Performance Evaluation of Bionomic Algorithm (BA) in Comparison with Genetic Algorithm (GA) for Shortest Path Finding Problem

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Abstract

This paper presents performance evaluation of Bionomic Algorithm (BA) for Shortest Path Finding (SPF) problem as compared with the performance of Genetic Algorithm (GA) for the same problem. SPF is a classical problem having many applications in networks, robotics and electronics etc. SPF problem has been solved using different algorithms such as Dijkstra's Algorithm, Floyd including GA, Neural Network (NN), Tabu Search (TS), and Ant Colony Optimization (ACO) etc. We have employed Bionomic Algorithm for solving the SPF problem and have given the performance comparison of BA vs. GA for the same problem. Simulation results are presented at the end which is carried out using MATLAB.

Keywords: *Bionomic Algorithm (BA), Genetic Algorithm (GA), Shortest Path First (SPF).*

1. Introduction

SPF has many applications in electronics, transportation, robotics and communication etc. This problem has been solved using different methods like Dijkstra's Algorithm [1-2], Floyd [1] including GA [2], Neural Network (NN) [3], Tabu Search (TS) [4], and Ant Colony Optimization (ACO) [5]. Choice of algorithm for any specific problem depends upon the complex tradeoffs in terms of cost, time, complexity and performance etc. [1]. BA algorithm also has potential to become a solution method for SPF problem. Among all different heuristic algorithms, it belongs to the family of type 3 heuristics, which focus on the mathematical programming contributions. In contrast, GA is from type 2 heuristics which focus on heuristics guidance and cannot be generalized when used for specific problem [6].

In this paper we discuss the performance of BA in comparison with the performance of GA for the SPF problem. We also discuss the advantages and disadvantages of each method. Section 2 discusses the basic information of GA, BA and SPF. Section 3 contains the simulation results and comparison. Finally we conclude the paper in section-4.

2. Preliminaries

2.1 Genetic Algorithm

Genetic Algorithm (GA) is a type of evolutionary algorithms inspired by the evolutionary theory of Darwin. It mimics the process of natural evolution. It is widely used for optimization and searching problems. It has three important operators; selection, crossover and mutation. The process of GA starts with the generation of random population of chromosomes, where a chromosome presents one particular solution for the given problem. Based on their fitness values, two parents are selected to exchange their genes for producing new children. This is called crossover. Mutation is a change (inversion) of a single bit on a random location in the chromosome. Probability of mutation is usually very low and it serves the purpose of avoiding local optima. At the end of the processes of crossover and mutation, we come up with a new generation which is iteratively crossed over and mutated until we reach a solution having a certain optimum value or until a certain number of iterations have been performed. GA has very general structure and because of this, GA is applicable to different areas such as software engineering, electrical engineering, telecommunication (especially in routing) and scheduling etc. figure 1 describes the basic structure of genetic algorithm [2, 7].

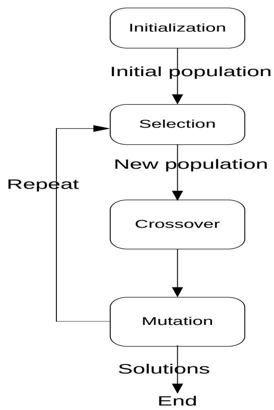

Fig. 1 Basic Structure of Genetic Algorithm

2.2 Bionomic Algorithm

Bionomic Algorithm (BA) was proposed by N. Christofides in 1994 [9]. It shares with GA its basic framework, but replaces the randomness of GA operators with a normative procedure. It accepts multiple parents' combination and variable cardinality solution sets; this approach is shared with the Scatter Search (SS). BA has five major methods; initialization, maturation, propagation of parents sets, propagation of Children sets and termination as shown in figure 2. Initialization process is the same as in GA; simply produce the initial solution set, than apply maturation on solutions. For maturation, bare steepest descent or any algorithm from type 2 heuristics, such as Tabu Search, can be used. After maturation, parents are selected for cross over in order to produce new child population. Such procedures will continue until the optimized solution set is produced or the number of iterations is completed [6, 8].

