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Multi-Criteria Decision Making

> Consider what you think justice requires, and decide accordingly. But never give your reasons; for your judgment will probably be right, but your reasons will certainly be wrong.
>
> Lord Mansfield

9.1 Introduction

One aspect that most of the current research on evolutionary multiobjective optimization (EMO) often disregards is the fact that the solution of a multiobjective optimization problem (MOP) really involves three stages: measurement, search, and decision making.

Being able to find P_{true} does not completely solve an MOP. The decision maker (DM) still has to choose a single solution out of this set. The process of selecting a single solution is not trivial. In fact, there is a set of methodologies regarding how and when to incorporate decisions from the DM into the search process.

Having several nondominated vectors does not provide any insight into the process of decision making itself. Nondominated vectors are really a useful generalization of a utility function under the conditions of minimum information (i.e., all attributes are considered as having equal importance; the DM does not express any preferences) [315, 316, 504, 719, 598].

Most of the current EMO research concentrates on adapting an evolutionary algorithm to generate P_{true} (i.e., search). However, the articulation of preferences has been dealt with by few researchers (see for example [1347, 1346, 315, 316, 314, 706, 504, 719, 598, 263]).

In this chapter, a brief review of the main concepts related to Multi-Criteria Decision Making (MCDM[1]) is provided. The most representative

[1] After the 1960s, the main emphasis of operations researchers has been to study the area known as "Multi-Criteria Decision-Aid" (MCDA) [1387, 1658]. The main

research on preference articulation found in the EMO literature is then reviewed, analyzing their contributions and weaknesses.

9.2 Multi-Criteria Decision Making

From the Operations Research (OR) perspective, there are two main lines of thought regarding MCDM [730]:

1. The French school, which is mainly based on the outranking concept [1659], and
2. The American Multi Attribute Utility Theory (MAUT) school [836].

The French school is based on an outranking relation which is built up under the form of pairwise comparisons of the objects under study (see Section 1.7.1 from Chapter 1). The main goal is to determine, on the basis of all relevant information for each pair of objects, if there exists preference, indifference, or incomparability between the two. For this purpose, preference or dominance indicators are defined and compared with certain threshold values.

The main disadvantage of this approach is that it can become very expensive (computationally speaking) when there is a large number of alternatives. Also, some authors consider the use of outranking methods as complementary to other techniques (e.g., MAUT) and are therefore intended for problems that present certain characteristics (e.g., at least one criterion is not quantitative) [1388].

MAUT is based, in contrast, on the formulation of an overall utility function, and its underlying assumption is that such a utility function is available or can be obtained through an interactive process. When this utility function is not available, the task is then to identify a set of nondominated solutions. In this case, strong preference can only be concluded if there exists enough evidence that one of the vectors is clearly dominating the vector against which it is compared. Weak preference (modeled as weak dominance[2] [997]), on the other hand, expresses a certain lack of conviction. Indifference means that both vectors are "equivalent" and that it does not matter which of them is selected. It is important to distinguish this "indifference" from the "incomparability" used with outranking methods, since the second indicates vectors with strong

difference between MCDM and MCDA is that MCDA assumes multiobjective optimization problems are ill-defined mathematical problems. That is, depending on the algorithm used and the preference information incorporated, different solutions to the same problem could be obtained. While MCDM focuses on finding a solution to a multiobjective optimization problem, MCDA focuses on the decision process itself. According to Roy [1387], the main aim of MCDA is "to construct or create something which is viewed as liable to help an actor taking part in a decision process either to shape, and/or to argue, and/or to transform the DM's preferences".

[2] See Section 1.2.3 from Chapter 1.