

OR in Collaboration

5th conference of the EURO Practitioners' Forum

Monday 14 October -
Tuesday 15 October, 2024
University of Coimbra

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Programme

Monday 14 October, 2024

- 12:30 *Registration*
- 13:30 *Welcome session*
- 13:45 **Keynote 1:** B. Romera-Paredes (Google DeepMind): *FunSearch: Discovering new mathematics and algorithms using Large Language Models*
- 14:45 **Contributed talks (C1)**
- R. Oberdieck, R. Menke, O. de Barys, Ch. Karsten (Banking Circle ApS): *What OR can learn from putting LLMs into production*
 - A. Gordini, M. Pozzi, S. Morandini, F. Fraboni, A. De Cesarei, S. Thiébaux (OPTIT / University of Bologna / LAAS-CNRS, University of Toulouse): *From OR to Trustworthy AI: the experience of the TUPLES project*
 - C. Gambella, L. Bertacco, S. Lannez, B. Willcocks, B. del Favero, R. Weber (FICO): *Generating predictive models with Action Effect for loan amount optimization*
- 15:45 *Coffee break*
- 16:15 **Keynote 2:** A. S. Pereira (Wide Scope): *Bridging the gap between theory and practice*
- 17:15 **Contributed talks (C2)**
- Jesús Martínez-Blanco (Flix SE): *Revenue Management at Flix and how to validate changes in the pricing automation pipeline*
 - Julien Darlay (Hexaly): *Effective collaboration between operations research and data science in online advertising*
- 17:55 *Parallel discussion groups*
- 19:00 *Close*
- 20:00 *Conference dinner (optional)*

Tuesday 15 October, 2024

- 8:30 *Registration & coffee*
- 9:00 **Keynote 3:** T. Koch (Technical University of Berlin, ZIB): *25 years of optimization: how to survive industry projects as a mathematician*
- 10:00 **Contributed talks (C3)**
- L. C. Dias (University of Coimbra): *Weighting life cycle environmental impacts*
 - M. Kaleta, P. D. Domanski (Warsaw University of Technology/Betacom As): *Integrated planning of vehicle routes and warehouse operations*
- 10:40 *Coffee break*
- 11:10 **Keynote 4:** M. Lindahl (DTU): *Large Language models: A new tool in the OR toolbox?*
- 12:20 **Contributed talks (C4)**
- S. Van Aken (Flix SE): *Practical challenges in building an ML- and OR-based decision support tool for network planning at Flix*
 - A. R. de Aguiar, M. I. Gomes, T. R. P. Ramos (University of Lisbon): *Optimizing home visit scheduling for family interventions: balancing service delivery and technician well-being*
- 13:00 *Lunch*
- 14:00 **Keynote 5:** J. Matos Dias (University of Coimbra): *Radiotherapy Treatment Planning: The role of Operations Research and multidisciplinary collaboration*
- 15:00 **Keynote 6:** Joaquim Gromicho (ORTEC): *From collaboration to Education and back: a continuously revolving cycle*
- 16:00 *Reports from discussion groups and closing remarks*
- 16:30 *End of event*

Sponsors

Many thanks to all the sponsors of this event that has been entirely financed through their generous contributions.



Keynote talks

FunSearch: Discovering new mathematics and algorithms using Large Language Models

Bernardino Romera-Paredes

Google DeepMind

In this talk I will present FunSearch, a method to search for new solutions in mathematics and computer science.

FunSearch works by pairing a pre-trained LLM, whose goal is to provide creative solutions in the form of computer code, with an automated “evaluator”, which guards against hallucinations and incorrect ideas. By iterating back-and-forth between these two components, initial solutions “evolve” into new knowledge. I will present the application of FunSearch to a central problem in extremal combinatorics – the cap set problem – where we discover new constructions of large cap sets going beyond the best known ones, both in finite dimensional and asymptotic cases. This represents the first discoveries made for established open problems using LLMs. Then, I will present the application of FunSearch to an algorithmic problem, online bin packing, which showcases the generality of the method. In this use case, FunSearch finds new heuristics that improve upon widely used baselines. I will conclude the talk by discussing the implications of searching in the space of code.

Biography



Bernardino Romera-Paredes has been working as a researcher at Google DeepMind for 8 years. He has been a core team member of AlphaFold2 for protein folding, and AlphaTensor for matrix multiplication algorithms. More recently, he initiated FunSearch, a system which uses Large Language Models for program search and has discovered new mathematical knowledge. Long before that, in 2009, Bernardino started his AI journey by studying the MSc Computational Statistics and Machine Learning at UCL. In 2010 he started a PhD, also at UCL, supervised by Prof. Massimiliano Pontil and Prof. Nadia Berthouze, and in 2013 he also did an internship at Microsoft Research. After finishing his PhD in 2014, he joined the Torr Vision Group as a Postdoc at the University of Oxford, researching about semantic segmentation and zero-shot learning. He has several papers published in Nature, as well as in machine learning conferences like NeurIPS and ICML. His main motivation is to leverage the power of AI to bring light to important scientific problems.

