Exploiting Comparative Studies Using Criteria: Generating Knowledge from an Analyst's Perspective

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Abstract. In this work the use of qualitative preferences for classifying and selecting MOEAs is introduced. The classical notions of the Analyst and the so called Prescriptive Analysis are introduced explicitly in EMO, identifying some difficulties in exploiting the results of the comparative studies performed by the current fashion. A methodology is developed that allows the analyst to translate DM's general preferences as well as quantitative benchmarking results into a practical tool for the comparison of MOEAs, facilitating the selection of the proper method and/or parameters for the MCDM problem at hand. A comparative experimentation is performed using well known state of the art functions, allowing drawing clear conclusions about the utility of the proposed methodology. The results are useful for research, practitioners and analysts involved in benchmarking, comparative studies and prescriptive analysis for EMO.

1 Introduction

When Multiple Criteria Decision Making (MCDM) is modelled, different stages and actors can appear as a part of the whole process. An actor is defined as any individual, group of individuals or entity, playing any role during the decision making process [1][2]. In this sense, besides the Decision Maker (DM), it is useful to identify another actor called the *analyst*. Arsham [3] lists a sequence -which allows feedback loops- of tasks accomplished by the analyst:

1. Understanding the Problem
2. Constructing an Analytical Model
3. Finding a Good Solution
4. Communicating the Results with the Decision-Maker

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Once the model is constructed, the analyst must choose a suitable method or solving technique. That is intended for "Finding a Good Solution". This stage (steps 2 and 3) is known as prescriptive analysis.

To our best knowledge, the notions of analyst and prescriptive analysis have not been introduced explicitly in Evolutionary Multiobjective Optimization (EMO) yet (despite they can be found in some way applied in practice, e.g. [4]), maybe due to these notions could seem more appropriate for decision making techniques which deal with problems not well defined (in terms of mathematical formulation) and where the preferences are articulated *a priori* or *interactively* (e.g. outranking methods). Even so, the lack of these concepts in EMO does not mean that EMO researchers and practitioners are not aware of them. Nevertheless, we do believe that considering prescriptive analysis explicitly in EMO can yield worthy results.

In this paper we concentrate in the case of *a posteriori* Multiple Objective Evolutionary Algorithms (MOEAs), which represent the most of available MOEA (Van Veldhuizen and Lamont [5] mention about 90%, and apparently this bias has not changed significantly in the last years). Consider now the role of an analyst who works with a posteriori MOEAs. Analyzing the No Free Lunch theorem, Knowles and Corne conclude in [6][7] that some multiobjectives optimizers are better than others. In consequence, it sounds reasonably that given a pool of MOEAs, the analyst should select the proper method for solving MCDM problem. The issue is *how* to do that; in fact, the selection could be far to be trivial in many cases.

In this research, we study a group of comparative analysis of some relevant state-of-art MOEAs, identifying some points which limit the ability of an analyst to choose a particular algorithm. Then, we developed a methodology, sustained in comparative studies, that allows the analyst to *translate* DM's preference as well as quantitative benchmarking results into a practical tool for the comparison of MOEAs. As a result, the influence of genetic parameters (crossover and mutation rates) and population size upon the overall performance were assessed empirically for three relevant MOEAs, and then interpreted, building qualitative preference maps which can help the analyst to achieve the prescriptive analysis. As the reader can intuit, the present work is relevant not only for persons interested in prescriptive analysis in EMO, but also for researchers and practitioners in general, involved in benchmarking and comparative studies.

The remainder of the paper is organized as follows. In the next section the concepts of analyst and prescriptive analysis are studied more deeply regarding the state of art in comparative studies in EMO. In section 3 the proposed methodology is developed step by step, showing how to exploit benchmarking by introducing preferences. Finally some concluding remarks are presented.

2 Background

In order to set this research in its context, we will discuss in this section how considering explicitly the notion of the analyst can be beneficial for EMO. To do that, let us begin considering the single MCDM/EMO model depicted in figure 1. In this proposed model, for the sake of simplicity, MOEAs are represented as black-box multiobjective optimizers. EMO is enclosed by a dashed line as is focused nowadays,