	DESDEO Forum		
	Monday (19.6.2023)		
Time	Event	Presenter	Place
8:30	**Registration opens**		Agora main hall
9:00 - 11:15	Tutorial: Structure of DESDEO	Giovanni Misitano	Agora Alfa
	Tutorial: Adding new Contents to DESDEO	Juuso Pajasmaa	
	Tutorial: Metallurgical Application to Demonstrate How Different Elements can be Connected	Bhupinder Saini	
11:30	**Registration closes**		Agora main hall
11.30 - 11.45	**Welcome session**	Kaisa Miettinen	Agora Alfa
11.45 - 12.30	Invited talk: Hybridizing Interactive Multiobjective Methods: Past Experiences and Future Trends	Francisco Ruiz	
12:30 – 13:15	**Lunch**		Restaurant Piato
13:15 - 14:00	Invited talk: Tuning and Optimizing Complex Engineering Systems through Interactive Visual Analysis	Kresimir Matkovic	Agora Alfa
14:00 – 14.20	Navigation under Uncertainty	Katrin Teichert	
14.20 – 14.40	An Approximation Aalgorithm for Multi-objective Mixed-integer Convex Optimization	Ina Lammel	
14.40 - 14.50	Questions		
14.50 – 15.20	Decision-Making Under Deep Uncertainty, Many-Objective Optimization, and Robustness: How are they connected, and how can Decision-Makers be Involved?	Jan Kwakkel	
15.20 – 15.35	Latest Advancement on Multiobjective Robust Decision-Making Under Deep Uncertainty: An Interactive Famework	Babooshka Shavazipour	
15.35 – 15.55	**Questions and coffee/tea break**		
15.55 – 16.10	Latest Advancements in User Interface Developments for Interactive Methods	Giomara Larraga	
16.10 – 16.25	Latest Advancements in Assessing and Comparing Interactive Multiobjective Optimization Methods	Bekir Afsar	
16.25 – 16.35	Questions		
16.35 – 16.50	Latest Advancements in a New Paradigm in Interactive Multiobjective Optimization	Bhupinder Saini	
16.50 – 17.05	Questions		
18:30 - 23:00	**Dinner**		

	Tuesday (20.6.2023)		
Time	Event	Presenter	Place
8:45 - 9:30	Invited talk: Teaching Multiobjective Design Optimization with the DESDEO Framework	Michael Emmerich	Agora Alfa
9:30 - 10:15	Invited talk: To Interact or not to Interact in Multi-Objective Bayesian Optimisation	Juergen Branke	
10:15 - 10:25	**Break**		
10:25 - 11:10	Invited talk: Multiobjective Optimization: on the Verge of Numerical Tractability	Ignacy Kaliszewski	Agora Alfa
11:10 - 12:30	Panel discussion part 1		
12:30 - 13:15	**Lunch**		Restaurant Piato
13:15 - 14:45	Panel discussion part 2		Agora Alfa
14.45 – 15.00	Future of DESDEO	DESDEO team	
15:00 - 15:20	**Coffee/tea break**		
15:20 - 17:20	DESDEO in action, bring your own problem session	DESDEO team	Agora Alfa

Time: 9:00 – 11:15
Giovanni Misitano (University of Jyväskylä, Finland)
Tutorial: The Structure of DESDEO: the Core Packages

In this tutorial, we discuss the structure of DESDEO consisting of packages and modules. We focus on the four core packages that can be used to utilize existing interactive multiobjective optimization methods or implement one's own. The first of these packages is desdeo-problem, which offers various means to model different kinds of multiobjective optimization problems. Next, desdeo-tools has a vast array of utilities to solve and manipulate multiobjective optimization problems, e.g., different kinds of scalarization functions. Interactive methods based on scalarization are found in the third package: desdeo-mcdm, where methods such as NIMBUS and NAUTILUS Navigator are found. The fourth package, desdeo-emo, contains various evolutionary interactive methods and general utilities for implementing these methods, such as evolutionary operators. In the desdeo-emo package, one can find interactive versions of the NSGA-III and interactive Kriging-assisted RVEA. The contents of the four core packages are further divided into modules to improve the clarity of the overall architecture of each package.