Bridging the gap between theory and practice

Ana Sofia Pereira

Wide Scope, Portugal

This talk is about sharing the experience of applying OR in the field of supply-chain while implementing Routyn.

Routyn is a fleet routing and scheduling system in the market for over 20 years and deployed successfully in transportation and logistics companies across the world. It stands on VRP techniques from the domains of mathematical programming, meta-heuristics, constraint programming and artificial intelligence. The broad use of techniques illustrates the multiple problems and sub-problems found when modelling real-life operations. In fact, the reality is made of constraints that hardly are documented in scientific literature or even taught at academia. While solving real-life complex problems may be exciting for an OR practitioner, having them adopted in practice may be frustrating as it often implies operational changes that companies and actors are not willing to take easily.

This talk is about sharing such experience of translating reality into a workable model and applying it to practice.

Biography



Ana Sofia Pereira co-founded Wide Scope with Filipe Carvalho in 2003 immediately after finishing her MSc in Operations Research at the Faculty of Sciences of the University of Lisbon. With nothing but her learnings and a deep will to build and deliver a novel approach to VRP she lead the company from zero to the scale of a high-growth company, as recognized by independent analysts in several occasions. The product Routyn is live in companies from all over the world, from Australia to Colombia, the UK to Angola. And, above all mother of two!

25 years of optimization: How to survive industry projects as a mathematician

Thorsten Koch

Zuse Institute Berlin, Germany

This talk aims at sharing the insights and learned from 25 years of employing integer programming in industry related projects with the audience. After numerous research-industry collaborations, we found that there are several reoccurring topics during these projects.

The problems encountered seem to be universally the same, as there are standard misunderstandings between the partners. We will try to draw some general conclusions and use the projects of the author as examples to demonstrate common pitfalls. We start with some details about acquiring projects, getting them running and how to explain the results to practitioners. Furthermore, we will try to outline what is essential to make collaboration projects with industry worthwhile for both partners and what impact and repercussions they can have on a mathematical career.

Furthermore, we will give some technical notes on how to solve problems efficiently and demonstrate the different attitudes and expectations.

Biography



Prof. Dr. Thorsten Koch is Professor for *Software and Algorithms for Discrete Optimization* at TU-Berlin and head of the *Applied Algorithmic Intelligence Methods* and the *Digital Data and Information for Society, Science, and Culture* departments at the Zuse Institute Berlin (ZIB). He worked especially on infrastructure networks, chip verification, mathematical education, and integer optimization. From 2000-20 he led the development of (M)I(N)LP Solvers at ZIB.

From 2008-14 he was the coordinator of the FORNE project, an industry collaboration project regarding gas transportation. The project received the 2016 EURO Excellence in Practice Award of the European OR Society. From 2013-19 he was head of the GasLab and the SynLab within the Research Campus MODAL (*Mathematical Optimization and Data Analysis Laboratory*). The project *Optimized Execution of Dispatching* conducted together with Germany's largest Gas TSO became finalist of the 2020 *INFORMS Innovative Applications in Analytics Award*.

Currently, his work is focused on developing high-performance methods for solving large-scale structured optimization problems, including *Steiner Tree Problems in Graphs* (STPG) and QUBO.

Large Language models: A new tool in the OR toolbox?

Michael Lindahl

Qampo, Denmark

Since the release of ChatGPT, large language models (LLMs) have seen unprecedented adoption and have become part of many people's daily workflow. These models are very easy to use and can work with large amounts of unstructured data, such as text and images. The output is also very easy to understand, but it can often also be wrong due to the lack of ability in these models to apply reason and logic.

Everyone who has tried to implement Mathematical Optimization Models in practice knows that getting adoption is hard. These models require structured and complete data, which can often be a challenge to collect within an organization. The users also need to be able to interact with the final application, understand the output, and trust it.

Is it possible to get the best of both worlds and use these models to complement each other when building OR applications?

Michael will give an introduction to generative AI and large language models, explaining their capabilities, the pitfalls, and how they can fit into the OR toolbox. He will also demonstrate an example application, <https://www.findgaven.ai>, and how LLM's and optimization can work together.

This will lead to discussion, with the audience invited to share not only their questions but also their own experiences, aspirations, and concerns.

Biography



Michael Lindahl has worked with applying Operations Research and Analytics for 12 years across various industries, such as airports, busses, container shipping, and offshore wind farms. This has built upon a mix of technologies including business intelligence, machine learning and optimization. He has been leading product development and strategy all the way from building initial proof of concepts to improving and maintaining mission critical software platforms. Michael has a PhD from the Technical University of Denmark, and was also president of the Danish OR Society from 2015-2018.

Radiotherapy treatment planning: The role of Operations Research and multidisciplinary collaboration

Joana Matos Dias

University of Coimbra, Portugal

One of the most remarkable applications of Operations Research (OR) that really makes an impact is the optimization of radiotherapy treatment planning. OR has significantly and positively influenced the treatment of millions of cancer patients undergoing radiotherapy worldwide, being at the core of all available commercial solutions in the highly competitive market of treatment planning systems software. This highlights the unique economic and social impact that OR can achieve.

