A Comparative Study of Progressive Preference Articulation Techniques for Multiobjective Optimisation

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Abstract. Multiobjective optimisation has traditionally focused on problems consisting of 2 or 3 objectives. Real-world problems often require the optimisation of a larger number of objectives. Research has shown that conclusions drawn from experimentations carried out on 2 or 3 objectives cannot be generalized for a higher number of objectives. The curse of dimensionality is a problem that faces decision makers when confronted with many objectives. Preference articulation techniques, and especially progressive preference articulation (PPA) techniques are effective methods for supporting the decision maker. In this paper, some of the most recent and most established PPA techniques are examined, and their utility for tackling *many*-objective optimisation problems is discussed and compared from the viewpoint of the decision maker.

Keywords: Progressive preference articulation, Multiobjective optimisation.

1 Introduction

Real-world problems commonly require the simultaneous consideration of multiple performance measures. Solving such problems is therefore concerned with finding an ideal solution that satisfies the decision maker's (DM) preferences and meets the goal values for the problem objectives without violating certain constraints. Conventionally, evolutionary multiobjective optimisation (EMO) has focused on dealing with optimisation problems comprising 2 or 3 objectives, mainly for the convenience of graphical demonstration and illustration. Conclusions drawn from such low-dimensional multiobjective frameworks used to be generalized for the multiobjective branch of evolutionary optimisation problems. Recently, research [1, 2] has shown that the case of high-dimensional optimisation problems (more than 3 objectives) also termed as "Many Objective Optimisation Problems" is a special case of evolutionary multiobjective problems that requires further investigation. Indeed a different set of difficulties and challenges can be associated the Evolutionary *Many*-Objective Optimisation sub-category, most importantly the unambiguous conflict of solutions convergence and diversity in such scenarios. Convergence and diversity are two of the primary requirements of a multiobjective optimiser. Other evolutionary *many*-objective optimisation difficulties involve the obvious dimensionality increase of the Pareto front, and the difficulty of visualizing such scenarios.

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Reducing the dimensionality and therefore the complexity of a problem is a straightforward way for dealing with the high-dimensional problems. Early approaches such as the weighted sum or the Tchebyshev method [3] consist of scaling techniques to convert multiobjective problems into a single objective counterpart. Such approaches presented several shortcomings, mainly the absence of the desired parallel search capacity. More recent techniques of dimensionality reduction for dealing with multiobjective optimisation problems consist of techniques to identify objectives redundancy and to eliminate it. Principal Component Analysis [4] ,[1] is an example of such a technique. Its aim is to identify redundant objectives whose absence has no substantial effect on the optimisation process, thereby simplifying the complexity of certain high dimensional problems and reducing the hyperspaces of solutions. While dimensionality reduction is a remedial measure to tackle multiobjective optimisation problems, it can only be deployed in reducible scenarios where redundancy or objective relationships such as independence or harmony are existent and detectable.

In scenarios, where insufficient redundancy can be detected in a high-dimensional problem, progressive preference articulation (PPA) is a proven useful alternative remedial measure. The incorporation of DM preference into evolutionary multiobjective optimisation algorithms is very useful for guiding the search into pertinent regions of interest (ROI), which are relevant to the decision maker. Coello [5] has produced a comprehensive survey about handling preferences in EMO. It can also provide advantages over the use of pure Pareto-optimality, which is unfettered in its search and is liable to produce solutions outside the ROI as well as within it. Until recently, most EMO research has focused on bi-objective problems where the need for incorporating the decision maker's preferences is less apparent. The aim of this paper is to encourage and promote the research of incorporating progressive preference articulation techniques into evolutionary multiobjective optimisation. In this paper, some of the most recent preference articulation techniques are discussed and upgraded to their progressive versions for incorporation into evolutionary multiobjective optimisation processes. Their major strengths and weaknesses for tackling *many*-objective optimisation problems are discussed and illustrated on a straightforward bi-objective scenario for simplicity. The preference articulation techniques investigated in this work include Branke's "Guided Dominance Scheme" [5], Deb's "Biased Crowding Technique" [6], the manipulation of the ε-dominance concept within the framework of Deb's steady state ε –MOEA [7] and Fonseca and Fleming's preferability operator (FF-PPA) [8], which we believe was the first truly PPA technique for EMO.

In section 2 of this paper, the requirements of a multiobjective optimiser are presented. In section 3, a brief description of the preference articulation techniques inspected in this paper is given. In section 4, the usefulness and practicality of the studied progressive preference articulation techniques are visually illustrated on simple bi-objective scenarios. (In some cases, we have introduced a progressive capability into existing preference articulation techniques.) In section 5, the strengths, weaknesses, user-friendliness and efficiency of these PPA techniques, in a many objective optimisation context, are discussed from the viewpoint of the decision maker. Lastly, some concluding remarks are presented.