After this tutorial, the audience will be familiar with the overall structure of DESDEO and the general contents of each of the core packages. This allows the audience members to readily start exploring and adapting DESDEO to meet one's own needs in interactive multiobjective optimization.

Time: 9:00 – 11:15
Juuso Pajasmaa (University of Jyväskylä, Finland)
Tutorial: Utilizing the DESDEO Framework and Adding New Content to DESDEO

In this tutorial, we will learn how to get started with DESDEO. We will learn how to install DESDEO, how to use various ready-to-use interactive multiobjective optimization methods and multiobjective optimization problems in DESDEO. Furthermore, we will demonstrate how to add new content to DESDEO.

First, we focus on learning how to use DESDEO to solve multiobjective optimization problems. We will demonstrate how to use test problems included in the desdeo-problem package and how to create your own multiobjective optimization problem. We will use interactive multiobjective optimization methods from the desdeo-mcmd and desdeo-emo packages. Next, we demonstrate how to add new content to DESDEO. We will show the steps required to get started with your own fork of DESDEO. Then, we will demonstrate how to implement a multiobjective optimization problem and how to add it to the DESDEO framework.

After this tutorial, the audience is familiar with the base usage of DESDEO framework, and they understand how they can utilize and extend DESDEO in their research. The audience is then ready to implement their multiobjective optimization problems or methods in DESDEO.

Time: 9:00 – 11:15
Bhupinder Singh Saini (University of Jyväskylä, Finland)
Tutorial: Solving a real data-driven multiobjective optimization problem with DESDEO

In this tutorial, we will discuss how to use DESDEO to solve a real, data-driven multiobjective optimization problem. We will tackle unexpected challenges that arise in real-life data-driven problems and learn how to use DESDEO alongside some other popular data analytics tools to overcome such challenges. One such challenge is the presence of not one but two decision-makers (DMs) with conflicting preferences. We will showcase how to implement new interactive methods using modular components of DESDEO to satisfy the needs of multiple DMs.
The tutorial will follow the structure of the so-called seamless chain process. It is a step-by-step process that spans all aspects of data-driven optimization: data gathering/processing, modeling the objectives and the problem, and decision-making. While the problem itself belongs to a specific domain, similar challenges can arise in problems from any domain. After this tutorial, the audience will be familiar with many domain-agnostic tools to help with their own problem formulations. They will learn how to implement complicated problem formulations within DESDEO, and how to custom-build new interactive methods to tackle specific needs with minimal effort. They will be able to incorporate these tools and DESDEO into their workflow seamlessly.

Time: 11:45 – 12:30
Invited talk
Prof. Francisco Ruiz (University of Malaga, Spain)
Hybridizing Interactive Multiobjctive Methods: Past Experiences and Future Trends

Interactive methods have proved to be efficient and effective tools for solving multiobjective optimization methods, because they ease the cognitive burden of the decision makers by allowing them to express their preferences in a gradual way. Nevertheless, there are two major issues that limit their applicability in real problems. On the one hand, the great number of existing interactive methods makes it difficult to decide which one to choose for each particular case. On the other hand, the growing complexity of the problems faced makes it impossible to solve the resulting single optimization problems in reasonable times, so that the interaction takes place smoothly. The answer to these problems is hybridizing interactive methods (among them in the former case and with other solving techniques in the latter). This communication reports the application of hybrid interactive approaches to three real problems in the electricity generation sector. Besides, some future lines for hybridization are sketched.

