FORS50: Schedule and program

Table of contents

How to get to Jyväskylä?

From Helsinki-Vanta airport

If you are arriving to the Helsinki-Vantaa airport, you can take a regional train from inside the airport to either Tikkurila or Helsinki. To buy a ticket for the regional train, a ticket vending machine on the train platform can be used. A ticket may also be bought on mobile using the HSL app (https://www.hsl.fi/en/tickets-and-fares/hsl-app).

From Tikkurila and Helsinki, you can take either a train or bus to Jyväskylä. Trains in Finland are all operated by VR. To book a train ticket, visit https://www.vr.fi/en#buy-tickets. Busses are also an option for traveling from Tikkurila/Helsinki to Jyväskylä. Long distance busses in Finland are mainly operated by OnniBus (https://www.onnibus.com/home) and Matkahuolto (https://www.matkahuolto.fi/en).

From Jyväskylä airport

If you are arriving to the Jyväskylä airport, your only choice of transport is a taxi. There are multiple taxi operators in Jyväskylä, but we recommend utilizing Jytaksi (https://jytaksi.fi/en/). It is further recommended to book a taxi in advance.

Moving around Jyväskylä

The main form of public transportation in Jyväskylä is by bus. The buses are operated by Linkki (https://linkki.jyvaskyla.fi/en) and tickets can be readily purchased on their mobile app (https://payiq.net/jyvaskyla). Rental electric scooters are also a convenient way to move around Jyväskylä, provided mainly by companies such as Voi (https://www.voi.com/), Tier (https://www.tier.app/en/), and Ryde (https://www.ryde-technology.com/). Moreover, walking is not just a possibility, but an enjoyable reality as the city is well-equipped with extensive walkways, making pedestrian travel efficient. Everything in the city area of Jyväskylä is relatively close, and the city's excellent walking conditions mean you could quite feasibly walk everywhere if you do not mind covering a couple of kilometers on foot. For instance, the distance between the conference venue and the Jyväskylä train station is around 1.5 kilometers. It is recommended to bring an umbrella since rain can be quite common in late September!

The venue

The main venue of the FORS50 conference is the Agora-building of the University of Jyväskylä. It is located in Mattilanniemi on the shore of lake Jyväsjärvi. The conference will take place on the ground floor of the building in rooms around its main hall. The conference dinner will take place in Restaurant Viilu, which is located in the harbor are of lake Jyväsjärvi.

For the main points of interest in Jyväskylä, please see the map below:

FORS50 conference schedule

The main venue of the event is the main hall of the Agora building at the university of Jyväskylä (Mattilanniemi 2, 40100 Jyväskylä).

Keynotes: 40 minutes + 10 minutes = 50 minutes
Parallel talks: 20 minutes + 5 minutes = 25 minutes. Each session has 3 talks (total 75 minutes)

Saturday (23.9.2023)

Time	What	Place
9:00	Registration opens	Agora main hall
10:00 - 10:10	Opening ceremony	Auditorium 2
10:10 - 11:00	Keynote 1	Auditorium 2
11:00 – 11:20	Coffee break	Agora main hall
11:20 – 12:35	Parallel session 1.A Parallel session 1.B	Room Alfa Room Beeta
12:35 – 13:25	Lunch break	Restaurant Piato
13:25 – 13:35	Group foto	In front of restaurant Piato
13:35 – 14:25	Keynote 2	Auditorium 2
14:25 – 14:45	Coffee break	Agora main hall
14:45 – 16:00	Parallel session 2.A Parallel session 2.B	Room Alfa Room Beeta
18:00 – 23:00	Banquet	Restaurant Viilu

Sunday (24.9.2023)

Time	What	Place
9:00 – 10:15	Parallel session 3.A Parallel session 3.B	Room Alfa Room Beeta
10:15 – 10:35	Coffee break	Agora main hall
10:35 – 11:25	Keynote 3	Auditorium 2
11:25 – 12:40	Parallel session 4.A Parallel session 4.B	Room Alfa Room Beeta
12:40 – 13:40	Lunch break	Restaurant Piato
13:40 – 14:55	Parallel session 5.A Parallel session 5.B	Room Alfa Room Beeta
14:55 – 15:15	Coffee break	Agora main hall
15:15 – 16:05	Keynote 4	Auditorium 2
16:05 – 16:15	Closing ceremony	Auditorium 2

Day 1: Saturday (23.9.2023)

Keynotes

Keynote 1: Operations Research in Finland: A Historical Perspective

Prof. Dr. Emeritus Jyrki Wallenius, Honorary Chairman of the Finnish Operations Society, Aalto University School of Business

Abstract

The history of Operations Research in the world and in Finland are briefly covered. The key persons are identified. The development of Operations Research is linked to the development of computers. Operations Research could not have found widespread applications without the simultaneous development of computers. I share my personal experiences how it was to conduct Operations Research in early 1970's. I identify some key trends, which we have experienced over decades. I conclude with the state-of-the art view of Operations Research today, with an emphasis on analytics.

Biography

Jyrki Wallenius is emeritus professor at Aalto University School of Business (Aalto BIZ), Department of Information and Service Management. He was appointed professor of Management Science at former Helsinki School of Economics (HSE) in 1998. During his career at Aalto BIZ and HSE, he served in many roles: as professor, MBA director, doctoral program director, department head, Vice Rector, and dean. Prior to joining the Helsinki School of Economics, Wallenius served as Associate Professor and department head at the Economics Department, University of Jyväskylä. He has spent several sabbaticals in the United States, including Purdue University, Texas A&M University, and Arizona State University. His research interests are in Multiple Criteria Decision Making (MCDM), in particular in multi-objective optimization and decision support. Wallenius has published widely in many leading journals, including Management Science, Operations Research, and European Journal of Operational Research. He is former President of the International Society on Multiple Criteria Decision Making and chair of its awards committee, past editor-in-chief of the European Journal of Operational Research, and a co-founder of INFORMS Section on MCDM. For over a decade, Wallenius has served on several boards of private Finnish foundations. Moreover, he served on Finnish IIASA Committee for several years. Wallenius is the recipient of numerous awards, both international and domestic. Among the awards are the Edgeworth-Pareto award of the International Society on Multiple Criteria Decision Making and Jaakko Honko-medal. Wallenius is the honorary President of the Finnish Operations Research Society.

