-Nadal, Exponential Approximation in Dynamic Bid Pricing

Valerio Dose, The price of anarchy as a function of the demand: how the amount of traffic affects the efficiency of selfish routing

Hua Jin, The impact of tax legislation on dynamic lot sizing and promotion decision

Kamyar Kargar, Robust mechanism for bilateral trade under discrete types

Stefano Vaccari, Dynamic Pricing with Online Reviews

Exponential Approximation in Dynamic Bid Pricing

Dan Adelman
The University of Chicago Booth School of Business;
Christiane Barz
Department of Business Administration, University of Zurich;
Alba V. Olivares-Nadal
Area of Statistics and Operations Research, University Pablo de Olavide (Seville);
avolinad@upo.es

The notion of bid-price control can be used in revenue management settings where the supply of resources is fixed and customer requests arrive over a finite time horizon to consume various resource configurations. The arriving requests must either be accepted or rejected, with the objective of maximizing expected profit over the time horizon. The basic idea of bid- price control is simple: Accept the request if the revenue earned exceeds the value of the resources consumed as measured by bid prices. In practice, major airlines have used bid-price control policies for deciding when to open and close customer fare classes for sale.

Although the system under control is dynamic, traditional models only compute static bid prices. Recently, dynamic bid pricing has been addressed by approximating the value function by a weighted sum of given basis functions. Affine, piecewise linear, or quadratic functions have been suggested as basis, but the affine case is by far the most widespread approach used. However, there is no reason to assume those choices will lead to a tight approximation of the value function. In our work we use a sum of weighted exponentials, which ensures the convergence to the real value function. As a consequence, our method will provide a tighter upper bound than previous approximations. In order to estimate the parameters of our basis functions, a highly dimensional problem must be solved. To deal with this issue, we propose a row-generation algorithm that involves repeatedly solving non- convex integer programs.

The price of anarchy as a function of the demand: how the amount of traffic affects the efficiency of selfish routing

***Valerio Dose*, Roberto Cominetti, Marco Scarsini**
LUISS "Guido Carli"; vdose@luiss.it

Price of Anarchy is a measure of how much, in a congested network, selfish routing can be inefficient with respect to the social optimum. Recent literature suggests that in many cases, in light or heavy traffic condition, selfish routing tends to be efficient. In this work, we study the Price of Anarchy as a function of the traffic inflow, considering its behaviour for intermediate amounts of traffic, between zero and infinity. We will present many results: concerning general networks with affine cost functions and parallel networks with polynomial cost functions.

The impact of tax legislation on dynamic lot sizing and promotion decision.

***Hua Jin*, Patrick Beullens**
University of Southampton; hj1g08@soton.ac.uk

Operational Research (OR) provides the methods and techniques by which firms can maximise their profits by taking smart decisions. The OR literature in the area of logistics, however, pays scant attention to cash flows that arise in order for the firm to fulfil its legal obligations. This paper develops a methodology for constructing models that explicitly account for the impact of tax legislation on dynamic lot sizing problem. It does this by expressing the future profits of the firm after tax as the Net Present Value or Annuity Stream Value of the cash flow function associated with the activity for the firm, including these cash flows exchanged with relevant third parties and the government that are needed in the context of ensuring compliance with tax legislation. Using the legislation in the United Kingdom, the research established how the explicit consideration of Value Added Tax (VAT) scheme, Corporate Tax (CT) affect optimal decisions for a firm with respect to the optimal associated product ordering policies and promotion strategy. We find that optimal inventory policy and promotion time is affected by government tax schemes. The timing of the in and out flow of tax happens important and helps firm to do the right time production and promotion decision and benefit for the whole supply chain.

Robust mechanisms for bilateral trade under discrete types

Kamyar Kargar
Bilkent University; kamyar.kargar@bilkent.edu.tr

In general, mechanism design is about investigating the necessary and sufficient conditions to achieve desired social, environmental or economic outcomes under many assumptions such as individuals' self-interest and incomplete information. One of the well-known problem in the mechanism design literature is "Bilateral Trading problem". Bilateral trade problem is the most common market interaction in which a seller and a buyer bargain over an indivisible object, and the valuation of each agent about the object is private information. This talk will discuss mechanisms for bilateral trade problem under Dominant Strategy Incentive Compatibility and Ex-post Individual Rationality properties. The talk will also consider ambiguity in the problem framework and derive robust counterparts for the proposed objective function under box and ϕ-divergence ambiguity specifications.

Dynamic Pricing with Online Reviews

***Stefano Vaccari*, Dongwook Shin, Assaf Zeevi**
LUISS University - Economics and Finance Department; svaccari@luiss.it

This paper investigates how the presence of product reviews can help inform a dynamic-pricing monopolist. A salient feature of our problem is that the customers' willingness-to-pay, and hence, the demand function, evolves over time in conjunction with the dynamics of the reviews where reviews mean numeric ratings to reflect the simplified nature of information in our model. The monopolist strives to maximize its total expected revenue over a finite horizon by adjusting prices in response to the evolving review dynamics. To formulate the problem in tractable form, we study a fluid model, which serves as a good approximation of the system dynamics when the volume of sales is large. This formulation lends itself to key structural insights, which are leveraged to design a well-performing dynamic pricing policy for the underlying revenue maximization problem.
The proposed policy admits a closed-form expression for price and its performance is asymptotically near-optimal.
To highlight the value of dynamic pricing, we compare the performances of the proposed policy with fixed price policies and discuss which market conditions the latter achieve significantly sub-optimal performances.
We illustrate the effectiveness of the proposed policy via simulation and counterfactual analysis in an online market with product reviews.

Parallel seminars session A2: Optimization in Routing Problems I

Katyanne Farias, A solving method for tactical two-echelon inventory routing problem

D.L Huerta-Muñoz, A matheuristic for the Flexible Periodic Vehicle Routing Problem with heterogeneous fleet

Arsham Atashi Khoei, Energy Minimizing Forklift Routing problem

Maximilian Loeffler, Synchronizing picking tours to reduce lighting cost

Christian Schröder, Granular local search for solving vehicle routing problems

A solving method for the tactical two-echelon inventory routing problem

Katyanne Farias
University of Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, F-38000 Grenoble, France;
katyanne.farias-de-araujo@grenoble-inp.fr
Dominique Feillet, Claude Yugma
Ecole des Mines de Saint-Etienne, CNRS, LIMOS, F-13541 Gardanne, France;
{feillet, yugma}@emse.fr
Khaled Hadj-Hamou
University of Lyon, INSA Lyon, DISP, F-69621 Villeurbanne, France;
khaled.hadj-hamou@insa-lyon.fr

In the recent years, new management policies have emerged aiming at limiting the traffic of large vehicles and their speed in city centers. In order to coordinate freight flows from a far supplier to customers located in urban areas, Distribution Centers (DCs) are introduced. According to [1], the use of DCs has proven to be efficient to reduce, for example, the emission of polluting gases and the noise levels. Therefore, we introduce the Tactical Two-Echelon Inventory Routing Problem (T-2E-IRP) based on an industrial problem faced by a gas distribution company. The T-2E-IRP consists of deciding from which DC will each customer be supplied and by using which vehicles. These decisions are made based on operational costs for a two-echelon vendor managed inventory delivery system on a long-term time horizon (several months) and with uncertain demands. Three inventory management policies are modeled and applied at one or both echelons. We develop a simulation approach to solve the T-2E-IRP on a long-term time horizon. The assignment of customers and vehicles to the DCs are made based on a short time horizon by a proposed mixed integer linear programming formulation. Then, we evaluate these assignment decisions through a simulation tool that solves the operational problem, i.e., the decisions of deliveries from the supplier to the DCs and from the DCs to the customers, on a rolling- horizon framework. In other words, the operational problem is solved for p-time periods. Then, the decisions made in the first r-time periods are fixed and the process iterates until the whole horizon has been considered. Computational experiments are performed for a set of randomly generated instances. The impact of several parameters on the total cost is analyzed.