Time: 13:15 – 14:00
Invited talk
Dr. Kresimir Matkovic (VRVis Research Center, Vienna, Austria)
Tuning and Optimizing Complex Engineering Systems through Interactive Visual Analysis

In modern engineering, simulation is ubiquitous and almost impossible to avoid. To better comprehend intricate physical phenomena, engineers frequently compute multiple versions of the same model, known as simulation ensembles or simulation experiments. Analyzing these ensembles is a challenging task, requiring a combination of computational and interactive methods, as a result of ill-defined problems, a high-dimensional parameter space, non-linearity, and complex subsystems

interplay. Automated optimization methods are frequently insufficient in such circumstances. In this talk, we will explain how interactive visual analysis can aid in the understanding, exploration, and optimization of simulation ensemble data. By cleverly combining computational and interactive methods, simulation experts can gain a deeper understanding of both the data and the physical phenomenon represented by the ensemble. Specifically, we will describe an interactive approach to optimize complex engineering systems in the automotive industry.

Time: 14:00 – 14:20
Katrin Teichert (Fraunhofer Institute, Germany)
Navigation Under Uncertainty

In many contexts of interactive decision making, uncertainties – originating, for example, from stochastic influences, variance in model parameters, or errors in execution – must be considered. The decision maker is tasked with not only assessing the trade-off between conflicting criteria, but also deciding about the level of robustness that he is willing to accept for the chosen solution. The security of hedging against unfavorable scenarios must be weighed against a loss for the most likely scenario ("price of robustness"). As a new approach to effectively communicate this complex decision-making task to the DM, we propose a slider-based UI interface. The tool extends previously established successful navigation methods for convex and patched Pareto fronts [Monz, Collicott]. Apart from retaining all functionality for exploring the inter-criteria trade-offs, the software allows the DM to investigate different levels of risk aversion in terms of nominal and worst-case outcome and associated price of robustness. Thereby, the DM can make a case-by-case decision on which amount of risk awareness is appropriate. We demonstrate the software for an example from chemical engineering, where uncertainty in the reaction parameters must be accounted for when choosing the layout and operating point of a distillation column.

Time: 14:20 – 14:40
Ina Lammel (Fraunhofer Institute, Germany)
An Approximation Algorithm for Multi-objective Mixed-integer Convex Optimization

Let us consider a multiobjective mixed integer program with the following property: for each fixed assignment of integer values, the resulting multiobjective optimization problem will be convex. These subproblems are called patches. Many practical applications fulfil these assumptions. We present a new patch approximation algorithm that combines Pareto front approximation methods that can run in the background with interactive elements. First, an initial, very coarse, approximation of every patch is computed. Then, these Pareto front approximations are presented to the decision maker which can restrict the objective space to those regions that are of interest to them. Then, the Pareto front is refined only in these regions. In our algorithm, the patch problems are solved using the (Simplicial) Sandwiching algorithm. We introduce methods that determine parts of patches that are dominated by other patches. Then, we remove these patch parts from further refinement by adding artificial Pareto points. After the Pareto front has been approximated sufficiently well, it is again presented to the decision maker who can then use navigation techniques to find their preferred solution.

Time: 14:50 – 15:20
Jan Kwakkel (Delft University of Technology, Netherlands)
Decision-Making Under Deep Uncertainty, Many-Objective Optimization, and Robustness: How are they connected, and how can Decision-Makers be Involved?

Many real-world decision problems are characterized by fundamental uncertainty. That is, the various parties to a decision do not know or cannot agree on the system model relating actions to consequences, the probability distributions to place over the inputs to these models, which consequences to consider and their relative importance. Under the umbrella of decision-making under deep uncertainty, over the last decade, various methods and techniques have been put forward to enable decision-making to proceed despite these uncertainties. Many objective robust decision making is one of the dominant methods for decision-making under deep uncertainty. In short, first, many-objective optimization is used to find promising candidate solutions conditional on a reference scenario. Next, these promising solutions are reevaluated for a much larger set of scenarios reflecting different possible realizations of the deeply uncertain factors to identify the most robust solutions. This robustness analysis is often complemented by identifying the deeply uncertain conditions under which solutions perform poorly. Based on the insights from both the robustness analysis and the vulnerability analysis, either the problem is reframed and another iteration takes place, or the results are deemed adequate and reported to the decision-makers so they can decide. In recent years, many objective robust decision making has been expanded to improve the consideration of robustness in the search for promising solutions. For example, the search can be repeated for several carefully chosen scenarios reflecting alternative challenging deeply uncertain future conditions or by optimizing for robustness directly. However, most expansions of many objective robust decision making focus on analytical advancements instead of exploring the question of how to support decision-makers in their deliberations and come to a decision based on these analytical results. In this talk, I will introduce the audience to the foundational ideas underpinning the decision making under deep uncertainty literature. I will show how these ideas are used in many-objective robust decision-making and problematize the limited attention given so far to questions surrounding the involvement of decision-makers within the process of searching for promising solutions using many-objective optimization and the stress-testing under uncertainty of these promising solutions.

