Decision-Maker Preference Modeling in Interactive Multiobjective Optimization

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Abstract. This work presents a methodology for modeling the information concerning preferences which is acquired from a Decision-Maker (DM), in the course of one run of an interactive evolutionary multiobjective optimization algorithm. Specifically, the Interactive Territory Defining Evolutionary Algorithm (iTDEA) is considered here. The preference model is encoded as a Neural Network (the NN-DM) which is trained using ordinal information only, as provided by the queries to the DM. With the NN-DM model, the preference information becomes available, after the first run of the interactive evolutionary multiobjective optimization algorithm, for being used in other decision processes. The proposed methodology can be useful in those situations in which a recurrent decision process must be performed, associated to several runs of a multiobjective optimization algorithm over the same problem with different parameters in each run, assuming that the utility function is not dependent on the changing parameters. The main point raised here is: the information obtained from the DM should not be discarded, leading to a new complete interaction with the DM each time a new run of a problem of the same class is required.

Keywords: progressive preference articulation, preference model, neural networks, interactive multiobjective optimization.

1 Introduction

It is well-known that the process of optimizing two or more conflicting objectives usually leads to a set of solutions, the Pareto-optimal solutions, which cannot be ordered by the simple comparison of their objective function values. These incomparable solutions, also called the non-dominated solutions, are delivered by the multiobjective optimization algorithms. The first canonical versions of algorithms for evolutionary multiobjective optimization were intended to deliver a detailed uniform sampling of the Pareto front [1,2,3]. Once this sampling was available, it was assumed that a Decision-Maker (DM) would compare those solutions, indicating the preferred one as the final solution of the problem.

In recent years, a new approach started to receive a growing attention. Due to the high cardinality of a detailed sampling of the entire Pareto front in some

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problems, with particular emphasis on the cases with more than three objectives, some works have proposed procedures that concentrate the sampling in some regions of the Pareto front, based on information which is obtained from interaction between the optimization algorithm and the DM [4,5].

Among the algorithms which consider the DM interaction with the optimization process, the work by Karahan and Köksalan [5] receives a special mention here. That work proposed the Interactive Territory Defining Evolutionary Algorithm (iTDEA), a preference-based multi-objective evolutionary algorithm which identifies the preferred region interacting with the DM on pre-determined generations. In each interaction with the DM, a new best individual is chosen and a new preferred region is stipulated, with a smaller territory for each individual in that region. Individuals falling in that region are assigned smaller territories than those located elsewhere, making the sampling density of the preferred regions higher.

It should be noticed that the information extracted from the DM by the iTDEA is useful only within the scope of the optimization process in which such information is obtained. Whenever the same (or a similar) problem needs to be solved, the DM has to answer the queries about the same region again. However, it should be noticed that, very often, a multiobjective optimization problem might be solved for slightly different conditions, which makes the Pareto-front to become different from one run to the other, with the DM's preferences kept unchanged. For instance, a product may be produced in different instances with different constraints in the resources availability, or with different parameters in some objective functions.

The work by Pedro and Takahashi [6] proposed the construction of a model for the DM's preferences considering the utility function level sets, the NN-DM. The preference information extracted from the DM involves ordinal description only, and is structured using a partial ranking procedure. An artificial neural network is constructed to approximate the DM's preferences in a specific domain, approximating the level sets of the underlying utility function. The proposed procedure was stated with the aim of helping in situations in which recurrent decisions are to be performed, with the same DM considering different sets of alternatives.

This paper presents the results of the hybridization of the iTDEA with an enhanced version of NN-DM. Using the same amount of preference information required by the iTDEA, the NN-DM is able to construct a model for the DM's preferences, so that no more queries are required from the DM related to that specific region of the objective space. This model can now solve similar decision-making problems that comes from optimization problem leading to Pareto-optimal fronts in the same region of the space. Once this preference model is adjusted, it can be used inside the optimization process to guide the search without demanding more information from the DM.

This paper is organized as follow. Section 2 presents some introductory discussion about decision-making theory and multi-objective optimization. Section 3 presents the Interactive Territory Defining Evolutionary Algorithm (iTDEA),