Radiotherapy treatment planning is a crucial step in the radiotherapy treatment workflow, responsible for creating individualized treatment plans tailored to each patient's specific characteristics, considering target volumes that must be irradiated and assuring the best possible preservation of surrounding healthy tissues and structures. Treatment planning is responsible for determining the irradiation directions (beam angles or arcs), as well as the radiation intensities that will be produced by the treatment machine.

Traditionally reliant on manual, trial-and-error methods, radiotherapy treatment planning has evolved to a semi-automated procedure but that, even with the most current advancements, remains a complex challenge. This task can be effectively represented by a mathematical optimisation problem, yet it presents numerous challenges: it is a multi-objective, non-linear, non-convex problem with many local minima, substantial uncertainty, and leading to high-dimensional problem instances. Few real-world applications of mathematical models and optimisation algorithms encompass such a broad array of complex features.

Furthermore, addressing this problem inherently requires collaboration across multiple dimensions. It relies on the cooperation of OR practitioners with experts from other fields such as medical doctors, medical physicists, and computer scientists. It requires collaboration among academia, health institutions and companies. It also requires the integration of methodological approaches from various scientific disciplines, including mathematics, artificial intelligence, and physics.

In this talk, I will present the optimisation of radiotherapy treatment planning from an OR perspective, highlighting the challenges that arise due to its interdisciplinary nature and the necessity of working with diverse teams. Additionally, I will share some advancements achieved by my research team, emphasizing that the best results are obtained when different tools are used in a coordinated, integrated manner, namely when we are able to join together OR and other approaches, namely Machine Learning. Automating the complex and labor-intensive task of radiotherapy treatment planning by such integrated approaches holds the promise of enhancing treatment outcomes, streamlining workflows, and ultimately improving patient care.

Biography



Joana Matos Dias is Associate Professor with Habilitation at the Faculty of Economics of the University of Coimbra. She holds a BSc in Computers Engineering (University of Coimbra, 1996), a MSc in Operations Research (University of Lisbon, 2000), a MSc in Quantitative Finance (University of London, 2011), a PhD and Habilitation in Management Science (University of Coimbra, 2006, 2017). She is researcher and President of the Scientific Council at INESC-Coimbra. Her research works are mostly dedicated to the development and application of quantitative models to support decision-making, integrating different methodologies coming from artificial intelligence, management or applied mathematics and addressing complex challenges across diverse domains, including supply chain management, location optimization, and healthcare. She has been involved, and has been responsible for, several academic and industry driven research projects. She is author of more than 100 publications in international journals, book chapters and conference proceedings. Scopus Author ID: 36238953500; <https://www.joanamatosdias.com/>

From collaboration to Education and back: A continuously revolving cycle

Joaquim Gromicho

ORTEC, The Netherlands

When I departed from the University of Lisbon to join ORTEC 28 years ago, I thought, as a good Portuguese, that I was moving from academia to industry in a one-way journey. I recall my master's students asking if I was going to work in the Netherlands or join a university. This dichotomy between 'work' and academia was also in my mind. Now, I am happy to realize that I did not just cross a cliff but have helped build two-way bridges: from Software Architect to Science and Education Officer, combined with a chair in Business Analytics at the University of Amsterdam. ORTEC employs several full professors, including one of the founders, and numerous assistant and associate professors. It hosts a constant flow of Master's students pursuing graduation on relevant topics with active co-supervision from the company and a regular flow of PhD research. ORTEC actively participates in the board of the Dutch OR Society and collaborates with the major graduate school in OR in the country. Lastly, ORTEC is involved with the EURO Practitioners' Forum.

Until about 10 years ago, the continuous education of ORTEC professionals was an organic process, always encouraged and facilitated by the company but left to individual initiatives. Now, ORTEC implements an ambitious in-house academy called the Education Factory. It offers a curriculum spanning seven domains:

- People Skills
- Business Delivery Skills
- ORTEC
- Portfolio & Go-To-Market Strategy
- Optimization
- Data Science
- Technology

Each domain offers training at different levels, from introductory to advanced, provided by the highest qualified ORTEC professionals or (occasionally) external teachers. Coordination is overseen by the Chief Science Officer (founder, board member, and past EURO keynote speaker in Poznan, Professor Gerrit Timmer), with each domain led by a domain expert, similar to the rector-dean system of a university, albeit on a different scale. I act as coordinator and active teacher of the Optimization curriculum.

Initially, attendance was based on personal interest, with only presence being registered. Now, attendance is aligned with career growth and skill development. Those who excel are awarded knowledge badges as individual assets. These badges have a time limit, reflecting the evolving nature of knowledge, and complement another program at ORTEC known as the 'belt certificates'. Successful completion of an online assessment grants a belt, which also expires and can be renewed.

The benefits extend beyond individuals to the entire organization. It is easier to staff teams with the required expertise, visible through badges and belts, reassuring customers of this tangible asset of knowledge. Additionally, our customers engage us in training them. For that, we developed the Analytics Academy together with the University of Amsterdam. The Education Factory is founded on ORTEC's academic collaborations and feeds back into academia: ORTEC staff teach university curricula related to our in-house developments. This leads to joint research projects fuelled by business knowledge, relevant research questions, and data—the new gold. Our in-house Centres of Excellence distil lessons learned from projects into teaching content, creating a self-amplifying loop.

