Swarm and Evolutionary Computation 27 (2016) 132–144

Contents lists available at ScienceDirect

Swarm and Evolutionary Computation

journal homepage: www.elsevier.com/locate/swevo

Regular Paper

Performance of Laplacian Biogeography-Based Optimization Algorithm on CEC 2014 continuous optimization benchmarks and camera calibration problem

Vanita Garg, Kusum Deep

Department of Mathematics, Indian Institute of Technology, Roorkee, India

ARTICLE INFO

Article history:
Received 19 March 2015
Received in revised form
11 September 2015
Accepted 10 October 2015
Available online 17 October 2015

Keywords:
Biogeography-based optimization
Laplace crossover
Camera calibration
CEC 2014 benchmarks

ABSTRACT

This paper provides three innovations. Firstly, a new Laplacian BBO is presented which introduces a Laplacian migration operator based on the Laplace Crossover of Real Coded Genetic Algorithms. Secondly, the performance of the Laplacian BBO and Blended BBO is exhibited on the latest benchmark collection of CEC 2014. (To the best of the knowledge of the authors, the complete CEC 2014 benchmarks have not been solved by Blended BBO). On the basis of the criteria laid down in CEC 2014 as well as popular evaluation criteria called Performance Index, It is shown that Laplacian BBO outperforms Blended BBO in terms of error value defined in CEC 2014 benchmark collection. T-Test has also been employed to strengthen the fact that Laplacian BBO performs better than Blended BBO. The third innovation of the paper is the use of the proposed Laplacian BBO and Blended BBO to solve a real life problem from the field of Computer Vision. It is concluded that proposed Laplacian BBO is an efficient and reliable algorithm for solving not only the continuous functions but also real life problems like camera calibration.
© 2016 Published by Elsevier B.V.

1. Introduction

Optimization is the process of finding the best alternative among a given number of solutions under specific constraints. Numerous optimization techniques are available in literature to solve different kind of optimization problems. Traditional optimization techniques have their own limitations which give rise to the emergence of non-traditional methods which are more robust and do not require any prior knowledge of the function to be optimized. Probabilistic methods are non-traditional methods which are frequently used to solve many complex optimization problems. Optimization techniques which draw their inspiration from nature, named as Nature inspired techniques, belong to the class of the probabilistic techniques. 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.

Biogeography-Based Optimization (BBO) is based upon Biogeography Theory given by McArthur and Wilson [25]. Biogeography is the study of speciation, migration between habitats and extinction of species. Habitats tend to show tendency to share features on the basis of Habitat Suitability Index (HSI), which is the measure of suitability of a habitat as residence. It is based upon Suitability Index Variables (SIV) e.g. vegetation, rainfall, climate etc. High HIS habitats have more number of species. This results in migration of the species from high HIS to low HIS habitats. Thus, high HSI habitats share their features with low HSI habitats.

Dan Simon introduced BBO in 2008 [28]. Although it has been introduced as evolutionary algorithm, But, in authors' point of view, it should not be called an Evolutionary Algorithm because in BBO, species get improved after each generation instead of dying. This makes BBO close to Swarm Intelligence Techniques, like Particle Swarm Optimization. But, in BBO species do not cluster around each other unlike PSO. Thus BBO does not contain all the features of Swarm Intelligence and Evolutionary Algorithms.

Many modified versions of BBO are available in literature. Linear migration models used in Basic BBO get replaced by different linear and non-linear migration models by Ma [23]. In order to reduce the harmful effect of creating similar habitats, Enhanced BBO (EBBO) approach is proposed by Pattnaik et al. [26]. Gong et al. [9] has tried to improve the exploration ability and population diversity of BBO by introducing different mutation operators. This approach is named as RCBBO. In order to make BBO more efficient to solve non-separable problems, Local BBO approach is used by Simon et al. [27]. The exploration ability of DE and exploitation ability of BBO is combined by Gong et al. [8] to form new hybridized version named DE/BBO. A new feature of

E-mail addresses: vanitagarg16@gmail.com (V. Garg), kusumdeep@gmail.com (K. Deep).

http://dx.doi.org/10.1016/j.swevo.2015.10.006
2210-6502/© 2016 Published by Elsevier B.V.

immigration refusal is introduced by Du et al. [5]. BBO combined with features of Evolutionary Strategy and immigration refusal is named as BBO/ES/RE. This approach makes BBO computational friendly. A sinusoidal migration model and Gaussian mutation, called Perturb BBO (PBBO), is incorporated in BBO by Li et al. [17]. Multi-operator Based Biogeography-Based Optimization is given by Li et al. [18]. Xiong et al. [33] has used Polyphyletic Migration Operator and Orthogonal Learning for enhancing the performance of BBO. In Ma et al. [20], different hybrid versions of BBO are studied in which BBO are incorporated with other different EAs. The behavior of BBO in noisy environments is given in Ma et al. [21]. Migration and mutation are two main operators of BBO. The performance of BBO can be significantly improved by enhancing these two operators. One such enhancement in performance of BBO is proposed by Ma and Simon [22] for constrained optimization problems. A brief literature study on BBO is done by Garg and Deep [7].