[1] Interface Transport. *Espaces logistiques urbains de Monaco et La Rochelle : Analyse comparative des systmes logistiques rochelais et mongasques*. Technical Report, Agence De lEnvironnement et de la Matrise de lnergie, 2004.

A matheuristic for the Flexible Periodic Vehicle Routing Problem with heterogeneous fleet

C. Archetti, *D.L. Huerta-Muñoz*
Department of Economics and Management Università degli Studi di Brescia Brescia, Italy;
{claudia.archetti, diana.huertamunoz}@unibs.it
E. Fernández
Department of Statistics and Operations Research Universidad de Cádiz, Cadiz, Spain;
elena.fernandez@uca.es
F. Perea
Department of Applied Statistics and Operations Research, and Quality Universitat Politècnica de València, Valencia, Spain;
perea@eio.upv.es

The Flexible Periodic Vehicle Routing Problem with heterogeneous fleet (HFPVRP) consists of finding the best design of routes that a heterogeneous fleet of vehicles, which departs from a depot at different speeds, must perform to serve the demands and storage capacities of a set of customers in a given time horizon. Three main decisions must be taken into account: the schedule of visits to customers, the amount of product to be delivered at each visit, and the routes performed by the vehicles at each time period. The aim is to minimize the total routing costs. We propose a mathematical model for the HFPVRP and a two-phase matheuristic, which solves the scheduling and delivery decisions in the first phase by solving a mixed-integer linear programming problem, and determines the routing decisions heuristically in the second phase. Preliminary results are presented to show the performance of the proposed matheuristic.

Energy Minimizing Forklift Routing Problem

***Arsham Atashi Khoei*, Haldun Sural, Mustafa Kemal Tural**
Industrial Engineering Department of Middle East Technical University; ar.at.kh@gmail.com

We introduce the energy minimizing (order picker) forklift routing problem (EMFRP) in Green Warehousing area. The EMFRP determines the route of an order picker forklift to pick the orders located on the shelves in different heights and gather them in depot. Its objective is to minimize the total energy consumed during the horizontal and vertical moves of the forklift through the tour. We present a mixed integer programming formulation for the EMFRP. Computational results are provided to recognize the amount of saving in energy consumption achieved by considering vertical moves in addition to horizontal ones.

Synchronizing picking tours to reduce lighting cost

***Maximilian Loeffler*, Patrick Massing**
Deutsche Post Chair - Optimization of Distribution Networks, RWTH Aachen;
massing@dpo.rwth-aachen.de

According to a survey that we conducted among operators of warehouses in Germany, the lighting of picking aisles contributes most to energy consumption. Based on EU directives, energy consumption is to be reduced for the benefit of sustainability [1]. In order to achieve this goal, it is very useful to use an intelligent light- ing control system which uses motion sensors to illuminate only those aisles where pickers are present. Since personnel costs are high, picking tours in picker-to-part warehouses should be planned in such a way that they have minimum length. In warehouses with regular layout, such tours can be determined in polynomial time by the Ratliff&Rosenthal algorithm [2]. In addition, batching and sequencing is done typically in advance so that possible due dates of the customers are met [3]. For each picker, multiple picking tours are created, each of which describes which aisles to be traversed. However, there exist at least two possibilities to traverse each tour. Often, there are many intersections in a tour where one has to decide how to continue picking. We call the complete order in which aisles are traversed an orientation. To our best knowledge, arbitrary orientations are chosen in practice and nobody has considered them during planning so far in the literature. Usually many pickers work in a warehouse at the same time [4] and if it happens that two or more pickers are present in one aisle at the same time, the aisle is illuminated regardless of whether only one or more employees are present. For each picker we consider multiple tours one after the other, as these overlap with tours of other lengths of other pickers and are thus dependent on each other. We suggest to synchronize the tours by choosing one orientation for each tour to reduce energy consumption.

We propose the Synchronizing Picking Tours Problem and introduce a compact and an extended mathematical formulation. For the extended model we develop a column generation based heuristic. Further we propose a metaheuristic based on simulated annealing. We generate test instances based on data obtained from our survey. Preliminary results for small test instances showed that it is possible to save 15-20% of lighting energy compared to randomly selected orientations.

[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance

[2] Ratliff, H. Donald, and Arnon S. Rosenthal. *Order-picking in a rectangular warehouse: a solvable case of the traveling salesman problem.* Operations Research 31.3 (1983): 507-521.

[3] Le-Duc, Tho, and Rene MBM de Koster. *Travel time estimation and order batching in a 2-block ware- house.* European Journal of Operational Research 176.1 (2007): 374-388.

[4] Gu, Jinxiang, Marc Goetschalckx, and Leon F. McGinnis. *Research on warehouse operation: A comprehensive review.* European journal of operational research 177.1 (2007): 1-21.

Granular Local Search for Solving Vehicle Routing Problems

***Christian Schröder*, Michael Schneider**
Deutsche Post Chair - Optimization of Distribution Networks, Rwth Aachen University, Germany;
{schroeder, schneider}@dpo.rwth-aachen.de
Jean-Bertrand Gauthier, Timo Gschwind
Chair of Logistics Management, Johannes Gutenberg University Mainz, Germany;
{jgauthie, gschwind@uni-mainz.de}

Local search belongs to the core components of many state-of-the-art metaheuristics for vehicle routing problems (VRPs). Within the last decades, many variants of local search using differ- ent neighborhood structures, operators, pruning rules, and search strategies have been developed. Despite the importance of local search in metaheuristics for VRPs, no systematic investigation of the effect of its components and no design recommendations exist. This study compares the performance of a large number of granular local search variants on benchmark instances of the capacitated VRP and the multidepot VRP. We use performance profiles to visualize the results with regards to solution quality and runtime. A Wilcoxon signed-rank test is used to determine dominated algorithm variants. In this way, we are able to assess the impact of different local search components and to give design recommendations.

Parallel seminars session B1: Optimization in Routing Problems II

Ondrej Osicka, Cooperation of customers in traveling salesman problem with profits

Sina Rastani, Effects of ambient temperature on the route planning of electric freight vehicles

Maria João Santos, A bilevel approach for the collaborative transportation planning problem

Ricardo Soares, Multiple vehicle synchronization in a full truck-load pickup and delivery problem: a case-study in the biomass supply chain

Cooperation of customers in traveling salesman problems with profits

***Ondrej Osicka*, Mario Guajardo, Kurt Jőrnsten**
Department of Business and Management Science NHH Norwegian School of Economics, Bergen, Norway; ondrej.osicka@nhh.no

In the profitable tour problem, a profit-maximizing carrier decides whether to visit a particular customer with respect to the prize the customer offers for being visited and traveling cost associated with the visit, all in the context of other customers. Our focus is on the prizes customers need to offer to ensure being visited by the carrier. This can also be formulated as a cooperative game where customers may form coalitions and make joint decisions on the prizes to be offered.
Such situation occurs in shipping for example when a carrier is able to serve demands of several customers with a single vehicle. Whether it comes to delivery or pickup of goods, the customers might need to induce the carrier to visit them by offering sufficient rewards. Subsequently, negotiation with other customers in the same position could lead to better prizes while the carrier's visit would remain guaranteed. This knowledge could also be utilized by the carrier by offering specifically tailored discounts on multiple orders from the same area or by evaluating and pricing of new customers.
We show that models currently present in the literature, such as the traveling salesman game [1] or the routing game with revenues [2], cannot be utilized to describe this problem due to additional assumptions on traveling costs. Therefore, we propose a definition of the profitable tour game and analyze the cost associated with each coalition of customers as well as prizes that help in achieving it. Then, our attention turns to investigation of the optimal prizes to be offered when the grand coalition is formed. We focus on properties describing relationship between the prizes and the underlying traveling salesman game to provide connection with extensive literature on core allocations in traveling salesman games [3], [4], [5]. We show that, if the core of the underlying traveling salesman game is non-empty, the set of optimal prizes coincides with the core. For problems in which this core happens to be empty, we present a linear optimization model to find the optimal prizes to be offered by the customers.