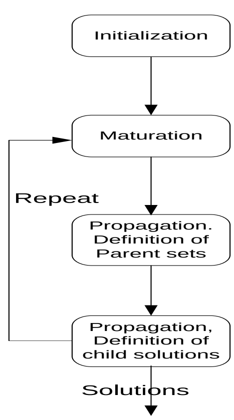

Fig. 2 Basic Structure of Bionomic Algorithm

2.3 Shortest Path Finding Problem

Shortest Path Finding (SPF) problem is very important problem and has many applications in other fields like communication networks and map reading etc. SPF generally finds the shortest path between two vertices Vi and Vj on an undirected graph G. Between any two consecutive nodes, there lies a weighted link E which represents the total cost (non-negative) required to traverse that particular path. SPF finds that shortest path between any two nodes (Vi and Vj) which may be represented as a sequence of nodes i.e. Vi-Va-Vb-……-Vk-Vj. Total cost of any possible path can be represented as E=Eia+Eab+Ebc+……Ekj [3].
Many different algorithms have been used to solve this particular problem, Dijkstra's algorithm being the oldest one. Dijkstra's algorithm, presented in 1959, finds the shortest path (with minimum cost) between any two nodes of a given network [10]. It traverses the whole network for finding a single shortest path between two nodes. For very extensive and complex networks, it proves to be very expensive. Many other algorithms have been proposed later on to solve the SPF problem. Evolutionary algorithms have also been used successfully, Genetic Algorithm being one of them. It finds an optimum path without traversing the whole network. Also, it provides more than one optimum results at every generation. It may sometimes, get stuck in local optima.
In this paper we have proposed Bionomic Algorithm for solving the shortest path finding problem. Bionomic Algorithm is also an evolutionary algorithm and it belongs to type 3 heuristic techniques. It overcomes many of the demerits of genetic algorithm like; it involves a scattered search approach for parents' selection which avoids getting stuck into local optima. It also involves a maturation step and multiple parent (more than 2 parents to mate) approach.

3. Simulation, Results and Discussion

For simulation purpose, we assumed two networks; one with 30 nodes and the other with 49 nodes as shown below in figure-3 and figure-5 respectively. We have used MATLAB for simulating the shortest path algorithms (both genetic algorithms and bionomic algorithm) for both of the networks. Results of both of the cases are given next. We have used those results to compare the performance of Genetic Algorithm and Bionomic Algorithm for the given problem. The networks shown in figure-3 and figure-5 contain all of the nodes present in respective networks along with all of the existing paths with their respective costs.

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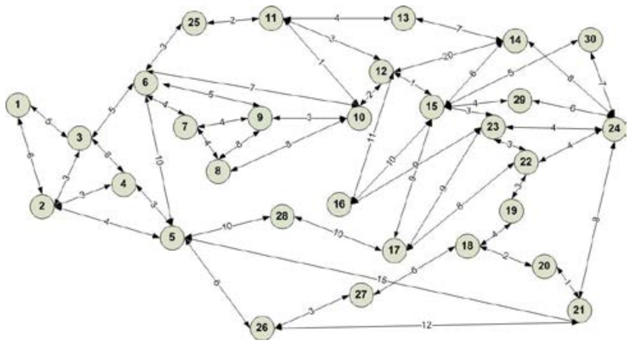

Fig. 3 30 nodes network

Performance of genetic algorithm varies with variations in different parameters like the population size, crossover rate and mutation rate etc [2]. Optimum values of these parameters were found for genetic algorithm and the same values of these parameters (population size, crossover rate, mutation rate etc) were used for bionomic algorithm. In case of the 30 nodes network, population size is 60 while for the 49 nodes network, it is 120 as shown in table-1. Crossover rate is 0.9 for both of the networks and similarly mutation rate is 0.2 for both of the networks.

Table 1: Describes the parameter for GA and BA algorithm

Parameter	**Values for 30 nodes Network**	**Values for 49 nodes Network**
Population Size	60	120
Max. length of chromosome	Equal to the number of nodes in network	Equal to the number of nodes in network
Max. Number of Generation	100	100
Crossover Rate	0.9	0.9
Mutation Rate	0.2	0.2

Table 2 shows the source-destination pairs of two networks, which to be applied on both BA and GA. For 30 nodes network, we select node 1 as a source node and node 24 as a destination node for both algorithm. Similarly, for 49 nodes network we select source node as a node 1 and destination node is node 49. Tables 3, 4, 5 and 6 show the results for both cases. During comparison we come to know that BA converges to optimum results in smaller number of generations but it takes more time than GA.

Table 2: Source- Destination pair for both networks

Cases	**Source Node**	**Destination Node**
1: for 30 node	1	24
2: for 49 node	1	49

Table 3: shows results of GA, when applied to 30 nodes network (case 1)

Path	**Cost**	**Time (sec)**	**Generation Number**
1 -2-3-6-10-11-12-15-23-24	33	0.2105	4
1-2-5-21-24	33	0.2243	8
1-2-3-6-25-11-12-15-23-24	30	0.2379	12
1-3-6-10-11-12-15-23-24	29	0.2516	16
1-3-6-10-11-12-15-23-24	29	0.2654	20
1-3-6-25-11-12-15-23-24	26	0.2721	24
1-3-6-25-11-12-15-23-24	26	0.2801	28

Table 4: shows results of BA, when applied to 30 nodes network (case 1)

