A Fast Two-objective Differential Evolutionary Algorithm based on Pareto-optimal Set

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ABSTRACT

The two-objective differential evolution with Pareto-optimal set, which is researched in this paper. Firstly, it is found that there are some redundant computations in the classic multi-objective evolutionary algorithm, such as the NSGA-II. Then, based on the concept of Pareto-optimal set, the non-dominated solution sorted and its potential features, the authors propose a ranking method for solution that only handles the highest rank individuals in current population. The highlight of the proposed method is that during the ranking process, the individuals can be chosen into the next generation meanwhile. When the individuals of next generation population are obtained the algorithm is broken out. Both the number of individuals for sorting process and the time complexity are reduced. Furthermore, a method of uniform crowding distance calculation is provided in this work. Finally, the authors incorporate the introduced ranking method and uniform crowding distance method into differential evolution, a fast two-objective differential evolution algorithm is obtained. For verifying the proposed method, they use the classical optimal problems ZDT1~ZDT4 and ZDT6 for testing. Simulation results show that the authors’ method has greatly improved in terms of time complexity and performance than other algorithms.

KEYWORDS
Computational Intelligence, Differential Evolution (DE), Multi-objective, Non-dominated Solution Sorted, Pareto

1. INTRODUCTION

In the optimization problem, the number of objective function more than two is called multi-objective optimization. For the multi-objective optimization problems, a solution for one target may be good, but for other targets may be poor. Thus, there is a compromise solution collection, which is called the Pareto-optimal set or Non-dominated set. Multi-objective optimization problems are often converted into single objectives by weighting, and then using the mathematical programming method to solve them. This method only can get an optimal solution in case of a certain weight at each run. However, the traditional mathematical programming is inefficiency, and more sensitive to the weight value or the order given by target (Deb, 2001).

Multi-objective evolutionary algorithms (MOEAs) began in the1980s. During the research results, the NSGA-II algorithm (Deb, 2002) proposed by Deb and the SPEA-II algorithm (Zitzler, 1999; Zitzler, 2002) proposed by Zitzler are the most famous, which all pursue two optimizations convergence and diversity index, and such algorithms are used the following two strategies: By constructing Pareto
candidate solution set to retain the Pareto solutions, and through the appropriate ways to maintain the diversity of solution; Based on the Pareto dominance relation and spatial density to determine the merits of the individual. Chinese scholars reviewed the development history of MOEAs, and the main technology, theoretical results of multi-objective evolutionary algorithm and the direction of further study (Tao, 2003; Cui, 2001; Gong, 2009; Geng, 2013).

Since Storn proposed the differential evolution (DE) algorithm (Das, 2011), many scholars have devoted to extend to their research of multi-objective optimization. (Abbass, 2002) introduced the PDE algorithm, which early using of DE combined with Pareto dominance relationship to solve multi-objective optimization problem. Subsequently, an improved differential evolution algorithm for solving multi-objective problems in power system PEDA (Yang, 2008) has been proposed. Xue according to the improved individual density calculations, based on Pareto dominance, multi-objective differential evolution algorithm MODE was proposed, and achieved a good result (Xue, 2005). The most famous algorithm using DE for solving multi-objective problem named DEMO was put forward by (Robic, 2005). The biggest difference between DEMO and other algorithms is that it is not in accordance with an individual level to select the next generation, but compared with offspring and parent individual directly, if the offspring dominate parent, choose the offspring enter the next generation directly, otherwise discarded. If the parent and offspring’s relationship is non-dominated solution, it will put the offspring in extra population to archive, which has significantly improved over NSGAII on convergence and diversity index.

Recently, an evolutionary multi-objective approach to sparse reconstruction is presented (Lin, 2014) for solving sparse solution problem in linear system. Zhang (Zhang, 2014) improved the multi-objective algorithm based on decomposition (MOEA/D). They used a simple and high-efficiency match mode to harmonize the selection process. (Tenaglia, 2014) researched the electromagnetic optimization problem and proposed using DE and Parteo to solve this problem.

However, when an algorithms using Parteo non-dominated ranking is the levels of all individuals are allocated firstly, and then based on level the individual is selected into the next generation. The process has a lot of redundant operations, because the low level of individuals have no chance enter the next generation, but the algorithm still need to assign them level, resulting in a higher complexity. In response to this problems, this paper introduce a fast sorting method based on non-dominated solutions of the grade assigned to individuals while selecting the next generation of individuals. When next generation is selected enough, finishing the program to reduce the time complexity. In addition, when calculating the distance of congestion, based on the distribution of the range of the individual, the individual is uniformly selected into the next generation to improve the performance of the algorithm. Then, first put forward a kind of rapid multi-objective differential evolution algorithm (FMODE) combined these two approaches and differential evolution algorithm, simulation results show the effectiveness of the algorithm.

2. CORRELATION THEORY

2.1. Differential Evolution

Differential evolution algorithm (Differential Evolution, DE) was firstly proposed by Price and Store (Das, 2011 & Storn, 1997), with the advantage of its fast speed, less parameters, easy to implement and so on, which has become one of the most famous classical computing algorithms current evolution.

DE has the following different mutation strategies are frequently used in the literature:

“DE/rand/1”
Role-Based Autonomic Systems
Haibin Zhu (2010). International Journal of Software Science and Computational Intelligence (pp. 32-51).
www.igi-global.com/article/role-based-autonomic-systems/46145?camid=4v1a

Entropy Quad-Trees for High Complexity Regions Detection
Rosanne Vetro, Dan A. Simovici and Wei Ding (2011). International Journal of Software Science and Computational Intelligence (pp. 16-33).
www.igi-global.com/article/entropy-quad-trees-high-complexity/53160?camid=4v1a