EWG POR PRACTICE OF OR

2nd conference of the EURO Working Group on the Practice of Operations Research

OPERATION RESEARCH MEETS MACHINE LEARNING

HOW TO GET THE MOST OF BOTH WORLDS TO ACHIEVE EXCELLENT DECISION SUPPORT SYSTEM

MARCH 11TH AND 12TH, 2019

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ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
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The codes used to generate this booklet, including the LaTeX template, are available at
`https://github.com/maximelucas/AMCOS_booklet`

Timetable

Monday, March 11

13:00-14:00	**Registration**	
14:00-14:30	**Welcome and introduction**	
14:30-14:45	**Damien Blanchon** *IBM France*	Optimizing a bike sharing system
14:45-15:00	**Thomas Bridi** *MindIT*	Empirical Model Learning: an industrial point of view
15:00-15:15	**Nitin Ahuja** *PTV Group*	Using machine learning to help solve online vehicle routing problems
15:15-15:30	**Stefano Gualandi** *University of Pavia*	Optimization via Machine Learning-based Simulation: Application to Modern Call Centers Management
15:30-15:45	**Tânia Ramos** *University of Lisbon*	No Routes Wasted for Waste Collection: exploring real-time information through ML techniques to improve waste collection
15:45-16:00	**Björn Thalén** *Boeing*	Machine Learning supported algorithm selection for real life airline pairing scheduling problem
16:00-16:15	**Matteo Pozzi** *OPTIT Srl*	Machine Learning and Optimisation: an ongoing journey
16:15-16:30	**Wouter Kool** *ORTEC*	Attention, Learn to Solve Routing Problems!
16:30-17:00	**Coffee break**	
17:00-17:45	**Presentation of relevant initiatives in OR and ML in Emilia-Romagna**	
17:45-19:00	**Mauricio Resende** *Amazon*	**Keynote speech** Logistics Optimization at Amazon: Big Data, Artificial Intelligence & Operations Research in Action
19:00-20:00	**Networking cocktail**	

Tuesday, March 12

08:00-08:30	**Registration and welcome**	
08:30-09:00	**Poster presentations**	
09:00-10:20	**Raffaele Maccioni** *ACT OR*	**Keynote speech** From Data to Decisions. The challenges of the digitalization era.
10:20-10:30	**Parallel sessions: discussion in smaller groups on selected topics**	
10:30-10:45	**Coffee break**	
10:45-13:00	**Parallel sessions**	
13:00-14:00	**Light lunch**	
14:00-15:00	**Wrap-up from parallel sessions, open discussion**	
15:00-15:30	**Closing**	

List of Abstracts – Keynotes

Logistics Optimization at Amazon: Big Data, AI & Operations Research in Action

Mauricio Resende[1,2]

[1] Amazon.com, Seattle, Washington
[2] University of Washington, Seattle, Washington

Abstract
We consider optimization problems at Amazon Logistics. Amazon.com is the world's largest e-commerce company, selling millions of units of merchandise worldwide on a typical day. To achieve this complex operation requires the solution of many classical operations research and AI problems. Furthermore, many of these problems are NP-hard, stochastic, and inter-related, contributing to make Amazon Logistics a stimulating environment for research in AI, optimization and algorithms.

Biography
Mauricio G. C. Resende grew up in Rio de Janeiro (BR), West Lafayette (IN-US), and Amherst (MA-US). He did his undergraduate training in electrical engineering (systems engineering concentration) at the Pontifical Catholic U. of Rio de Janeiro. He obtained an MS in operations research from Georgia Tech and a PhD in operations research from the U. of California, Berkeley. He is most known for his work with metaheuristics, in particular GRASP and biased random-key genetic algorithms, as well as for his work with interior point methods for linear programming and network flows. Dr. Resende has published over 200 papers on optimization and holds 15 U.S. patents. He has edited four handbooks, including the Handbook of Heuristics, the Handbook of Applied Optimization, the Handbook of Massive Datasets, and the Handbook of Optimization in Telecommunications, and is coauthor of the book "Optimization by GRASP." He sits on the editorial boards of several optimization journals, including Networks, J. of Global Optimization, R.A.I.R.O., and International Transactions in Operational Research. Dr. Resende is an INFORMS Fellow.