Biography



Joaquim Gromicho returned to Lisbon as Assistant Professor after an MSc at University of Lisbon and a PhD at Erasmus University Rotterdam. An offer from ORTEC brought him back to the Netherlands as a Software Architect, and now as Science and Education Officer. He fosters relationships with higher education institutions, emphasizing the synergy between ORTEC and academia, noting that collaborative environments attract top students. His longing for academia led to a part-time position at Vrije Universiteit Amsterdam, which evolved into an endowed chair of Applied Optimization in OR. He moved to the Amsterdam Business School to help design BSc and MSc programs in Data Science and Business Analytics, leading to chairing the Programme Committee for Data Science and Business Analytics at the University of Amsterdam. As Optimization Architect at the Analytics for a Better World Institute, he contributes to improving societies. His forthcoming book, *Hands-on Mathematical Optimization with Python*, published by Cambridge University Press, aims to make mathematical optimization accessible to Data Science professionals. Within the EURO Practitioners' Forum, Joaquim helps bridge the gap between theory and practice of OR.

Abstracts of contributed talks

What OR can learn from putting LLMs into production

Richard Oberdieck, Ruben Menke, Oscar de Barys, Christian Karsten

Banking Circle ApS, Laurrupsgade 13-15, 2100 Copenhagen, Denmark

Developing a new optimization model is arguably the most exciting part of being an OR professional. Creativity, mathematics and experience all are involved. However, once a passable version of a model is created, it can become quite a journey of getting such a model into production. This is even more so the case, when the model is part of a critical part of the business, where the number of 9s in availability is key. So, when the authors geared up to deploy a large-language model (LLM), arguably a much less mature technology than mathematical optimization models, we expected a tall mountain to climb. Instead, we were able to go from first experimentation to successful deployment in a few weeks. Even more surprisingly, the system has since performed very well without any major outages, indicating that the path and preparation we put into it was the correct choice. In this talk, we will discuss what decisions we took in this process, how they affected the outcome and what we believe the field of OR can learn from our experience. Specifically, this includes:

- Those who develop models are also able to put those models into production.
- Selecting a modular design that separates model and code
- Incorporating and automating the model tests into the code base
- Enforcing rigorous code quality and code tests, independent of the actual model

We will use this case study to show how such a setup can be achieved for OR projects, both in terms of teams and skill composition as well as actual code and architecture setup.

Biography

Richard Oberdieck obtained his PhD from Imperial College London in mathematical programming in 2017. After working for Orsted, a Danish utility company, he spent 3 years working at Gurobi Optimization in the technical sales team, gaining a profound understanding of the astonishing diversity of problems optimization solvers are used for. Since early 2023, he has been working at Banking Circle, a Danish fintech company, as a Lead Data Scientist, working with machine learning and optimization.

Ruben Menke obtained his PhD from Imperial College London in 2017. After working for Orsted, a Danish utility company, he joined Banking Circle in 2020 as a Principal Data Scientist.

Oscar de Barys is a member of the Advanced Analytics department at Banking Circle, where he primarily works with Large Language Models. He is currently completing his MSc in Artificial Intelligence at the University of Manchester.

Christian Karsten is the Chief Analytics Officer at Banking Circle, where he is responsible for the Advanced Analytics department. He holds a PhD from DTU and has been working with optimization and machine learning for more than 10 years.

From OR to Trustworthy AI: the experience of the TUPLES project

Matteo Pozzi¹, Angelo Gordini¹, Sofia Morandini², Federico Fraboni², Andrea De Cesarei², Sylvie Thiébaux³

¹OPTIT s.r.l. a socio unico, Bologna, Italy

²University of Bologna, Italy, Department of Psychology "Renzo Canestrari"

³LAAS-CNRS, University of Toulouse, France, Artificial and Natural Intelligence Toulouse Institute (ANITI)

Artificial Intelligence and hybrid approaches are increasingly relevant in Decision Science and Operation Research. While symbolic approaches enjoy well-established techniques to verify their behaviour, data-driven or hybrid approaches can pose a risk in terms of robustness under uncertain conditions, and their behaviour can be less predictable and explainable in unexpected conditions. Following the wave initiated by the European Commission who presented in 2019 the Ethics Guidelines for Trustworthy AI [1], amongst other initiatives, the TUPLES project [2] was initiated to develop the foundations, approaches and tools needed to achieve transparent, robust, and safe algorithmic solutions Planning and scheduling (P&S), and increase confidence in these systems to accelerate their adoption, with a focus in 5 different use cases ranging from Scheduling workflow in a manufacturing environment to Smart energy systems supply optimisation and Waste collection optimisation. We outline the challenges, approaches and objectives of the project, focusing on the variety of skills involved in Human Centred AI and the results of the ongoing collaboration between different European Universities, including Psychology researchers. The TUPLES project involved a close interaction between Computer Science experts (including AI and OR experts), domain experts, and Psychologists in order to deeply investigate the human factors involved in the interaction of the users with AI-based Decision Support Systems and the degree of users' trust in those systems, including methods for measuring the quality of explanations and identifying the relative weight (or priority) between conflicting objectives. Finally, the beneficial or detrimental effects on human-AI trust when human and artificial decisions agree or disagree have been assessed both in general purpose problems and in an expert population in an applied (waste collection planning) setting.

