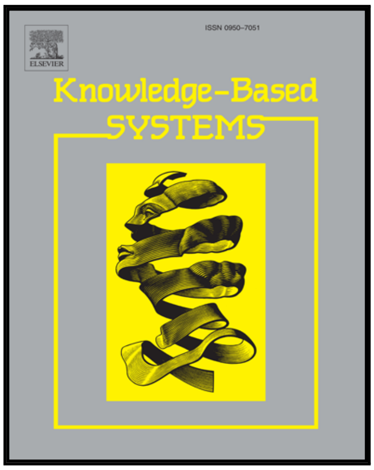

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Parameters with Adaptive Learning Mechanism (PALM) for the enhancement of Differential Evolution

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Abstract

Differential Evolution (DE) is a simple but powerful population-based stochastic optimization algorithm. Owing to its simplicity, easy implementation and excellent performance, DE has been wildly applied in scientific and engineering areas. However, there are still some inconveniences and weaknesses in DE algorithm, such as the inconveniences in the choice of proper control parameters and the defects existing in a given mutation strategy. In this paper, a new DE variant, called Parameters with Adaptive Learning Mechanism Differential Evolution (PALM-DE), is proposed to tackle the inconvenience in control parameter selection as well as to enhance a former mutation strategy. The new variant is verified on 44 commonly used real-parameter single objective benchmark functions selected from CEC2013 and CEC2014 competitions. Several recently proposed well-known DE variants are also contrasted in the paper, and the experiment results show that the proposed PALM-DE algorithm is competitive in comparison with these DE variants. An attempt to enhance the performance of PALM-DE by employing linear population size reduction is also presented, and the performance is still competitive.

Keywords:
Adaptive learning mechanism, differential evolution, PALM, real-parameter optimization, state-of-the-art

1. Introduction

Optimization algorithm plays an important role in tackling kinds of optimization demands arising from different areas in our lives nowadays. The key criterion is that the tool tackling these complex optimization problems should not itself be complicated [36], and Differential Evolution (DE) is such a simple but powerful optimization algorithm. DE was firstly proposed in 1995 [38, 27, 26], and became well known by the paper [39] published in literature. Because of its simplicity, easy implementation, and excellent performance, DE became arguably one of the most popular optimization algorithms in evolutionary computation domain. Moreover, the variants of DE have secured front ranks at conferences on evolutionary computation competitions for many years [33, 30, 13, 51, 41, 42, 43, 34, 1]. The canonical DE algorithm is originated from Genetic Annealing algorithm [26] which can be considered as a hybrid algorithm of Genetic Algorithm (GA) [12] and Simulated Annealing (SA) [14]. Therefore, operations such as mutation, crossover and selection used in GA are also inherited into DE algorithm, though the sequence of these operations is different from one another.

There are three control parameters, the mutation scale factor F, the crossover rate Cr, and the population size ps, in the canonical DE algorithm. Different settings of F value can make a balance between exploitation and exploration characteristics of a DE variant [35, 23, 4, 15, 10]. A larger F value means the DE variant has a better exploration characteristic while a smaller one means better exploitation characteristic. Cr value can be considered as the probability of each parameter (in the trial vector) inherited from donor vector. That Cr equals to 0 means no parameter in the trial vector is inherited from the donor vector while Cr equals to 1 means all parameters are inherited from the donor vector. ps denotes the population size of individuals, and it means the number of potential solutions in each generation for a certain optimization problem.

As there are many claims and counter-claims reported in literature concerning the rules for the choice of control parameters, these may confuse people who utilize DE in applications [27, 11, 37, 10]. Moreover, one fixed control parameter setting for a specific benchmark function may perform worse on another benchmark function. Therefore adaptive parameter control scheme became welcome not only for engineers but also for researchers. Liu and Lampinen [19] proposed a fuzzy adaptive DE (FADE), which employed a fuzzy logic controller to tune the control parameters both for the mutation and crossover operations. Later, another DE variant, called jDE, with adaptive control parameters was proposed by Brest et al. [4], the control parameters (F and Cr) were adaptively updated according to the performance of each individual in evolution. Qin et al. [29] proposed another adaptive DE algorithm and the parameter Cr was gradually updated by the knowledge learnt from the previous generations. Control parameter F of each individual in this DE variant was randomly generated according to a fixed normal distribution. Zhang and Sanderson [53] proposed a new

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