Prior to joining Amazon.com in 2014 as a Principal Research Scientist in the transportation area, Dr. Resende was a Lead Inventive Scientist at the Mathematical Foundations of Computing Department of AT&T Bell Labs and at the Algorithms and Optimization Research Department of AT&T Labs Research in New Jersey. Since 2016, Dr. Resende is also Affiliate Professor of Industrial and Systems Engineering at the University of Washington in Seattle.

From Data to Decisions. The challenges of the digitalization era.

Raffaele Maccioni[1]

[1] ACT OR

Abstract
It is not always so easy to take the best decisions, both strategic, like to redesign the supply chain, or operative like to deliver goods at min costs, or to define prices and promotions. Even more, sometimes it is not so clear what "best" really means.

During his speech, Raffaele Maccioni (ACT Operations Research) will introduce the solution that has been awarded by Informs as a finalist of the Franz Edelman Award. Raffaele, based on his daily interaction with Customers that are often global players in their market, will provide a view on the role, and the criticalities related to the adaption of “deep-analytical” solutions.

Biography
Control engineer from the Polytechnic of Milan, Raffaele has an innovation and entrepreneurship DNA. Raffaele with over 25 years of experience in the decision science & process control, is a dynamic executive. Natural relational capabilities, intense creativity, and proven team building skill. Raffaele is an entrepreneur, with experience in building a market presence with a result-driven approach.

After five years in Ansaldo, a company in the Power Plants sector, working as simulation and advanced control specialist, Raffaele founded ACT Operations Research (ACT OR) in 1996 as a research company in the area of the advanced analytics. ACT OR is also a spin-off of the University Sapienza in Rome, has offices in London (UK) and Charlotte (USA). Raffaele worked on several business projects with key clients, including 20% of listed and 2% of Global 2000 corporations and leads research projects at national and European level.

Raffaele has a significant role in the invention and design of several of the math-based products and solutions that today ACT OR sells on the market. He has been the solution architect and team leader of the capacity & revenue optimization solution for the customer Europcar. Such solution permitted ACT OR and Europcar, to be awarded as finalists at the prestigious Franz Edelman Award, by Informs.org, the international organization promoting Decision Science and Operations Research.

List of Abstracts – Talks

Optimizing a bike sharing system

Damien Blanchon[1], **Sofiane Oussedik**[1]

[1] IBM, France

Abstract
Operators in a bike sharing system control room are constantly re-allocating bikes where they are most likely to be needed, this requires an insight on the optimum number of bikes needed in each station, and the most efficient way to distribute teams to move the bikes around. Forecasting engines and Decision Optimization is used to calculate the optimal number of bikes for each station at any given time, and plan efficient routes to help the redistribution of bikes accordingly. A solution delivered by DecisionBrain and IBM for the bike sharing system in London is the first application of its kind that uses both optimization and machine learning to solve cycle hire inventory, distribution and maintenance problems, and could easily be re-deployed for other cycle sharing systems around the world.

Biography
Damien is a senior Decision Optimization consultant at IBM Europe, he has 20 years of experience helping clients implement solutions in multiple industries. In addition to supporting clients around OR & modeling capabilities, Damien supports setting up the right architectures and ergonomic graphical user interfaces that enable the deployment of the solutions to the business users.

Sofiane leads Decision Optimization within the Data Science Technical Sales Group at IBM in Europe, he also leads the Data Science industry use cases practice of the IBM Data Science Center of Excellence in Europe. As a lead Decision Optimization and Data Scientist, he works with his team to support clients in multiple industries harness the value of Decision Optimization and Data Science within their business processes, to improve operations.

