Implementation of Genetic Algorithm for Optimization of Network Route

Kamal Kant Sharma and Inderpreet Kaur

Abstract Problem in the real world requires modeling the problem mathematically and drawing conclusions based on the solutions of the mathematical problem. One of the alternatives is evolutionary computation, which encompasses three main components—evolution strategies, genetic algorithms, and evolution programs. Genetic algorithm takes a possible solution to a particular problem on a simple chromosome with variable genes and uses the data structure to apply the combination of operators to these structures in order to protect vital assets and search for optimum solutions. Shortest path routing algorithms are a well-established problem and addressed by many researchers in different ways. In the present work, one such algorithm was used for routing which is based on genetic algorithm.

Keywords Mathematical modeling · Genetic algorithm · Evolution strategies · Chromosomes · Optimized path

1 Introduction

Routing is defined as a finding between two entities with minimum disturbance. There are mainly two types of available routings, active routing and passive routing. In the first type of routing, the paths are precomputed based on predetermined factors and saved [1]. Information between any two selected entities follows the determined path. In dynamic routings, the paths are rearranged based on factors like congestion and optimization, in order to get the outcome when required by storing the data. Depending on the requirement and with utmost satisfaction, routing can be performed in a centralized or decentralized manner. In centralized, master–slave

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operation is performed like center entity decide path for other entities irrespective of their limitations, whereas in decentralized, every entity generates its respective route and independent of other entities. The outcome of routing technique should be optimum and less time-consuming; in order to achieve the desirable outcome policy various algorithms are designed for routing which should be multi-objective and multi-constraint.

1.1 Genetic Algorithm

Genetic algorithm (GA) is a programming technique that uses biological spectrum for solving the problem. GA selects a group of elements with similar or dissimilar characteristics over a population in which every element plays an integral part in deciding the optimum solution from a bench of selected group [2]. Using crossover and mutation, new offspring are generated, and only those offspring that are the best to fit stay, while others are discarded. This process of survival of the fittest goes on until the optimum solution is obtained [3]. The narrower the selection gets, the more the optimum solution is obtained. The accuracy of solution also depends on the selection of population, achieved target, and element selected for the process. Genetic algorithm refers to a model introduced and investigated by [4, 5].

1.2 Optimization

Optimization relates to the optimum solution of a problem. When a model is proposed, cost and profit value analysis is a selective parameter for decision-making. Proposed cost should be less and profit should be more, in other words, for minimum input, maximum output should be achieved; the process of attaining the selected parameters at minimum rate is optimization. Optimization uses the theory of ordinary differential equations and methods involved in solving of iterations [6, 7]. The main objective is to develop objective function based on a defined set of criteria F = {f1, f2… fn}. Figure 1 sketches a characterization of different types of optimization methods. In general, optimization deals with two types of algorithms, namely deterministic and probabilistic algorithm. Deterministic algorithms are only used where output has a relation with input, whether direct or indirect [8]. Likewise in a machine, if output is speed and input is voltage, and by varying the input voltage speed is varying to a certain range, then a relation can be established and deterministic algorithms can be used. However, if the relation is complex between input and output and fitness among element cannot be established, in particular and it is harder to explain the relation, then the above-mentioned algorithm is not able to succeed in providing optimization to a selected problem.