Time: 15:20 – 15:35
Babooshka Shavazipour (University of Jyväskylä, Finland)
Latest Advancement on Multiobjective Robust Decision-making under Deep Uncertainty: An Interactive Framework

Many real-life decision-making problems involve multiple conflicting objectives and various sources of uncertainty. The decision-makers need decision-support tools to deal with such complex problems. Many sources of uncertainty, such as the effects of climate change, cannot be handled through probabilistic models. They, however, might be described as a set of plausible outcomes of future states called scenarios. When decision-makers do not have (or cannot agree upon) the likelihood of these scenarios to occur (also known as deep uncertainty), they can be supported to find robust decisions that perform satisfactorily in a wide range of scenarios. Here, support is needed in balancing the trade-offs of conflicting objectives and scenarios.

The most popular framework for decision-making under deep uncertainty, called the Robust Decision Making (RDM) framework, has been successfully applied in various real-world applications. It also extended for the simultaneous consideration of multiple objectives and scenarios (known as

MORDM). However, MORDM is a posteriori method; i.e., the analyst first generates alternative solutions and performs all the robustness analyses, then displays the results to the decision-makers to choose the most preferred one among many solutions. Indeed, the decision-makers need to track all the trade-offs between objectives to find a balanced solution that is also robust in various scenarios, introducing a substantial cognitive load. In problems with many objectives, tracking all the trade-offs and uncertainty effects is too laborious and makes decision-making tricky. This issue has been counted as one of the reasons why MORDM is not widely applied beyond academia. To overcome this issue, in this study, we propose a novel interactive framework involving the decision-makers in the search for the most preferred robust solutions utilizing interactive multiobjective optimization methods. In this way, the decision-makers can learn about the problem limitations, the feasibility of their preferences, how uncertainty may affect the outcomes of a decision, and interactively study the trade-offs between objectives in various scenarios. This involvement and learning give them additional insight into the problem and allows them to directly control and lead the search during the solution generation process and decision-making, boosting their confidence and assurance in implementing the identified robust solutions in practice.

Time: 15:55 – 16:10
Giomara Larraga (University of Jyväskylä, Finland)
Latest Advancements in User Interface Developments for Interactive Methods

Interactive multiobjective optimization methods allow decision-makers to actively participate in the solution process by providing preference information iteratively. Throughout the process, decision-makers gain insights into the problem's tradeoffs and can update their preference information to obtain solutions that align with their expectations. In real-world optimization problems, a user interface (UI) facilitates the interaction between the decision-maker and the method. Unfortunately, most implementations of interactive methods do not consider visual elements to retrieve preferences and show solutions, affecting the decision-makers' satisfaction and hindering the utilization of these methods, despite their ability to provide high-quality solutions.

This presentation will describe the process of designing and implementing UIs tailored for interactive methods. This process involves the collaboration of experts in cognitive science, multiobjective optimization, and decision-making to ensure the UI's intuitiveness and the accuracy of the underlying process. We will describe the main steps we consider during the UI design process: identifying requirements, prototyping, iterating, and final implementation. During the initial step, we identify the different types of users and the specific functionalities available to each user category. This understanding forms the foundation for subsequent design decisions. The prototyping phase involves creating UI sketches incorporating the identified functionalities from the previous step. Additionally, essential design elements such as layout, color palette, and icons are carefully considered and incorporated into the prototype. This prototype undergoes multiple refinement iterations based on experts' feedback to ensure an optimal user experience. Once an acceptable prototype version is achieved, the UI is implemented, and experimental studies are conducted to assess its effectiveness and usability. These studies further contribute to refining and enhancing the UI's design.

