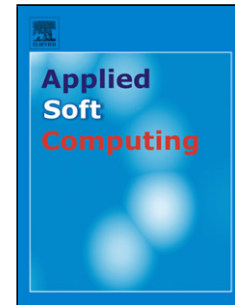


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Neighborhood-adaptive Differential Evolution for Global Numerical Optimization

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Abstract

In this study, we consider the scenario that differential evolution (DE) is applied for global numerical optimization and the index-based neighborhood information of population is used for enhancing the performance of DE. Although many methods are developed under this scenario, neighborhood information of current population has not been systematically exploited in the DE algorithm design. Furthermore, previous studies have shown the effect of neighborhood topology interacted with the function being solved. However, there are few investigations of DE that consider different topologies for different functions during the evolutionary process. Motivated by these observations, a new DE framework, named neighborhood-adaptive DE (NaDE), is presented. In NaDE, a pool of index-based neighborhood topologies is firstly used to define multiple neighborhood relationships for each individual and then the neighborhood relationships are adaptively selected for the specific functions during the evolutionary process. In this way, a more appropriate neighborhood relationship for each individual can be determined adaptively to match different phases of the search process for the function being solved. After that, a neighborhood-dependent directional mutation operator is introduced into NaDE to generate a new solution with the selected neighborhood topology. Being a general framework, NaDE is easy to implement and can be realized with most existing DE algorithms. In order to test the effectiveness of the proposed framework, we have evaluated NaDE via investigating several instantiations of it. Experimental results have shown that NaDE generally outperforms its corresponding DE algorithm on different kinds of optimization problems. Moreover, the synergy among different neighborhood topologies in NaDE is also revealed when compared with the DE variants with single neighborhood topology.

Keywords: Differential evolution, Neighborhood topology, Adaptive selection, Mutation operator, Numerical optimization

1. Introduction

Differential evolution (DE), proposed by Storn and Price [1], is a simple and powerful evolutionary algorithm (EA) for numerical optimization. During the last few years, DE has been the subject of much attention due to its attractive characteristics of compact structure, ease of use, speed, and robustness. Furthermore, DE has been extended for handling multi-objective, constrained, large scale, dynamic, and uncertain optimization problems [2, 3] and also has been used successfully in various scientific and engineering fields [4, 5, 6, 7]. In DE, the optimization performance not only significantly depends on the selection of the control parameters (i.e., population size NP , mutation scaling factor F and crossover rate Cr) [8, 9], but also on the evolutionary operators (i.e., mutation, crossover and selection) [10, 11]. In the literature, many researchers have focused on the improvement of DE by devising new mutation operators [11, 12, 13, 14], adopting self-adaptive strategies for parameters controlling [8, 15, 16, 17, 18], developing ensemble strategies [19, 20, 21], and proposing a hybrid DE with other optimization algorithms [22, 23, 24], etc.

Distinct from other EAs, the salient feature of DE is its mutation mechanism. In DE, a mutant vector, generated by the mutation operator, can be treated as a leading individual to explore the search space and is constructed by

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