Path	**Cost**	**Time (sec)**	**Generation Number**
1-3-6-25-11-12-15-29-24	29	1.8991	6
1-3-6-25-11-12-15-23-24	26	1.9361	12
1-3-6-25-11-12-15-23-24	26	1.9730	18

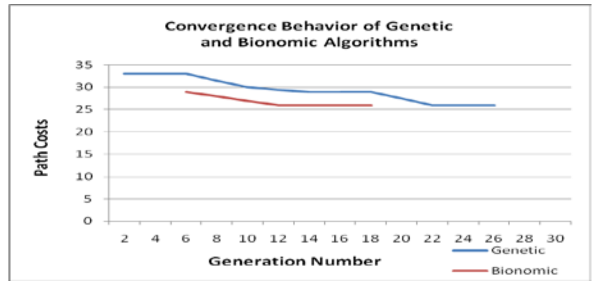

Fig. 4 convergence behavior (case 1)

The graph in figure 4 shows the convergence behavior of both genetic and bionomic algorithms for SPF problem for the 30 nodes network show in figure 3. It is evident that bionomic algorithm converges in lesser number of generations as compared to genetic algorithm. It also gives a more optimum result (a low cost path in the end) as compared to that given by genetic algorithm.

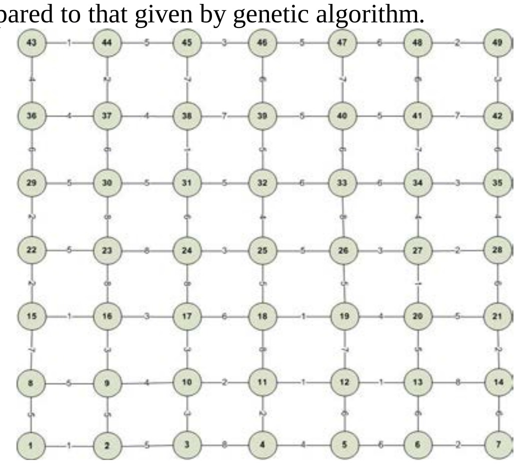

Fig. 5 49 nodes network (case 2)

Table 5: shows results of GA, when applied to 49 nodes network (case 2)

Path	**Cost**	**Time (sec)**	**Generation Number**
1-2-3-10-11-18-19-20-27-34-35-42-49	41	1.0470	12
1-2-3-10-11-12-19-20-27-28-35-42-49	39	1.1091	24
1-2-3-10-11-12-13-20-27-28-35-42-49	34	1.1789	36
1-2-3-10-11-12-13-20-27-28-35-42-49	34	1.2493	48
1-2-3-10-11-12-13-20-27-28-35-42-49	34	1.3210	60

Table 6: shows results of BA, when applied to 49 nodes network (case 2)

Path	**Cost**	**Time (sec)**	**Generation Number**
1-2-3-4-11-18-19-12-13-20-21-28-27-34-35-42-49	45	2.9731	6
1-2-3-10-11-12-13-20-21-28-35-42-49	42	3.0146	12

1-2-3-10-11-12-13-20-21-28-35-42-49	42	3.0509	18
1-2-3-10-11-12-13-20-27-28-35-42-49	34	3.0867	24
1-2-3-10-11-12-13-20-27-28-35-42-49	34	3.1210	30

Graph in figure 6 shows the convergence behavior of both genetic and bionomic algorithms for solving SPF for a 49 nodes network (case 2).

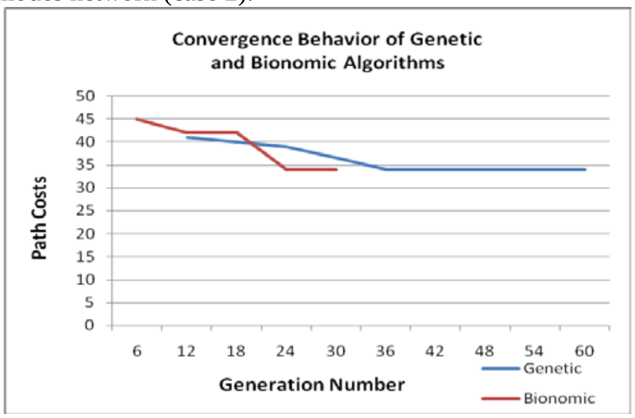

Fig. 6 Convergence behaviour (case 2)

4. Conclusion

Our simulation results, first of all, prove that the SPF problem can be solved by another evolutionary algorithm known as Bionomic Algorithm. It is further evident that Bionomic Algorithm solves the problem better than Genetic Algorithm because of its certain properties like it uses scattered search technique for avoiding local optima and it uses problem specific heuristics. It converges earlier i.e. in lesser number of generations but takes more time because of the increased complexity involved. This algorithm seems to work better for many other problems involving even greater risk of encountering local optima. We aim to apply this very algorithm to other such problems in future.

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