Optimal Route Finder using Genetic Algorithm

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Abstract— The primary operation requirement in a large area network is a query of shortest distance. Finding the shortest route from source to destination is one of the major problems faced in the network. This paper provides an implementation of solving one of the problems of finding a shortest route using a algorithm known as Genetic algorithm. Genetic algorithms are the evolutionary techniques for finding the fittest gene amongst all the combination of chromosomes using crossover and mutations over the chromosomes. The purpose is to find the most approximate solution that gives us the least distance, which is the shortest route for traversing the cities. This problem a salesman has to traverse n number of cities in such way that it gives a 'uni' directed graph and each city is visited only once. We accomplish this by carrying out the algorithm through generating a fitness formula and with the help of genetic operators like selection, crossover and mutation.

Key words: Genetic Algorithm, Genetic Operators, Travelling Salesman Problem

I. INTRODUCTION

Genetic Algorithm (GA) is an algorithm which is basically used in the optimization tasks. This algorithm follows the theory, given by Charles Darwin which is "Survival of the fittest". [6] This algorithm generates n number of offspring depending upon the parents with the help of mutation and crossover and the selects the best chromosome which is most fit amongst all. For Example: If there are certain number of animals of same species and in which some of them are more fit physically and mentally and due some factor the resources to them are limited, then the chances of the survival for the less fit animals becomes harder and leads to extinction. The same above concept is used in the genetic algorithm.

GA consists of many functions which are similar to the processes which occur in genetics. Travelling Salesman Problem (TSP) is one of the most popular optimization problem studied in the world, it is a nondeterministic polynomial time (NP) –hard problem which cannot be exactly solved in polynomial time. In TSP a salesman has to choose a shortest path for traversing n number of cities without repeating any path and without visiting any city more than once. TSP can be solved easily when the number of cities are less in number, whereas the complexity increases as there is an increase in number of cities. TSP can be used in many fields like circuit designing, military, traffic etc.

This paper implements the code the GA in order to satisfy the need of Travelling Salesman Problem and to find an optimal path for the salesman or the user that he/she can used to traverse. GA is used to perform all the computations for finding the optimal path. We have used MATLAB as platform as it only work with matrices and mathematical problem. All the data of nodes, displacement, gene combination, node coordinates are stored in 2 dimensional matrix, even the calculated data is stored in matrix format.

Following are the important factors of this project:

1) NP-hard Problem
2) Matrix
3) MATLAB
4) Roulette Wheel
5) Chromosomes

A. NP-Hard Problem

It stands for nondeterministic polynomial time. A decision problem H comes under NP-hard problems which is not possible to solve in polynomial-time which means exact solution cannot be found by a computer. Only an optimal solution can be obtained.

B. Matrix

Matrix is mathematical method for keeping a similar kind of data together. Matrices are of various type, but the matrix used here is 2Dimensional matrix.

C. MATLAB

The name MATLAB stands for Matrix Laboratory. MATLAB was written originally to provide easy access to matrix software which was developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming environment. Furthermore MATLAB is a modern programming language environment; it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent tool for teaching and research.

D. Roulette Wheel

Fitness proportionate selection, also known as roulette wheel selection, is a genetic operator used in genetic algorithms for selecting potentially useful solutions for recombination. In fitness proportionate selection, as in all selection methods, the fitness function assigns a fitness to possible solutions or chromosomes.

E. Chromosomes

In genetic algorithms, a chromosome (also sometimes called a genotype) is a set of parameters which define a proposed solution to the problem that the genetic algorithm is trying to solve. The set of all solutions is known as the population. The chromosome is often represented as a binary string, although a wide variety of other data structures are also used.

II. LITERATURE SURVEY

1) Gilbert Laporte, "The Traveling Salesman Problem: An overview of exact and approximate algorithms", European Journal of Operational Research 59 (1992) 231-247 North-Holland, Centre de recherche sur les transports, Universit~ de Montr&l, C.P. 6128, Station A,

Montreal, Canada H3C M7 Received May 1991; received July 1991.

This paper surveys on some of the main known algorithms for the traveling salesman problem. It presents an integrated overview of some of the best exact and approximate algorithms which includes Integrated Linear Programming and Branch and Bound algorithm. The paper concludes that problems involving a few hundred vertices can be solved routinely to an optimal solution. The instances involving more than 2000 vertices have also been solved exactly by means of these algorithms.