Toward the end of the presentation, we will showcase UIs developed using the DESDEO framework, providing tangible illustrations of the discussed design principles and methodologies.

Time: 16:10 – 16:25
Bekir Afsar (University of Jyväskylä, Finland)
Latest Advancements in Assessing and Comparing Interactive Multiobjective Optimization Methods

Interactive multiobjective optimization methods have demonstrated their potential in various practical applications, allowing a decision maker (DM) to actively participate in the solution process and obtain solutions according to their preferences. By presenting a limited number of solutions at a time, these methods aim to reduce the computational cost and the cognitive load experienced by a DM. Through interaction, the DM gains insights into the trade-offs among conflicting objectives, the feasibility of their preferences, and the opportunity to refine their desires based on acquired knowledge. As a result of these benefits, literature has witnessed a substantial increase in the number of interactive methods available. However, the majority of these methods lack real-world assessments or direct comparisons with each other, warranting further attention to selecting the most suitable method for a given problem.

While some aspects of interactive methods can be evaluated without human involvement, others, such as usability and cognitive load, necessitate assessments with human subjects. This work aims to present a comprehensive journey, beginning with a systematic review and culminating in practical means of assessing and comparing interactive methods. We commence by identifying the desirable properties that characterize the effectiveness of interactive methods. Subsequently, we introduce experimental setups and designs that incorporate both human DMs and artificial DMs, enabling thorough evaluations of the methods' performance. Additionally, we propose future research directions, emphasizing the development of quality indicators specifically tailored for interactive methods.
By embarking on this path, we aim to enhance our understanding of interactive multiobjective optimization methods, their strengths, limitations, and their suitability for different decision-making contexts. Ultimately, this line of research will contribute to informed method selection and facilitate the advancement of interactive methods.

Time: 16:35 – 16:50
Bhupinder Singh Saini (University of Jyväskylä, Finland)
Latest Advancements in a New Paradigm in Interactive Multiobjective Optimization

The Multiple Criteria and Decision Making (MCDM) and Evolutionary Multiobjective Optimization (EMO) communities have proposed many interactive methods to help decision makers (DMs) solve multiobjective optimization problems. As these methods only focus on a small subset of solutions at a time, they lower the cognitive load on the DM, as well as the computational cost of running the method. However, different interactive methods can take the preferences of the DM in different formats. Even for methods that take the preference in the same format, the interpretation of the preference, and hence the solution found by the method, can vary dramatically. Finding an appropriate interactive method for a DM may therefore be an arduous task. With the IOPIS algorithm, we proposed a solution to the aforementioned issues by combining ideas from the MCDM and EMO communities and forming a new paradigm in multiobjective optimization. In brief, the core concept behind the algorithm is the Preference Incorporated Space (PIS), a space built from multiple scalarization functions which can each take the DM’s preference. We map the objective vectors to this new space and then use an evolutionary algorithm to find all non-dominated solutions in this new space. We prove that all solutions found thusly are also non-dominated in the objective space and preferred according to all scalarization functions used to build the PIS. Additionally, we have control over the number and properties of the scalarization functions; therefore, we can control the

complexity of the optimization problem. Finally, by encoding the preferences directly in the PIS, we can make any no-preference evolutionary algorithm interactive modularly.

In today's presentation, we will describe the next evolution of the IOPIS algorithm. We will demonstrate how to choose the set of scalarization functions based on the preferences of the DM and how to adapt the PIS over time as the DM preferences evolve. We will also show how to choose the number of scalarization functions to balance the computational complexity of the algorithm and the exploration needs of the DM. Lastly, we will showcase the new algorithm on some test problems.

