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Multi-Criteria Decision-Making: The Intersection of Search, Preference Tradeoff, and Interaction Visualization Processes

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***Abstract*—The goal of the *First IEEE Symposium of Computational Intelligence in Multicriteria Decision Making (MCDM 2007)* is to provide a common forum for three scientific communities that have addressed different aspects of the MCDM problem and provided complementary approaches to its solution. The first approach is the *search process* over the space of possible solutions. We must perform efficient searches in multi- (or sometimes many-) dimensional spaces to identify the non-dominated solutions that compose the Pareto set. This search is driven by the solution evaluations, which might be probabilistic, stochastic, or imprecise, rather than deterministic. The second approach is the *preference tradeoff process*. We need to elicit, represent, evaluate, and aggregate the decision-maker's preferences to select a single solution (or a small subset of solutions) from the Pareto set. These preferences may be ill defined, and state or time-dependent rather than constant values. The aggregation mechanism may be as simple as a linear combination or as complex as a knowledge-driven model. The third approach is the *interactive visualization process,* which enables progressive decisions. We often want to *embed* the decision-maker in the solution refinement and selection loop. To this end, we need to show the impacts that intermediate tradeoffs in one sub-space could have in the other ones, while allowing him/her to retract or modify any intermediate steps to strike appropriate tradeoff balances. Given this perspective, we believe that MCDM resides in the intersections of these approaches.**

For this purpose, we have invited researchers in meta-heuristics and evolutionary multi-objective optimization (EMO) to contribute their most efficient search algorithms, analyzing them for robustness, scalability, tolerance for imprecise solution evaluation, etc. We have also invited scientists from the Fuzzy Sets and Bayesian decision-making communities to discuss their selection methods, while asking researchers from the interactive visualization community to present their visualization tools and underlying cognitive models. As in all scientific endeavors, we must also create a baseline derived from the best traditional approaches to properly assess the benefits derived from newer techniques, such as Computational intelligence. Therefore, we have invited scientists from the International Society on MCDM to assess the current state-of-the-art in MCDM from an Operational Research perspective.

With such a broad perspective, we will focus on the intersection of the three aforementioned areas (*search, preference tradeoff, and interactive visualization*) and highlight some research challenges, representing potential gaps in the intersection. We introduce a requirement framework to compare most MCDM problems, their solutions, and analyze their performances.

Specifically, we consider the following eight categories:

1) ***Performance requirements:* real-time or batch mode, for on-board or off-board deployment;**
2) ***Deployment architecture:* centralized or distributed;**
3) ***Response evaluation:* deterministic, uncertain, or imprecise;**
4) ***Search complexity*: scalability in high-dimensional performance spaces, hybrid search methods, leverage of domain knowledge and problem structure;**
5) ***Objectives and constraints complexity*: non-convex regions;**
6) ***Uncertainty management*: vagueness and/or uncertainty in response evaluation requiring fusion of multiple evaluators;**
7) ***Decision-making needs:* automated for real-time applications, interactive and progressive decision-making for batch applications;**
8) ***Update requirements for solution fidelity:* retraining and updating of data- or knowledge-driven evaluators.**

Within this framework, we will have a sampling of real-world MCDM problems. We will also identify potential combinations that will require additional research efforts.

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