Empirical Model Learning: an industrial point of view

Thomas Bridi[1]

[1] MindIT, Italy

Abstract
The integration between predictive and prescriptive techniques is receiving more and more attention from both the academic and the industrial world. In this talk, we present a methodology called Empirical Model Learning (EML) that relies on Machine Learning for obtaining components of a combinatorial optimization model, using data either extracted from a simulator or harvested from a real system. With EML you can integrate different Machine Learning methods, such as for instance Artificial Neural Networks and Decision Trees in a number of optimization techniques, such as Local Search, Constraint Programming, Mixed Integer Non-Linear Programming. At the end, we'll show how we have used EML in a real-world product.

Biography
Thomas Bridi received a Ph.D. degree in Computer Science and Engineering. During his doctorate, he studied new Artificial Intelligence techniques: Specifically, he developed solutions for the Scheduling Optimization in Supercomputers designed for the minimization of the energy impact. He published several papers in conferences and international journals. He is Team Leader of the Artificial Intelligence group at MindIT and his duty is the integration of the Machine Learning models into the Optimization framework.

Using machine learning to help solve online vehicle routing problems

Nitin Ahuja[1]

[1] PTV Group, Germany

Abstract
For solving dynamic and online vehicle routing problems, a good, realistic and quick estimate of the shortest travel time between any two locations is a basic and valuable ingredient. Estimates based on a set of given reference routes can be calculated quickly but are not always realistic. On the other hand, the use of refined routing engines leads to bottlenecks whenever lots of queries need to be answered in a short amount of time.

We will talk about how travel time prediction with the help of machine learning can bridge the gap between the two extremes stated above. Furthermore, we will touch upon the usefulness and challenges of forecasting where the next few orders, that need to be served, will come from.

Biography
Nitin Ahuja works as a chief software developer for the PTV Group in Germany. His focus is on developing, prototyping and integrating methods and algorithms into commercial software products. He has been active in the areas of optimization, operations research and their real-world applications for more than ten years.

Optimization via Machine Learning-based Simulation: Application to Modern Call Centers Management

Stefano Gualandi[1]

[1] Department of Mathematics, University of Pavia, Italy

Abstract
We share our experience of the Resource ALLocation Optimization (RALLO) project, funded by the ComData Group via the Mathesia brain-sourcing platform. During the project, we have developed a Machine Learning-based simulator of a modern call center, which takes as input the daily backlog of the last 30 days and is able to predict a whole working day involving hundreds of resources and tens of thousands of jobs. The simulator kernel is based on the solution of bimodal regression problems via Expectation Maximization, and of classification problems via a Naive Bayes classifier. The Machine Learning-based simulator is used as a black box within a customized optimization algorithm, which has been integrated into the analytics software owned by ComData.

Biography
Gualandi Stefano is a Senior Reseacher (RTDb) at the Department of Mathematics, University of Pavia, from November 2016. Before joining the Math Dept., Gualandi has worked three years for AntOptima SA, a Swiss company specialized in the development of Optimization and Machine Learning software.

Current Research Topics: Development of Hybrid Models and Algorithms of Combinatorial Optimization, Integer Programming, Constraint Programming, and Machine Learning.

No Routes Wasted for Waste Collection: exploring real-time information through ML techniques to improve waste collection

Tânia Ramos[1], Manuel Lopes[2], Carolina Morais[1], Ana Póvoa[1]

[1] Centre for Management Studies, Instituto Superior Técnico, University of Lisbon
[2] INESC-ID, Instituto Superior Técnico, University of Lisbon, Portugal

Abstract
The use of real-time information can improve efficiency and adaptability in the decision-making processes. An adequate treatment of the available data is however required to feed the decision-making process creating added value to the user. This work investigates how real-time data, transmitted by volumetric sensors located inside waste bins, can be treated and used to improve waste collection operation towards the trade-off efficiency versus service level. Different ways of exploring real-time data are studied using machine learning techniques. These are coupled with a Dynamic Inventory Routing Problem approach that defines optimal waste collection routes. We compare the efficiency of the obtained routes between an estimation method relying on hidden-markov models, a naïve prediction method, and use as baseline an omniscient system and real data.