In this paper, a new BBO is presented called Laplacian BBO (LX-BBO). The proposed Laplacian BBO is similar to Blended BBO [22]. In fact, the idea of Laplacian BBO draws its inspiration from Blended BBO. The difference between the two is that Blended BBO uses the blended migration operator based on blended crossover for real coded Genetic Algorithms whereas the Laplacian BBO uses a Laplacian migration operator based on the Laplace crossover for real coed Genetic Algorithm [4]. The performance of the two is shown on CEC 2014 benchmark problems as well as a real life application problem from the field of Computer Vision.

The paper is organized as follows: Section 2 gives brief introduction to Basic BBO, Section 3 explains Blended BBO for unconstrained optimization. The proposed version of BBO (LX-BBO) is presented in Section 4. Section 5 gives the numerical results and analysis based on CEC 2014 benchmarks. Section 6 shows the results of statistical test used for comparison of the proposed version as compared to the Blended BBO. Section 7 presents the use of LX-BBO and Blended BBO for solving the problem of Camera Calibration. Finally Section 8 concludes the paper and some future ideas are suggested.

2. Biogeography-Based Optimization

In Biogeography-Based Optimization, a candidate solution considered as a habitat. Solution is improved using "migration operator" based on immigration and emigration rate and "mutation operator". These main operators of BBO are as follows:

2.1. 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 λ_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 μ_i of the other solution is used to decide which of the solutions is to migrate a randomly selected SIV to solution S_i.

$$\lambda_i = I\left(1 - \frac{k(i)}{n}\right)$$

$$\mu_i = E\left(\frac{k(i)}{n}\right)$$

where μ_i is the emigration rate for i^{th} species and λ_i is the immigration rate for i^{th} species and n is the population size. I and E are the maximum possible immigration and emigration rate and are set equal to 1. $k(i)$ is the fitness rank of the i^{th} species.

2.2. Mutation

A sudden change in natural calamity or disease etc. can change the HSI of a habitat. This sudden change is termed as Mutation. Species count probability is used to calculate mutation rates. The probabilities of each species count is controlled and determined by differential equations [28]. If a solution has a low probability P_s, then it is likely to mutate to other solutions. Conversely, a solution having high probability is less likely to mutate to a different solution. Hence, mutation rate is set as inversely proportional to the solution probability P_s.

$$m(S) = m_{max}\left(\frac{1-P_s}{P_{max}}\right) \quad (1)$$

where m_{max} is a user-defined parameter.

$$P_{max} = argmax(P_s) \quad (2)$$

3. Blended BBO

In Blended BBO, given by Ma and Simon [22] a migration operator, called blended migration operator, called blended migration is proposed. This is motivated by Blended Crossover of Real Coded Genetic Algorithm. In Blended crossover, the offsprings are created by a combination of parents genes. This philosophy is implemented in BBO as follows: instead of replacing a feature of solution H_i, by the feature of solution H_j, a new solution feature in a BBO solution is comprised of two components, namely the migration of a feature of another solution and the migration of a feature from itself. Mathematically, Blended migration is defined as:

$$H_i(SIV) \rightarrow \alpha H_i(SIV) + (1-\alpha)H_j(SIV) \quad (3)$$

where α is a real number between 0 and 1. Note that α could be random or deterministic or it could be proportional to the relative fitness of the solution H_i and H_j. The pseudo code of Blended BBO is given in Fig.1.

4. Proposed Laplacian BBO

4.1. Motivation

As a substitute to Blended Crossover, it is proposed to use the Laplace Crossover proposed by the authors in Deep and Thakur [4].

```
Begin
 Initialize: Generate a random set of habitats (Islands)
   Compute HSI values of each habitat
     While (Stopping condition is not satisfied)
     For each habitat
     For each SIV
      Calculate the immigration rate and emigration rate based on HSI values
      Select habitat Hi (i=1 to n, where n is the number of habitats)with the help of
  immigration rate

          If Hi is selected then
               Select habitat  Hj (j=1 to n) with the help of emigration rate
                    If Hj is selected then
                         Hi (SIV) ← αHi (SIV) + (1 − α)Hj (SIV)
                    End if
          End if
               Select Hi (SIV) based on mutation probability
                    If Hi (SIV) is selected then
                      Replace Hi (SIV) with a randomly generated SIV;
                    End if
      End for
      End for
         For each habitat
            Re-compute HSI values
         End for
     End while
End
```

Fig.1. Pseudo code of Blended BBO.

Download English Version:

https://daneshyari.com/en/article/494004

Download Persian Version:

https://daneshyari.com/article/494004

Daneshyari.com