[1] J.A.M. Potters, I.J. Curiel and S.H. Tijs, "Traveling salesman games", Math. Program. 53, 199-211 (1992).

[2] A. Estévez-Fernández, P. Borm, M. Meertens and H. Reijnierse, "On the core of routing games with revenues", Int. J. Game Theory 38, 291-304 (2009).

[3] A. Kimms and I. Kozeletskyi, "Core-based cost allocation methods in collaborative transportation", Int. Trans. Oper. Res. 23, 371-392 (2016).

[4] L. Sun and M.H. Karwan, "On the core of traveling salesman games", Oper. Res. Lett. 43, 365-369 (2015).

[5] A. Tamir, "On the core of a traveling salesman cost allocation game", Oper. Res. Lett. 8, 31-34 (1989).

Effects of ambient temperature on the route planning of electric freight vehicles

***Sina Rastani*, Tuğçe Yüksela, Bülent Çatay**
Sabanci University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey;
srastani@sabanciuniv.edu
Smart Mobility and Logistics Lab, Sabanci University, Istanbul, Turkey

Range anxiety poses crucial limitations for logistics operations performed with electric freight vehicles despite the advancements in the battery technology. Accurate route planning by considering external conditions is of critical importance for operational efficiency since various factors may affect the energy consumption. Ambient temperature is a key factor because cabin heating or cooling may significantly increase the energy discharged during the trip and reduce the driving range. In addition, the battery efficiency drops in low temperatures. In this study, we investigate the influence of ambient temperature on the fleet composition and routing decisions in last-mile delivery operations. We formulate this problem as a mixed integer linear programming model and propose new preprocessing techniques to accelerate the solution time. We perform an extensive experimental study to investigate how these techniques contribute to the computational performance and to observe how routing decisions change in different temperatures. The results reveal that preprocessing enhances the solution quality and neglecting temperature effect on the battery performance may yield route plans that cannot be implemented in the real business environment.

A bilevel approach for the collaborative transportation planning problem

***Maria João Santos*, Eduardo Curcio, Pedro Amorim, Alexandra Marques**
NESC TEC, FEUP - Faculty of Engineering, University of Porto, Porto, Portugal;
mjsantos@inesctec.pt
Margarida Carvalho
Department of Computer Science and Operations Research at University of Montreal, Canada

This work investigates an integrated transportation problem that considers collaboration between a shipper (e.g., manufacturer) and a carrier. The transportation network is composed of a depot (manufacturer), a set of customers that receives products from the depot and a set of suppliers that sends raw-materials to the depot. All customers demand must be satisfied in a single visit, by a single vehicle of the carrier. The demand of the depot can be satisfied using either the vehicles of the carrier, after all deliveries made, or vehicles outsourced to the suppliers. If the vehicles of the carrier are used to perform both the deliveries to customers and the pickups at suppliers (integrated routes), the manufacturer must pay an incentive to the carrier. On the other hand, the carrier will only agree if the incentive is sufficient to compensate the cost increase in distance and is better than other potential incentives offered by other shippers.
The problem is addressed as a Vehicle Routing Problem with Selective Backhauls (VRPSB) and is formulated as a bilevel mixed integer programming (MIP). In the bilevel formulation, the upper level describes the problem of the manufacturer, which aims to minimize the total costs, and the lower level describes the problem of the carrier, which aims to maximize the total profits. A reformulation technique is used to reduce the problem to a single-level and an exact method is developed to solve the problem.
This work aims to evaluate the benefits of a collaborative vehicle routing problem compared with a non- collaborative problem and determine the potential of the bilevel approach investigated.

Multiple vehicle synchronisation in a full truck-load pickup and delivery problem: a case-study in the biomass supply chain

***Ricardo Soares*, Pedro Amorim**
INESC TEC, FEUP - Faculty of Engineering, University of Porto, R. Dr. Roberto Frias, 4200-465 Porto, Portugal; ricardo.s@fe.up.pt
Alexandra Marques
INESC TEC - INESC Technology and Science, R. Dr. Roberto Frias, 4200-465 Porto, Portugal
Jussi Rasinmäki
Simosol Oy, Rautatietori 4, 11130 Riihimäki, Finland

In this work, the full truckload pickup and delivery problem with multiple vehicle synchronisation (FT-PDP-mVS) is presented. The FT-PDP-mVS consists in determining the integrated routes for three distinct types of vehicles, which need to perform interrelated operations with minimum logistics costs. This problem is motivated by a real-life application in the biomass supply chain "hotsystem", where it is necessary to simultaneously perform chipping and transportation operations at the forest roadside. The synchronisation of wood chipping operations with its subsequent transportation to bioenergy centrals can enforce a better use of vehicle fleets and decrease travelled distances and non-productive times, leading to a reduction of logistics costs. We extend existing studies in synchronisation of multiple routes by acknowledging several synchronisation aspects, such as operations and movement synchronisation. A novel mixed integer programming model (MIP) is presented and a solution method approach is developed based on the fix-and-optimise principles under a variable neighbourhood decomposition search. Results of its application to 19 instances based on a real-world case-study demonstrate its performance. For a baseline instance, the synchronisation aspects tackled in this problem allowed for significant gains when compared to the company's current planning approach. Furthermore, the proposed approach can enhance planning and decision making processes by providing valuable insights about the impact of key parameters of biomass logistics over the routing results.

Parallel seminars session B2: Machine Learning

Sandra Benítez, Cost-sensitive classification and probabilities estimation for SVM

Alberto Japón, A new approach to multiclass Support Vector Machines

Cristina Molero, On the construction of decision trees via mathematical optimization

María Remedios Sillero, Constrained Lasso regression

Cost-sensitive classification and probabilities estimation for SVM

Sandra Benítez
IMUS, University os Seville, Spain; sbenitez1@us.es

Support Vector Machine (SVM) is a powerful tool to solve binary classification problems. Many realworld classification problems, such as those found in credit-scoring or fraud prediction, involve misclassification costs which may be different in the different classes. Providing precise values for such misclassification costs may be hard for the user, whereas it may be much easier to identify acceptable misclassification rates values. Hence, we propose here a novel SVM model in which misclassification costs are considered by incorporating performance constraints in the problem formulation. In particular, our target is to seek the hyperplane with maximal margin yielding misclassification rates below given threshold values. This novel model is extended by performing Feature Selection (FS), which is a crucial task in Data Science, making thus the classification procedures more interpretable and more effective.
The reported numerical experience demonstrates that our model gives the user control on the misclassification rates in addition to the usefulness of the proposed FS procedure. Indeed, our results on benchmark data sets show that a substantial decrease of the number of features is obtained, whilst the desired trade-off between false positive and false negative rates is achieved.
On the other hand, SVM does not provide probabilities as other classifiers do in a natural way. Here, a bootstrap-based method yielding class probabilities and confidence intervals is proposed for a novel version of the SVM, namely, the cost-sensitive SVM in which misclassification costs are considered by incorporating performance constraints in the problem formulation. This is important in many contexts as credit scoring and fraud detection where misclassification costs may be different indifferent classes. In particular, our target is to seek the hyperplane with maximal margin yielding misclassification rates below given threshold values.

A new approach to multiclass Support Vector Machines

Víctor Blanco
IEMath-Granada, Universidad de Granada, Granada, Spain; vblanco@ugr.es
***Alberto Japón*, Justo Puerto**
IMUS, Universidad de Sevilla, Sevilla, Spain; {ajapon1, puerto}@us.es

In this work we present a novel approach to construct multiclass classiffiers by means of arrangements of hyperplanes. We propose different mixed integer non linear programming formulations for the problem by using extensions of widely measures for misclassifying observations.

