

Chapter 9

Differential Operators Embedded Artificial Bee Colony Algorithm

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ABSTRACT

Artificial Bee Colony (ABC) is one of the most recent nature inspired (NIA) algorithms based on swarming metaphor. Proposed by Karaboga in 2005, ABC has proven to be a robust and efficient algorithm for solving global optimization problems over continuous space. However, it has been observed that the structure of ABC is such that it supports exploration more in comparison to exploitation. In order to maintain a balance between these two antagonist factors, this paper suggests incorporation of differential evolution (DE) operators in the structure of basic ABC algorithm. The proposed algorithm called DE-ABC is validated on a set of 10 benchmark problems and the numerical results are compared with basic DE and basic ABC algorithm. The numerical results indicate that the presence of DE operators help in a significant improvement in the performance of ABC algorithm.

1. INTRODUCTION

In the past few decades several nature inspired algorithms (NIA) have emerged for solving global optimization problems. NIA algorithms may be classified as the ones based on natural evolution, commonly known as Evolutionary Algorithms

(EA) and the ones that are based on behavioral pattern displayed by various species, particularly the ones that live in groups (or swarms). Evolutionary Algorithms (EAs) are optimization techniques based on the concept of a population of individuals that evolve and improve their fitness through probabilistic operators like recombination and mutation. These individuals are evaluated and those that perform better are selected to compose the population in the next generation. After several

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generations these individuals improve their fitness as they explore the solution space for optimal value. Some popular EA are Genetic Algorithms (GA) (Goldberg, 1989; Holland, 1975), Evolutionary Strategies (ES) (Rechenberg, 1994), Evolutionary Programming (EP) (Back & Schwefel, 1996; Back, Hammel, & Schwefel, 1997; Fogel, 1995; Fogel, Owens, & Walsh, 1996), and Differential Evolution (DE) (Storn & Price, 1995, 1997).

The other class of NIA is based on the intelligent behavior exhibited by various species like fish birds, bees, ants, termites etc. The algorithms belonging to this class are also known as swarm algorithms and are modeled on the information sharing mechanism of the species. Some popular algorithms belonging to this class include Particle Swarm Optimization (PSO) (Kennedy & Eberhart, 1995), Ant Colony Optimization (ACO) (Dorigo & Gambardella, 1997), Artificial Bee Colony (ABC) algorithm (Karaboga & Basturk, 2007, 2008; Karaboga, 2005; Basturk & Karaboga, 2006), Bacteria Foraging Algorithm (BFO) (Passino, 2002), and Biogeography Based Algorithm (BBO) (Simon, 2008). A survey of algorithms based on bee swarm algorithms is given by Karaboga and Akay in (2009).

In the present study, the focus is on ABC, which is one of the recently proposed NIA. ABC follows the analogy of the socio-cooperative behavior demonstrated by honey bees in their search for nectar. A brief overview of the working of ABC algorithm is given in section 3.

ABC has been successfully applied for solving a variety of real life and benchmark problems. Its comparison with the contemporary algorithms has shown its competence in dealing with different types of problems (Singh, 2009; Karaboga, 2009; Ponton & Klemes, 1993; Rao, Narasimham, & Ramalingaraju, 2008; Karaboga, Akay, & Ozturk, 2007; Pawar, Rao, & Davim, 2008; Karaboga & Basturk, 2007; Pan, Tasgetiren, Suganthan, & Chua, 2011).

However, like most of the NIA in their basic form, ABC is not completely flawless. As pointed out by Zhu and Kwong (2010), ABC has a structure

which supports *exploration (diversification)* more in comparison to *exploitation (intensification)*. These two antagonist factors should be balanced judiciously for the success of an optimization algorithm. In the present study an attempt is made to include the Differential Evolution (DE) operators in the structure of basic ABC. The rationale is to improve the exploitation capabilities of ABC algorithm. In the proposed algorithm named as Differential Evolution Operators Embedded Artificial Bee Colony (DE-ABC), ABC is used to explore the solution space in search of positions of potential food sources while the DE operators are used to exploit those sources with the hope of finding a better location (or position) of food sources.

The remaining of paper is organized as follow. Section 2 and 3 introduces DE algorithm & ABC algorithm respectively. The proposed DE – ABC algorithm is discussed in section 4. Parameter settings for all the algorithms, the considered benchmark problems and the criteria for the comparison of the algorithms are given in section 5. The simulation results obtained are presented and discussed in section 6. Finally, the paper concludes with section 7.

2. DIFFERENTIAL EVOLUTION

Differential evolution (DE) is an Evolutionary Algorithm (EA) proposed by Storn and Price in 1995 and 1997. DE starts with an initial population vector, which is randomly generated when no preliminary knowledge about the solution space is available.

Let $X_{i,G}$, $i = 1, 2, \dots, NP$ be the solution vector, where i denote the population and G denote the generation to which the population belongs. The initial population should ideally cover the entire parameter space by randomly distributing each parameter of an individual vector with uniform distribution between the prescribed upper and lower parameter bounds x_j^u and x_j^l . At each generation G , DE employs mutation and crossover

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