2) X.H. Shi [a], Y.C. Liang [a,b,*], H.P. Lee [b,c], C. Lu [b], Q.X. Wang [a], "Particle swarm optimization-based algorithm for TSP and generalized TSP", [a] College of Computer Science and Technology, Jilin University, Key Laboratory of Symbol Computation and Knowledge Engineering of the Ministry of Education, Changchun 130012, China, [b] Institute of High Performance Computing, Singapore 117528, Singapore, [c] Department of Mechanical Engineering, National University of Singapore, 9 Engineering Drive 1, Singapore 119260, Singapore, Received 31 July 2005; received in revised form 10 February 2007.

This paper surveys on particle swarm optimization (PSO)-based algorithm for the traveling salesman problem. It presents an overview of solving TSP using an uncertain searching strategy in which crossover is eliminated to accelerate the convergence speed. The paper concludes that the modified PSO algorithm is effective and can solve the larger size problems than the existing PSO algorithm.

3) Elizabeth F. G. Goldbarg, Marco C. Goldbarg and Givanaldo R. de Souza, "Particle Swarm Optimization Algorithm for the Traveling Salesman Problem", University Campus STeP Ri Slavka Krautzeka 83/A 51000 Rijeka, Croatia, Published online 01, September, 2008.

This paper provides an overview for the optimization of Particle Swarm Optimization algorithm by using a new velocity operator for discrete PSO by which the positions of cities or nodes are updated by means of velocity operators that direct the search to exact (promising) regions of the space of solutions. The unary and a binary concept of velocity operators also solves the problem for distinguishing pbest or gbest which the particle requires to know.

4) Khushboo Arora, Mamta Arora, "Better Result for Solving TSP: GA versus ACO", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 3, March 2016.

This paper surveys on the comparison on some main heuristic algorithms for travelling salesman problem. It presents an overview of the Genetic Algorithm and Ant Colony Optimization algorithms. The GA uses the fitness function whereas the ACO use the pheromone concept. This paper states that Genetic Algorithm gives better results in terms of the distance travelled whereas the ACO gives the better result when the complexity increases or the number of nodes increases.

5) Naixue Xiong 1,2, Wenliang Wu 1 and Chunxue Wu 1*, "An Improved Routing Optimization Algorithm Based on Travelling Salesman Problem for Social Networks", 1 School of Optical-Electrical and Computer Engineering, University of Shanghai for Science and Technology, Military Road, No. 516, Shanghai 200093, China; xiongnaixue@gmail.com (N.X.); wwl@st.usst.edu.cn (W.W.) 2 Department of Mathematics and Computer Science, Northeastern State University Address: 611 N, Grand Ave, Tahlequah, OK 74464, USA, Received: 5 April 2017; Accepted: 6 June 2017; Published: 8 June 2017.

This paper focuses on a routing optimization algorithm. This paper provides an improved scheme for considering the about searching next better city, even new parameters are introduced to improve the probability of selection. It states that Ant colony algorithm is proposed to solve this problem effectively, but random selection strategy of the traditional algorithm causes evolution speed to be slow. This paper discusses on the new parameters for the pheromone in Ant Colony Optimization algorithm to increase the selection probability. Improvement in the sensitivity of the shortest path to find the shortest path is done and hence Ant Colony algorithm is optimized in it selection optimization and to find the short path.

III. SYSTEM OVERVIEW

The system aims in finding optimal path using genetic algorithm. The Figure 1 shows the process of finding the optimized path using Genetic algorithm.

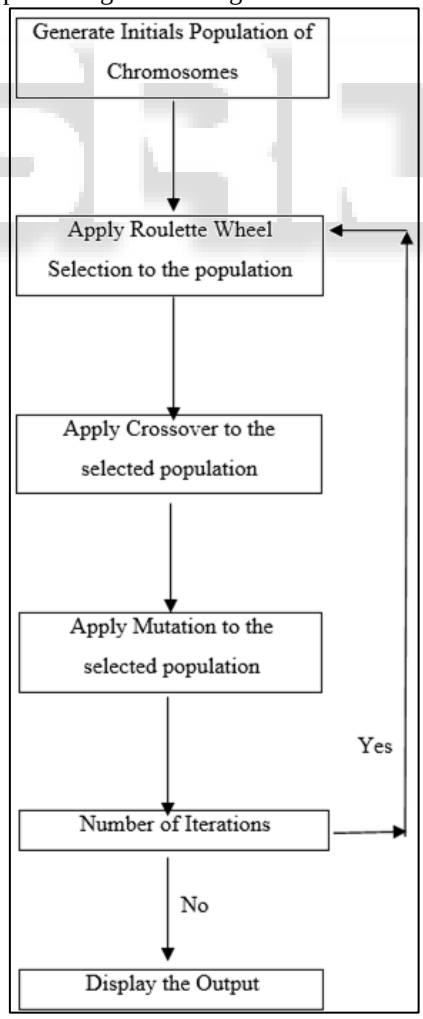

Fig. 1: Flowchart of Applied GA

The system module has been divided into two parts:
1) With Map Plotting
2) Without Map Plotting
The procedure for the same is as follows:

A. Module 1.With Map Plotting

1) Input
1) Take actual coordinates of Earth in terms of longitude and latitude.
2) Enter Number of Population
3) Enter number of generation.

