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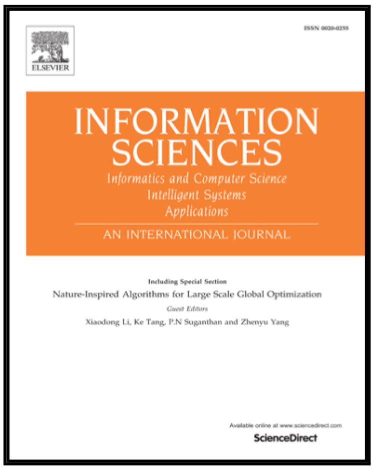

Social Learning Differential Evolution

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Abstract

Differential evolution (DE) has attracted much attention in the field of evolutionary computation and has proved to be one of the most successful evolutionary algorithms (EAs) for global optimization. Mutation, as the core operator of DE, is essential for guiding the search of DE. In this study, inspired by the phenomenon of social learning in animal societies, we propose an adaptive social learning (ASL) strategy for DE to extract the neighborhood relationship information of individuals in the current population. The new DE framework is named social learning DE (SL-DE). Unlike the classical DE algorithms where the parents in mutation are randomly selected from the current population, SL-DE uses the ASL strategy to intelligently guide the selection of parents. With ASL, each individual is only allowed to interact with its neighbors and the parents in mutation will be selected from its neighboring solutions. To evaluate the effectiveness of the proposed framework, SL-DE is applied to several classical and advanced DE algorithms. The simulation results on forty-three real-parameter functions and seventeen real-world application problems have demonstrated the advantages of SL-DE over several representative DE variants and the state-of-the-art EAs.

Keywords: Differential evolution, Mutation, Social learning, Neighborhood, Parents selection, Numerical optimization

1. Introduction

Evolutionary algorithms (EAs) are stochastic optimization techniques that mimic the evolutionary process of nature. The common conceptual base of EAs is to evolve a population of candidate solutions with the help of information exchange procedures. In the last few decades, numerous EAs have been proposed based on different inspirations taken from the evolutionary process of nature. These include genetic algorithm (GA), evolution strategy (ES) , evolutionary programming (EP), particle swarm optimization (PSO), and ant colony optimization (ACO). The major differences among these EAs lie in the way new trial solutions are generated. Meanwhile, the question of how to utilize the population information to further enhance the reproduction operator's search ability is still one of the most salient and active topics in EAs.

Differential evolution (DE), proposed by Storn and Price [39], is a simple yet efficient EA for global numerical optimization. Due to its attractive characteristics, such as ease of use, compact structure, robustness and speediness, DE has been extended to handle large-scale, multi-objective, constrained, dynamic, and uncertain optimization problems [11]. Furthermore, DE has been successfully applied to many scientific and engineering fields [11], such as pattern recognition, signal processing, satellite communications, wireless sensor networks, and so on.

In DE, three main operators, i.e., mutation, crossover and selection, are used to evolve the population. Among them, mutation is the core operator that distinguishes DE from other EAs. However, we have observed, in most DE algorithms, the parents for mutation are selected randomly from the current population, and thus, all vectors are likely to be selected equally as parents without any selective pressure at all. Although this mutation strategy is easy to use and may be good at exploring the search space, it is slow to exploit solutions. In addition, the need for parent selection in DE has been advocated in [40][13][4][20][49]. In these work, the selection of parents for mutation has been proven to be very important to the performance of DE when solving complex problems.

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