Keynote 2: AI in Engineering Design: From Tool to Partner

Prof. Dr. Bernhard Sendhoff, CEO – Global Network Honda Research Institutes

Abstract

The role of AI in Engineering and particularly in Engineering Design has made significant progress in the last years. In the first part of my presentation, I will outline the CAE/AI enhanced approach to engineering design from an industrial perspective. This will include examples from design and topology optimization and concludes with some of the remaining challenges like robustness and many-objective optimization.

In the second part of my presentation, I will introduce approaches to go beyond the tool-based AI in the engineering design process chain and enable the AI methods to improve their performance over time. Experience-based Computation: learning to optimise has been an EU Horizon 2020 project that addresses the issue on how optimization can be improved through learning just like the engineer becomes more and more experienced over time. I will look at one approach inspired from data mining and knowledge extraction and one from transfer learning and the advantage of multi-task optimization.

AI as a cooperative partner in the engineering design process will be the subject of the last part of my presentation. I will briefly introduce the general concept of cooperative intelligence and then outline some of the challenges in understanding the engineer for optimal support. Many if not most engineering design decisions are made in a team, therefore, it is necessary to go beyond the cooperative interaction between the engineer and AI as a partner, but to also study the effect that an AI system can have on the decision dynamics in a team.

The presentation will conclude with a summary and some additional issues that have to be addressed to evolve AI from a tool to a partner in Engineering and in Engineering Design.

Biography

Prof. Dr. Bernhard Sendhoff has had a distinguished career in both academia and industry. He obtained his PhD in Applied Physics from Ruhr-Universität Bochum, Germany in 1998. From 2011 to 2018, he served as the President of Honda Research Institute Europe GmbH. Concurrently, he was an Honorary Professor at the School of Computer Science, University of Birmingham, UK from 2007 to 2020.

In 2019, Dr. Sendhoff became the President of Honda Research Institute Japan Co., Ltd., a position he held until 2021. Since 2008, he has been an External Professor at the Technical University of Darmstadt, Germany. In 2017, he was appointed as an Operating Officer at Honda R&D Co., Ltd., Japan.

As of 2021, Dr. Sendhoff has taken on the role of CEO for the Global Network Honda Research Institutes. He is a Fellow of the IEEE and a Senior Member of the ACM, reflecting his significant contributions to the field.

Parallel session block 1

Session 1.A: Operations Research in Healthcare

Presentation 1: A flexible approach for the nurse scheduling problem in real world

Alaouchiche, Yasmine (University of Technology of Troyes, SAS OPTA LP); Ouazene, Yassine (University of Technology of Troyes); Yalaoui, Farouk (University of Technology of Troyes); Chehade, Hicham (SAS OPTA LP)

Improving the efficiency of healthcare organizations requires primarily improving the quality of service and the well-being of medical staff. The Nurse Scheduling Problem has drawn significant attention during the last few decades. In practice, the schedules are usually generated manually by head service nurses. However, it is often both difficult and time consuming. Although the NSP was extensively studied considering different constraints and objectives, real world constraints and instances tend to be more challenging.

Hence, we propose a mathematical model to solve the Nurse Scheduling Problem for a real case study from a French hospital. Specific constraints are considered and the problem is solved with the objectives of balancing shift-type assignments, balancing total workload, and fairly satisfying nurse preferences. In addition, specific nurse contracts and restrictions are considered.

The proposed approach offers the possibility of a long time horizon planning satisfying work and regulation constraints, workload and shift-type balance, and nurse preferences, in order to come up with a fair planning centered on the well being of the healthcare personnel. Tests on real data from the hospital service enable to confirm the effectiveness of the approach compared to the manual planning. Indeed, the considered constraints are respected, nurse preferences are satisfied, and workload as well as shift-type assignments are better balanced. Finally, the proposed algorithm is able to return optimal schedules in few seconds.

Presentation 2: Decision-making under deep uncertainty: basics, state-of-the-art, and the Future

Shavazipour, Babooshka (University of Jyväskylä)

Real-life problems often face various sources of uncertainties, and most of the decisions need to be made in the absence of complete knowledge about the parameters, probability distributions, outcomes, and consequences of the alternative decisions. In some cases, the experts do not know or cannot agree upon the appropriate models, probability distributions, or measures of desirability for alternative outcomes. This condition defines deep uncertainty, which is in line with the definition of Knightian uncertainty related to the incalculable and uncontrollable part of the unknown. Decision-making under deep uncertainty (DMDU) has attracted more and more attention in the last two decades and is particularly becoming a hot research topic in various disciplines, as well as among governors seeking

more robust and resilient decisions, particularly after recent worldwide crises such as COVID-19, the Russian invasion of Ukraine, and their economic and social effects.

This talk will briefly review the basic concepts and state-of-the-art of the most potent DMDU methods and highlight crucial future research directions for practical usage.

