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Research on an Improved Coordinating Method Based on Genetic Algorithms and Particle Swarm Optimization

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ABSTRACT

In this article, a hierarchical cooperative algorithm based on the genetic algorithm and the particle swarm optimization is proposed that the paper should utilize the global searching ability of genetic algorithm and the fast convergence speed of particle swarm optimization. The proposed algorithm starts from Individual organizational structure of subgroups and takes full advantage of the merits of the particle swarm optimization algorithm and the genetic algorithm (HCGA-PSO). The algorithm uses a layered structure with two layers. The bottom layer is composed of a series of genetic algorithm by subgroup that contributes to the global searching ability of the algorithm. The upper layer is an elite group consisting of the best individuals of each subgroup and the particle swarm algorithm is used to perform precise local search. The experimental results demonstrate that the HCGA-PSO algorithm has better convergence and stronger continuous search capability, which makes it suitable for solving complex optimization problems.

KEYWORDS

Cooperative Algorithm, Genetic Algorithm, Hybrid Algorithm, Particle Swarm Optimization

1. INTRODUCTION

The genetic algorithm (GA) and the particle swarm optimization (PSO) are both evolutionary computation techniques based on population (Jiang & Wang, 2010). Both have their own characteristics and advantages, but also have some shortcomings and deficiencies. The genetic algorithm has a strong global search ability, but its local search ability is poor, which makes the simple genetic algorithm more time-consuming and reduce its late evolutionary search efficiency. Whereas, the particle swarm optimization can achieve a simple and fast convergence. However, the fast convergence also leads to fast population decline reducing the overall search ability prone to premature convergence. In the face of small-scale optimization problems, the GA and the PSO both have promising performance (Chang, Bai, Huang & Yang, 2013). However, as practical optimization problems have become more complex,

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their defects are becoming increasingly prominent and the optimization efficiency (time) and the quality of the solution are "powerless". Therefore, improvement in their optimization performance is imminent (Rao, Kumar & Rajeswari, 2015). In view that the genetic algorithm and the particle swarm optimization have almost complementary advantages, researchers suggest the combination of the two so that they can learn from each other in order to develop an algorithm with better performance. A common approach is to mix the two algorithms in the same position. There are two main mixing methods that can be summed up from some of the proposed hybrid algorithms; and parallel refers to the genetic process and the particle swarm optimization for all individuals in the evolution of each generation (Le & Pimiento, 2013). Parallel is the individual that divides the population into two generations in the evolution of each generation: the evolution of the genetic algorithm and the particle swarm optimization. If the algorithm uses the same population size, the series mixing will be more than twice the amount of parallel mixing (Wan & Birch, 2013). In both mixing methods, the resultant algorithm's search ability will be stronger than a single genetic algorithm or particle swarm optimization (Jiang, Fan, Wang & Automation, 2014). However, both of these mixing methods face the same problem, that is, the division of labor between the genetic algorithm and the particle swarm optimization is not clear when both are in the same position, which makes their respective advantages unaffected. Therefore, there is a lot of space to be excavated in the fusion of genetic algorithm and particle swarm optimization (Dai & Song, 2012).

In this paper, a new genetic algorithm and particle swarm optimization cooperative algorithm is proposed. The proposed algorithm uses a hierarchical structure, the bottom consists of a series of subgroups using the genetic algorithm evolution that contributes to the global search ability of the algorithm; the upper layer is composed of the optimal individuals of each subgroup of elite groups using the PSO algorithm for accurate local search to speed up the convergence. This paper starts from the organizational structure of the population, and separates the global search from the local search, which can speed up the convergence speed and avoid the decrease of the diversity caused by the convergence. The global search ability and the convergence rate both are effectively improved.

2. RELATED ALGORITHM ANALYSIS

2.1. Genetic Algorithm

The genetic algorithm (GA) is a stochastic search method based on the natural evolution of Biology (Yang, Rao, Xu & Sheng, 2015). It was first proposed by Professor Holland in the United States in 1975. The algorithm adopts the evolution of "survival of the fittest" (including selection, crossover and mutation), so that the population is evolved in order to meet the requirements of the optimal solution (Feng, Liu, Guo, Zhang & Wang, 2014). Currently, the genetic algorithm is being successfully applied to various areas, such as optimizing the design, neutral network training, pattern recognition, timing prediction. The genetic algorithm can use the genetic phenomenon as a prototype to solve many problems (Ma, Li, Wu, Dong & Xu, 2013). Using the genetic algorithm to solve the problem includes the following steps:

1. The problems to be solved are analyzed and translated into all aspects of the genetic phenomenon;
2. Encoding;
3. The fitness value of each individual is calculated by using objective function;
4. A certain number of individuals in the population are selected for free random hybridization, resulting in the next generation. The process of breeding the next generation will be genetic, mutation, and so on. This process will produce more adaptive value high individual until the request is reached;
5. Once the individual that meets the requirements is found, the whole problem is solved and the individual that meets the requirements is the optimal solution for the problem.