Adaptive strategy selection in differential evolution for numerical optimization: An empirical study

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ABSTRACT

Differential evolution (DE) is a versatile and efficient evolutionary algorithm for global numerical optimization, which has been widely used in different application fields. However, different strategies have been proposed for the generation of new solutions, and the selection of which of them should be applied is critical for the DE performance, besides being problem-dependent. In this paper, we present two DE variants with adaptive strategy selection: two different techniques, namely Probability Matching and Adaptive Pursuit, are employed in DE to autonomously select the most suitable strategy while solving the problem, according to their recent impact on the optimization process. For the measurement of this impact, four credit assignment methods are assessed, which update the known performance of each strategy in different ways, based on the relative fitness improvement achieved by its recent applications. The performance of the analyzed approaches is evaluated on 22 benchmark functions. Experimental results confirm that they are able to adaptively choose the most suitable strategy for a specific problem in an efficient way. Compared with other state-of-the-art DE variants, better results are obtained on most of the functions in terms of quality of the final solutions and convergence speed.

1. Introduction

Differential evolution (DE), proposed by Storn and Price [35], is an efficient and versatile population-based direct search algorithm that implements the evolutionary generation-and-test paradigm for global optimization, using the distance and direction informations from the current population to guide the search. Among its advantages are its simple structure, ease of use, speed, and robustness, which enables its application on many real-world applications, such as data mining, IIR design, neural network training [29], power systems [43], financial market dynamics modeling [16], data mining [4], and so on. A good survey of DE can be found in [5], where its basic concepts and major variants, as well as some theoretical studies and application examples to complex environments, are reviewed in detail.

In the seminal DE algorithm [35], a single mutation strategy was used for the generation of new solutions; later on, Price and Storn suggested nine other different strategies [29,36]. In addition, other mutation strategies are also proposed in the DE...
2.2. Differential evolution

DE [35] is a simple evolutionary algorithm (EA) for global numerical optimization. It creates new candidate solutions by combining the parent individual and several other individuals of the same population. A candidate replaces the parent only if it has an equal or better fitness value. The pseudo-code of the original DE algorithm is shown in Algorithm 1, where \( D \) refers to the number of decision variables (or problem dimension); \( NP \) is the population size; \( F \) is the mutation scaling factor; \( CR \) is the crossover rate; \( x_i \) is the \( i \)th variable of the solution \( x \); \( u \) is the offspring. The function \( \text{rand} \{1,D\} \) returns a uniformly distributed random integer number between 1 and \( D \), while \( \text{rand} \{0,1\} \) gives a uniformly distributed random real number in \([0,1)\), generated anew for each value of \( j \). With respect to the population initialization, the widely used method is uniformly random initialization within the search space. Other initialization methods are also available, for example, orthogonal initialization [13], opposition-based initialization [32], chaotic initialization [27], etc.
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