Session 1.B: Supply Chain and Inventory Management

Presentation 1: Multi-item dynamic lot sizing with multiple transportation modes and item fragmentation

Tamssaouet, Karim (BI Norwegian Business School, Oslo, Norway); Engebrethsen, Erna (BI Norwegian Business School, Oslo, Norway); Dauzère-Pérès, Stéphane (Ecole des Mines de Saint-Etienne, Gardanne, France)

We address a tactical joint inventory and transportation planning problem for multiple items considering various transportation modes. We incorporate different operational policies for loading and splitting the items among several trucks or containers, termed fragmentation, into the model and investigate their effect on the costs and computational complexity. To accomplish such integration, the assignments of the items to the transportation containers must be modeled explicitly, which leads to a problem combining a multi-item lot-sizing problem and a variable cost and size bin packing problem with fragmentation.

Different formulations of the problem are proposed, and the most efficient ones are identified using a standard solver. The most efficient formulation is also used to design several heuristics. In addition to comparing the different approaches, the computational experiments also help analyze the effect of varying some of the problem parameters and fragmentation constraints on the computational times and potential cost savings, providing managerial insights and directions for future research.

Presentation 2: Recycling of probiotic food products after deterioration utilising intelligence computing in multi-echelon supply chain

Sharma, Nidhi (Indian Institute of Technology Roorkee); Jain, Madhu (Indian Institute of Technology Roorkee); Sharma, Dinesh (Dept. of Business, Management & Accounting University of Maryland Eastern Shore Princess Anne)

Some products may degrade while being stored, transported, or produced, which negatively affects the supply chain in terms of the overall profit. In this study, a two-stage supply chain is considered in which the primary chain consists of manufacturer, retailer and supplier. In order to reduce the degradation in raw material at supplier’s end, a manual inspection policy is used. During production, if defective units are generated, the rework of these defectives are done so as to convert into original items. The combined online and offline sales channel is considered for the retailer. A utility-based method has been suggested to reflect the consumers' decisions among the various choices. The deteriorated units recovered from the primary supply chain are supposed to recycled by a recycler in the secondary chain. The global optimal solution for the optimization issue is obtained with the help of Differential Evolution (DE) and Particle Swarm Optimization (PSO) and compared with a numerical optimization scheme named Sequential Quadratic Programming (SQP). The validity of the proposed model and its efficacy in maximising the combined profit of the supply chain of probiotic food are established via sensitivity

analysis. The managerial insights are also facilitated based on numerical simulation and optimization outcome.

Presentation 3: Inventory Policy for Degrading Items under Advance Payment with Price and Memory Sensitive Demand using Metaheuristic Techniques

Singh, Praveendra (Research Scholar, Dept. of Mathematics, IIT Roorkee, Roorkee); Jain, Madhu (Associate Professor, Dept. of Mathematics, IIT Roorkee, Roorkee)

The integer-order methods may fail to adequately describe the behavior of many real-world inventory systems. A fractional order inventory model can provide useful insights to the decision-makers to examine the presence of memory effect in the system. The present study develops a fractional order inventory control model for non-immediately degrading goods by incorporating memory and selling price sensitive demand rate. The mathematical model is developed using Caputo fractional derivatives and analyzed using the Laplace transform approach. An appropriate preservation policy is established to reduce the degradation in the inventory system. This article examines a partial pre-payment plan where the vendor provides a discount on the purchase price. It is evident from the literature that the advance payment schemes for memory-based inventory systems have not previously been investigated. Three metaheuristics, viz, particle swarm optimization (PSO), quantum behaved PSO, and differential evolution are employed to handle the profit maximization problem. The usefulness of the memory-based model is examined with a numerical example. The proposed study also reveals that the memory indices significantly impact the optimal profit. Several management insights are established by considering the model's applicability through sensitivity assessments of the key inventory parameters.

Parallel session block 2

Session 2.A: Utilizing Analytics and Machine Learning in Operations Research

Presentation 1: Analytics offers mobilisation of tacit knowledge for line managers

Carlsson, Christer, Honorary Chairman of the Finnish Operations Research Society (Institute for Advanced Management Systems Research, Abo Akademi University)

A growing mantra is appearing in business magazines – powerful, intelligent systems will be effective tools for the digitalization of industrial processes – much less attention is paid to the fact that users need advanced knowledge and skills to benefit from the intelligent systems – or even to manage them.

Classical operational research is being rebranded as analytics, with further specification in descriptive, prescriptive, and predictive analytics. Prescriptive analytics is close to what we traditionally include in operational research, both in terms of approach, methodology and algorithms. The context has, however, changed dramatically from the problem solving and decision-making environments of the 1970'es - when FORS was young.

The digitalization of industrial processes brings new challenges for line managers. Classical OR modelling works out situational logic and offers data to support optimal problem solving to guide decisions. Advances in information technology process fast growing data and add enhanced information support to OR modelling. Digitalization builds on advanced, complex, and automated systems combined with the vision that effective problem-solving supports fast, real-time decisions in competitive environments ("the fast eat the slows"). Line managers face challenges to master detailed knowledge of new, complex environments and seem to rely on experience and semi-formulated tacit knowledge for guidance.

Our work with Finnish industry line managers shows that analytics can mobilize insight and tacit knowledge of experienced process operators and managers. Some lessons learned are that (i) analytics models should be explainable, not black boxes; (ii) problem solving can be logical and intuitively understandable, not magical, and (iii) imprecision reduces unnecessary complexity. We introduce fuzzy entropy and soft computing to allow analytics models to benefit from imprecision and to give line managers tools to tackle complexity.

Presentation 2: Convex support vector regression

Liao, Zhiqiang (Aalto University School of Business); Dai, Sheng (University of Turku); Kuosmanen, Timo (University of Turku)

Nonparametric convex regression with shape constraints is increasingly popular in economics, finance, operations research, machine learning, and statistics. However, the conventional convex regression based on the least squares loss function often suffers from overfitting and outliers. This paper proposes to address these two issues by introducing the convex support vector regression (CSVR) method, which effectively combines the key elements of convex regression and support vector regression. Numerical experiments demonstrate the performance of CSVR in prediction accuracy and robustness that compares favorably with other state-of-the-art methods.

