Efficient Mutation Strategies Embedded in Laplacian-Biogeography-Based Optimization Algorithm for Unconstrained Function Minimization

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ABSTRACT
Biogeography-Based optimization (BBO) is a nature inspired optimization technique that has excellent exploitation ability but the exploration ability needs to be improved to make it more robust. With this objective in mind, Garg and Deep proposed Laplacian BBO (LX-BBO) based on the Laplace Crossover which is a Real Coded Genetic Crossover Operator. It was concluded that LX-BBO outperforms its competitors. A natural question is to incorporate real coded mutation strategies into LX-BBO in order to improve its diversity. Therefore, in this paper, the exploring ability of LX-BBO is further investigated by using six different types of mutation operators present in literature. Gaussian, Cauchy, Levy, Power, Polynomial and Random mutation are used to test which mutation works best for LX-BBO. The performance of all these versions of BBO are measured on the benchmark problem set proposed in CEC 2014. On the basis of the criteria lay down by CEC, analysis of numerical and graphical results and statistical tests it is concluded that LX-BBO works best with Random and Cauchy Mutation.

KEYWORDS
Biogeography-Based Optimization, Laplacian BBO, Polynomial Mutation, Power Mutation, Random Mutation

1. INTRODUCTION
The process of obtaining the best alternative among a set of alternate solutions under given constraints is called optimization which have a wide applicability to solve optimization problems. Although, a variety of optimization techniques exist in literature, the traditional optimization methods require a priori knowledge and/or continuity and differentiability condition of the objective function and/or constraints. Therefore, the non-traditional methods, particularly Nature Inspired Optimization Techniques have become popular with a view to solve real life application problems. Genetic Algorithm, Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), Glow Swarm Optimization (GSO), Biogeography-Based Optimization (BBO) are some of the famous nature Inspired techniques.
Based upon mathematical idea of biogeography, Dan Simon introduced Biogeography Based Optimization (BBO). BBO has two operators i.e. migration and mutation. Migration operator is the key operator which helps in exploitation of the solution. Mutation operator is important in exploring new solutions. Many attempts have been made in order to improve the exploring quality of BBO. An attempt is made in Garg and Deep, 2015 to collect different versions of improved BBO based on its migration and mutation operator. Gong et.al (2010) has tried to improve the exploration ability and population diversity of BBO by introducing different mutation operators. This approach is named as RCBBO. The exploration ability of DE and exploitation ability of BBO is combined by Gong et.al (2011) to form new hybridized version named BBO/DE. A sinusoidal migration model and Gaussian mutation is incorporated in BBO by Li et.al (2011). This approach is named as Perturb BBO (PBBO). In Savsani et. al(2014), Artificial Immune Algorithm(AIA) and Ant Colony Optimization (ACO) has been used for the hybridization of BBO. In Wang et al., 2013 Cauchy Biogeography based Optimization with lateral inhibition mechanism is proposed for improving the exploring part of the algorithm. In a recent publication Guo et al., 2016 have used six different migration operator in BBO for solving multi-objective optimization problems. In Garg and Deep, LX-BBO has been tested on CEC 2014 to claim the better performance than Blended BBO for unconstrained optimization problems.

LX-BBO (Garg & Deep, 2016) has shown a good performance. To further improve LX-BBO, this paper proposes six new variants of LX-BBO which includes change in mutation operator by incorporating Power mutation (LX-PM BBO), Polynomial mutation (LX-Poly BBO) and Random mutation (LX-Rand BBO) of Genetic Algorithm. The other three versions are proposed by incorporating Cauchy mutation, Levy mutation and Gaussian mutation.

The paper is organized as follows: Section 2 and Section 3 give brief introduction to Basic BBO, LX-BBO respectively. Section 4 gives six different versions of LX-BBO. Section 5 gives the numerical results and analysis based on CEC 2014 benchmarks. Section 6 gives the statistical analysis of the two best versions of LX-BBO among six. In Section 7, stereo camera calibration problem is solved using proposed versions of LX-BBO. Finally, Section 8 concludes the paper and some future opportunities are suggested.

2. BIOGEOGRAPHY-BASED OPTIMIZATION

Biogeography Based Optimization is based on the idea of migration, speciation and extinction of species. The idea of biogeography theory is given by McArthur and E. Wilson (1963). The idea of Biogeography give rise to Biogeography based Optimization Algorithm which is proposed by Dan Simon in 2008. In Biogeography Based Optimization, a candidate solution is improved using two operators. These operators are given as follows:

Migration: The information sharing between the solutions (habitats) is termed as Migration. This information is shared probabilistically. If a solution S_i is selected to be modified, then its immigration rate $\lambda_i$ is used probabilistically to decide whether each SIV of the solution is to be modified or not. If a given SIV in a given solution is selected to be modified, then the emigration rate $\mu_i$ of the other solution is used to decide which of the solutions is to migrate a randomly selected SIV to solution $S_j$: 
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