Cooperative Multi-objective Genetic Algorithm with Parallel Implementation

Christina Brester(✉) and Eugene Semenkin

Siberian State Aerospace University, Krasnoyarsk, Russia
christina.brester@gmail.com, eugenesemenkin@yandex.ru

Abstract. In this paper we introduce the multi-agent heuristic procedure to solve multi-objective optimization problems. To diminish the drawbacks of the evolutionary search, an island model is used to involve various genetic algorithms which are based on different concepts (NSGA-II, SPEA2, and PICEA-g). The main benefit of our proposal is that it does not require additional experiments to expose the most appropriate algorithm for the problem considered. For most of the test problems the effectiveness of the developed algorithmic scheme is comparable with (or even better than) the performance of its component which provides the best results separately. Owing to the parallel work of island model components we have managed to decrease computational time significantly (approximately by a factor of 2.7).

Keywords: Heuristic search · Multi-objective genetic algorithm · Multi-agent approach · Island model · Cooperation

1 Introduction

In recent times there has been a growing interest in the sphere of Evolutionary Ma-chine Learning: owing to a number of benefits which heuristic-based optimization methods have demonstrated, researchers have proposed several effective applications of Evolutionary Computation in the Machine Learning field [1], [2], [3]. This has become possible for several reasons: evolutionary algorithms are universal and might be used to find the optimal solution in both continuous and discrete search spaces; they could be applied in a dynamic environment; in most cases the effectiveness of evolutionary approaches is not lower than the performance of non-evolutionary ones [4].

However, some researchers highlight the negative sides of the Evolutionary Computation and Machine Learning integration. Firstly, it is always necessary to investigate a number of algorithms to define the most effective one for the problem considered because the performance of evolutionary algorithms varies significantly for different problems. Secondly, these methods require more computational resources compared with alternative non-evolutionary algorithms.

This paper is devoted to solving optimization problems with several criteria, and therefore, we attempt to develop a modified multi-objective genetic algorithm (MOGA) with these drawbacks removed.

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To overcome the disadvantages of the evolutionary search, an island model is used to involve genetic algorithms (GA) which are based on different concepts (NSGA-II, SPEA2, and PICEA-g). Moreover, this model allows us to parallelize calculations and, consequently, to reduce computational time.

As a result, we have managed to implement the multi-agent heuristic procedure to solve multi-objective optimization problems, which does not require additional experiments to expose the most appropriate algorithm for the problem considered. Besides, due to the parallel work of island model components we have achieved a significant decrease in computational time (roughly by a factor of 2.7). According to the results obtained, for most of the test problems the effectiveness of the developed algorithmic scheme is comparable with the performance of its component which provides the best results separately.

The rest of the paper is organized as follows: in Section 2 a description of the cooperative algorithm developed is presented. The test problems used to investigate the effectiveness of our proposal are introduced in Section 3. The experiments conducted, the results obtained, and the main inferences are included in Section 4. The conclusion and future work are presented in Section 5.

2 Developed Approach

2.1 Cooperative Multi-objective Genetic Algorithm

Designing a MOGA, researchers are faced with some issues which are referred to fitness assignment strategies, diversity preservation techniques, and ways of elitism implementation. However, the common scheme of any MOGA includes the same steps as any conventional one-criterion GA:

Generate the initial population
Evaluate criteria values
While (stop-criterion!=true), do:
{Estimate fitness-values;
Choose the most appropriate individuals with the mating selection operator based on their fitness-values;
Produce new candidate solutions with recombination;
Modify the obtained individuals with mutation;
Compose the new population (environmental selection);
}

In contrast to one-criterion GAs, the outcome of MOGAs is the set of non-dominated points which form the Pareto set approximation.

To eliminate a number of questions which are raised while designing multi-criteria evolutionary methods, in this study we propose a cooperation of several GAs based on various heuristic mechanisms.

Generally speaking, an *island model* [5] of a GA implies the parallel work of several algorithms. A parallel implementation of GAs has shown not just an ability to preserve genetic diversity, since each island can potentially follow a different search trajectory,