Presentation 3: How Operations Research supports AI in Silo's client projects: decision support perspective

Hakanen, Jussi (Silo AI); Hartikainen, Markus (Silo AI); Nieminen, Tomi (Silo AI)

Silo AI delivers AI-driven solutions and products in various fields with the main emphasis being AI for people. Our goal is to support clients in their decision making context with data-driven tools utilizing the power of machine learning. Operations research is central to decision making and we combine methods of operations research in different ways to machine learning. First of all, optimization is a crucial part of training machine learning models to learn the most important characteristics of the available data. The optimization techniques used in training needs sometimes to be tailored case-by-case in order to improve the accuracy and reliability of the machine learning models. Secondly, optimization-driven decision making is in our case often based on machine learning models providing information on the phenomena in question and how they behave under different decisions. Here machine learning models provide optimization objective and constraint function values for different decisions. Thus, all the methods of (multiobjective) optimization can be applied on an optimization problem based on machine learning models. Practical examples of combining OR and AI are demonstrated through selected client projects in the fields of renewable energy, retail and food industry.

Session 2.B: Operations Research in Energy and Sustainability

Presentation 1: The Nordic Capacity Reserve Markets in Practice

Bell, Gaving (Optimeering AS); Hausken, Magnus (Optimeering AS)

Electricity prices - and electricity markets - have become a hot topic in dinner table conversation over the past year as prices have risen to previously unseen levels in the Nordics and Europe. Hidden behind the headlines has been an increasing trend to comprehensive use of markets to procure many products and services necessary to operate the power sector, such as power reserve capacity and energy. Markets for so-called primary, secondary and tertiary capacity reserves are being introduced in the

Nordic power markets and are proposed or under development for a number of other European power markets. Such markets are often characterized by multiple, complex products. Bids may be linked over time and across products. Procurement can be driven by multiple objectives such as price and security of supply, that may be difficult to define quantitatively and difficult to compare.

In this presentation, I introduce the Nordic capacity reserve markets, and talk about our experience in developing and implementing the clearing algorithms used by the Nordic TSOs to clear and price them.

Presentation 2: Fleet Renewal for a Zero-emission Fishery Fleet

Msakni, Mohamed Kais (*); Sønnervik, Helle Hagli (*); Schütz Peter (*)

**Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology (NTNU).*

Europe and Norway have implemented the 'Fit for 55' climate package, reflecting the global push to reduce greenhouse gas (GHG) emissions. This ambitious plan aims to achieve a net GHG emissions reduction of at least 55% by 2030 compared to 1990 levels, surpassing the original target of 40% by 2019. Norway, in particular, has set even more ambitious goals by aiming to cut GHG emissions by 95% by 2050.

Our study aims to contribute to these emission reduction targets within the fishery industry. Currently, the Norwegian fishing fleet heavily relies on Marine Gas Oil (MGO), which accounted for 23.5% of Norway's total petroleum product sales in 2021. The Directorate of Fisheries estimates that the fishery industry is responsible for approximately 2.7% of Norway's annual CO2 and greenhouse gas emissions. To achieve the GHG reduction target within this sector, the Norwegian fishing fleet must transition to low- and zero-emission vessels.

Various propulsion systems can be considered for this purpose, including combustion engines, battery electric systems, and hydrogen/ammonia fuel cells, either in combination or as standalone solutions. The integration of these low- and zero-emission solutions can be achieved through vessel replacement or retrofitting. However, such integration requires substantial investments from both authorities (e.g., expanding power grids and ensuring fuel supply) and operators (e.g., premature vessel replacement and high costs of new propulsion systems).

Our work aims to support decision-makers in the fishery industry by assisting them in identifying the optimal timing for these investments. A strategic plan will be developed, considering multiple factors, including operational costs (such as maintenance and fuel expenses), CO2 taxation, and regeneration costs. By evaluating these aspects, decision-makers can make informed choices to address the complex challenges associated with reducing emissions in the fishery industry.

Day 2: Sunday (24.9.2023)

Keynotes

Keynote 3: A true story of an operations researcher

Dr. Jukka Ruusunen, CEO – Fingrid

Abstract

I am going to tell you a true story of an operations researcher who started his operations research career at the same time when Commodore 64 was published. During my journey I have been looking at operations research from the academic point of view, as a market analyst and business developer in energy business, and finally as a CEO of an electricity transmission company. I have seen in practice how operations research works, and the central role of a human being in operations research.

With my personal journey as a “backbone”, I will take up some lessons learned that I would like to share with other operations researchers. The importance of understanding when models work and when they don't work. The importance of combining modelling with common sense. Simplifying and communicating results to non-experts. Responsibility of the operations researcher – you are responsible, not the model ("the model says..."). And like in any modelling, a model is a simplification of reality, and you have to understand how you have simplified the reality.

Finally, some ideas for the future…

Biography

Jukka Ruusunen is President & CEO of Fingrid Oyj, the national transmission system operator in Finland. He has previously served in various positions at Fortum Power and Heat Oy and Imatran Voima Oy. Before that he worked at Helsinki University of Technology and Helsinki School of Economics. Jukka Ruusunen is docent at Aalto University School of Science and Technology, and Aalto University School of Economics. He is the chairman of the National Emergency Supply Council.

Jukka Ruusunen holds a doctoral degree from Helsinki University of Technology.

Keynote 4: Nonlinear optimization: Methods and applications

Prof. Dr. Anders Forsgren, KTH Royal Institute of Technology

Abstract

The talk will give a presentation of research related to nonlinear optimization in which the speaker has been involved. This includes method development related to different types of nonlinear optimization problems. Particular focus will be put on mathematical challenges that arise. Optimization related to applications areas such as radiation therapy and cell metabolism will also be covered. In particular, the close connection between fundamental optimization research and clinical treatment planning systems for radiation therapy will be discussed.

