Alternated Chaotic Biogeography Based Algorithm for Optimization Problems

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ABSTRACT

Chaotic maps have improved the performance of BBO algorithm as chaotic migration and chaotic mutation help in maintaining diversity of the population on a higher level to avoid a habitat’s entrapment in the local optimal solutions. Many chaotic maps have been used in BBO algorithm. Recently, alternation method in discrete dynamics has emerged as a powerful tool for control and anti-control of chaos. In this article, it is proposed to use alternated chaotic logistic map in BBO algorithm to improve the performance further.

KEYWORDS

ACBBO, Alternated Logistic Map, BBO, CBBO

1. INTRODUCTION

Dan Simon, an American Scientist, gave BBO evolutionary algorithm in 2008 which was inspired from biogeography (Simon, 2008). The term biogeography refers to the study of migration of different species living in geographically separate ecosystems. The movement of species completes the information flow between different habitats. However, entrapment of the solution in local optima (exploration) and slower rate of convergence (exploitation) are the two possible problems, which are similar to the other evolutionary algorithms (Du, Simon & Ergezer, 2009; Simon, 2011).

Many meta-heuristic algorithms have used chaotic data to improve upon the performance of these algorithms by forming a proper balance between the exploration and exploitation activities (Gandomi, Yang, Talatahari & Alavi, 2013; Li-Jiang & Tian-Lun, 2002; Liu, Wang, Jin, Tang & Huang, 2005; Strogartz, 1994). The approach uses chaotic migration and chaotic mutation operators which help in maintaining diversity of the population on a higher level to avoid habitat’s entrapment in local optimal solutions. Saremi and Mirjalili (2013) employed three chaotic maps on four test functions to check the competitiveness of the proposed optimization algorithm. The experimental results have proved that the integration of chaotic maps with the BBO algorithm improved the performance of BBO. The sine map out of all the other chaotic maps has shown excellent results. Later on, the authors expanded their idea further (Saremi, Mirjalili & Lewis, 2014) by using ten chaotic maps and ten benchmark functions. They employed their idea in five different ways. First, they used chaotic

DOI: 10.4018/IJAEC.2019100102

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maps to define the selection, emigration and mutation probabilities, then combined the selection and migration operators and finally combined selection, migration and mutation operators. Guo-ping et al. (2016) employed BBO algorithm for parameter estimation of discrete chaotic systems using minimal number of time series data and controlling chaos by a constant feedback method. Giri et al. (2017) used chaos in improving the local and global parameters of the BBO algorithm. They have shown improved performance over the non-chaotic BBO approach in terms of higher speed of convergence.

Jalili et al. (2014) used chaos based BBO algorithm to solve the optimization problem of truss structures with natural frequency constraints which is inherently a nonlinear dynamic optimization problem. Heidari et al. (2015) used chaotic BBO to predict the EIDS (Earthquake-originated Slope Displacements) in combination with SVR (Support Vector Regression) to explore the best values of SVR parameters. They found the unknown system parameters of discrete chaotic systems by searching the global optimal values. Wang et al. (2016) applied chaotic BBO method on centroid based clustering optimization. Wang and Song (2017) used the proximity of the combination of the BBO algorithm with the optimal chaos mapping strategy towards the migration model under the natural law to achieve overall increased convergence velocity and higher level of optimization accuracy. To understand the different kind of modifications in BBO and its combination with other meta-heuristic techniques, one may refer to a comprehensive review of 10 years prepared by Ma et al. (2017).

Independent of ecological studies, theoretical analysts have focussed on alternate dynamical strategies also which is, initially, due to Parrondo’s paradox (Danca, Fečkan & Romera, 2014). The basic idea of the alternate discrete dynamics is that when two logistic maps are combined together alternatively, they may behave differently. One of the situations may be that the two ordered logistic maps may show chaotic behaviour when iterated together alternatively, i.e., $order_1 + order_2 = chaos$ (Danca, Fečkan & Romera, 2014; Danca & Tang, 2016; Levinsohn, Mendoza & Peacock-lópez, 2012; Maier & Peacock-lópez, 2010; Mendoza, Matt, Guimarães-Blandón & Peacock-lópez, 2018; Peacock-lópez, 2011). Rani and Yadav (2016) (see also Yadav & Rani, 2015) studied logistic map and its variants in superior orbit and showed examples of $chaos_1 + chaos_2 = order$. Mendoza et al. (2018) used this technique on 2-D maps for generalization of alternating strategies on dynamic behaviour of ecological systems.

Many chaotic maps have been used in BBO algorithm (Saremi, Mirjalili & Lewis, 2014). It is proposed to use the chaotic sequence obtained from two ordered logistic maps by iterating them together alternatively and evaluate the performance of BBO algorithm. The paper has been organized as follows. Section 2 gives a brief introduction about the BBO algorithm. Section 3 introduces the concept of Parrondo’s paradox and Section 4 proposes the method of combining it with BBO. The experimental results are explained in Section 5 followed by concluding remarks in Section 6.

2. BIOGEOGRAPHY BASED OPTIMIZATION ALGORITHM

As the name implies this algorithm has taken its inspiration from the biogeography discipline (MacArthur & Wilson, 1967; Wallace, 2005). In this algorithm, the species spread across different ecosystems are studied. A habitat is characterized by habitat suitability index, abbreviated as HSI. An HSI shows various survival parameters like climatic conditions, food availability etc. As a result, the habitats with higher HSI have bigger number of species and lower HSI habitats have smaller number of species. Since high HSI habitats are saturated and low HSI habitats have rare population, therefore there is opportunity for inhabitants in high HSI habitat to move to low HSI habitats. In this situation, evolution of habitats takes place according to the following rules (Saremi & Mirjalili, 2013; Saremi, Mirjalili & Lewis, 2014):

1. Habitants living in higher HSI tend to immigrate to habitats with lower HSI;
2. Habitants residing in lower HSI are more likely to allow immigration of new habitants from habitats with higher HSI;
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