1 General description

Given a training sample $\{(x_1, y_1), ..., (x_n, y_n)\} \subseteq \mathbb{R}^p \times \{1, ..., k\}$ the goal of supervised classification is to find a separation rule to assign labels (y) to data (x), in order to be applied out of sample. We assume that a given number of linear separators (hyperpanes in $\mathbb{R}^p$) have to be built to obtain a partition of the space into polyhedral cells. Each of the subdivisions obtained with such an arrangement of hyperplanes will be then assigned to a label in $\{1, ..., k\}$, see [5]. In Figure 1, where colors represent the different labels of (y), we can see two examples with 5 hyperplanes partitioning $\mathbb{R}^2$ reaching a perfect classification. The formulations are based on the Support Vector Machines paradigm in which a maximum separation between classes is desired and in which different measures for the misclassifying errors are considered. Also, for the sake of solving larger instances, different strategies are proposed for the dimensionality reduction of the MINLP problems. We have run a series of experiments over some well known multiclass datasets from UCI machine learning repository [4]. In those we have tried four different versions of our model, using hinge-loss and ramp-loss measures for evaluating errors, and combining these with the l_1 and l_2 norms for measuring distances. We compare the results obtained with some of the most popular multiclass SVM techniques: One Vs One [1], Weston-Watkins [2], and Crammer-Singer [3].

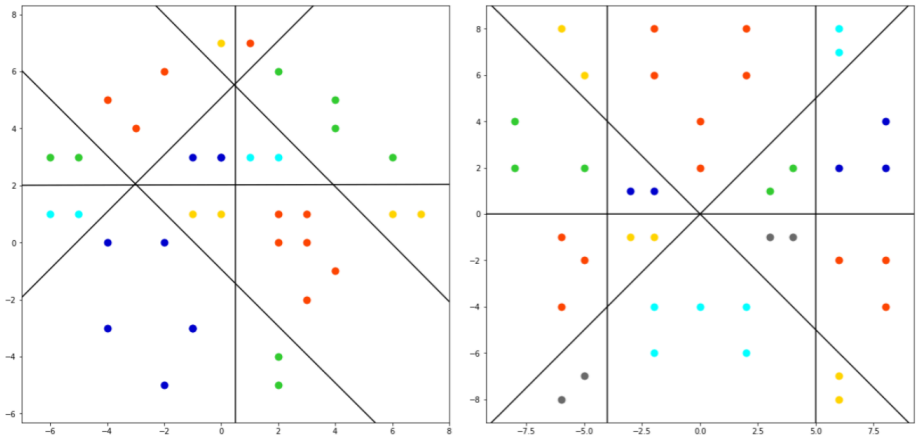

Figure 1. 5 hyperplanes multiclass SVM

[1] Cortes, C., Vapnik, V.: *Support-vector networks.*, Machine learning, 20(3): 273-297 (1995)

[2] Weston, J., Watkins, C.: *Support vector machines for multi-class pattern recognition.*, European Symposium on Artificial Neural Networks, pp. 219-224 (1999)

[3] Crammer, K., Singer, Y.: *On the algorithmic implementation of multiclass kernel-based vector machines.*, Journal of Machine Learning Research 2, 265-292 (2001)

[4] Lichman, M.: *UCI machine learning repository*, (2013). http://archive.ics. uci.edu/ml

[5] Blanco, V., Japón, A. and Puerto, J.: *Optimal arrangements of hyper- planes for multiclass classification*, Preprint available at https://arxiv.org/ abs/1810.09167, (2018).

On the construction of decision trees via mathematical optimization

Cristina Molero
IMUS, University of Seville, Spain; mmolero@us.es

Classic decision trees are defined by a set of orthogonal cuts, i.e., the branching rules are of the form variable X not lower than threshold c. The variables and thresholds are obtained by a greedy procedure. The use of a greedy strategy yields low computational cost, but may lead to myopic decisions. Although oblique cuts, with at least two variables, have also been proposed, they involve cumbersome algorithms to identify each cut of the tree. The latest advances in Optimization techniques have motivated further research on procedures to build optimal decision trees, with either orthogonal or oblique cuts. Mixed-Integer Optimization models have been recently proposed to tackle this problem. Although the results of such optimal decision trees are encouraging, the use of integer decision variables leads to hard optimization problems. In this talk, we propose to build optimal decision trees by solving nonlinear continuous optimization problems, thus avoiding the difficulties associated with integer decision variables. This is achieved by including a cumulative density function that will indicate the path to be followed inside the tree. Numerical results show the usefulness of this approach: we obtain better accuracies than classic decision trees, being much more flexible that those since sparsity or preference of performance in a subsample can be easily controlled.

Constrained Lasso regression

María Remedios Sillero
IMUS, University of Seville, Spain; rsillero@us.es

The Lasso has become a benchmark data analysis procedure, and it has been studied in depth and extended by many authors. Although the Lasso formulations are stated so that overall prediction error is optimized, no full control over the accuracy prediction on certain individuals of interest is allowed.
In this work we propose a novel version of the Lasso (constrained Lasso) in which performance constraints are added to Lasso-based objective functions, in such a way that threshold values are set to bound the prediction errors in the different groups of interest. As a result, a constrained sparse regression model is obtained, addressed by solving a nonlinear optimization problem. This methodology has a direct application in heterogeneous samples where data are collected from distinct sources, as it is standard in many biomedical contexts. Both theoretical properties and empirical studies concerning the new method have been explored.

Parallel seminars session C1: Optimization Involving Realistic Behaviour Patterns

Andrea Prieto García, Network analysis with game theory

Dmiitri Thykonenko, Rational Merging and Irrational Traffic Patterns

Giorgia Cappello, A variational formulation for a human migration problem

Michael Kahr, Influence maximization with competition in social networks

Nihal Berktas, Team formulation on social networks

Network Analysis with game theory

Andrea Prieto García
Universidad de Sevilla, Facultad de Matemáticas; homotopia8@gmail.com

Game theory is the mathematical theory of interactive decision problems [1]. We focus on transferable utility cooperative games and how to solve them with the Owen value, instead of using the well-known Shapley value [2]. Furthermore, we detail the Owen value and their characterization. Due to the fact that calculate both values is a NP-hard problem, we analyze a procedure based on sampling to estimate the Owen value and then, we make a comparison of the results obtained by both values.

[1] Saavedra, A., García, I. y., Fiestras, M. G.: *Estimation of the Owen value based on sampling.*, The Mathematics of the Uncertain. Universidad de Vigo. 347-358 (2018)

[2] Costa J.: *Valores coalicionales en juegos cooperativos con utilidad transferible.*, Tesis doctoral, Universidad de A Coruña (2015).

Rational Merging and Irrational Traffic Patterns

Dmiitri Thykonenko
Universitat Pompeu Fabra, Barcelona, Spain; dmitrii.tikhonenko@upf.edu

Driverless car technologies and vehicle-to-vehicle communication are reaching maturity, and bring urgency to research on driver behavior, incentives, and control policies for "optimal" traffic flow. Along these lines, in this work we focus on a very common merging scenario, and wish to understand the (technology-enabled) optimal merging process of rational (vis-a-vis "behavioral") self-interested drivers, as well as the traffic repercussions this may have. In particular, we study a two-lane road segment that has one lane blocked unexpectedly, e.g., due to accident or construction. All cars on the blocked lane need to merge to the (relatively dense) free lane in order to continue their routes. Drivers wish to minimize their individual travel times, having the following decisions at their disposition: (i) at what velocity to move; (ii) whether to merge or not to the free lane, given the opportunity. What makes the problem interesting is that moving at higher velocities reduces the chance of finding a large enough gap to merge. Our analysis starts with a microscopic model with a single merging car. We provide a Dynamic Programming formulation of the problem and characterize the optimal policy, which turns out to be a multi-threshold one with a non-trivial structure: in the presence of uncertainty regarding the future state of the target lane, it may be optimal for a driver to oscillate between high and low velocities while attempting to merge, i.e., rational driving may lead to "irrational" traffic patterns. We validate our theoretical analysis via extensive discrete-event simulations with multiple merging cars, where we establish the macroscopic impact of the proposed approach: rational merging increases the capacity of the bottleneck relative to a variety of benchmark merging rules.