Biography

Anders Forsgren is a professor of optimization and systems theory at the Department of Mathematics, KTH Royal Institute of Technology, Stockholm, Sweden, since 2003. He was born in Danderyd, Sweden, in 1961.

His main research area is nonlinear programming. Anders Forsgren works mainly with method development, in particular research questions related to Newton-type methods for solving smooth nonlinear optimization problems. He also works on applications related to optimization of intensity-modulated radiation therapy. In addition, Anders Forsgren has been involved in optimization applications related to cell biology and telecommunications.

Parallel session block 3

Session 3.A: Optimization and Decision-Making in Operations Research

Presentation 1: An Optimization Model for Determining Cost-Efficient Maintenance Policies for Multi-Component Systems with Economic and Structural Dependencies

Leppinen, Jussi (Aalto University School of Science); Salo, Ahti (Aalto University School of Science); Punkka, Antti (SOK Corporation); Ekholm, Tommi (Finnish Meteorological Institute)

Multi-component systems typically require maintenance to operate reliably. The cost of maintaining many components is usually not equal to the sum of costs for component-specific maintenance actions but, rather, depends on the entire portfolio of maintenance actions. Moreover, some portfolios of maintenance actions may not be feasible, because there may be structural dependencies that call for

preceding disassembly decisions or the maintenance of other components, or because the system may have to operate with high enough probability.

We determine the optimal maintenance scheduling policy for multi-component system whose economic and structural dependencies are represented as a directed graph. In the system, component lifetimes are random, and the system operates only if all its components are operational. Components can be replaced periodically only at pre-defined maintenance intervals. The problem is modeled as a discrete time Markov Decision Process in which the system state is defined by the components' ages and their failure states. System-level risk is constrained by a reliability threshold. The optimal portfolios of long-term maintenance actions are computed with modified policy-iteration.

We illustrate this approach with a system of four components. Specifically, our approach outperforms simple heuristic policies in achieving cost savings across different maintenance intervals and reliability thresholds. It also helps specify these intervals and thresholds optimally. We also discuss how this approach helps assess how suboptimal decisions, caused for instance by the lack of information about the system state, will impact the cost-efficiency of condition-based maintenance.

Presentation 2: Different hybridization strategies for solving systems of nonlinear equations

Yury Nikulin (University of Turku); Bishwesvar Sing (University of Turku); Marko Mäkelä (University of Turku)

We consider eight various hybridization strategies for solving a system of nonlinear equations. Extensive numerical experiments performed on a selected set of test problems confirm the fact that the hybridization of the conjugate gradient algorithm with Newton's method outperforms other hybrid methods considered. In the hybrid algorithm Newton's method is supposed to increase the convergence rate and the conjugate gradient method is supposed to follow the orthogonality of the residuals and conjugacy of the search directions. Taken in combination, methods try to discover global optima and keep computer memory requirements relatively low. We also perform ranking analysis which provides some flexible choices in hybridization strategies for decision-makers based on their individual preferences and biases. In addition, using the Wilcoxon signed-rank test we confirm that in almost all cases considered in our computational experiments, the hybridization strategies demonstrate a statistically significant difference in produced results.

Presentation 3: Spatial decision analysis under incomplete preference information

Harju, Mikko (Aalto University School of Science); Liesiö, Juuso (Aalto University School of Business); Virtanen, Kai (Aalto University School of Science / National Defence University)

Decision alternatives with geographically varying consequences can be compared via spatial value functions. For instance, suppose that we are selecting a site for a new fire station. Each alternative site results in a response time that varies from location to location within the region of interest. Decision alternatives are therefore described as functions from the set of locations to a set of consequences. The spatial value function yields a value for each alternative by aggregating its preferability across the region.

In practice, determining a spatial value function precisely is a challenging task as each location within the region must be taken into consideration. We present approaches for utilizing spatial value functions

based on incomplete preference information provided by the decision maker. This allows us to compare alternatives without requiring precise specification of the relative importance of each location.

The approaches considered are the identification of non-dominated alternatives, the use of decision rules, and the forming of a value function by fitting spatial weights to the available preference information. In each case, the region is partitioned into subregions and the decision maker judges the relative importance of the subregions. The strengths and weaknesses of each approach are discussed. We also demonstrate the use of these approaches with an example application.

Session 3.B: Fuzzy Logic and Uncertainty in Operations Research

Presentation 1: Utilizing imprecise information in strategic investment decision-making – some advances from the last 10 years

Collan, Mikael (VATT Institute for Economic Research and LUT University)

Making strategic investment decisions is often preceded by planning that involves having to make highly imprecise estimates about the uncertain future. The type of uncertainty faced may be structural and even borderline ignorance. This means that construction of models about the future is difficult or impossible, and creating information by interpolating from historical data (if available) is not credible. An often-used tool for estimating the future under these circumstances is the expert and when possible, multiple experts. Expert estimation is subjective and future-oriented estimates are imprecise. Capturing subjective representations of imprecision in a coherent way is a problem that can be solved by using fuzzy concepts. When estimates are highly imprecise and their "information density" is low, it may still be possible to extract relevant information by extracting longitudinal trend and change related information. Even when an imprecise estimate can be formulated explicitly the aggregation of information contained in estimates presents problems and requires working solutions. When multiple experts are used the level of difficulty is increased. Problems such as the order in which estimates are aggregated, information loss, and the treatment of overlapping information should be considered. Presentation of the imprecise results in an open and understandable way is an issue of high importance for decision-makers.

This presentation discusses decision-support methods developed during the last ten years that tackle the afore mentioned problems including the use of scorecards, lossless aggregation of estimates, considering overlapping information, and presenting results to decision-makers.