Biography

Matteo Pozzi is partner and the CEO of Optit since 2010, following a MSci in Physics, a Diploma in International Relations, and 15 years of management consulting in Italy and the UK.

Angelo Gordini has designed and coordinated the implementation of several Optit's Decision Support Systems in the District Energy industry. Reporting directly to the CEO, he is in charge of the EU projects management, including TUPLES.

Sofia Morandini, **Federico Fraboni** and **Andrea De Cesarei** are research fellows and full professor at the University of Bologna. Their research activity focus on Human-AI, Human-Machine and Human-Robot Interaction for improving safety in industrial environments, Human Factors and interaction between artificial models with human cognition.

Sylvie Thiébaux is the holder of the ANITI Chair on Automated Planning and a Research Director at the Federal University of Toulouse and is the main coordinator of the TUPLES project.

References

1. Ethics guidelines for Trustworthy AI, <https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai>
2. TUPLES description, Trustworthy Planning and Scheduling with Learning and Explanations, <https://cordis.europa.eu/project/id/101070149>
3. TUPLES website, Trustworthy Planning and Scheduling with Learning and Explanations, <https://tuples.ai/>

Generating predictive models with Action Effect for loan amount optimization

Claudio Gambella¹, Livio Bertacco¹, Sebastien Lannez¹, Ben Willcocks¹,
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The FICO Decision Optimizer (DO) application is an optimization software package to perform optimal assignment of treatments to a portfolio of customers. DO leverages optimization algorithms with the goal to empower non-OR professionals with a tool that creates and solves Generalized Assignment Problems, without requiring them to formulate the models. DO considers different kinds of constraints (e.g., budget, ratio) and allows users to generate highly interpretable decision trees.

The DO models depend on structural inputs (e.g., portfolio or customer attributes) and uncertain inputs (predictable target values, such as the impact of treatments on customers). While the DO interface enables configuring and editing of the predictive models required to produce the uncertain data, developing Predictive Causal Models usually requires additional tools and knowledge from a Business Analyst. Furthermore, there is inherent historical data bias, because the historical actions are likely to be targeted on certain segments. Consequently, there may be significant data gaps for some actions.

To address these challenges and simplify the user experience, we developed an iterative, 2-step Action Effect (AE) approach to predict the impact of the treatment assignment on every customer of the portfolio. First, AE predicts a base target score by considering that all predictors are receiving a constant action effect. The final regression model refines the base scores thanks to the scores determined by the action variables. The methodology allows for rank-ordered predictions and includes cross-effect terms.

We present the logic behind the quadratic programming models that are solved to create the predictive models, and the advantages of this methodology over standard regression approaches. The results presented on a loan amount problem solved for an international bank demonstrate that AE methodology can capture action sensitivity to make accurate predictions of how the bad rate changes when different loan amounts are offered to the same customer segment.

Biography

Claudio Gambella is an Operations Research Modeler at FICO since 2021. After receiving a PhD in Operations Research from University of Bologna on mathematical optimization for routing and logistic problem, he has been a Researcher at IBM Research Ireland for 5 years. Current interests include intersections between mathematical optimization and machine learning, and generalized assignment problems in finance. Dr. Gambella has been recipient of an AIRO Best Application Oriented Paper, an IBM Research Division Award, an IBM Eminence & Excellence Award and a Best EJOR Survey Paper Award.

Revenue Management at Flix and how to validate changes in the pricing automation pipeline

Jesús Martínez-Blanco

Flix SE, Warschauer Platz 11-13, 10245 Berlin, Germany

As a mobility tech provider, Flix (the mother company of FlixBus, FlixTrain, Greyhound and Kamil Koç) serves a large and dense network of long distance buses and trains across the globe. Its rapid expansion into markets around the world requires a scalable and automated revenue management system, that is able to decide prices for every route and departure, in real time. Prices are optimized based on estimated demands and price elasticities, which are forecasted using machine learning models that learn from past demand patterns.

During this talk, we will discuss the key components of the pricing automation pipeline built by the Tech teams, as well as how the Operations Research team can validate and quantify the potential revenue uplift brought by new pricing policies resulting from changes or improvements implemented in the pricing automation algorithm.

Biography

Jesús Martínez-Blanco has a PhD in Physics from Universidad Autónoma de Madrid. As a scientist, he worked in several laboratories in the field of nanotechnology. Following his passion for data modelling and automation, he turned into a data scientist at the end of 2015, working in industries like online marketing and mobility. He is currently Principal Data Scientist at Flix, a leading global travel-tech company. He is also a teacher and mentor at Data Science Retreat, where he teaches courses on Interactive Data Visualization using web technologies.

