Feature cluster: Learning perspectives in Multiple Criteria Decision Analysis

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1. Editorial

The framework of Multiple Criteria Decision Analysis (MCDA) supplies a theoretical basis and a diversity of methods for dealing with complex decision problems involving conflicting criteria. After more than forty years of research and applications in MCDA, it appears clear that to effectively handle such problems, learning has a key role to play. Solving decision problems involves at least two simultaneous learning processes. On one hand, the Decision Maker (DM) learns about the problem, and about her/his own preferences which are initially only vaguely formed in her/his mind. On the other hand, the method learns about the DM's preferences so that to suggest justifiable and transparent recommendation that can be accepted by the DM. The implementation of such a mutual learning process is particularly important in view of an increasing interest in MCDA in domains ranging from environmental management through industrial design and urban planning to finance.

The purpose of this feature cluster was to relate the current discussion on the learning perspectives in MCDA and to advance their understanding in the Operational Research community. Although we strongly encouraged the submission of papers presented at MCDM 2015 - 23rd International Conference on Multiple Criteria Decision Making (Hamburg; August 2-7, 2015), the call for contributions to the feature cluster was open to the entire community of academics and practitioners working in the field of MCDA. The call solicited 38 submissions, eight of which were accepted for publication following the rigorous review process of the European Journal of Operational Research.

The papers contained in the feature cluster consider a wide range of problems with multiple criteria, showcasing the variety of interests in the current research in MCDA. They exhibit new

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theoretical insights, algorithmic approaches, computational studies, and applications in the context of MCDA methods implementing different paradigms. The accepted papers cover a wide spectrum of topics, from problem structuring through preference elicitation and preference modelling to problem solving. As a result, the feature cluster emphasizes the role of learning in a rich interplay between human judgement, data analysis, and computational processes, which is at the core of MCDA. We briefly summarize the content of individual papers in this editorial.

Olivier Sobrie, Nicolas Gillis, Vincent Mousseau, and Marc Pirlot present new preference learning methods – UTA-poly and UTA-splines – that employ pairwise comparisons of selected alternatives as examples for learning an additive value function. These approaches implement the principle of posterior rationality, aiming at explaining the rationale underlying the provided holistic judgements with an assumed preference model. The main contribution of this paper to the field of preference elicitation consists in proposing an algorithm based on semi-definite programming that is able to model marginal value functions using polynomials or splines instead of piecewise linear functions. As a result, the inferred functions are more smooth. This increases their interpretability and descriptive power, which is particularly important in fields such as economy or marketing.

Sandor Bozóki and János Fülöp account for learning a set priorities (weights) from a pairwise comparison matrix. The authors prove that using a popular eigenvector method results in the weakly efficient solution. This means that some of the pairwise ratios corresponding to the priorities inferred with this approach do not approximate the matrix elements provided by the DM in the best possible way. To address this problem, Bozóki and Fülöp develop linear programs for testing whether a given vector of priorities is efficient with respect to a fixed pairwise comparison matrix, as well as for deriving an efficient dominating vector of priorities. Overall, the proposed algorithms put emphasis on the faithful representation of the DM's value system by the constructed preference model. The importance of this topic is enhanced by the enormous use of pairwise comparison matrix for weighting criteria or assessing alternatives in MCDA.

Jianping Li, Xiaoyang Yao, Xiaolei Sun, and Dengsheng Wu deal with preference modelling in view of representing the interactions between criteria by means of fuzzy measures. This is a cognitively and computationally demanding problem, because the measures have to be estimated over the exponential number of subsets. To approach it in a realistic setting, the authors propose to infer the interactions from the DM's tolerance attitudes to certain criteria. The attitudes capture the role of individual attributes in either promoting or preventing the implementation of respective alternatives. Li et al. introduce a dedicated scale for directly expressing the tolerance degrees, and clearly demonstrate their impact on the interactions between criteria. In particular, if the DM has a low (high) tolerance degree to criteria, the interactions are positive (negative), which means a high level of complementarity (substitutability) corresponding to risk aversion (seeking). Such intuitive interdependencies increase the interpretability and transparency of a preference model. They are also important from the mutual learning perspective, because the obtained fuzzy measures and their impact on the comprehensive assessment of alternatives can influence the DM's attitudes,

leading to their revision.