Presentation 2: Optimality conditions in fuzzy nonsmooth optimization with invex functions

Rinne, Ville (University of Turku); Nikulin, Yury (University of Turku); Mäkelä, Marko M. (University of Turku)

Several new classes of generalized convex functions have been recently introduced in optimization literature to handle carefully some nice features of convexity. One such generalization is the class of invex functions. In constrained optimization, the Karush-Kuhn-Tucker (KKT) necessary conditions for optimality are also sufficient if the functions delimiting the problem are convex or satisfy certain generalized convexity properties such as pseudo- or quasiconvexity. The concept of invexity generalizes the notion of convexity and provides a broader class of functions in which the KKT conditions are sufficient for optimality.

In optimization theory operations research problems are usually modelled as deterministic optimization problems. In most real-world applications optimization problems contain uncertain data due to estimation errors, prediction errors, or lack of information. One approach for solving optimization problems with uncertainty data is fuzzy optimization. Recently, different types of generalized convexity notions for fuzzy mappings have been defined and used to prove optimality and duality results for nonconvex fuzzy optimization problems. A solution to the considered nonsmooth convex fuzzy optimization problem is Pareto optimal for its associated biobjective optimization problem. It has been shown that a solution of the considered nonsmooth fuzzy optimization problem is Pareto optimal for its associated biobjective optimization problem when the functions involved are invex. To establish KKT optimality conditions, we construct the associated biobjective optimization problem of the considered nonsmooth fuzzy optimization problem. The biobjective optimization problem is then solved by its associated scalarized problem constructed in the weighting method. Using generalized invexity assumption, the (weakly) nondominated solutions of the considered nonsmooth fuzzy optimization problem are characterized through Pareto solutions in the associated biobjective optimization problem and KKT points of the scalarized problem.

Parallel session block 4

Session 4.A: Advances in Multi-criteria Decision Making

Presentation 1: Getting soft in multiple criteria evaluation and decision support – psychologists' perspective on OR and OR perspectives in psychology

Stoklasa, Jan (LUT University, Business School); Stoklasová, Jana (LUT University, Business School)

The contribution focuses on a psychology-inspired (or human centred) approach to multiple criteria decision support and multiple criteria evaluation. It summarizes some of the areas of MCDM and evaluation that can benefit from currently available psychological methods and methodology. We also show how some inherently psychological tools can be updated and modified to provide better and new insights. We draw attention to some problems stemming from the inability to measure or from the intangibility of criteria in the models, as well as from the lower perceived relevance or applicability of the tools being used by their users or assumptions of risk-neutrality. Subsequently we either suggest some solutions to these problems, or hope to open a debate on them if no viable solution is currently available. We recall some of the recent results of our LUT University based team concerning the processing of social science data (partial or fully self-report based, i.e. non-measurable). Main topics include questionnaire data processing (Likert-scale based), losslessness of information presentation and processing, fuzzy grouping variable based analysis, semantic differentiation in MCDM and group decision support, spin creation, forced active involvement of the evaluators in the evaluation process, risk attitude reflection in multiple-criteria evaluation and data analysis etc. In essence, what we intend to show is that even though humans are sometimes making a mess in our models (or by the use of our models), they are also a great and needed impulse for further development of OR methods.

Presentation 2: Multi-criteria group decision-making approach based on q-rung orthopair fuzzy entropy measure with weighted averaging operator and its applications in food supply chain

Bhat, Shahid Ahmad Bhat (LUT Business School, LUT University); Luukka, Pasi (LUT Business School, LUT University)

In recent years, the COVID-19 pandemic and the Russian-Ukrainian war have significantly affected food supply chains (SCs) globally. These events have severely affected the inherent vulnerabilities of modern food SCs, leading to a highly unpredictable uncertainty and long-term scaling disruptions. To deal with these uncertainties, recently several researchers have used q-rung orthopair fuzzy sets (q-ROFSs) as these q-ROFSs are more advantageous for expressing the preferences more accurately under uncertainty environment. This research article aims to propose a new entropy measure of q-ROFSs and q-rung orthopair fuzzy weighted arithmetic mean (q-ROFWAM) aggregation operator (AO). The proposed q-ROFS entropy measure and q-ROFWAM AO can overcome the flaws of the existing q-ROFS entropy measure and q-ROFS AOs such as q-rung orthopair fuzzy Aczel–Alsina weighted averaging (q-ROFAAWA) operator, q-rung orthopair fuzzy Aczel–Alsina weighted geometric (q-ROFAAWG) operator etc. Based on the newly proposed q-ROFS entropy measure and q-ROFWAM a novel multi-criteria group decision-making (MCGDM) approach is developed under q-rung orthopair fuzzy environment. The proposed MCGDM approach can also overcome the flaws of the existing MCGDM approaches, where the existing approaches fails to distinguish the prioritizing orders of alternatives in some circumstances. Further, to validate the accuracy and effectiveness of the proposed MCGDM approach, this study has identified and prioritized the most severe food SC disruptions under the extraordinary disruptive events. Moreover, a comparative analysis of the proposed MCGDM approach have been carried out in comparison of the existing approaches. Therefore, the obtained results of this study and their relationships can help the researchers and practitioners of the food industry to develop effective recovery policies and processes to mitigate the impactful risks and improve the overall efficiency of the entire food industry to ensure the survival of food businesses and SCs under these extraordinary disruptive events.

Presentation 3: Challenges of Group Decision-Making in Multiobjective Optimization

Pajasmaa, Juuso (University of Jyväskylä)

Decision making problems involving multiple decision makers are common in both every day and professional life. Group decision making considers problems with multiple decision makers with different opinions and a common problem to solve. Generally, in the context of MCDM, approaches to solve group decision making problems involve methods such as voting, negotiating and aggregating preferences of the decision makers. The literature on group decision making contains various properties regarding the group of decision makers such as whether the decision makers can communicate among each other during the solution process.

Multiobjective optimization considers problems that have multiple conflicting objective functions. The combination of group decision making and multiobjective optimization has not received much research action. This talk will discuss some of the challenges of solving multiobjective optimization problems involving multiple decision makers. The challenges include how to incorporate multiple preferences (from several decision makers) into the solution process of multiobjective optimization methods and how to support the decision makers in selecting the final solution to be implemented in practice. Moreover, we discuss what properties of the group should be considered in optimization methods designed to solve these types of problems.

Session 4.B: Operations Research in Manufacturing and Quality Control

Presentation 1: Performance measures in feature selection do not tell the whole story

Luukka, Pasi (School of business, LUT University)

In feature selection methods main evaluation method for performance seems to be classification accuracy (or MSE in regression) or similar performance measures (F-score, Sensitivity, Specificity etc.) when dealing with machine learning problems. In multicriteria decision making (MCDM) they are mainly concentrating on single performance value of given filter-based feature selection method. Besides this, one important subject where researchers have concentrated is on how many features one was able to remove without deteriorating accuracy. Recently also sometimes stability of the measures are considered to see how stable the selected set is. These measures however do not tell the full story of how good the particular method is in comparison of others. In this presentation we present comparison of different feature selection methods and show how one can not really evaluate the differences with them using ordinary performance measures and propose a new measure of fitness for evaluation. This is done by concentrating on area under curve for accuracy and number of removed features. In MCDM same can be done if we can evaluate the performance of our rankings (e.g., in forming portfolios, the performance of selected portfolio). We show how this new measure is clearly capable of differentiate between methods where traditional measures fail.

Presentation 2: A DSS Utilizing Belief-Rules: Most-preferred Solution in Multi-objective Stochastic Perishable Inventory Routing Problem

Chen, Xi-Yi (The University of Manchester); Xu, Dong-Ling (The University of Manchester); Yang, Jian-Bo (The University of Manchester)

Many real-life problems involve collaboration between different parties and conflicting interests. No single objective is able to reflect such a dilemma properly. Decision-makers often face difficulties selecting the most appropriate solution in the pool of Pareto-optimal solutions. This situation is commonly seen in many areas and companies such as in health care, finance, supply chain, etc. This research studies a multi-objective stochastic Perishable Inventory Routing Problem, making inventory and routing decisions while considering cost, waste, and carbon emission elements. A decision support system (DSS) is proposed to assist the decision-making process. Belonging to the interactive methods, in each interaction, the DSS first captures the preference of decision-makers, then searches for the most preferred solution according to the captured preference. In this way, instead of going through a lengthy and overwhelming interaction process, the DSS provides a more efficient and accurate experience.

The DSS consists of two main modules: learning and searching modules. The learning module learns the preferences of decision-makers by utilizing the Belief-Rule-Based (BRB) system, whose accuracy in describing complicated functions has been shown by many papers and applications such as in fault diagnosis, system identification, and decision analysis. The searching module searches for the most preferred solution using Sequential-Linear-Programming (SLP) for its ability to provide good quality solutions for highly nonlinear and heavily constrained mixed-integer linear programs (MILP) within an acceptable time. The commercial solver Gurobi is used to assist the optimization process in the SLP algorithm. The learning and searching processes are repeated several times until the recommended solution remains the most preferred one according to the decision-maker. To the best of our knowledge, it is the first multi-objective optimization method that can explain its logic by an interpretable machine-

learning method and has the ability to assist decision-making on a heavily constrained multi-objective MILP.

Parallel session block 5

Session 5.A: Innovations in Operations Research

Presentation 1: Voting theory and Engestroemian triangles: an activity theoretical view of OR

Hakula, Jaakko (University of Oulu)

The aim of the abstract is to present a preliminary sketch between voting (theory) and semiotics of Engestroemian triangles. Operations Research (OR) is the art and science of making better decisions through mathematical models. Voting theory in the field of social choice, elections, games, statistics, AI etc. determines a procedure to choose a winner or produce a certain preference order from among a set of candidates, based on the preferences of the voters. Individual votes as inputs are aggregated into preferences or collective decisions by using specific ranking rules.

Engestroemian triangles refer to a model of the second generation activity systems. Activity systems are central concepts in Cultural-Historical Activity Theory (CHAT) or Activity Theory (AT) in short. AT can be applied as both a conceptual and analytical framework to better understand complex human activities in learning contexts. An activity system comprises seven components: subject, mediational tools, object, rules, community, divisions of labour, and outcomes. An activity system can be visualised in a triangle diagram, i.e. Engestroemian triangles. The upper part of the diagram represents action mediated between an individual subject and an object with the aid of abstract or concrete tools.The lower part with rules, community and division of labour represents collective object-oriented activity. The whole activity ends up with an outcome, which represents interrelational changes between the components of the activity system.

Central concepts of voting theory can be placed in the context of an activity system. Voters stand for subject(s), candidates for object(s), and voting procedures for abstract tools. Further, rules can be named voting rules, community a group of voters (with potential candidates), and division of labour division of voting power between voters. An outcome is that of an election – candidates put into a preference order.