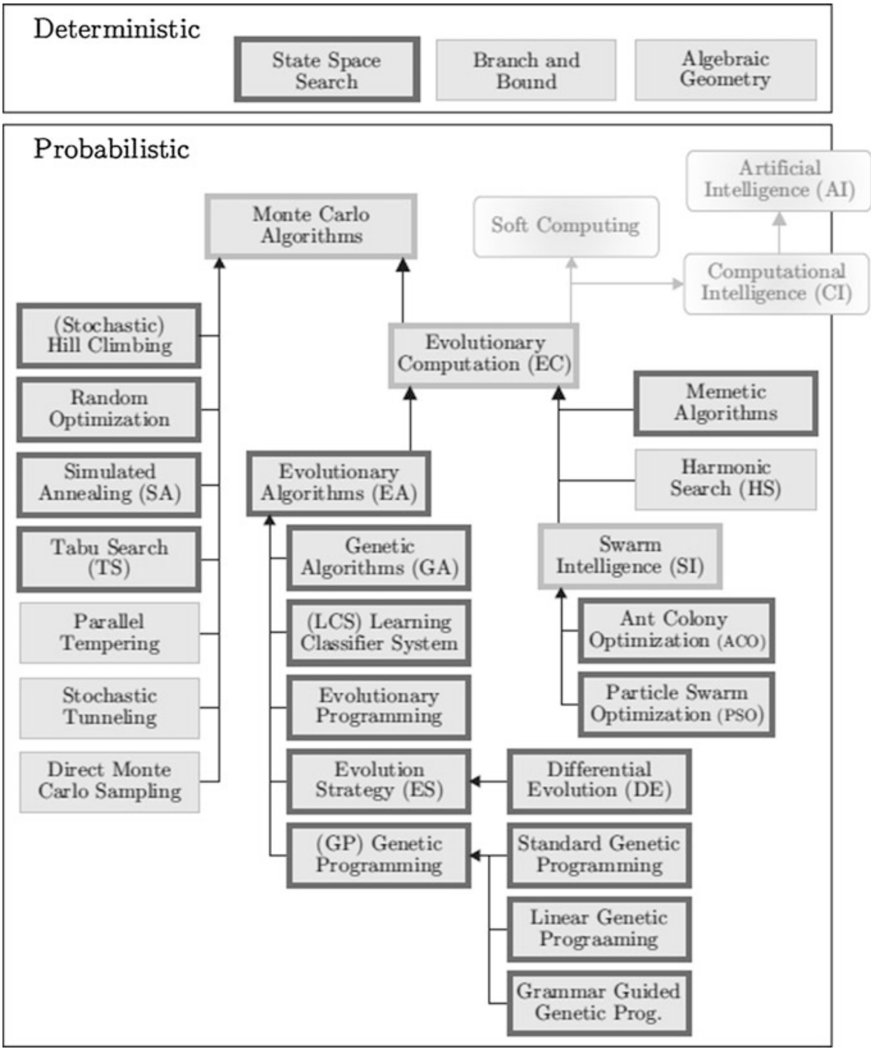

Fig. 1 Description of optimization algorithms [6, 7]

1.3 Problem Formulation and Implementation

Congestion problem in a network is as complex as multiple nerves in the human brain. The severity of congestion in a network affects the network in terms of its performance, efficiency, and delivery time. If no proper routing technique is followed, and congestion problem is not considered as a major roadblock, then the network may fail and also lead to failure of a whole system. In some papers, congestion is considered as a roadblock in achieving the optimum output across a

Table 1 Algorithm for implementation

(i) Selection of terminal with abscissa and ordinate values with their respective congestion values
(ii) Mark the start and end terminals
(iii) Starting every terminal with their respective gene and followed a path, with how many terminals encountered. This step will engross the element at every terminal and can check the behavior of the same
(iv) Access the fitness of every element over a selected population using objective function by the calculation of total path covered with their respective congestion values
(v) Execute Roulette wheel procedure
(vi) For faster convergence of algorithm, execute crossover for a selected element with high fitness factor, with probalistic index of 0.8
(vii) Now as discussed, execute mutation between the range of 0.0001 and 0.0003
(viii) This step is similar to if-then-else command. If convergence occurs and if selected criterion is fulfilled, algorithm will stop, otherwise it will again execute fitness values and so on
(ix) Results with optimum solution with path and their optimum congestion values

viable network [9]. Considering the effect of congestion and routing principles to be followed, genetic algorithm is proposed for finding the optimum solution for active routing and congestion in the present work. The problem does not involve factious values but takes care of real values of genes for coding. Some assumptions and certain parameters are kept fixed for solving the problem and the range of a system is kept fixed, like in the present work; the number of entities are fixed, the terminal where congestion is expected to be more is given the value as unity (1) and where the congestion is nil it is given the value of zero. For maximum congested terminal, high priority value is fixed, whereas terminal termed as free is where congestion is not present (Table 1).

