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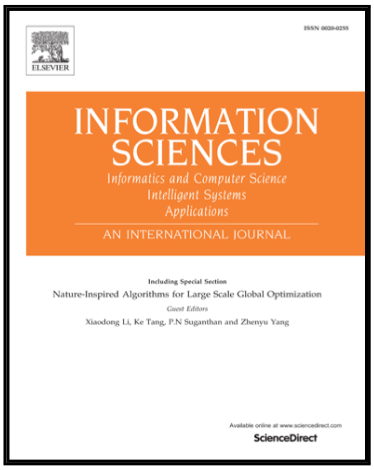

Differential evolution with individual-dependent topology adaptation

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Differential evolution with individual-dependent topology adaptation

Guo Sun[a], Yiqiao Cai[a,*], Tian Wang[a], Hui Tian[a], Cheng Wang[a], Yonghong Chen[a]

[a] College of Computer Science and Technology, Huaqiao University, Xiamen, 361021, China.

Abstract

Differential evolution (DE) is an efficient and robust evolutionary algorithm (EA), that has been widely and successfully applied to solve global optimization problems in diverse real-world applications. As the population structure has a major influence on the behavior of an EA, effectively incorporating population topology into DE has recently attracted increasing attention. Previous works have shown the effectiveness of different topologies in improving the performance of DE and revealed that different topologies can have different effects on the population's ability to solve optimization problems. However, the synergy of different topologies for the problems being solved has not been systematically investigated in most DE variants. Moreover, individuals with different fitness values play different roles in guiding the search during the evolutionary process. Nevertheless, the individual-dependent roles are not considered in most DE variants that consider the population topology. To overcome these drawbacks and utilize the information that is derived from the differences between the fitness values of individuals for topology adaption, we propose a multi-topology-based DE (MTDE) algorithm that includes an ensemble of multiple population topologies (MPT), an individual-dependent adaptive topology selection (ITS) scheme, and a topology-dependent mutation (TDM) strategy. In the ensemble of MPT, multiple population topologies with different degrees of connectivity are employed. In the ITS scheme, each individual adaptively selects the topology that is most compatible its role in guiding the search based on its fitness value. In the TDM strategy, the parents for mutation are chosen from the neighborhood of the current individual based on the corresponding topology to generate offspring. The effectiveness of the proposed algorithm is extensively evaluated on a suite of benchmark functions. Experimental results demonstrate the competitive performance of MTDE when compared with other state-of-the-art DE variants and EAs.

Keywords: Differential evolution, multi-topology, individual-dependent, adaptive topology selection, global optimization

1. Introduction

Differential evolution (DE), which was proposed by Storn and Price [37], is a simple yet powerful evolutionary algorithm (EA) for global numerical optimization. Over the years, DE has been the subject of much attention and has been extended to handle multi-objective, constrained, large-scale, dynamic, and uncertain optimization problems [8]. Furthermore, in various scientific and engineering fields, different DE variants have been proposed for solving the complicated optimization problems in chemical engineering, economics, pattern recognition, engineering design, and so on [32][22][31][45]. The mutation strategy, as the salient feature of DE, can greatly influence the ability of DE to optimize different types of problems [4]. In most mutation operators of DE, both base and difference vectors are selected randomly from the current population. Thus, all individuals of the current population are equally likely to be selected as parents, without any selective pressure [8] [4]. This high degree of randomness will cause DE to be slow in exploiting solutions. Therefore, to overcome these shortcomings and further enhance the performance of DE, many variants have been developed, mainly through the following approaches [44]: setting control parameters adaptively, designing new mutation operators, adopting an ensemble mechanism, and combining DE with other optimization methods.

*Corresponding author
Email address: `yiqiao00@163.com` (Yiqiao Cai)