Wen Sheng Du and Bao Qing Hu consider a classical problem of finding a reduct of a given system, being a minimal subset of criteria that maintains the classification quality of the entire set of criteria. In this regard, a reduct indicates the attributes from the original feature set which are relevant for comprehensively explaining the DM's holistic preferences. This is useful for the DM's learning. Such a feature (subset) selection problem is important not only in MCDA, but also in machine learning, pattern recognition, and data mining. Du and Hu focus on the algorithmic aspects of identifying a single reduct, which is often sufficient in real-world applications. By incorporating a new accelerator, they significantly reduce the time needed by some popular heuristic methods, ensuring, however, that the reducts constructed by the accelerated version and its original counterpart are the same. These characteristics make the proposed algorithm usable even with large scale information systems.

Adiel Teixeira de Almeida-Filho, Thárcylla Negreiros Clemente, Danielle Costa Morais, and Adiel Teixeira de Almeida raise the problem of learning faithful weights from the partial preference information in form of criteria ranking. In particular, they compare four state-of-the-art surrogate weighting procedures in view of their joint use with the outranking-based PROMETHEE method. The carefully designed computational study involves artificial (simulated) DMs. This provides a convenient means of examining more theoretical properties of MCDA methods due to the ability to fully control the experimental situation, avoiding undesired biases and fatigue. The results indicate that the Rank-Order-Centroid (ROC) method vastly outperforms other procedures in providing recommendation that is more consistent with the simulated true preferences of the DMs. It is an important finding that indicates more favourable ways of capturing DM's preferences, potentially increasing acceptance of the recommendation suggested by PROMETHEE coupled with the surrogate weighting procedures.

Alessio Ishizaka and Sajid Siraj verify the practical usefulness of three selected MCDA methods in the incentive-based experiments conducted under controlled laboratory conditions. The experiments involved university staff and students acting as real-world DMs aiming to rank the coffee shops available on the university campus. The usefulness of AHP, SMART, and MACBETH was assessed by comparing the recommendations they suggested for each participant with the rankings provided before and after using the respective method. The employed tools helped the participants in their decision making, supporting them in revising the ranking in case the recommendation suggested by the MCDA method was not consistent with their initial preferences. This confirms a clear learning effect that takes place when using MCDA in problem solving. The experimental findings confirmed moreover, that a user-friendly interface strongly enhances the effectiveness of the method.

Miłosz Kadziński, Marco Cinelli, Krzysztof Ciomek, Stuart Coles, Mallikarjuna Nadagouda, Rajender Varma, and Kerry Kirwan propose a preference learning method that infers a threshold-based value-driven classification model from a set of assignment examples. The implemented

approach derives the representative and robust results from the analysis of all maximal subsets of consistent assignment examples. Its practical usefulness is illustrated by a real-world problem of assessing the synthesis processes of silver nanoparticles based on green chemistry principles implementation. The authors thoroughly discuss the learning insights that MCDA provided during the co-constructive development of the classification model, distinguishing between problem structuring, preference elicitation, learning, modeling, and problem-solving stages. In particular, they demonstrate that the inferred model permits to work out highly insightful recommendations being concordant with a value system of the involved experts, at the same time leading them to a better understanding of their preferences.

Raffaele Attardi, Maria Cerreta, Valentina Sannicandro, and Carmelo Maria Torrea report a successful application of the outranking-based ELECTRE III method for construction of the non-compensatory Land-Use Policy Efficiency Index. The considered real-world problem concerns evaluation of some Italian municipalities based on their environmental and social performances in the spatial planning domain. Above all, the authors demonstrate that performing such a complex assessment of alternatives needs to incorporate a cyclic mutual learning process between the stakeholders, decision analysts, and the method. In particular, the stakeholders provide a set of relevant descriptions, preferences, and targets. Then, this information is used by the analyst to model the problem in a technical manner and select appropriate aggregation conventions. The results computed with the MCDA method are returned to the stakeholders who are expected to assess their quality and coherence with the reality, in order to trigger possible calibration of the mathematical model by interaction with the analyst. Overall, the study emphasizes the role of MCDA in increasing knowledge and providing deeper insights into complex phenomena in the domains of urban and regional planning.

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