2 Methodology and Results

Coding is done with variable length of element selected with their respective paths and hindrance through the path due to congestion values at the respective terminal. The terminals are kept fixed as discussed above with their respective values of associated network. Genetic algorithm is applied for more than 50 terminals approximately near to 56 terminals in total considering crowded or easy paths. The attributes related to terminals are selected while considering congestion values in a path. Objective function during coding process is so designed that starting and ending terminal is selected and the congestion values get summed up together while considering their fitness value. Objective function marks the fitness value to the element depending on their journey across various paths involving crowdedness across them. The starting terminal is taken as S = [0, 5, 0.1], and the ending terminal is E = [10, 2, 0.1]. The element can take any path between the two above-mentioned terminals but some paths used by the elements may contain more time and disturbance in completing their respective journey. The ordinate and abscissa of terminals mentioned the points from where the element started their path and where it ends. But for finding optimum values, genetic algorithm is preferred. Genetic algorithm helps to find the minimum distance covered with least congestion values by taking the maximum value of objective function (By taking derivative) as objective function is so designed and is opposite to the total distance covered. For a network, it is important to take optimum time from the starting to the ending terminal by an element so that the network can be termed 'Smart Network' (Figs. 2, 3 and 4).

$$T.D = \sum_{i=S}^{E} \sqrt{(x_i - x_{i+1})^2 + (y_i - y_{i+1})^2} \tag{1}$$

$$T.DF = \sum_{i=S}^{E} \sqrt{(x_i - x_{i+1})^2 + (y_i - y_{i+1})^2} + w.\sum_{i=S}^{E} C_i \tag{2}$$

$$ObjFun = 1 \Big/ \sum_{i=S}^{E} \sqrt{(x_i - x_{i+1})^2 + (y_i - y_{i+1})^2} + w.\sum_{i=S}^{E} C_i \tag{3}$$

