Applied Acoustics 118 (2017) 15–29

Contents lists available at ScienceDirect

Applied Acoustics

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

Improved migration models of biogeography-based optimization for sonar dataset classification by using neural network

M. Khishe [a], M.R. Mosavi [a,*], M. Kaveh [b]

[a] Department of Electrical Engineering, Iran University of Science and Technology, Narmak, Tehran 16846-13114, Iran
[b] Department of Electronic and Communication Engineering, Marine Sciences University of Nowshahr Imam Khomeini, Nowshahr, Iran

ARTICLE INFO

Article history:
Received 11 June 2016
Received in revised form 2 October 2016
Accepted 17 November 2016

Keywords:
BBO
Classification
Clutter
MLP NN
Migration models
Sonar

ABSTRACT

Classification of experimental datasets such as target and clutter in sonar applications is a complex and challenging problem. One of the most useful instrument to classify sonar datasets is Multi-Layer Perceptron Neural Network (MLP NN). In this paper, due to the optimally updating the weights and biases vector of the MLP NN, Biogeography-Based Optimization (BBO) is used to train the network. BBO has a fair ability to solve high-dimensional real-world problems (such as sonar dataset classification) by maintaining a suitable balance between exploration and exploitation phases. The performance of BBO is sensitive to the migration model, especially for high-dimensional problems. To improve the exploitation ability of BBO and to record the better results for classifying sonar dataset, we propose novel migration models such as exponential-logarithmic, and some improved migration models having different emigration and immigration mathematical functions. To validate the performance of the proposed classifiers, this network will classify three datasets with various sizes and complexities. The simulation results indicate that our newly proposed classifiers perform better than the other benchmark algorithms in addition to original BBO in terms of avoiding gets stuck in local minima, classification accuracy, and convergence speed.

1. Introduction

The targets, which are detected by active sonar, are real targets, noise, reverberation, and clutter. Due to differences in noise with the transmitted signal, it is easy to distinguish noise from the real target. As for the reflected echoes of reverberation have homogenous and uniform amplitude, detection of this unwanted signal is easy, although reverberation is the same kind of transmitted signal. When the seabed is very non-homogenous, the reflected echoes of the seabed have a close Probability Density Function (PDF) to the sonar target. This kind of echoes is named clutter [1,2]. Considering the complexities of classification between clutter (non-target) and real target, many classification schemes have been proposed in recent years. Scientists propose new classifier to classify sonar dataset effectively. Many efforts have been done to propose effective classifier in this field. Recently, using Artificial Neural Networks (ANNs) is taken account into consideration for their outstanding achievements [3,4]. Multi-Layer Perceptron Neural Network (MLP NN) is one of the most significant inventions in soft computing. Learning is a vital part of all NNs which may be divided into two types: (a) supervised learning [5] and (b) unsupervised learning [6]. Back Propagation (BP) algorithm [7] as a supervised learning method, is based on gradient descent method and has drawbacks such as low convergence speed [8] and being trapped in local minima. Therefore, it cannot be confidently used for practical purposes. These weaknesses of BP caused to increase the willing to use meta-heuristic optimization algorithms [9,10] which stochastic nature of these algorithms allows them to avoid local minima better than gradient-based techniques and also optimize challenging problems [11–14].

Biogeography-based Optimization (BBO) is a newly proposed meta-heuristic algorithm, which inspired by biogeography science. It was first introduced by Simon in 2008 [15]. It has demonstrated good performance on real-world optimization problems and different benchmark functions [16–19]. Like to other meta-heuristics, BBO is based on the idea of probabilistically sharing information between the proportions of candidate solutions to their fitness values. Each solution supposed as a habitat (island) [20] which has species to living in it. The distribution of species across geographical areas can often be caused by a combination of environmental reasons. In the natural world, species tend to live in more suitable environments. Islands, where are more suitable for species, have a

* Corresponding author.
E-mail addresses: m_khishe@elec.iust.ac.ir (M. Khishe), m_mosavi@iust.ac.ir (M. R. Mosavi).

http://dx.doi.org/10.1016/j.apacoust.2016.11.012
0003-682X/

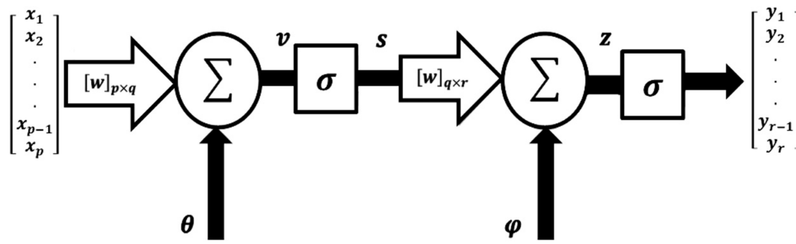

Fig. 1. MLP NN with one hidden layer.

higher Habitat Suitability Index (HSI) while islands are not suitable for species to have a lower HSI [21]. Habitats with a high HSI have many species those emigrate to nearby habitats, simply by virtue of the big number of species that they host. Habitats with a high HSI have a low species immigration rate because they are already nearly saturated with species. Conceptually, high HSI habitats have a high emigration rate and low HIS habitats have a high immigration rate.

One distinctive feature is that, for each generation, BBO algorithm uses fitness of each solution to determine its emigration and immigration rate. Specifically, the emigration rate is proportional to the fitness of candidate solution and the immigration rate is inversely proportional to the fitness of candidate solution. But these rates shall not always be linear functions. In this paper, we propose some non-linear migration methods to train an MLP NN.

At first, we use a quadratic migration model of BBO (QBBO), sinusoidal migration (SBBO), and generalized sinusoidal migration (GSBBO) for training an MLP NN. These models of BBO have used for some optimization problems such as short-term hydrothermal scheduling, global numerical, and approaching to secondary protein prediction in recent years [22–26]. In this paper, we use these models of BBO for training an MLP NN to classify some datasets for the first time.

Next in the paper, we propose a new migration model entitled "exponential-logarithmic migration (ELBBO)" and some models which have combined functions of mentioned models (IBBOs) to improve the exploitation ability of BBO. We will show that QBBO, SBBO, and GSBBO have better performances than standard BBO and other meta-heuristic algorithms while our new proposed migration models (ELBBO and IBBOs) have better performances in classification rate and convergence speed than all of them.

The remainder of this paper is organized as follows: Section 2 describes an overview of the standard BBO and used it for training an MLP NN; Section 3 presents the novel migration models for BBO. The simulation and results comparison are presented in Section 4 and finally the conclusion will be expressed in Section 5.

2. Training an MLP NN by using BBO

BBO is inspired by biogeography theory to solve general optimization problems. It employs a number of habitat as search agents which are the solutions to achieve the best way to solve the optimization problem.

In this paper, the weights and biases vectors of NN composed habitats which can be like to the chromosomes in Genetic Algorithm (GA). Each habitat consists of such matrix or vector of variables those have named habitants (analogous to genes in GA). The fitness of a solution is denoted by HSI which corresponds to cost function in evolutionary approaches. If a solution has a more suitable fitness has a higher HSI. In other words, a habitat has a higher HIS it has large number of species to live in it while

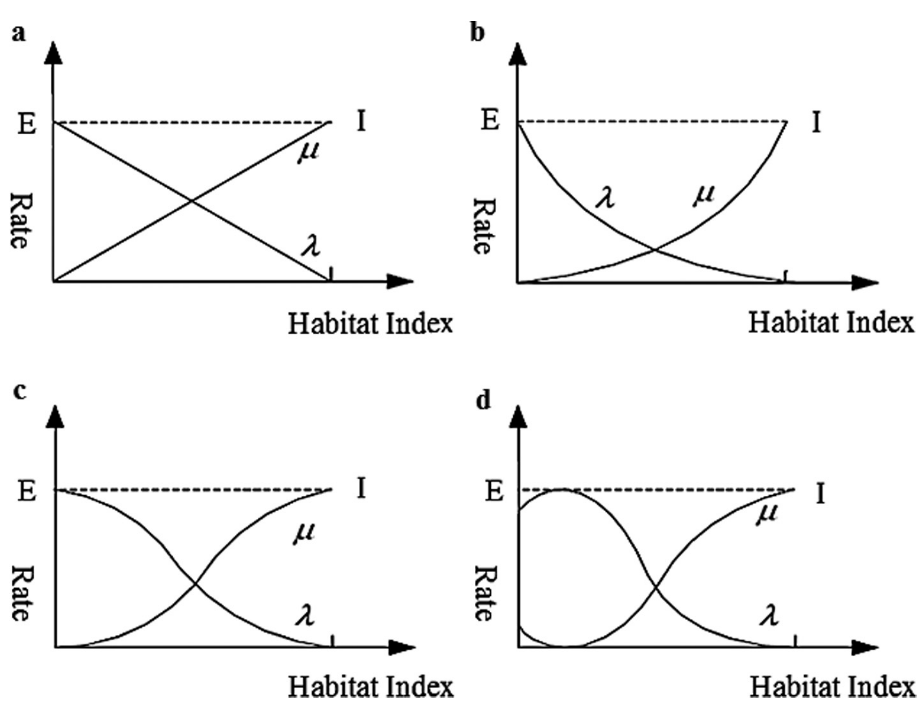

Fig. 2. Four migration model curves where from (a) to (d) denote the linear, quadratic, sinusoidal, and generalized sinusoidal migration curve respectively.