Working Group 4: MCDM and RIMO

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1 Focus

We were looking at robustness and related issues in the context of interactive MCDM, in different stages of the decision process.

2 Overview of State-of-the-art

Robustness, uncertainty and objectivity vs. subjectivity appear in different parts of decision processes. For this reason, we first collect several viewpoints of them as a starting point for discussing interactivity.
Robustness and uncertainty. Robustness is needed because of uncertainty in different levels. There are different robustness issues in different stages of the decision process. Possibilities to approach robustness are, e.g.

- problem formulation (criteria or actions are not yet known, general characterization of problem considered)
- model formulation (mathematical formulation, simplifications)
- solution method (applying some method)

Objectivity vs. subjectivity. Objectivity and subjectivity are not absolute concepts. These concepts also appear in different stages of the decision process:

- problem formulation (more or less subjective)
- model formulation (data more objective, model simplifications more subjective)
- solution method (hammer and nail effect, question deepest assumptions)

Interactivity. Interaction in computer science can be defined as follows: interaction between human decision maker (DM) and a computer system, generally we naturally have also interaction between people. In the MCDM field, there has long existed a classification according to at which stage the DM participates in the solution process. The DM may articulate preferences either a priori, a posteriori or progressively. (It may be also possible that no preference information is available.) The progressive articulation is typically understood as interactivity. However, interactivity is also present in different stages of the decision process as mentioned before and there are also different robustness issues related to interactivity in these different stages.

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1. Problem perception and formulation (e.g., maximization of utility function or other needs of the DMs)

- What are the needs of the DM?
- Objective decision making vs. subjective decision making.
- Even though lots of literature in problem structuring exists, it has not been integrated into mainstream MCDM.

2. Mathematical model formulation

- Often, problem formulation and mathematical model formulation are assumed to be given which hides the importance of the first one.
- There are different types of models. Typical MCDM/OR models consists of objectives and constraints expressed in terms of variables, whereas e.g. process models are characterized by inputs and outputs. Conversion is not trivial (see objectivity vs. subjectivity above), but it is easier from process models to MCDM models.
- There must be interaction with the DM on which objectives and constraints should be used.
- Sometimes the problem to be solved is formulated at a too early phase of the solution process and then it is impossible to capture the real nature of the decision situation.
- There is always a need to choose between the model which is accurate enough and which is possible to compute/solve in a reasonable time.

3. Solution process

- The DM is expected to specify preference information in some coherent form and (s)he receives some feedback in the form of new solution candidates.
- DMs might have different needs, e.g. learning about the problem in question. Although most of the DMs want to use interactive solution process, there can be some DMs that do not want to specify preferences.
- There should be interaction with the DM when the solution method is chosen.
- Different phases of the decision process can be identified with different needs.
- There exist many different interactive methods. Methods requiring different types of preference information can be used during the solution process.

- There are also studies related to cognitive validity of different types of ways to specify preference information. Their findings can be used in selecting such methods that do not set too high cognitive burden on the DM.

- Examples of types of preference information include reference points, classification, marginal rate of substitution (subjective trade-offs), opinions related to local trade-off information, ranking.

4. Decision implementation (closed-loop implementation with feedback in order to modify/correct the implementation)

- This area has not been investigated sufficiently!

- Robustness should be investigated related to the implementation.

As already mentioned, there are robustness issues arising from uncertainty in different stages of the decision process. These issues are of various types in different stages, so there is a need for many ways of how robustness and uncertainty can be included in both MCDM models and in interactive MCDM methods.

Ways of including robustness and uncertainty in MCDM models.

- Some MCDM problems include criteria measuring uncertainty (e.g., portfolio optimization).

- Stochastic programming (two stage SP with recourse) is a scalarized multicriteria stochastic programme, usually with a deterministic and a stochastic objective (problem dependent). They are not necessarily commensurable, so, e.g., adding them may be problematic.

- It may be possible to capture the uncertainty/robustness issue in a deterministic objective to obtain a deterministic multiobjective problem (e.g., in aircrew scheduling).

- A problem with random variables can be formulated as an infinite dimensional vector optimization problem. Either on probabilities to fail targets (cumlative distribution function, cdf) or on quantiles (inverse cdf). The dominance relation can be expressed in the form of the First order Stochastic Dominance (FSD).

- Risk aversion/robust preferences can be guaranteed and differently modeled with the Second order Stochastic Dominance (SSD). They can be represented either by the multiple criteria model of Tail Averages (Average VaR, CVaR, Expected Shortfalls) (integrated quantile function, absolute Lorenz curve) or expected shortages to given targets (integrated cdf); expected utility can be represented as linear scalarizations of this but there exist also many other opportunities. Some mean-risk models are consistent with SSD.

- There is a classical duality relation between quantiles and cdf SSD.
- Robustness is essentially represented by an unknown distribution. Some examples include intervals, equally probable scenarios and parametric changes.
- The concept of robust preferences means risk aversion (strong risk aversion) but with an unknown distribution.
- Completely free perturbations lead to minmax models. Taking into account the entire distribution relates to Tail Averages, weighted ordered averages, ordered minmax optimization problems, equitable solutions, etc.

Ways of including robustness and uncertainty in interactive MCDM Methods

- Interactive reference point methods in which DM expresses preferences by giving desirable values for each objective (possibly minimal probability).
- Dominance relation can be modified to include robustness.
- One can aim at finding efficient solutions with certain properties.
- The method can be adapted during the solution process.

3 Major Research Challenges

- How to implement final decisions?
- How to analyze consequences of the decision during implementation, in other words, how to test implementation (e.g., by using a virtual simulation laboratory for testing)?
- How to test robustness and how to incorporate feedback between optimization and implementation testing?
- How to combine EMO with testing (e.g. robustness, implementation)?
- How to analyze robustness in interactive MCDM?
- What kind of quantitative measures of robustness should be used in MCDM?
- How to analyze the nature of interactivity in diverse stages of decision processes?
- What kind of desirable properties should decision processes contain (transparency, fairness, objectivity, ...)?
- What kind of methodologies should be used for dealing with the issues of fairness, objectivity, etc. in MCDM?
- How to handle problems with a large number of objectives?

4 Potential Synergies between MCDM and EMO

Actually, many of the topics discussed above are valid for both the MCDM and EMO approaches. Therefore, there is no need for listing any specific synergies.

5 Keywords

Because of lack of time, we had to settle for collecting a mixed set of keywords related to the focus of the working group without any particular order:

- robustness, uncertainty, scalarization, stochastic dominance, robust solutions, dominance relation, solution process, solution method, problem formulation, objective functions, actions, model simplification, objectivity, subjectivity, interactivity, decision implementation, problem structuring, preference information, learning, cognitive validity, visualization techniques, testing, large number of objectives, portfolio optimization, stochastic programming, infinite dimensional vector optimization, weighted ordered averages, ordered min max, equitable solutions, reference point methods, process models, input/output, MCDM/OR models, trade-off