Biography
Tânia Ramos is an Assistant Professor at the Engineering and Management Department at IST – University of Lisbon, where she teaches Logistics and Distribution, Supply Chain Management, and Project Management courses at the Master's level. She received her Bachelor's degree in Management from ISCTE-IUL, her Master's degree in Operations Research and Systems Engineering at IST and her PhD in Engineering and Management from IST. Tânia's research focuses mainly on modelling and solving real-world problems related with logistics systems planning, routing, sustainability, reverse logistics and waste management systems. She has several papers published in international journals. She has coordinated national projects on the fields of logistics and waste management.

Manuel Lopes is an Associate Professor at the Computer Science and Engineering Department at IST - University of Lisbon. He did his PhD in Electrical Engineering in the field of machine learning and intelligent machines. During his career, he was a researcher at VTT Finland, a lecturer at Plymouth University and a researcher at Inria France. Manuel's research interest lies in the application of machine learning methods for problems of computational biology, robotics, sensing technologies, human-machine collaboration and data analysis. He teaches courses on machine learning and robotics. He published more than 50 papers in international journals and conferences for the domains of data science, machine learning, robotics, and computational biology. He has coordinated projects at the European and national level on the fields of intelligent machines, human-machine collaboration, and computational modeling.

Machine Learning supported algorithm selection for real life airline pairing scheduling problem

Björn Thalén[1], **Jin Guo**[2]

[1] Boeing, Sweden
[2] Chalmers University, Sweden

Abstract
Using machine learning methods to look at the features of a problem and select which algorithm to use for solving the problem has been a common topic for several papers already. Using well-known academic problems which are both quick to solve and easy to generate are usually a corner stone in this methods. In our real life situation the run-times for most interesting problems are measured in hours and not seconds, and acquiring a single test case is time consuming. I'll talk about findings where we tried this approach on real life data in a master thesis and focus on the challenges of transferring the approach into the practitioner's world.

Biography
Björn Thalén is a senior OR-professional working with developing optimization algorithms for airline planning software. His background is from applied mathematics at Linköping University.

Jin Guo is a master student in Applied Machine Learning at the University of Gothenburg. She has successful experience of extracting business value from million-row data using machine learning.

Machine Learning and Optimisation: an ongoing journey

Matteo Pozzi[1]

[1] OPTIT Srl, Italy

Abstract
The application of prescriptive models in real-life business processes is almost intrinsically dependent on prediction of the future context, which creates a pattern where DSSs rely on forecasting and optimisation modules. While the latter call for MI(N)LP or math-heuristic methods typical of OR, the former use methods and tools that fall within the Machine Learning (ML) paradigm.
Starting from a project for customer contact desk optimisation, finalist at the EURO Excellence in Practice Award and Wagner Prize in 2013, the talk will show how ML approaches have evolved over the years in Optit's projects, highlighting key shifts in paradigm that not only rely in increasingly sophisticated approaches (including neural network and deep learning), but also a more complex relation between optimisation, simulation and data analytics techniques, sharing with the audience some of the current challenges coming from the current business environment fuelled by the IoT revolution.

Biography
Matteo Pozzi is Partner and Chief Executive Officer of Optit since 2010. Following his MSci in Physics and Diploma in International Relations, he spent more than 15 years in management consulting in the UK and Italy, working with increasing responsibilities in large business transformation projects with strong focus on the interdependencies between processes and ICT. This experience is now being leveraged upon in Optit, whose business model is evolving to meet market challenges leveraging on the potential of OR and data science at large.

Attention, Learn to Solve Routing Problems!

Wouter Kool[1]

[1] ORTEC, The Netherlands

Abstract

The idea of learning heuristics for combinatorial optimization problems using Neural Networks is promising, and we push this idea further towards practical implementation. We propose a new model and effective way of training by a Reinforcement Learning algorithm, which significantly improves over recent learned heuristics for the Travelling Salesman Problem (TSP), getting close to optimal results for problems up to 100 nodes, and we learn strong heuristics for two variants of the Vehicle Routing Problem (VRP), the Orienteering Problem (OP) and (a stochastic variant of) the Prize Collecting TSP (PCTSP), outperforming a wide range of baselines and getting results close to highly optimized and specialized algorithms.

Biography

Wouter Kool is Operations Research Engineer at ORTEC and PhD candidate at the Amsterdam Machine Learning Lab (AMLab). His research focuses on using (Deep) Reinforcement Learning to learn algorithms capable of solving practical (combinatorial) optimization problems.

List of Abstracts – Posters

Integrating quality considerations for logistic distribution

Claudio Ciancio[1], **Wout Dullaert**[1], **Said Dabia**[1]

[1] Department of Information, Logistics and Innovation, Vrije Universiteit Amsterdam, The Netherlands

Abstract
The problem we address takes inspiration by the food distribution in which different parameters such as temperature, number of stops and spoilage rate have to be monitored during transportation. The objective of the problem consists of determining a set of least-cost vehicle routes that satisfy quality criteria, while respecting pre-specified time windows and without exceeding the vehicle capacity. A column generation algorithm integrated with a metamodel is presented. The novelty of this work is given by the fact that the quality decay of the products during the route is estimated by means of metamodel techniques in which monotony conditions are enforced by constraining the signs of the weights. The metamodel is trained by using historical data in which geographical coordinates and temperature values were recorded through sensors installed inside the reefer container.

Biography
Claudio Ciancio is a Post-doc at the School of Business and Economics, Logistics, Vrije Universiteit Amsterdam. He holds a PhD in Mechanical Engineering. His research interests are in the fields of machine learning, manufacturing systems, logistic and optimization algorithms.

Forecasting harvests for agricultural commodities

Joana Dias[1], **Humberto Rocha**[1]

[1] Faculdade de Economia, CeBER and Inesc-Coimbra, Universidade de Coimbra, Portugal

Abstract

In this talk we will describe a work that was done for a Portuguese company, the 4th world leading company in its field, for which the most important raw material is an agricultural commodity. The company needed to be able to forecast in advance the quantities that would be available in the market in the next harvest. The forecasts should be solely based on meteorological data and harvest areas, considering information of the past 16 years. Different machine learning approaches were tested, and the one showing the best results was Multivariate Adaptive Regression Splines. As more than 1500 attributes were available, variable selection was optimized using a genetic algorithm. Different models were created, producing different forecasts for different time periods. These models are presently being used by the company (the name of the company cannot be disclosed due to confidentiality obligations).

Biography

Joana Dias is a tenured Assistant Professor with Habilitation in the Faculty of Economics of the University of Coimbra. She holds a Licenciatura in Computer Engineering (1996, University of Coimbra), a MSc in Operations Research (2000, University of Lisbon) and in Quantitative Finance (2011, University of London), and a PhD in Management Science (2006, University of Coimbra). Her main research interests are decision making models and algorithms in general, and operations research applied to health problems, combinatorial optimization, multiobjective optimization, in particular. Personal homepage: https://www.uc.pt/feuc/joanamatosdias

A mathematical model for three dimensional cell formation problem with variable number of manufacturing cells

Soukaina Triki[1], **Malek Masmoudi**[2], **Hichem Kamoun**[1]

[1] University of Sfax, Faculty of Economics and Management of Sfax, MODILS, Tunisia
[2] University of Lyon, F-42023, Saint Etienne, France; University of Saint Etienne, Jean Monnet, F- 42000, Saint- Etienne, France; LASPI, F-42334, IUT de Roanne

Abstract
Group technology is a manufacturing philosophy that is used to increase the flexibility of the manufacturing systems. This paper deals with group technology and attempts to divide the manufacturing system into a number of cells. Cellular manufacturing is an application of group technology. To implement a cellular manufacturing system, three decisions must be made which are cell formation, scheduling of jobs in cell and cell layout. Among them, cell formation is the first and the most difficult step. This paper deals with the first design step where part families and machine cells are formed, followed by the assignment of the operators.

In order to solve the three-dimensional cell formation problem (parts, machines and workers) a three- indexed mathematical model is proposed that consider the objectives of minimizing the number of exceptional elements and the number of voids simultaneously. We consider a variable number of manufacturing cells in order to determine the ideal number of cells corresponding to a manufacturing system with minimum cost and high utilization of resources. A multi-objective study based on augmented ε-constraint method has been applied to solve the models and help the layout designer to take the best decision. Several instances from literature have been used to illustrate the performance of the mathematical model and augmented ε-constraint solving approach.

Biography
Soukaina Triki Ph.D student in management science: Operations research and decision aid, at the faculty of economics science and managements Sfax Tunisia, University of Sfax.

NedBank, Predictive and Prescriptive for ATM management

Gianmaria Leo[1], **Virginie Grandhave**[1]

[1] IBM, Germany and France

Abstract
ATM terminals are integral to the operations of banking institutions. As equipment, these terminals can experience outages and these result in loss of transactional revenue to the organization, not forgetting the inconvenience and frustration to the ordinary users. Most banks employ teams of ATM technicians to help in managing these ATM terminals. Like most operating businesses, these human resources are scarce and hence it is critical to deploy them to optimal usage. This presentation and demo serves to demonstrate how machine learning can be used to predict when an ATM terminal is likely to experience an outage and what fault type it is. In addition, we'll also demonstrate how decision optimization can be used to optimize assignment of outage incidents to technicians in a manner that best minimize revenue loss or distance covered.

Biography
Gianmaria is a Senior OR Engineer of IBM Data Science Elite Team. He has over 7 years of experience with Prescriptive Analytics across multiple industries. In IBM, he leads PoCs with customer worldwide, mainly in Energy and Banking. Before joining IBM, he worked in the Airline and Railway industries, where he prototyped solutions for Flight Operations, Traffic Control, Network Planning, Pricing & Revenue Management. Gian holds a PhD in Operations Research focusing on Integer Programming and Combinatorial Optimization. In Academia, he worked on OR applications for Healthcare, Aerospace and Defense.

Virginie is offering manager (product manager) for IBM Decision Optimization portfolio (including public cloud, on-prem and private cloud offerings). She has a strong mathematical background with a master in applied mathematics. She spent 14 years doing and leading quality assurance on optimization softwares. She is passionate supporting clients discover the benefits of operations research and supporting them in their digital transformation journey. Virginie is also teaching business applications of analytics and data science in academia.

Red Electrica de Espana, Predictive and OR to plan electricity generation

Gianmaria Leo[1], **Sofiane Oussedik**[1]

[1] IBM, Germany and France

Abstract
Planning the electricity generation is a critical decision problem which many utility companies have to deal with. A major goal of this decision-making process is achieving an optimal balance between safety, continuity of electricity supplies and cost sustainability. This often leads to a challenging problem, since uncertain operating conditions and varying electricity demand profiles turn out to be crucial factors, which impact remarkably the business operations. The problem could become even more challenging when the electric power system includes renewable energy farms.The underlying optimization problem is well-known in Operations Research as Unit Commitment, however, it is often difficult to determine a priori what the most effective approach would be for any specific use-case.

Biography
Gianmaria is a Senior OR Engineer of IBM Data Science Elite Team. He has over 7 years of experience with Prescriptive Analytics across multiple industries. In IBM, he leads PoCs with customer worldwide, mainly in Energy and Banking. Before joining IBM, he worked in the Airline and Railway industries, where he prototyped solutions for Flight Operations, Traffic Control, Network Planning, Pricing & Revenue Management. Gian holds a PhD in Operations Research focusing on Integer Programming and Combinatorial Optimization. In Academia, he worked on OR applications for Healthcare, Aerospace and Defense.

Sofiane leads Decision Optimization within the Data Science Technical Sales Group at IBM in Europe, he also leads the Data Science industry use cases practice of the IBM Data Science Center of Excellence in Europe. As a lead Decision Optimization and Data Scientist, he works with his team to support clients in multiple industries harness the value of Decision Optimization and Data Science within their business processes, to improve operations.