Time: 8:45 – 9:30
Invited talk
Assoc. Prof. Michael Emmerich (Leiden University, the Netherlands)
Teaching Multiobjective Design Optimization with the DESDEO Framework The "Multi-criterion Optimization and Decision Analysis"

Course at Leiden University is a 6ECT course in the Master of Artificial Intelligence and Computer Science and it covers both the theory and practice of multiobjective optimization for students with a computer science background. In this talk, we focus on the practical aspects of teaching design optimization, using the DESDEO library as the basis for implementing examples on real-world problems. During the practical part of the lecture, students learn about design theory and how to distinguish between functional objectives and constraints and subjective criteria, such as Carpenter's affordances and aesthetics. We demonstrate the use of concepts such as Pareto-Optimization, (Nautilus) Navigation, Quality-Diversity and Innovization with examples from 3-D geometrical shapes optimization and solutions to combinatorial problems. Salient topics covered in the talk include interactive exploration of solution sets by the human designer, tailoring the parameterization of shapes, and using design-space specific search operators. We also discuss constraint enforcement and the use of algorithms with different search paradigms (e.g. gradient-based, Bayesian, or evolutionary optimization). The DESDEO framework offers an ideal environment for teaching multiobjective design optimization, as it allows for covering algorithm design aspects, interactive elements, and visualization of solutions and criteria in a single framework.

Time: 9:30 – 10:15
Invited talk
Prof. Juergen Branke (University of Warwick, UK)
To Interact or not to Interact in Multiobjective Bayesian Optimisation

This talk will start by discussing the potential benefits of interactively eliciting preference information in multi-objective Bayesian optimisation. We then show that even if user interaction is considered very costly, it may be beneficial to let the decision maker choose from an approximated frontier instead of the final solution set. Finally, we propose a way to estimate the value of a user interaction, thereby allowing Bayesian optimisation to decide when it should ask the decision maker for input rather than following a pre-set interaction scheme. Ignacy Kaliszewski (Polish Academy of Sciences, Poland): Multiobjective Optimization: on the Verge of Numerical Tractability Quantum computers are believed to be a breakthrough in large-scale optimization. But as they still are a remote possibility, the classical computing paradigms are the best that we have to cope with "the curse of dimensionality". This talk will point to sources of large-scale multiobjective problems arising

in practice. When attempting to solve them, they often become numerically intractable. They consume the allocated “budgets”, be it time or memory space, before producing satisfactory (preferably, Pareto optimal) solutions. To handle such cases, three approaches have been developed and successfully applied to real problems. The first one relates to the concept of information granules, the term borrowed from information processing, though in the bottom line, it reduces to simpler notions like bounds, hyperrectangles, and clusters. The second approach can be termed “abolish the dogma,” which refers to the problem rethinking and reframing. The third one is to marry exact optimization methods with heuristics into an effective combo. All three approaches fit the interactive framework of multiobjective problem solving, with the active role of the decision maker. Results of numerical experiments and hardware and software harnessed to do the job will be discussed.

Time: 10:25 – 11:10
Invited talk
Prof. Ignacy Kaliszewski (Polish Academy of Sciences, Poland)
Multiobjective Optimization: on the Verge of Numerical Tractability

Quantum computers are believed to be a breakthrough in large-scale optimization. But as they still are a remote possibility, the classical computing paradigms are the best that we have to cope with “the curse of dimensionality”. This talk will point to sources of large-scale multiobjective problems arising in practice. When attempting to solve them, they often become numerically intractable. They consume the allocated “budgets”, be it time or memory space, before producing satisfactory (preferably, Pareto optimal) solutions. To handle such cases, three approaches have been developed and successfully applied to real problems. The first one relates to the concept of information granules, the term borrowed from information processing, though in the bottom line, it reduces to simpler notions like bounds, hyperrectangles, and clusters. The second approach can be termed “abolish the dogma,” which refers to the problem rethinking and reframing. The third one is to marry exact optimization methods with heuristics into an effective combo. All three approaches fit the interactive framework of multiobjective problem solving, with the active role of the decision maker. Results of numerical experiments and hardware and software harnessed to do the job will be discussed.