Effective collaboration between operations research and data science in online advertising

Julien Darlay

Hexaly, 251 Boulevard Pereire, 75017 Paris, France

This talk provides feedback about a successful project developed in 2022 for one of Hexaly's clients with an important online business. It involved the revenue management team, data science experts, and an operations research team from Hexaly. The application has been used daily by multiple users since 2023. The business problem can be described as follows: suppose that you have a database of qualified users (age, gender, location, buying patterns, etc.) and the history of all visits for the past few years, and you want to estimate the number of distinct women aged 20 to 40, located in a specific region who are interested in reading books or cinema and are likely to visit your website next week. Answering this question on past visits can be done with an SQL request on a classical database. Still, it requires considerable memory and several hours of computation time because of the history size. Our client needs a precise estimate in less than one second.

The data science team was already able to derive a precise forecast of the number of future visits for a particular period. The remaining difficulty was to estimate the proportion of visits satisfying the request's criteria. We derived a high-speed algorithm with the data science team based on approximate counting and the HyperLogLog algorithms. It requires the offline precomputation of data structures by scanning the visit history, which can be done weekly in a few hours. These data structures allow a fast computation of the approximation of the cardinality of the union of sets and are the key elements in estimating the answers. We later generalize their usage inside standard operations research algorithms and models to solve the MAX- k -COVER and the MIN- k -UNION problems.

The success of this project was a result of the close collaboration between the revenue management team, which defined the industrial needs and explained the data, the data science team, which had all the resources to perform massive data analysis, and finally, an O.R. team, which handled the algorithmic aspects. We found a way to summarize the database using HyperLogLogs, keep this aggregate in memory, and develop a fast web service to answer requests in a few milliseconds.

Biography

Julien Darlay is head of science at Hexaly, a software editor developing Hexaly Optimizer and a services company specializing in operations research. In the past ten years, Julien has been in charge of several industrial projects in various domains, such as telecom, media, construction, etc. Julien received a Ph.D. in computer science from Grenoble University (2011). His research was at the intersection of mathematical optimization and machine learning.

Weighting life cycle environmental impacts

Luis C. Dias

University of Coimbra, CeBER, Faculty of Economics, Av Dias da Silva 165, Coimbra, Portugal

In the fields of industrial ecology and environmental management, Life-Cycle Assessment (LCA) is one of the most applied methodologies to quantify the environmental impacts of a product or service throughout its life cycle, from materials extraction to end of life. Environmental impacts are assessed in multiple impact categories (climate change, ozone layer depletion, eutrophication, etc.) and therefore LCA results are multidimensional, but researchers and practitioners often seek to aggregate them using some weighting scheme, as a means to reach synthetic conclusions and to support decision making. In the field of operational research, this can be seen as a multi-criteria decision analysis (MCDA) problem, for which a myriad of techniques has been developed to support the evaluation of

alternatives (projects, applicants, suppliers, etc.) by eliciting preferences from decision makers and aggregating assessments performed across multiple criteria. Many studies have therefore combined LCA and MCDA methodologies, but a crucial distinction must be made between using MCDA for decision support and using MCDA for other purposes. Moreover, the existence of a decision maker, a single individual or a group, is a fundamental assumption of MCDA which is often missing in LCA studies. Instead, LCA practitioners may wish to use more general weights, such as the weights that reflect preferences of an entire population of individuals. For this purpose, experts on different fields, namely economics and econometrics, typically use approaches based on a population's stated or revealed preferences.

This presentation discusses the different perspectives from LCA, MCDA and econometrics when dealing with the issue of weighting LCA impacts. This is illustrated with examples in which the author – who has worked mainly in operational research and decision analysis – was part of teams interacting with policy- and decision-makers, subject experts and end-users, in applications requiring collaboration with scholars and practitioners from other fields. These applications included assessing innovative bio-based films for food packaging, finding a biodiesel supply chain alternative, or proposing a default weighting vector to be used by LCA practitioners. MCDA extensions such as robustness analysis, stochastic multi-criteria acceptability analysis (SMAA) and preference disaggregation approaches are presented as useful instruments in this context.

Biography

Luis Dias obtained a Ph.D. in Management (2001) and Habilitation in Decision Aiding Science (2013), from the University of Coimbra. He is currently a Professor of Management Science at the Faculty of Economics, Univ. Coimbra, where he has been teaching courses on decision analysis, operational research, and related areas. Luis is currently the Director of the Centre for Business and Economics Research at Univ. Coimbra (CeBER), a collaborator at INESC Coimbra, a member of the coordination board of Univ. Coimbra's Energy for Sustainability Initiative, and Chair of the General Assembly of APDIO, the Portuguese Operational Research Society. He is on the Editorial Board of Omega, EURO Journal on Decision Processes, Group Decision and Negotiation and Journal of Multi-Criteria Decision Analysis. His research interests include multicriteria decision analysis, performance assessment, group decision and negotiation support, with applications in different areas. He has published over 100 articles in peer-reviewed international journals, in journals such as Computers & Operations Research, Decision Analysis, Decision Support Systems, European J. of Operational Research and Omega (in the operational research area) as well as prominent journals in other areas (energy, environment, healthcare).