A variational formulation for a human migration problem

Giorgia Cappello
University of Catania; giorg_91@hotmail.it

Many social and economical factors affect the dynamics of human populations, such as poverty, violence, war, dictatorships, persecutions, oppression, genocide, ethnic cleansing, climate change, tsunamis, floods, earthquakes, famines, family reunification as well as economic and educational possibilities or a job. The increasing role of migration in the social, economic and demographic development of countries, regions and the whole of the world, especially in the Mediterranean Basin which has become the theatre of a humanitarian crisis that has challenged the collective leadership around the sea, is becoming more and more evident, thus stimulating interest in mathematical modeling of migration. We consider a network based model where the aim is to maximize the attractivenss of the origin country and we prove that the optimization model can be formulated in terms of a variational inequality for which existence and uniqueness resuts are given. Finally, some numerical results applied to the human migration from Africa to Europe are presented and analyzed.

Influence maximization with competition in social networks

***Michael Kahr*, Markus Leitner, Mario Ruthmair, Markus Sinnl**
VGSCO, VCOR & ISOR, University of Vienna, Austria; m.kahr@univie.ac.at

We study influence maximization in social networks under competition. In the considered problem setting an entity tries to maximize its influence as a best response to a given set of (seed) nodes influenced by a competitor. Two propagation processes that occur in a discrete time setting are triggered by the two disjoint sets of seed nodes (one set for each involved entity). Influence propagation to further nodes is based on the well-known independent cascade model (i.e., based on a given probability distribution). We assume that each node can be influenced by at most one of the two entities, i.e., by the one whose influence reaches a node first where ties are broken in favor of the competitor. Since the competitors seed set is fixed in our setting, the objective of the entity is to identify a seed set (of given cardinality) that maximizes the expected number of influenced nodes triggered by that seed set. Unlike the majority of the related literature that focusses on heuristic methods, we aim for solving problem instances to proven optimality using formulations and methods based on (stochastic) integer linear programming techniques. We will also present results of our previous work in which only one entity tries to influence a given number of network nodes at minimum cost.

Team Formation on Social Networks

Nihal Berktas
Bilkent University; nihalberktas@bilkent.edu.tr

The success of a team depends on the quality of the communication among the team members as well as their technical capabilities. We study the Team Formation Problem (TFP) in which the quality of communication is taken into account using the proximity of the potential members in a social network. Given a set of required skills, TFP aims to construct a capable team that can communicate effectively. We study TFP with two measures for communication: sum of distances and diameter. We compare the quality of solutions using various performance measures. Our experiments indicate the following: First, considering only one type of cost may yield solutions that perform poorly in other performance measures. Second, the heuristics in the literature find solutions that are far from optimal whereas a general purpose solver is capable of solving small and medium size instances to optimality. To find solutions that perform well on several performance measures, we propose the diameter constrained TFP with sum of distances objective. To solve larger sizes, we propose a novel branch and bound approach: we formulate the problem as a constrained quadratic set covering problem, use the reformulation-linearization technique and relaxation to be able to decompose it into a series of linear set covering problems and impose the relaxed constraints through branching. Our computational experiments show that the algorithm is capable of solving large sizes that are intractable for the solver.

Parallel seminars session C2: Topics on Planning and Allocation Optimization

Amin Ahmadi, Multi-period Line planning with Vehicle Rotation

Beizhen Jia, Cargo Stowage Optimization in RoRo Shipping

Nilson Felipe Matos Mendes, A Decision Support System for Storage Allocation in the Field of Pharmaceutical Distribution

Ramón Piedra-de-la-Cuadra, Optimal allocation of fleet for "skip-stop" strategies in public transport networks

Nahid Rezaeinia, An assignment problem with side constraints and preference applied to math students with CEMS business projects

Multi-period Line Planning with Vehicle Rotation

***Amin Ahmadi*, Güvenç Şahin**
Sabanci University, Industrial Engineering, 34956 Orhanli Tuzla/Istanbul;{aminahmadi, guvencs}@sabanciuniv.edu
Ralf Borndörfer
Zuse Institute Berlin, Takustr. 7, 14195 Berlin; {surname}@zib.de
Thomas Schlechte
LBW Optimization GmbH; schlechte@lbw-optimization.de

Urban transportation planning is composed of several phases: network design for infrastructure, line planning, timetabling, vehicle scheduling and crew scheduling. In the last two decades, line planning has received growing attention from optimization viewpoint. Traditional literature on line planning assumes that demand is stationary during a finite-length planning horizon. However, demand in the real world varies heavily over the day and/or during different days of a week. Thereby, it is important to establish a line plan which considers demand fluctuation. Besides, the transportation systems are usually limited in terms of fleet. In this regard, allocation of vehicles to line services and transfer of vehicles from one line to another dynamically, are two crucial tasks to generate a feasible line plan. In this context, we propose a multi-period mathematical model which led us to solve the line planning problem with vehicle rotation over a planning horizon of an entire day. We present our results with a case study from the Istanbul Metrobüs that shows the effect of multi-period approach and the effectiveness of our vehicle transfer on the solutions.

Cargo Stowage Optimization in RoRo Shipping

Beizhen Jia
Aalborg University; bj@m-tech.aau.dk

The project aims to digitalize the end2end cargo stowage processes which consist of gate-in, yard positioning, loading, stowage, discharging, yard positioning and gate-out. As the core of the processes, cargo stowage is very critical to not only ship operations but also terminal planning. An optimized stowage plan can reduce fuel consumption and shorten port turnaround time compared to the current manual stowage planning process. Therefore, the project plans to improve the eco-efficiency by developing an integrated stowage optimization model. However, there are many considerations and challenges:

- Cargo complexity (availability and composition)
- Ballast water convention
- Ship stability and safety
- Trim optimization
- Ship turnaround time in port
- Integration with other systems

We have mapped out the cargo stowage process and collected data for model testing. Next steps are to incorporate above mentioned considerations into constraints one by one.

A Decision Support System for Storage Allocation in the Field of Pharmaceutical Distribution

Giovanni Vitorassi Moreira
Departamento de Informática, Universidade Federal de Viçosa
***Nilson Felipe Matos Mendes*, Manuel Iori**
Dipartimento di Science e Metodi dell'Ingegneria, Universitá degli Studi di Modena e Reggio Emilia; nilson.mendes@unimore.it
Giorgio Zucchi
Research and Development, Coopservice Scpa

In warehouses where the flow of stock keeping units (SKUs) is intense and diversified, the process of picking items is one of the main sources of logistic costs. To deal with this, decision makers must constantly consider questions related to storage constraints, request priorities, pickers routes, SKU demand seasonality and even human behavior. Our research deals with a major problem in this area, called Storage Allocation Problem. It consists in assigning products to cells of a warehouse so as to minimize the total picking distance. We base our study on a real scenario in the field of pharmaceutical distribution that has been provided by Coopservice, a major Italian logistic company. The main contribution of our work is provide a robust data-driven algorithm that receives in input the warehouse structure and a huge database of the performed SKU picking lists, and finds a good-quality solution by means of an Iterated Local Search (ILS). The ILS swaps SKUs assigned to different cells initially defined in a greedy way, and evaluates the quality of the new solution by approximately solving TSPs for entries in the pool of picking lists. Computational tests indicate that a basic MILP model works only on very small instances, whereas the ILS is effective and improves consistently the solutions obtained by the initial greedy heuristic. The algorithm has been embedded into a Decision Support System equipped with a user-friendly graphical interface.

