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A perturb biogeography based optimization with mutation for global numerical optimization

Xiangtao Li [a,b], Jinyan Wang [a], Junping Zhou [a], Minghao Yin [a,b,*]

[a] College of Computer Science, Northeast Normal University, Changchun 130117, PR China
[b] Key Laboratory of Symbolic Computation and Knowledge Engineering of Ministry of Education, Jilin University, Changchun 130012, PR China

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ABSTRACT

Biogeography based optimization (BBO) is a new evolutionary optimization algorithm based on the science of biogeography for global optimization. We propose three extensions to BBO. First, we propose a new migration operation based sinusoidal migration model called perturb migration, which is a generalization of the standard BBO migration operator. Then, the Gaussian mutation operator is integrated into perturb biogeography based optimization (PBBO) to enhance its exploration ability and to improve the diversity of population. Experiments have been conducted on 23 benchmark problems of a wide range of dimensions and diverse complexities. Simulation results and comparisons demonstrate the proposed PBBO algorithm using sinusoidal migration model is better, or at least comparable to, the RCBBO based linear model, RCBBO-G, RCBBO–L and evolutionary algorithms from literature when considering the quality of the solutions obtained.

1. Introduction

Optimization problems play an important role in both industrial application fields and the scientific research world. During the past decade, we have viewed significant progresses on tackling optimization problems. Different kinds of classical techniques have been advanced to handle optimization problems [1–4]. Among them, meta-heuristic based methods, such as simulated annealing algorithm (SA) [5], genetic algorithm (GA) [6,7], Artificial Immune system Algorithm (AIS) [8], particle swarm optimization algorithm (PSO) [9–12], ant colony algorithm (ACO) [13,14], differential evolution algorithm (DE) [15–17], biogeography based optimization [18,19], estimation of distribution algorithm (EDA) [20,21], may be one of the most popular methods.

Particularly, biogeography based optimization (BBO) is a novel meta-heuristic algorithm for global optimization that was introduced in 2008. The basic idea of BBO is based on the biogeography theory, which is the study of the geographical distribution of biological organisms. Different from other population based algorithms, in BBO, poor solutions can improve their qualities by accepting new features from good ones. Several variations of BBO have been proposed to enhance the performance of the standard BBO recently. Du and simon [22] proposed a new biogeography based optimization based on evolution strategy, where a new immigration refusal approach is added to BBO, and F-tests and T-tests were used to demonstrate the differences among different implementations of BBOs. Ergezer and Simon [23] proposed an oppositional biogeography based optimization (OBBO). The algorithm employed the opposition-based learning (OBL) alongside BBO's migration rates to create oppositional BBO. The results demonstrated that with the assistance of quasi-reflection, OBBO significantly outperforms BBO. Boussaïd and chatterjee [24] proposed an algorithm combining the biogeography based optimization with

* Corresponding author at: College of Computer Science, Northeast Normal University, Changchun 130117, PR China.
E-mail address: ymh@nenu.edu.cn (M. Yin).

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differential evolution algorithm. The populations of this algorithm were updated by applying the BBO and DE updating methods alternatively. The paper also proposed an additional selection procedure for BBO, which preserved fitter habitats or subsequent generations. Gong et.al [25] proposed a real-code BBO approach, called RCBBO, for the global optimization problems in the continuous domain. What's more, in order to enhance the diversity of the population and to improve the exploration of RCBBO, the mutation operation was incorporated into RCBBO. Simon [26] proposed a simplified version of BBO and performed an approximate analysis of the BBO population by using probability theory to find three quantities: the probability per generation that its population optimum improves, the state transition matrix of the algorithm, and the excepted amount of improvement in the population optimum.

In this paper, we propose a perturb biogeography based optimization method, integrating perturb operator into biogeography based optimization, as we called PBBO. First, we propose a new migration operation based sinusoidal migration model called perturb migration, which is a generalization of the standard BBO migration operator. In perturb migration model, instead of copying a parent's island if H_j is not chosen with the probability proportional to μ_j, we use the operator of perturb method from the neighborhood island to update H_j. Then the Gaussian mutation operator is integrated into PBBO to enhance the algorithm's exploration ability and to improve the diversity of population. Simulation results and comparisons demonstrate the effectiveness of the proposed algorithm.

The rest of this paper is organized as follows: in Section 2 we will review the basic biogeography based optimization. Section 3 describes the proposed PBBO algorithm. Benchmark problems and corresponding experimental results are given in Section 4. In the last section we conclude this paper and point out some future research directions.

2. Biogeography based optimization

Biogeography based optimization [18] is a new evolution algorithm developed for the global optimization. It is inspired by the immigration and emigration of species between islands in search of more friendly habitats. Each solution is called a "habitat" with a habitat suitability index (HSI) and represented by an n-dimension real vector. The variables of the individual that characterize habitability are called suitability index variables (*SIV*s). An initial individual of the habitat vectors is randomly generated. Those good solutions are considered to be habitats with a high HSI. Those poor ones are considered to be habitats with a low HSI. The solutions with high HSI tends to share their features with those with low HSI. In BBO, A habitat H is a vector (*SIV*s) which follows migration and mutation step to reach the optimal solution. The new candidate habitat is generated from all of the salutation in population by using the migration and mutation operators.

In BBO, the migration strategy is similar to the evolutionary strategy in which many parents can contribute to a single offspring. BBO migration is used to change existing solution and modify existing island. Migration is a probabilistic operator that adjusts a habitat H_i. The probability H_i that is modified is proportional to its immigration rate λ_i, and the source of the modified probability comes from H_j is proportional to the emigration rate μ_j. Migration can be described as follows:

procedure Habitat migration

```
Begin
  for i = 1 to NP
    Select X_i with probability baced on λ_i
    if rand(0,1) < λ_i then
      for j = 1 to NP
        Select H_j with probability baced on μ_j
        if rand(0,1) < μ_j then
          H_i(SIV) ← H_j(SIV)
        end if
      end for
    end if
  end for
End
```

Mutation is a probabilistic operator that randomly modifies habitat *SIV*s based on the habitat's a priori probability of existence. Very high HSI solutions and very low HSI solutions are equally improbable. Medium HSI solutions are relatively probable. The mutation rate m is expressed as follows:

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

where $m_{\max}$ is a user-defined parameter. This mutation scheme tends to increase diversity among the population. Mutation can be described as follows: