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BIOGEOGRAPHY BASED OPTIMIZATION OF NETWORK ROUTING PROBLEM

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ABSTRACT

Biogeography based optimization (BBO) is one of nature inspired algorithms used for solving complex engineering problems. BBO is the science of biogeography studying the immigration and emigration of species on geographical islands. In this study, we propose a new technique based on BBO for minimization of distance and congestion in a network.

Key words: Biogeography Based Optimization, Emigration Rate, Immigration Rate, Congestion Factor.

INTRODUCTION

The biogeography is the study of geographical distribution of biological organisms on earth. MacArthur and Wilson (1967) worked on mathematical modeling of biogeography and published it in the "Theory of Island Biogeography" in 1967. This modeling later proved crucial in using this phenomenon for inducing computation intelligence in engineering systems. While also developing a versatile method of optimization for solving complex engineering problems. Simon (2008) presented the biogeography based optimization method to demonstrate 14 benchmark functions effectively as well as solved the problem of sensor selection for aircraft engine health assessment. In literature, several researchers have reported many applications of this robust computational intelligence method (Simon, 2008; Bansal et al., 2013; Boussaid and Chatterjee, 2013; Zhu and Duan, 2014). In this study, we address the optimization of path distance and congestion in a network. The Biogeography Based Optimization (BBO), encode a potential solution to a specific problem on island-like data structure and apply emigration and mutation operators to arrive at an optimal solution. Shortest path routing is a well-known problem, and many researchers reported different algorithms to solve it.

In this study, we present an innovative and novel in the form of BBO based routing algorithm. However, it is also known that BBO is faster than many other nature inspired algorithms like GA (Simon, 2008) but still is not fast enough for real-time computation for a fast network. This stochastic optimization tool is proposed for Optimum Path Routing Problem for the first time in this study. BBO is employed for optimization of both the distance and the congestion problem in a network. The algorithm for the proposed scheme is encoded in Matlab.

BIOGEOGRAPHY BASED OPTIMIZATION

In the early 1960s, mathematical models of biogeography (MacArthur and Wilson, 1967) appeared in literature. Simon (2008) shown the performance of BBO on a set of 14 standard benchmark problems and reported it better than seven other biology-based optimization algorithms and also taken up a real-world sensor selection problem for aircraft engine health monitoring.

Biogeography is a branch of knowledge dealing with the geographical distribution of biological organisms, their migration from one island to another and of the rise and extinction of species (Simon, 2008). An island (geographical area) isolated from other islands is termed as habitat. Habitat Suitability Index (HSI) corresponds to favorability of an island for residence to an organism or species. The HSI is affected by rainfall, diversity of vegetation, land area, topographic conditions, and temperature. Suitability Index Variables (SIVs) are independent variables corresponding to the habitability of a habitat. SIVs are used to compute HSI. Habitats with low HSI have a low number of species while those with high HSI have a high number of species. Emigration is the migration of species away from a habitat while the reverse process is immigration. Habitats with high HSI density of species support low immigration rate but have high emigration rate. Habitats with a low HSI, have low species density and thus support high species immigration rate. HSI of habitat increases with biological diversity thus immigration of new species increases HIS (Simon, 2008).

NETWORK ROUTING

In a network, routing means to find different paths between two nodes based upon some criterion. There are two routing schemes namely 'static' and 'dynamic' in practice. The routes between the given nodes are precompiled based on certain factors and are saved in the routing table in case of static routing (Tannenbaum, 2003). The packets trail this specified route between these two nodes. In the case of dynamic routing, the routes are generated dynamically when there is a requirement for the same. While selecting a route, various factors e.g. traffic congestion, utilization of link, the distance of path traveled, etc. are kept in mind so as to maximize the data transfer rates between the designated nodes. There may be centralized or distributed routing based upon the routing policy. The routing policy may take care of shortest path routing and optimal routing based upon certain other specified criterion. The routing problem is distributed, time-varying and stochastic, multi-objective along-with multi-constraint.

Biogeography Based Optimization (BBO) is a nature inspired optimization method that uses the migration and mutation of species as the evolution method for problem-solving. BBO starts with search space called population, and each element of the population is called a habitat. Each habitat is a candidate solution to the problem at hand. Each habitat is evaluated for HSI, and the HSI defines the quality of the solution. The BBO uses emigration, immigration and mutation operators for the evolution of its population. The average HSI increases with evolution (iterations of the algorithm). The stopping criterion may be fixed number of turns, stagnation of algorithms, fixed value of HSI or any other user defined condition.

THE PROPOSED SCHEME

In the present paper, BBO is employed for optimization of path routing in a network for optimization of both the distance and the congestion at different nodes in the network. The real number coding is done in Matlab. This section explains the algorithm for the proposed scheme.

The Algorithm

The habitats contain real values for SIVs in the present implementation of BBO for the problem at hand. The variable habitat size is used for the present application. There are 52 numbers of nodes in the network under consideration. Each node has different traffic on it thereby resulting in a different amount of congestion factor associated. The value of congestion factor is taken between 1 to 10; a node with congestion factor 1 corresponds to no traffic on the node, while its value 10 corresponds to maximally congested node. The following steps are used for developing the proposed algorithm:

1. Initialize the network with specified number of nodes having some congestion factor value between 1 to 10 associated with each node.

2. Find the two nodes between which the communication path is to be established.

3. Initialize the population of habitats, each of them representing a valid path in the network. Each SIV in the habitat represents a node in the path represented by the corresponding habitat. The first SIV in a habitat represents starting node while the last represents the ending node of the path represented.

4. Calculate the Habitat Suitability Index (HSI) for each of the habitat. The HSI is computed by following equation:

$$HSI = 1 \Big/ \sum_{j=B}^{T} \sqrt{(x_j - x_{j-1})^2 + (y_j - y_{j-1})^2} + \sum_{j=B}^{T} K_i$$

Here (x_j, y_j) are Cartesian co-ordinates of the node while K_i is congestion factor at the jth node. B is beginning node while T is terminating node.

5. Apply migration operators of BBO algorithm.
6. Perform Mutation.
7. Evaluate the HIS of the population as in step (4).
8. Evaluate stopping condition, if stopping condition is met, stop the BBO else go to (4), Iterations to be continued till stopping condition is met.
9. Give the output optimized path.

The algorithm is designed to find optimum path having minimum distance as well as the congestion factor encountered while communicating through the selected path.

RESULTS AND DISCUSSIONS

The network consisting of 52 nodes is graphically shown in Figure 1. The starting node is (0, 5) and terminating node is (10, 1). Five different paths P1 to P5 are depicted in Figure 2. The path P3 is the optimal path selected by the proposed scheme. This path has highest HSI value; that means the computed total of congestion and distance of the path is minimum. Table 1 gives the comparative HSI values for different paths depicted in Figure 2. The present scheme is robust and can be extended to larger networks with more parameters to be optimized. The dynamic conditions can be taken care of by making the algorithm adaptive. The future directions include a real-time application of the proposed scheme.

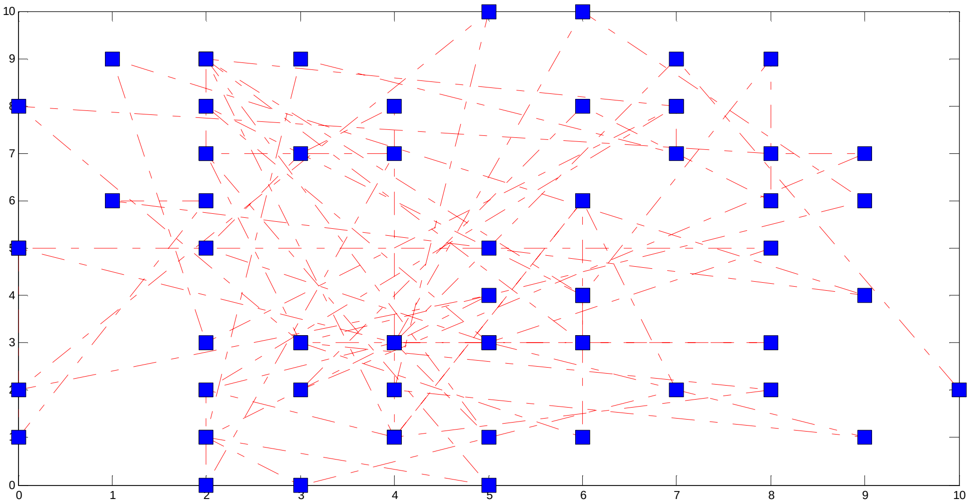

Figure 1: Network of 52 nodes

Table 1: Comparative HSI values for different					
S. No.	Path	Total Distance (D)	Congestion within path (K) $\sum_{j=B}^{T} K_i$	F = D +K	HSI =1/F
1.	P1	17.58	19.8	37.38	0.02675
2	P2	16.28	29.6	45.88	0.02179
3.	**P3**	**11.71**	**12.4**	**24.11**	**0.04147**
4.	P4	11.89	34.07	45.96	0.02175
5.	P5	12.43	17.84	30.27	0.03303

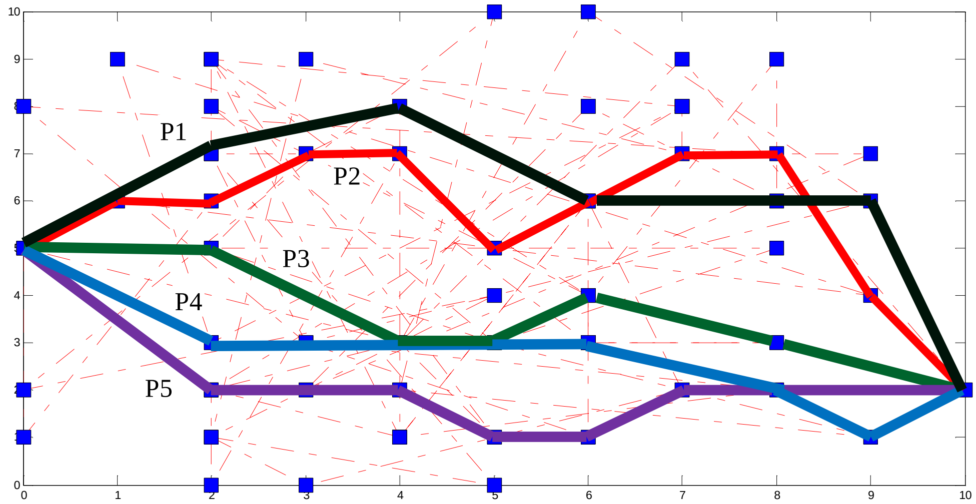

Figure 2: Different paths along-with the optimal path selected by proposed algorithm in the Network of 52 nodes.

CONCLUDING REMARKS

The Biogeography-based optimization algorithm is successfully implemented for simultaneous optimization distance and congestion problem in a network. The total distance of the path along with the overall congestion in the path is minimized so that the network route selected by the proposed algorithm gives fastest communication path between the starting node and ending node. The future scope of the proposed work includes a real time application of the algorithm for a network and evaluating the performance of the system in comparison to other routing strategies for the network.

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(A complete list of references is available upon request from Dinesh K. Sharma at dksharma@umes.edu)