Integrated planning of vehicle routes and warehouse operations

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The Vehicle Routing Problem with Pickup and Delivery with Time Windows (VRPPDTW) is a widely recognized challenge in scientific literature. However, practical applications involve considering constraints and key aspects often omitted in theoretical models, such as those arising from labor laws or transport resource management strategies. Additionally, vehicle route planning must be aligned with warehouse operations and delivery schedules. These considerations imply that effective planning of warehouse operations and vehicle routes extends beyond the classic tasks familiar to operations research (OR) specialists.

To address the specific needs of warehouse operations, we propose a digital model of the warehouse implemented as a multi-agent system. Experts in multi-agent simulations and machine learning (ML) play a dominant role in this area. Resource consumption estimates for specific operations required by the simulation can be determined by ML models, which update and improve the model's performance in real-time. While warehouse operations can be modeled within a self-learning multi-agent framework, operational research tools remains essential for vehicle route planning. Although the vehicle routing problem can be approached using mathematical programming models, and its complexity managed with decomposition methods, the variability of requirements in business practice led to the choice of an evolutionary strategy-based solution. To align vehicle route planning with warehouse operations, warehouse capacities are considered in an aggregated manner while solving the planning problem. Under this assumption, vehicle routes are first determined, and then a multi-agent warehouse digital model is used to simulate operations and impose corrections on the vehicle plan as necessary.

In this talk, we share our experience in developing a system for optimizing warehouse operations and vehicle route planning, as part of a solution developed at Betacom SA. Our expertise comes from joint research and projects between the academia and Betacom SA, which allows us to confront research ideas with the reality of the logistics and, therefore, develop solutions that address present challenges. Once the research phase is completed, the commercial version will be validated by industry partners and prepared for real-world deployment. Although the solution is general, it is specifically dedicated to large sales networks in the FMCG (fast-moving consumer goods) industry. We will discuss the challenges faced during the project, emphasizing the importance of collaboration between experts in OR, ML, and multi-agent systems.

Biography

Paweł D. Domański was born in Warsaw, Poland in 1967. He received the M.S. degree in 1991, Ph.D. degree in 1996 and D.Sc. degree in 2018, all in control engineering from the Warsaw University of Technology (WUT), Faculty of Electronics and Information Technology. He works as a professor in the Institute of Control and Computational Engineering, WUT. He is the author of three books and more than 150 publications. His main research interest is with industrial APC applications, multi-agent modeling, control performance assessment and optimization. Apart from scientific research he participated in dozens of industrial implementations of control and optimization in power, chemical engineering and logistics all over the world. Currently, he plays the role of the R&D leader at Betacom SA.

Mariusz Kaleta is an assistant professor at the Institute of Control and Computational Engineering at Warsaw University of Technology. His main research interests include decision support systems, operations research, mathematical modeling for decision-making, and mechanism design. His recent interests revolve around the integration of machine learning and operational research. Mariusz is an author or co-author of over 100 peer-reviewed publications. He was involved in 10 granted research projects and several commercial projects, including audits of the Polish balancing electricity market, business process modeling and simulations, pallet packing problems, and vehicle routing problems. He also serves as a mentor in several acceleration programs and hackathons focused on innovation, entrepreneurship, and Design Thinking.

Practical challenges in building an ML- and OR-based decision support tool for network planning at Flix

Sander Van Aken

Flix SE, Warschauer Platz 11-13, 10245 Berlin, Germany

Flix has rapidly become a global player in the long-distance passenger transportation market, operating in 44 different countries across 4 continents as FlixBus, FlixTrain, Greyhound (North America) and Kamil Koc (Turkey). Being a commercial company, thoroughly matching supply and demand is a key element for sustainable growth and profitability for both Flix and its 1000+ mobility partners operating the network. Our network planners create timetables, bus and driver schedules with the aim to build these profitable networks.

Our tech teams support them with a range of internally developed tools, amongst which a granular PAX and revenue-forecasting model, and a product for bus and driver schedule optimization. Our next step is to support planners with profit-oriented timetable optimization algorithms. Planners anticipate and adapt to highly seasonal demand in a strongly data-driven manner. On one hand, we could offer a flat supply, which is easy-to-manage yet expensive. On the other hand, we can perfectly fit supply to demand, which improves profitability but introduces complexity for downstream stakeholders.

Hence, our planners aim to strike the right balance using a particular way to plan timetables and deal with variability and seasonality on day, week and yearly level. The (algorithm-) methodological aspect has been – and still is – widely studied in academic research. Yet it doesn't align with that planning methodology.

Beyond methodological and business challenges, adherence to software-engineering best-practices, and integration in the existing user flow are key. We are at the early stages of development, and during this talk, we will delve into some of these challenges and how we address – or plan to address – these in a multidisciplinary approach.

