PhD thesis topics for DEMO

General methodological development in interactive multiobjective optimization and decision making

(i) Quality indicators for interactive multiobjective optimization methods (Kaisa Miettinen, Bekir Afsar, Giovanni Misitano)
   a. We need indicators that can handle different types of preferences and are applicable with various types of methods (e.g. current few developments are focused at evolutionary methods).
   b. Experiments would add value.

(ii) Interactive methods for group decision making (Kaisa Miettinen, Bhupinder Saini, Babooshka Shavazipour)
   a. We need methods for different group decision making settings – where the decision makers negotiate or not, where they have different levels of importance, where they can provide preference information in different formats etc. The number of decision makers can vary a lot, there can be situations where stakeholders should also be heard etc. All these examples show that there is a need to develop many methods that can address various needs.

(iii) Methods for multiobjective optimization problems where function evaluations have different computing times (Kaisa Miettinen, Babooshka Shavazipour)
   a. There is a conference paper (https://doi.org/10.1145/3205455.3205514) for biobjective problems but a lot of work is needed in this field to use the time efficiently when some function evaluation(s) takes more time than the others (not to just wait till they all are finished)

(iv) Numerical methods to speed up computations in computationally expensive multiobjective optimization problems (Kaisa Miettinen, Babooshka Shavazipour)
   a. Approximating Pareto front (e.g., extending the PAINT (http://dx.doi.org/10.1007/s10589-011-9441-z) or PAINT-SiCon (https://doi.org/10.1007/s10898-014-0232-9))
   b. Handlng computationally expensive problems

Software developments related to multiobjective optimization and decision making (DESDEO)

1. Methods related topic

i. Applying agents in the DESDEO framework: modeling decision maker's preferences with belief-desire-intention frameworks (Bekir Afsar, Giovanni Misitano, Kaisa Miettinen)

ii. Next generation of interactive methods: Developing a system of building blocks that enables developing new interactive methods by combining the building blocks in different ways (Kaisa Miettinen)

a) This topic can include hybridization ideas – combining elements from different types of methods.

2. Visualizations and graphical user-interface (GUI) related topics

(i) Visualizations to support various needs of multiobjective optimization (Bhupinder Saini, Kaisa Miettinen)

a. We need tools to visualize many objectives, many solutions, attention to both objective and decision spaces, decision maker's preferences and all this in an interactive manner, that is, enabling the user to affect the appearance of visualizations

b. Needs of supporting multiple decision makers in group decision making setting is another direction.

c. Another possible direction is visualizing uncertainty aspects like scenarios going beyond the paper https://doi.org/10.1016/j.ins.2021.07.025

d. The work involves implementing different visual components and enabling the decision maker to select the appropriate visualizations for various needs.

e. All visualizations need validations through experimental studies.

f. This could include designing user interfaces (UIs) and dashboards that support interactive decision making

Cognitive and behavorial aspects of multiobjective optimization and decision making

(i) Supporting decision making with visualizations (cognitive side) (Johanna Silvennoinen, Kaisa Miettinen,)

a. Cognitive aspects (examples):
   i. Going to the element level. How the information is presented to the decision maker.
   ii. Fitting to the cognitive styles of the decision maker
   iii. How the visualization methods affect the decision process

b. Research method aspect as well
   i. Exploratory factor analysis?

(Explainable) Artificial Intelligence ((X)AI) and decision making (including agents)

- Explainable artificial intelligence/machine learning in modeling data-driven multiobjective optimization problems (Bekir Afsar, Kaisa Miettinen)
  - Extending the multi-agent architecture sketched in https://doi.org/10.1016/j.procs.2020.08.030 and putting the ides in practice
  a. Modeling (e.g., surrogates) data-driven multiobjective optimization problems has not been explored in the existing literature yet.

(ii) Explanations to support decision makers (Kaisa Miettinen)

a. We need novel ideas for supporting decision-making with explanations – explanations related to how solutions generated reflect preference information provided, how objective and decision spaces are connected, how to set new preferences etc.

b. One could extend from https://doi.org/10.1007/s10458-022-09577-3 or develop new approaches
c. Experiments would be needed as well.

Real-life applications of multiobjective optimization and decision making

1. Environment and forestry

- Sustainable forest management under deep uncertainty (handling natural hazards and disruptions) (Babooshka Shavazipour)
    - Sustainable decision-making in forest management involves long-term planning and multiple stockholders with conflicting objectives such as economics (maximizing revenues), environmental (minimizing carbon emissions and biodiversity loss), and social (maximizing employment rate, and recreational values). Sustainable forest planning can be helpful in climate change mitigation (e.g., by increasing carbon storage in trees, soils, and wood products) and biodiversity conservation (sustainable use of natural resources). There is an acute need to adapt management practices encompassing climate and other environmental benefits. The primary purpose of this thesis is to develop interactive multiobjective optimization methods supporting sustainable forestry and to assess its potential in climate change mitigation and biodiversity conservation while addressing various challenges, such as conflicting objectives of different stakeholders and handling different sources of uncertainty including coping with plausible disruptions.

2. (Energy) supply chain

- Green energy supply management under deep uncertainty (handling natural hazards and disruptions)[Babooshka Shavazipour]
    - The Russian invasion of Ukraine was a wake-up call highlighting the vulnerability of our previous decisions on trusting unreliable but cheap supply options. Thus, there is an essential need for European countries to accelerate the green energy transition and their energy independence from doubtful suppliers. However, Decision-making in this crucial issue involves long-term planning, multiple stockholders with conflicting objectives, and handling various sources of deep uncertainty. This thesis paves the way for addressing the abovementioned challenges by developing a decision-support tool based on multiobjective optimization for sustainable and resilient planning in green energy supply chain management.

3. Finance

- Portfolio selection under deep uncertainty (Babooshka Shavazipour)
    - The aim is to develop a decision support tool by integrating multiobjective optimization, forecasting, and decision making under deep uncertainty for portfolio selection.