Presentation 2: Forecasting firm bankruptcy using an ER rule-based interpretable machine learning method

Tan, Meng-Meng (Alliance Manchester Business School, UK); Xu, Dong-Ling (Alliance Manchester Business School, UK); Yang, Jian-Bo (Alliance Manchester Business School, UK)

A financial default takes place when a company becomes incapable of fulfilling its debt obligations, potentially resulting in bankruptcy. An early-warning bankruptcy prediction model is valuable to stakeholders. It aids internal managers in enhancing firm performance and helps external users like investors, creditors, banks, and rating agencies in making investment decisions. Moreover, suppliers and retailers use it to evaluate a company's creditworthiness. The prediction of corporate bankruptcy is a binary classification issue. To enhance the prediction accuracy and ensure the interpretability of models, numerous algorithms have been developed, namely eXplainable AI (XAI) and Multiple Criteria Decision-Making (MCDA). When assessing firms' default risk, opaque AI algorithms make extracting information difficult and may lead to unfair usage of these technologies. This study applies the evidential reasoning

(ER) rule combined with a heuristic algorithm to achieve interpretable machine learning (ML) for bankruptcy prediction. After comparing with other traditional ML methods using a UK dataset, the results show that the ER model demonstrates commendable performance. It is comparable to traditional ML in terms of accuracy and outperforms them in interpretability for users. The main contributions of this research are as follows: Firstly, it facilitates the use of a novel MCDA-based transparent ML model in financial decision-making. Secondly, it contributes to the validation of ER in bankruptcy prediction using a real dataset. Thirdly, the research provides detailed explanations on how to make the ER rule-based interpretable model comprehensible for decision-makers (DMs) in discriminating failure and non-failure firms, regardless of an observer's level of expertise. Finally, it strengthens the connection between MCDA and XAI in the classification area, thereby contributing to interdisciplinary study.

Presentation 3: What are tomorrow's researchers working on today?

Herrala, Olli (Aalto University)

All academic professionals were once students. When we think about the future of operations research, we should be interested in what the students are doing today. One of the major academic milestones in a student's academic life is the bachelor's thesis, which for many is their first large, independent research project. While a bachelor's thesis may often seem like a small step for science, it is often a giant leap for the student.

This talk will present an overview of recent bachelor's theses in the Systems Analysis Laboratory at Aalto University. We will discuss the different research topics, the recent trends in the number and language of the theses, and the process of writing a thesis in our department.

Additionally, we will present some highlights from student feedback on best practices for a bachelor's thesis seminar. We believe these insights should be valuable for both supervisors and anyone responsible for such seminars.

Session 5.B: Transport and Network Design

Presentation 1: Combinatorial Approaches to Network Design in Public Transport

Schiewe, Philine (Aalto University); Heinrich, Irene (Technical University of Darmstadt); Olli Herrala (Aalto University); Terho, Topias (Aalto University)

A crucial part of designing a public transport supply is to determine where vehicles are operating. While operating vehicles on every street would be ideal from a passengers' perspective, this would lead to prohibitively high operational costs for the operator. On the other hand, the cheapest public transport system from the operator’s perspective is not necessarily the ideal solution for the passengers. We therefore aim to find an optimal compromise by sparsifying the underlying network with spanners, i.e. subgraphs that guarantee connectivity, while ensuring reasonable travel times for passengers. We consider two alternative approaches. On the one hand, we aim to find lightest spanners which guarantee a fixed maximal detour factor for all passengers. On the other hand, we generalize the notion of optimum requirement graphs, where the total travel time is minimized amongst all subgraphs of a given fixed size. We develop solution approaches for finding corresponding spanners and evaluate them experimentally. In addition, we analyze the impact of the solutions on later planning stages, especially

line planning and timetabling. Having sparse graphs as input to these problems allows for using more elaborate models and can improve the quality of the overall public transport supply.

Presentation 2: Decision programming on influence diagrams with information decisions

Terho, Topias (Aalto University); Salo, Ahti (Aalto University); Oliveira, Fabricio (Aalto University)

In decision analysis, influence diagrams are widely used to represent decision problems in which dependencies between uncertainties, decisions and consequences are structured as an acyclic graph. Decision Programming (Salo et al., EJOR 299/2, 2022) allows these problems to be solved through mixed-integer linear programming (MILP), which eliminates limitations of earlier solution approaches as it is possible to omit the no-forgetting assumption and to handle a large variety of logical, risk, chance or resource constraints.

However, the drawback of this enormous flexibility is that the size of the optimization problems grows exponentially with the number of chance and decision nodes. In response to this computational challenge, we propose formulations for influence diagrams in which there are information nodes representing decision on whether to acquire information to support subsequent decisions. Our formulations are based on replacing such information decisions with binary variables so that the optimal strategies can be determined by solving a much smaller MILP problem. The presented formulations are particularly powerful for the optimization of testing strategies. We illustrate the effectiveness of the new formulations and potential applications with numerical examples.

Presentation 3: Navigating the Near Win-Win Path: Finding Trade-off Optimal Solutions for Quality of Service, Robustness, Sustainability, and Cost in Green Vehicle Routing with Flexible Time Windows

Emmerich, Michael (LIACS, Leiden University, The Netherlands); Fan, Yingjie (LIACS, Leiden University, The Netherlands); Gülmez, Burak (LIACS, Leiden University, The Netherlands)

In the realm of operational research, our study unravels the potential for near win-win situations in vehicle routing and scheduling. We establish two fundamental pillars to achieve this. The first pillar involves injecting a touch of flexibility where traditional OR models tend to exhibit rigidity by letting customers instead of fixed time windows chose additional alternative time windows, that might be applied in case the preferred time window is in strong conflict with route planning objectives, e.g., resulting in a detour. The second pillar of achieving near win-win situations harnesses the power of advanced multi-objective optimization algorithm portfolios to pinpoint near win-win scenarios within a given optimization model. To illustrate our findings, we present a proof of concept study where we employ a range of Pareto optimization algorithms for a delivery routing problem with time windows. Our results showcase the remarkable impact of incorporating a slight degree of flexibility in time windows, leading to significant enhancements in fossil fuel consumption reduction, resilience, and cost efficiency. Moreover, we underscore the role of solution algorithm selection, emphasizing that the optimal choice cannot be predetermined based solely on existing literature. Instead, we advocate for a strategy that embraces diversity by betting on different algorithms, when computational resources permit, to maximize outcomes.