Biography

Sander Van Aken is Operations Research Engineer in the network planning optimization team at Flix SE (known from FlixBus, FlixTrain, Greyhound US and Kamil Koç). The team designs, develops and tests custom-built OR-algorithms for timetable, bus and driver scheduling, in close collaboration with both tech- and business stakeholders. These get embedded in a software product owned and developed by the team. Sander holds a MSc. in Traffic and Logistics Engineering and prior to joining Flix worked as advanced analytics consultant mainly in the public transportation industry on projects including simulation-, data science and optimization-based projects.

Optimizing home visit scheduling for family interventions: balancing service delivery and technician well-being

A. R. de Aguiar¹, M. I. Gomes², T. R. P. Ramos¹

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This talk addresses the complex challenge social organizations face in scheduling home visits for family interventions. We present a novel multi-period mixed-integer linear programming model that simultaneously allocates and schedules home visits over an extended planning horizon. The model allows for different visit intervals to meet different family needs, incorporates flexible worker schedules to address work-life balance, and tailors schedules based on the personal preferences of technicians. The goal is to improve the current scheduling process while balancing the competing priorities of maximizing service delivery and ensuring technician well-being.

The ComDignitatis case study, a real-world application, was solved for a three-month planning horizon. The results show significant improvements in service quality and efficiency. The total number of home visits increased from 56 to 203, a remarkable improvement of 263%. In addition, scheduling capacity utilization increased from 57% to 83%, and the number of duplicate visits increased by a factor of 7, indicating a better use of technician time. However, this optimization also led to a corresponding increase in the use of inconvenient time slots, the evening hours, highlighting the potential work-life balance challenges faced by technicians.

This study introduces a new tactical planning approach specifically tailored to family interventions. By highlighting the complex trade-offs between increased service delivery and technician schedules, this work also underscores the importance of managing workload balance and accommodating technician preferences. The potential for real-world implementation highlights the practical relevance of this work, which highlights the delicate balance between improving service quality and ensuring the well-being of frontline professionals delivering these much-needed family interventions.

The results presented in this talk concern a first approach to the problem. As this is a work in progress, the practical impact of this collaboration was mainly to make the ComDignitas team more aware of the possibility of medium-term planning. They had never developed monthly plans for visits, as their approach is only weekly. Every week they have a morning meeting where they plan the work for the next week and assign new families according to the availability of technicians for the next day. The meeting where we presented these results was therefore very enlightening for them, as it was the first time they had seen a tactical plan for a period of more than a week. Furthermore, the data analysis showed them how unevenly the work is distributed among the technicians.

Biography

Maria Isabel Gomes is an Associate Professor at the Department of Mathematics at NOVA School of Science and Technology and a researcher at NOVA Math. Her research has focused on modeling logistics and operations management problems, such as supply chains with reverse flows, vehicle routing problems in solid waste collection, among others. Recently, she has been working on the modeling of logistics challenges faced by the social sector in what she calls Social Care Logistic.

Discussion group topics

Explainable OR: Are ideas from Explainable AI relevant to OR?

Room A

Andy Harrison (QinetiQ)

Many AI models, specifically deep learning models, are black boxes; *i.e.* it is not clear why they give the outputs they do. Explainable AI tools, such as Feature Importance Analysis, SHAP (SHapley Additive exPlanations) or LIME (Local Interpretable Model-agnostic Explanations), aim to explain the behaviour of these models.

As AI increasingly becomes another tool in the OR toolbox, can these tools be used to help explain more traditional OR models, such as optimisation models? And can they help to integrate AI and optimisation models as hybrid solutions?

Navigating careers in Operations Research: Challenges, opportunities, and future trends

Room B

Susanne Heipcke (FICO), Vladimir Fux (Zalando)

This interactive discussion group explores the landscape of careers in Operations Research (OR). We will delve into various aspects of professional development, industry demands, and emerging trends in the field. Participants will engage in discussions on topics ranging from continuous learning to effective job search strategies and the impact of emerging technologies. We will also touch on the employer and hiring side of things—discussing expectations, hiring processes, and challenges encountered. Furthermore, we plan to address the importance of soft skills and common career challenges faced by OR professionals. This session is designed for OR professionals at all career stages, offering a platform to share insights, ask questions, and network with peers.

Collaboration

Room C

Ruth Kaufman (Chair of EURO Practitioners' Forum), Ricardo Saldanha (SISCOG)

The theme of this conference is 'OR in collaboration', and many of our speakers will be illustrating practical examples of this. Working with people from other disciplines, who have different roles, can be exciting and inspiring, and transform what our work can achieve. It can also be frustrating, confusing, time-wasting, and ineffective. This discussion session will give us a safe space to share good and bad experiences, and to explore how we can get the most out of the opportunities that collaboration can bring, and how we can manage the risks.

Maps

Conference venue:

Student Hub, University of Coimbra, Rua Larga, Edifício da FMUC, r/c, 3000-370 Coimbra, Portugal; Google maps link: <https://maps.app.goo.gl/KDZYoaFxtXpBM3ZW7>



Conference dinner:

Tertúlia d'Eventos, Quinta da Insua, Azinhaga do Convento Velho, 3040-252 Coimbra
GPS: N 40° 12'3.212" O 8° 25'51.516
Google maps link: <https://maps.app.goo.gl/7tMNN0JqHrYYEgnh7>

