New Ideas in Applying Scatter Search to Multiobjective Optimization

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Abstract. This paper elaborates on new ideas of a scatter search algorithm for solving multiobjective problems. Our approach adapts the well-known scatter search template for single objective optimization to the multiobjective field. The result is a simple and new metaheuristic called SSMO, which incorporates typical concepts from the multiobjective optimization domain such as Pareto dominance, crowding, and Pareto ranking. We evaluate SSMO with both constrained and unconstrained problems and compare it against NSGA-II. Preliminary results indicate that scatter search is a promising approach for multiobjective optimization.

1 Introduction

Most optimization problems in the real world involve the optimization of more than one function, which in turn can require a significant computational time to be evaluated. This feature and the fact that the search space tends to be very large in multiobjective problems (MOPs) make deterministic techniques difficult to apply in order to obtain the Pareto-optimal solutions of MOPs. As a consequence, stochastic techniques have been widely proposed and applied in this domain. Among them, evolutionary algorithms have been investigated by many authors, and some of the most well-known algorithms for solving MOPs belong to this class (e.g. NSGA-II [1], PAES [2], SPEA-2 [3], and micro-GA [4]).

Many evolutionary algorithms for solving MOPs are some kind of genetic algorithm. This implies they use the concepts of population, crossover, mutation, and similar genetic operators (an exception is PAES, which is an (1+1) evolution strategy). We are interested in studying the application of scatter search, another kind of population-based evolutionary algorithm, to solve MOPs. Scatter search has proved to be very effective for solving a diverse set of single objective optimization problems from both classical and real world settings [5], but little attention has been paid to its use in multiobjective optimization (existing works almost reduce to [6, 7, 8]).

Scatter search is based on using a small population known as the reference set, whose individuals are combined to construct new solutions which, in contrast to

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other evolutionary algorithms, are obtained in a systematic way (i.e., stochastic procedures such as crossover and mutation are not used). Furthermore, these solutions can be improved by applying a local search method. The reference set is initialized from an initial population composed of dispersed solutions, and it is updated taking into account the results of the local search improvement.

The *scatter search template* presented in [9] has served as the main reference for most of the scatter search implementations to date. The template consists of five methods: diversification generation, improvement, reference set update, subset generation, and solution combination. This template is used in [10] to design a scatter search procedure for single objective optimization problems with continuous bounded variables. In this paper, we have taken this implementation as the basis of a scatter search algorithm for multiobjective optimization, trying to modify it as little as possible with the idea of getting a simple algorithm. We have named this algorithm SSMO (Scatter Search for Multiobjective Optimization). Our main goal is to identify and study new issues that can affect the performance of the algorithm for MOPs.

The contributions of our work can be summarized as follows:

- We propose a scatter search algorithm for solving constrained as well as unconstrained MOPs. The algorithm is based on incorporating the concepts of Pareto dominance, ranking, and crowding, and they are applied to define the improvement and reference set update methods of the scatter search algorithm.
- Two strategies for building the reference set are studied. The first one uses ranking and crowding to carry out a sorting of the population to obtain the best individuals, while the second strategy is based on applying a clustering technique to get a set of centroids of the individuals with best rank.
- The algorithm is evaluated using a benchmark of constrained plus unconstrained MOPs, and it is compared against the NSGA-II algorithm.

The remaining of the paper is organized as follows. In Section 2, we discuss related works concerning multiobjective optimization and scatter search. In Section 3, we describe our proposal. Experimental results are presented in Section 4. Finally, in Section 5 we give some conclusions and lines for future research.

2 Related Work

The application of scatter search to multiobjective optimization has received little attention until recently. We analyze here the proposals presented in [6], [7], and [8]. We use the following terminology: P is the initial set, k is the number of objective functions, and the reference set is composed of $p + q$ individuals, which are obtained by selecting the best p solutions of P, while the remaining q individuals are selected from both P and the current reference set by using a mechanism promoting diversity.

MOSS [6] is an algorithm that proposes a tabu/scatter search hybrid method for solving nonlinear multiobjective optimization problems. Tabu search is used