Optimal allocation of fleet for "skip-stop" strategies in public transport networks

Juan A. Mesa, Francisco A. Ortega, *Ramón Piedra-de-la-Cuadra*, Miguel A. Pozo
Universidad de Sevilla, Sevilla, Spain;
{jmesa, riejos, rpiedra, miguelpozo}@us.es

In this research work a methodology is developed to implement a redistribution of services along a line of railway traffic, which must be carried out by the operator choosing new train schedules within a series of feasible space-time windows, previously established by the railway infrastructure manager. The objective is to minimize the loss of users, who could perceive a worsening in the quality of the service that until now they had been receiving.
In addition, the result obtained in that first phase will condition the subsequent decision of the transport operator, consisting of classifying the fleet of its trains into two types (A and B) and, furthermore, the stations in three types of stops: type A, where the trains identified with the distinction A will stop; type B, where the trains identified as mode B will stop; Type AB, where both kinds of trains will stop. This double assignment, both trains and stations, is called the Jump-Stop strategy.

2 Skip-Stop Strategie and Knapsack Problem

The Skip-Stop mechanism consists of privileging a larger number of passengers offering shorter travel times, as a result of having previously selected a group of low-activity stations, where trains would not stop to leave. pick up passengers.
The travel time between stations in a railway line consists of five components, identified as phases of acceleration, constant speed, inertia, braking and downtime. In consequence, the operation of omission stops reduces the travel time within the vehicle for the users and increases the speed of operation in the provision of the service. However, some users will experience a longer waiting time, access time, exit time and, possibly, transfer time. Therefore, there is no guarantee that any omission operation will decrease the total travel time of the potential passage. The selection and coordination of stops must be made using a criterion according to an objective function. In the optimization of transport systems there are three types of objective functions: minimization of the user's travel time, maximization of the benefit of the operator and minimization of the total cost.
The Skip-Stop strategy always increases the speed of operation, which entails for the operator a reduction in costs and the size of the fleet. How- ever, this option does not always produce advantages for operators. If the total travel time of the passengers increases due to the omission of stops, fewer people will use the transit service and the corresponding revenues will be lost.

We propose, in this work, to model an existing problem (Skip-Stop problem) through the knapsack problem taking advantage of the large amount of material available from the KP. The solution of the Skip-Stop problem will consist of two phases, in the first one we find the optimal solution of eliminating stops of a fleet of trains and in the second phase we will calculate by a heuristic the classification of trains in type A/B introducing the concept of proximity between the railway routes and basing on the article of the Method Hall [1] to produce the heuristic (Math-heuristic one) that optimizes the classification.

[1] Hall, K. M. (1970). *An r-Dimensional Quadratic Placement Algorithm.* Management Science.

[2] Lee, Y.-J. (2012). *Mathematical modeling for optimizing skip-stop rail transit operation strategy using genetic algorithm.* National Transportation Center Research Report 26, Morgan State University.

[3] Mesa, J. A., Ortega, F. A. and Pozo, M. A. (2009). *Effective allocation of fleet frequencies by reducing intermediate stops and short turning in transit systems.* Lecture Notes in Computer Science 5868(8), pp. 293 - 309.

An assignment problem with side constraints and preferences applied to match students with CEMS business projects

***Nahid Rezaeinia*, Julio Cesar Goez, Mario Guajardo**
Department of Business and Management Science, NHH Norwegian School of Economics;
nahid.rezaeinia@nhh.no

The assignment problem consists of allocating objects in one set to objects in another set and arises in numerous applications. The literature offers a number of variants incorporating several features, such as preferences and multiple attributes constraints. Allocating faculty members to committees, applicants to study programmes, and staff to projects are examples of such assignment problems. In this paper, we study an assignment problem arising in the allocation of students to business projects, in the context of the CEMS programme at NHH. With the increasing student mobility and the stimulation of multidisciplinary team work, it is important that the allocation defines suitable teams. This involves, for example, teams that satisfy gender diversity and the inclusion of members with different backgrounds and language skills. Also, since the projects are in collaboration with different companies, there can also be specific requirements of the companies on the teams they get allocated. The students also have their preferences on which projects to carry out, so it turns important to find an allocation that complies with their preferences. The resulting problem has a difficult combinatorial structure, which is naturally hard to approach by traditional manual techniques. We develop an integer linear model that incorporates a number of criteria, such as efficiency and fairness. We run the model in different versions using a two-step procedure, aimed at finding a solution that captures all the involved criteria. We test the model using real data of 2018 and 2019, in joint collaboration with the administration at NHH. One of the solutions obtained by our approach is the one implemented in practice for the allocation of students to project during the current semester.

Parallel seminars session D1: Optimization Under Uncertainty

Hannah Bakker, K-adaptive Facility location: New Insights on Dynamic Facility location under Uncertainty

Marta Baldomero-Naranjo, On covering location problems in networks with uncertain edge demands

Markus Gabl, Uncertainty Aversion for Robust Linear Optimization with Endogenous Uncertainty

Riccardo Giusti, A Stochastic Multi-period Transshipment Selection Problem with Synchronized Handling Operations

K-adaptive Facility Location: New Insights on Dynamic Facility Location under Uncertainty

Hannah Bakker
Karlsruhe Institute of Technology, Institute for Operations Research,
hannah.bakker@kit.edu

Facility location under demand uncertainty is a well-studied problem and several papers exist applying techniques from stochastic programming and robust optimization. As location decisions are of strategic nature most of these studies assume that they have to be fixed at the beginning of the planning horizon and only allocation decisions may adapt to observed demand realizations at later stages. However, in deterministic models it is well-established that the flexibility of opening some facilities at later stages can considerably improve the solution. The difficulty for transferring this result to uncertain models lies in modeling the binary recourse decisions associated with the opening of individual facilities.

A recent concept to overcome this issue is k-adaptable robust optimization. As is practice in robust optimization, uncertainty is described via an uncertainty set. This set is then split into k partitions and for each partition a robust recourse decision is determined. The structure of the solution to a k-adaptable problem thereby equals that of a multi-stage stochastic program. Yet, it yields different information, as in particular it does not prescribe a sequence of optimal actions for individual scenarios but for any realization of the uncertain parameter within the uncertainty set.

In this talk, k-adaptable robust optimization is applied to a dynamic capacitated facility location problem (CFLP) with uncertain demand. Facilities can be opened at every stage which leads to binary recourse decisions. For this purpose the recently presented "Partition and Bound" method is modified. Computational results are presented for small instances. The solutions obtained are compared to solutions from a multi-stage stochastic program. In this context, not only the worst-case and average-case objective values but also the resulting network topologies are compared.

On covering location problems in networks with uncertain edge demands [1]

***Marta Baldomero-Naranjo*, M. Rodríguez-Chía**
Departamento de Estadística e Investigación Operativa, Universidad de Cádiz, Spain;
{marta.baldomero, antonio.rodriguezchia}@uca.es
Jörg Kalcsics
School of Mathematics, University of Edinburgh, United Kingdom, joerg.kalcsics@ed.ac.uk

Location problems with covering objectives in networks are widely extended in the service sector (bus stops, bank branches, etc.) as well as in the location of emergency facilities (ambulances, automated external defibrillators, etc.). Almost all models proposed in the literature to deal with these situations assume that demand only occurs at the nodes of the network. However, in the location of emergency facilities or other situations where the coverage areas are extremely distance-dependent this assumption is not realistic. Therefore, assuming that the demand is concentrated at nodes may lead to gaps in service levels that are not acceptable, rendering the solutions useless. Hence, our goal is to solve the single-facility location problem trying to cover the maximum demand on a network where the demand is distributed along the edges.

A framework to deal with this kind of problems was presented in [1], the resolution method proposed assume that the demand is known exactly along the edges. Nevertheless, the demand for a specific service is often uncertain and usually varies from one day to another or even within a day. Hence, we have to find locations for those facilities that provide an adequate level of service even under changing and unknown service demands. For this reason, we will treat demands as being unknown. However, we are usually able to estimate the minimal and the maximal demand, so we assume that demand lie within a known range. In the face of this situation of total uncertainty in the demand, we propose to employ concepts from robust optimization, more concretely minimizing the maximal regret, a well-known criterion used by many researchers, see e.g. [2].

In this talk, we provide mathematical models considering that demand is uncertain and distributed along the edges of a network and that the service facilities can, essentially, be located anywhere along the network. Furthermore, we will propose polynomial time algorithms for finding the location that minimizes the maximal regret assuming that the demand lies within a known range and it is constant or linear on each edge.