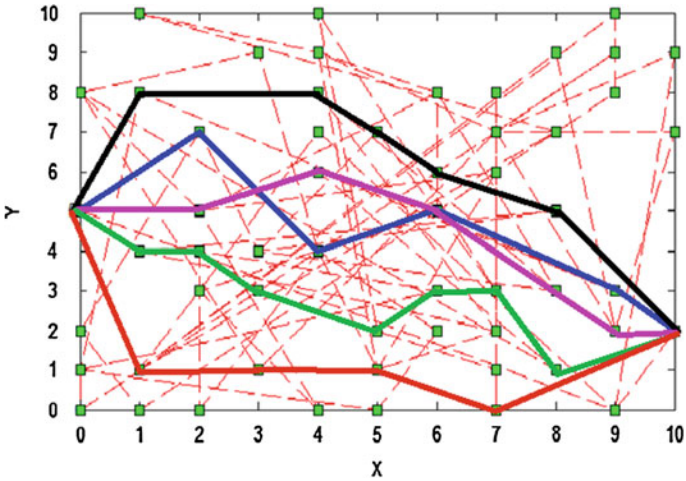

Fig. 2 Possible optimized paths for route management

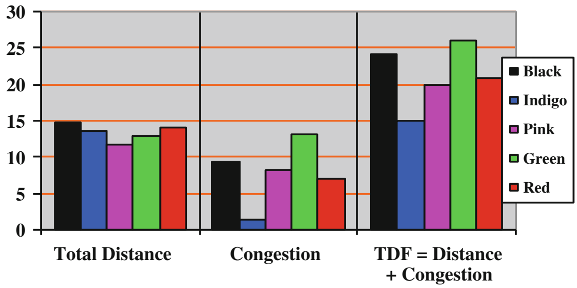

Fig. 3 Analysis of available paths: total distance, congestion, and TDF

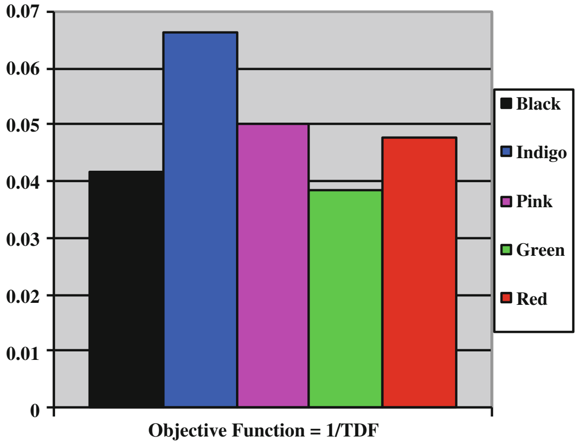

Fig. 4 Analysis of available paths: designed entity

In this work, algorithm chooses a path between two terminuses as provided based on least congestion values. The optimum path found by GA has terminals [2, 7, 0]; [4, 4, 0.2]; [6, 4, 0.1]; [9, 3, 0.2]. As shown above, the selected path is identified while considering the total distance covered with very less value of congestion. There can be various permutations and combinations for selection as lesser distance, less congestion; less congestion, more distance; more distance, more congestion. In this work, the algorithm is so delivered that congestion value should be less even with more distance calculated. There are other parameters in the background to design objective function as well. For finding optimal solution to the problem using genetic algorithm, convergence of algorithms is important, if convergence does not occur as desired; the solution can be suboptimal or blur which increases the complexity of the problem with no solution. Whenever the fitness value remains constant for possible inputs or output reached, the fitness value declines as occurred in this work, then it is an indication of convergence for genetic algorithm. Here the optimum solution is given by a dark line considering distance and congestion values (Figs. 5 and 6).

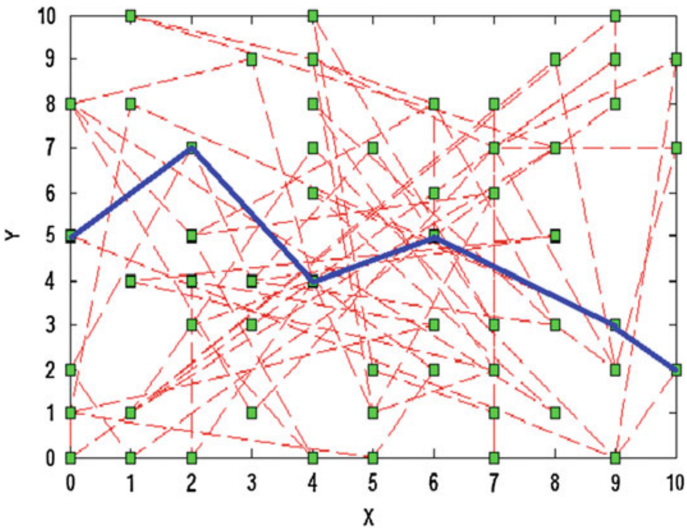

Fig. 5 Optimized path

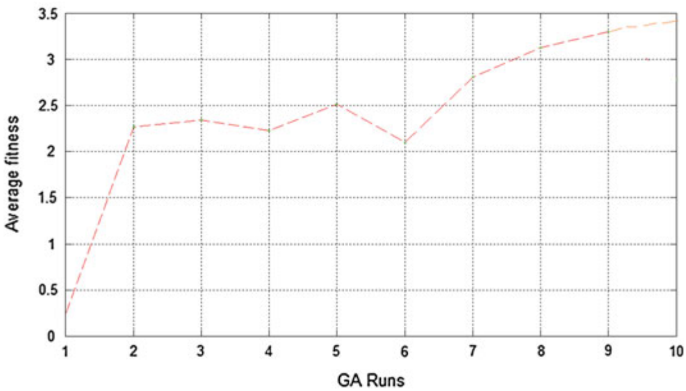

Fig. 6 Convergence curve for GA

3 Conclusions

Genetic algorithms for optimization of both distance and congestion factor are proposed to be used. This approach is different from other approaches in the fact that congestion in the network is also taken care of for optimization of path in the network. Congestion plays an important role in deciding the optimal solution. The strategy of optimizing the path in a network with many nodes having different congestions on them has been presented in this paper and genetic algorithms as optimization tool has been used for this purpose.

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