Interpolation Based Mutation Variants of Differential Evolution

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ABSTRACT

Differential evolution algorithm (DE) is an efficient and versatile population-based search technique for global optimization. In this paper, two novel mutation variants for DE are presented. These mutation variants are based on interpolation rules; first variant is based on Inverse Quadratic Interpolation called IQI-DE and the second variant is based on sequential parabolic interpolation called SPI-DE. Both variants aim at efficiently generating the base vector in the mutation phase of DE. The performance of proposed variants is implemented on 12 benchmark problems and compares with basic DE and five other enhanced versions of DE such as DERL, ODE, jDE, JADE, and LeDE. Experimental results show that the proposed variants are significantly better or at least comparable to other variants in term of convergence speed and solution accuracy.

Keywords: Differential Evolution (DE), Global Optimization, Inverse Quadratic Interpolation, Mutation, Sequential Parabolic Interpolation

1. INTRODUCTION

Differential evolution is a kind of evolutionary algorithm which is proposed by Storn and Price (1997). It 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 information from the current population to guide the search (Gong et al., 2011). Among its advantages are its simple structure, ease of use, speed, and robustness, which enables its application on many real-world applications of real life problems of science and engineering field such that engineering design, chemical engineering, mechanical engineering pattern recognition, and so on (Cai et al., 2011). However, the DE does not guarantee the convergence to the global optimum. It is easily trapped into local optima resulting in a low optimizing precision or even failure (Jia et al., 2011).
In order to improve the performance of DE, several versions of DE variants have been proposed by many researchers over the last few decades. Some of the recent modified variants of DE are given in Section 3.

In basic DE, the base vector is either randomly selected (DE/rand/bin) or is selected ‘greedily.’ In this paper we have proposed two new mutation schemes for DE. The first scheme is Inverse Quadratic Interpolation (IQI) scheme and the second one is named Sequential Parabolic Interpolation (SPI). The corresponding DE variants are named as IQI-DE and SPI-DE. Both schemes aim at efficiently generating the base vector in the mutation phase of DE. The only difference to DE and both proposed algorithms at base vector in mutation operation. The significance of selecting efficient base vector is discussed later in the paper.

Here we would like to mention that in this paper we are presenting the extended work of our previous study about IQI-DE and SPI-DE, given in Kumar et al. (2011). The rest of the paper is organized as follows: The basic DE is given in Section 2. A brief literature review is given in Section 3. Section 4 discusses the proposed SPI-DE and IQI-DE algorithms. In Section 5 experimental settings are given. In Section 6, numerical results are discussed; finally the paper concludes with Section 7.

2. THE BASIC DE

Differential evolution algorithm a simple, powerful and iteration based search technique for global optimization. It starts with a set of solution, which is randomly generated when no preliminary knowledge about the solution space is available. This set of solution is called population. Let \( P_i = \{ X_i, i = 1, 2, ..., NP \} \) be the population at any generation \( G \) which contain \( NP \) individuals and an individual \( X_i^G \) can be defined as a \( D \) dimensional vector i.e., \( X_i^G = (x_{i1}, x_{i2}, ..., x_{iD}) \). For basic DE (DE/rand/1/bin) mutation, crossover and selection operations are defined as:

**Mutation:** For each target vector \( X_i^G \) mutant vector \( V_i^G \) is defined by:

\[
V_i^G = X_{r1}^G + F(X_{r2}^G - X_{r3}^G)
\]

**Crossover:** Crossover is introduced to increase the diversity of perturbed parameter vectors \( V_i^G \) as:

\[
V_i^G = \begin{cases} V_{ji}^G, & \text{if } Cr < \text{rand}(01) \forall j = j_{rand} \\ x_{ji}^G, & \text{otherwise} \end{cases}
\]

**Selection:** It is an approach to decide which vector \( X_i^G \) or \( U_i^G \) should be a member of next generation \( G+1 \). During the selection operation we generate a new population \( P^{G+1} = \{ X_i^{G+1}, i = 1, 2, ..., NP \} \) for next generation \( G+1 \) by choosing the best vector between trial vector and target vector.

\[
\text{rand}(0, 1) \text{ is uniform random number between 0 and 1; } Cr \text{ is the crossover constant takes values in the range [0, 1] and } j_{rand} \in 1, 2, ..., D \text{ is the randomly chosen index}
\]
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