[1] O.Berman, J.Kalcsics and D.Krass. *On covering location problems on networks with edge demand*. Computers&Operations Research, 74:214-227, 2016.

[2] J. Puerto, A. M. Rodríguez-Chía, and A. Tamir. *Minimax regret single-facility ordered median location problems on networks*. INFORMS Journal on Computing, 21(1):77-87, 2009.

[1]Thanks to the support of Agencia Estatal de Investigacíon (AEI) and the European Regional Development's funds (FEDER): project MTM2016- 74983-C2-2-R, Universidad de Cádiz: PhD grant UCA/REC01VI/2017, Telefónica and the BritishSpanish Society Grant.

Uncertainty Aversion for Robust Linear Optimization with Endogenous Uncertainty

Markus Gabl
University of Vienna; markus@gabl.com

In robust optimization one seeks to make a decision under uncertainty where the goal is to find the solution with the best worst-case performance. The set of possible realizations of the uncertain data is described by a so called uncertainty set. In many scenarios, a decision maker may influence the uncertainty regime she is facing, for example, by investing in market research, or in machines which work with higher precision. Recently, this situation was addressed in the literature by introducing decision dependent uncertainty sets (endogenous uncertainty), i.e., uncertainty sets whose structure depends on (typically binary) decision variables. In this way, one can model the trade-off between reducing the cost of robustness versus the cost the investment necessary for reducing uncertainty. However, there is another trade-off to be made here. One might be willing to forgo the benefit of a good worst case performance achievable under a specific uncertainty-regime in favour of operating under a different uncertainty-regime where the performance of the robust solution comes with less uncertainty attached. Inspired by the concept of risk-aversion, which models the trade-off between risk and expected value we introduce the concept uncertainty-aversion (UA), which models the trade-off between worst case performance and uncertainty of performance. We present two ways to conceptualize and formalize UA, based on economic reasoning and study the resulting mathematical models. The goal, is to have refomulations/approximations of these models which can be solved with standard methods. The workhorse is mixed-integer linear and conic optimization.

A Stochastic Multi-period Transshipment Selection Problem with Synchronized Handling Operations

***Riccardo Giusti*, Roberto Tadei**
Department of Control and Computer Engineering, Politecnico di Torino, Turin (Italy);
{riccardo.giusti, roberto.tadei}@polito.it
Daniele Manerba
Department of Control and Computer Engineering, Politecnico di Torino, Turin (Italy);
ICT for City Logistics and Enterprise Lab, Politecnico di Torino, Turin (Italy);
daniele.manerba@polito.it

In the Transshipment Selection Problem, we want to select transshipment facilities (e.g, inter- modal hubs) to transport freight from origins to destinations such that a given total transportation utility is maximized. However, to consider flexible and reliable networks within the most advanced synchro-modal supply-chains, flow synchronization at facilities must be ensured. Clearly, synchronization depends on a large set of unknown events (lateness of transportation, slow execution of handling operations, service interruptions, etc.). Therefore, the selection of transshipment facilities must be done under uncertainty. In fact, congestion, significant containers leftover, and loss of connections could cause both unexpected reductions of facilities capacity (over time horizons) and stochastic handling utilities. Hence, we introduce a stochastic and multi- period variant of the Transshipment Selection Problem in which uncertainty of facility capacity and handling utilities are both considered. We aim to select transshipment facilities and to allocate freight flows to maximize the expected total net transportation utility. We propose a two-stage Stochastic Programming (SP) formulation with recourse and calculate several standard SP measures (VSS, EVPI, LUSS, LUDS) to assess our modelling framework. Finally, given the computational burden to solve exactly this model for real-life instances, some heuristic approaches will be presented, and their performance carefully tested.

Parallel seminars session D2: Scheduling Problems

Markó Horváth, Polyhedral results for position-based scheduling of chains on a single machine

Amin Mallek , Scheduling unit-time jobs with split conflict graphs

Gabrijela Obradović, Modeling deterioration costs for preventive maintenance scheduling of multi-component systems

Carla Talens Fayos, New efficient constructive heuristic for the two stage multi-machine assembly scheduling problem

Polyhedral results for position-based scheduling of chains on a single machine

Markó Horváth
Institute for Computer Science and Control (Hungarian Academy of Sciences);
marko.horvath@sztaki.mta.hu

We consider a scheduling problem where a set of unit-time jobs have to be sequenced on a single machine without preemption, and without any idle times between the jobs. In addition, the ordering of the jobs must satisfy the given precedence constraints. One has to determine a sequence of jobs which minimizes the total cost where the processing cost of a job depends on its position in the sequence. Note that this problem can be considered as a generalization of the linear assignment problem, where one has to assign n jobs to n positions such that the set of positions is ordered, and each job must be assigned a later position than any of its predecessors according to the precedence constraints. In this talk we deal with chain precedence constraints, and investigate the polyhedron associated with the set of feasible solutions. In particular, we show that already a special case is NP-hard, that is, when each chain is of length 2, then optimizing over the polyhedron is strongly NP-hard, furthermore, for the same special case we present a class of facet-defining inequalities along with a polynomial-time separation procedure. We extend these results for the general case, i.e., where chains have arbitrary lengths. Our computational results show that separating our inequalities can significantly improve an LP-based branch- and-cut procedure to solve the problem. That is, when applying our cutting planes in branch-and-cut, our procedure is up-to two orders of magnitude faster than default CPLEX

Scheduling unit-time jobs with split conflict graphs

***Mallek Amin*, Bendraouche Mohamed, Boudhar Mourad**
RECITS Laboratory, Faculty of Mathematics, USTHB, Algiers, Algeria; aminn.mallek@gmail.com

We address the problem of scheduling n conflicting unit-time jobs on m parallel uniform machines with speeds $s_1 \geq ... \geq s_m$. The conflict between the jobs is modeled by a graph G, called the conflict graph, in which two adjacent jobs cannot be processed on the same machine. The problem of minimizing the maximum job completion time (schedule length) is known to be NP-hard in presence of arbitrary graphs. Herein, we show that this problem remains NP-hard even when G is restricted to split graphs. However, due to divers practical applications that pertain to this particular case, we propose a polynomial time approximation algorithm that provides high quality solutions.

[1] Bodlaender, H.L., Jansen, K.: *On the complexity of scheduling incompatible jobs with unit-times.*, LNCS 711: 291-300, (1993)

[2] Furmanczyk, H., Kubale, M.: *Scheduling of unit-length jobs with bipartite incompatibility graphs on four uniform machines.*, Bulletin of the Polish Academy of Sciences Technical Sciences 65(1): 29-34, (2017)

[3] Furmanczyk, H., Kubale, M: *Scheduling of unit-length jobs with cubic incompatibility graphs on three uniform machines.*, Discrete Applied Mathematics 234: 210-217, (2018)

[4] Lawler, E.L., J Lenstra, .K., Rinnooy Kan, A. H. G.: *Recent developments in deterministic sequencing and scheduling : a survey..* In Dempster, M. A. H., Lenstra, J. K., Rinnooy Kan, A. H. G. (Eds.): Deterministic and stochastic scheduling, proceedings of the NATO Advanced Study and Research Institute, July 1981, Durham, pp. 35-73, Springer, (1982).

[5] Dessouky, M.I., Lageweg, B. J., Lenstra, J.K., van de Velde, S.L. : *Scheduling identical jobs on parallel uniform machines*, Statistica Neerlandica 44(3): 115-123, (1990).

Modelling deterioration costs for preventive maintenance scheduling of multi-component systems

Gabrijela Obradović
Department of Mathematical Sciences, Chalmers University of Technology, Sweden;
gabrijela994@gmail.com

While a system operates, its components deteriorate and in order for the system to remain operational, maintenance of its components is required. We study two types of maintenance: preventive (PM) and corrective (CM). PM is performed so that component failure is avoided, while CM is performed after a failure has occurred in order to restore the system back to an operational state. Typically, costs incurred by failure and CM are larger than those incurred by PM.
This research aims at scheduling maintenance activities for a multi-component system within a finite horizon. The system to be maintained possesses positive economic dependences, meaning that each time any maintenance activity is performed, a common set-up cost is generated. Each component PM generates a cost, including replacement, service, and spare parts costs. Because of unexpected events (e.g., component breakdowns) leading to CM, the maintenance scheduling problem is dynamic.
We start from a 0-1 integer linear programming model of the preventive maintenance scheduling problem with interval costs (PMSPIC; *Gustavsson et al., Computers & Industrial Engineering 76:390-400, 2014*), which is to schedule PM of the components of a system over a finite and discretized time horizon, given common set-up costs and component costs. In addition, each PM interval generates a deterioration cost, that depend on the length of the interval from the latest PM. We then present several models for the deterioration cost function and investigate their mathematical and computational properties.

New efficient constructive heuristics for the two stage multi-machine assembly scheduling problem

***Carla Talens Fayos*, Victor Fernandez-Viagas Escudero, Paz Perez Gonzalez, Jose M Framinan**

University of Seville; cartafa@us.es

In this paper, we analyse the two-stage multi-machine assembly scheduling problem with the objective of minimising total completion time. The objective of this work is to improve the existing heuristic for the problem under consideration by proposing two new constructive heuristics. The first one is a fast-constructive heuristic, and, in the light of its results, it is inserted in a beam search based constructive heuristic that constitutes the second heuristic proposed. Consequently, a computational evaluation is performed to obtain an efficient set of heuristics using the quality of solutions obtained by each heuristic and its computational efforts as indicators. Finally, with respect to the second proposed heuristic, a beam search-based constructive heuristic, an analysis about the influence of modifying the beam width over the different iterations is performed. Additionally, some existing heuristics have been implemented and compared to our proposal.

Seminars session E: Insights on Solvers and Challenges in OR

Carolina Castañeda, Aggregation errors in large discrete location models

Brais Gonzalez, RAPOSa, a freely available solver for polynomial optimization problems

Yewen Gu, Autonomous maritime navigation: state of the art and future perspectives

Gabriele Iommazzo, A methodology for addressing the Algorithm Configuration problem on mathematical programming solver

Aggregation errors in large discrete location models

***Carolina Castañeda P.*, Daniel Serra**
Department of Economics and Business, Universitat Pompeu Fabra, Barcelona, Spain;
{carolina.castaneda, bdaniel.serra}@upf.edu

Large and discrete location problems are time consuming or intractable, in terms of traditional solution methods, like Mixed Binary Linear Programming, due to the presence of a large number of demand points, that usually are aggregated to obtain smaller models. This aggregation introduces errors in the solution when solving location models to optimality because the aggregated model is an approximation where the solution is optimal for the aggregated data but not necessarily for the non-aggregated data.
Research in location problems has been mainly focused on modeling or the development of better solution methods, and data aggregation is often taken for granted, even when is usually unavoidable, because of the solution methods limitations to find a solution for instances with a larger number of demand points than the current bound.
We propose a heuristic aggregation framework that integrates a solution method for large location problems with an algorithm that finds a suitable demand aggregation for them. The main aim of this framework is to reduce error caused by aggregated demand points in discrete location models on networks. Solving large location problems accurately provides valuable support in decision making processes and has recognized application in many real-world systems in public and private sectors.

RAPOSa, a freely available solver for polynomial optimization problems

Brais González
University of Santiago de Compostela; braisgonzalez.rodriguez@usc.es

We will present a new implementation of the reformulation linearization techniques, RLT, in the context of polynomial programming problems, originally introduced in Sherali and Tuncbilek (1991). RLT is a branch and bound algorithm based on linear relaxations and ensures convergence to a global optimum. This new implementation has been developed with two main goals in mind:

- Computational efficiency. The implementation incorporates most of the features of the RLT algorithm discussed in past literature. Moreover, additional enhancements have been introduced, such as parallelization and warm start features at various levels of the branching process. The current version of the algorithm has proven to be very efficient, and comparisons with other global optimization solvers such as BARON and Couenne will be presented.
- Free availability. This implementation can be used in conjunction with a wide variety of free and commercial linear and nonlinear solvers for the computation of the lower and upper bounds, respectively (for the use with commercial solvers, the corresponding licence is required).

Autonomous maritime navigation: state of the art and futures perspectives

Yewen Gu

Norwegian School of Economics; yewen.gu@nhh.no

Growing technology on autonomous transportation systems is currently motivating a number of research initiatives. We conduct a survey on the literature about autonomous maritime navigation in this paper. Nine categories firstly are defined based on the main research interests in this field. The collected articles are then classified according to the categories and the main findings of these studies are also briefly summarized. A statistical analysis of the literature shows that the popularity of the research in autonomous navigation increases dramatically in the past decade, especially in the research community in EU. Moreover, the published articles about autonomous maritime craft mainly focus on the navigation control and safety issues. The studies regarding other topics in this field are, nevertheless, very limited. While our main interest lies on autonomous systems in maritime navigation, we contrast its development with respect to autonomous systems on road. The comparison shows that great potentials can be expected in the studies about transportation and logistics with autonomous marine craft. As the technology behind remote-controlled and autonomous ships is maturing rapidly, we believe that it is already the time for researchers in the field to start look into the future water-borne transport and logistics with the application of autonomous marine craft.

A methodology for addressing the Algorithm Configuration problem on mathematical programming solver

***Gabriele Iommazzo*, Claudia D'Ambrosio, Leo Liberti**
CNRS LIX, École Polytechnique, F-91128 Palaiseau, France;
{giommazz,dambrosio}@lix.polytechnique.fr
Antonio Frangioni
Dip. di Informatica, Università di Pisa, Italy;
frangio@di.unipi.it

In this work we address the tuning of *general-purpose* Mathematical Programming (MP) solvers. Most solvers have long lists of user-configurable parameters; tweaking them influences how the available algorithmic components work and how they interact with each other, and it can consequently have a significant impact on the quality of the obtained solution and/or on the efficiency of the solution process.
Good solvers have effective default parameter configurations, carefully selected to provide "good" performances in most cases. However, default parameter configurations may still prove to be highly suboptimal with specific instances, which requires to search for the best parameter values manually. The motivation to our work lies in the fact that, due to the sheer amount of available parameters, manual tuning is highly non-trivial and time-consuming. We remark that this setting, also known as the Algorithm Configuration (AC) problem, problems encompasses many other applications besides MP solvers.
Our approach for addressing the AC problem on MP solvers is based on a two-fold idea:

(i) in the *Performance Map Learning Phase* (PMLP), supervised ML techniques are used to automatically learn a *performance function* which maps the (numerical) properties of the instance being solved and a given parameter configuration into some measure of solver efficiency and effectiveness;

(ii) such a map can be directly employed to formulate the *Configuration Space Search Problem* (CSSP), a MI(N)LP problem which, for a given instance, finds the configuration providing optimal performances according to the learnt performance function. We remark that the CSSP may employ the learnt performance function as objective and/or the equations defining the mathematical structure of the PMLP as constraints.

The main technical novelty of our approach lies in the fact that we explicitly use the mathe- matical model underlying the PMLP in order to formulate the CSSP as a Mixed-Integer (Non) Linear) Programming (MINLP) problem, i.e. we treat the PMLP as a "white-box": this requires striking a careful balance between ML *generalization on an unknown test set* and the *CSSP cost*.
The proposed approach is suited to many other applications - besides MP solvers - where

the outcome of executing some action (say, run a target algorithm) depends upon two distinct sets of elements: the unalterable characteristics of a problem instance (*features*) and the different choices of action operated by the user (*controls*, in other words, the parameters of the target algorithm).

The 1^{st} EUROYoung Workshop took place thanks to

Doctoral Programme in Mathematics of the University of Seville (R.D. 99/2011) (III PPD)