2) Process
1) Storing data in 2D matrix
2) Plotting of coordinates in graph
3) Processing the data

3) Output
1) Map Generation with optimal path
2) Graph generation using color code sequence.

B. Module 2: Without Map Plotting

1) Input
1) Enter number of coordinates /cities
2) Enter number of population.
3) Enter number of generation

2) Process:
1) Store data in 2 D matrix
2) Plotting coordinates in graph
3) Processing the data

3) Output:
1) Graph with optimal path
2) Graph generation with individual coordinates using color code sequence.

IV. Implementation of System

The implementation of the system is performed in various stages as below

A. Encoding

Firstly for implementing TSP using GA the chromosomes length is considered as the total number of nodes, which are cities. Five cities or nodes are considered and the possible chromosomes are:
1) Chromosome 1: 2 4 5 3 1
2) Chromosome 2: 3 1 2 5 4
3) Chromosome 3: 3 5 2 1 4
4) Chromosome 4: 2 5 1 4 3
5) Chromosome 5: 2 4 5 3 1

City	1	2	3	4	5
1	0	4.4531	4.1502	6.2789	2.4564
2	4.4531	0	6.9994	2.8626	6.8143
3	4.1502	6.9994	0	9.5985	4.8619
4	6.2789	2.8626	9.5985	0	8.2254
5	2.4564	6.8143	4.8619	8.2254	0

Table 1: Distance Matrix of 5 Cities

B. Fitness Function

The main motive of fitness function is to choose if a chromosome is good. The criteria in the travelling salesman problem for good chromosome are its length. The fitness function will be the total cost of the tour represented by each chromosome. This can be calculated as the sum of the distances traversed in each travel segment. Lesser the sum, fitter is the solution.

C. Selection

It is used to select the chromosome whose fitness value is small. We have used the tournament selection by using Sorting method. Selection is used to pick the chromosome whose fitness value is less. Figure 2 shows the selected tournament selection. As the name reflects tournaments are played between two solutions and the superior solution is selected and placed in the mating pool.

2	4	5	3	1

Fig. 2: Selection

D. Mutation

A few numbers of cities or genes from chromosomes are selected and then are exchanged with each other as shown in Figure 3 below. The exchange process is done only when the exchange process is done only when the exchange of this genes or cities increases the fitness value of chromosomes. This process is done only to the fit chromosome in order to get the most fit path or chromosomes.

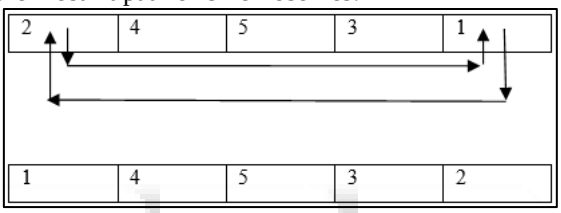

Fig. 3: New Mutated Chromosome

E. Crossover

One point - part of the first parent is copied and the rest is taken in the same order as in the second parent. Two point - two parts of the first parent are copied and the rest between is taken in the same order as in the second parent.
The implementation output is as shown in the Figure 4, Figure 5 and Figure 6 below.

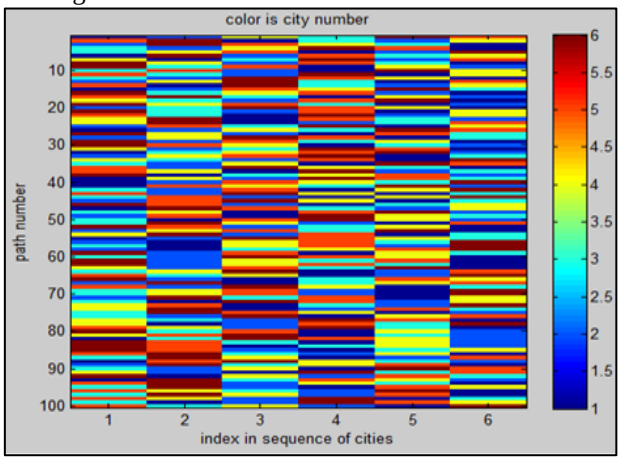

Fig. 4: Sequenced COLOR of EACH NODE

F. Output

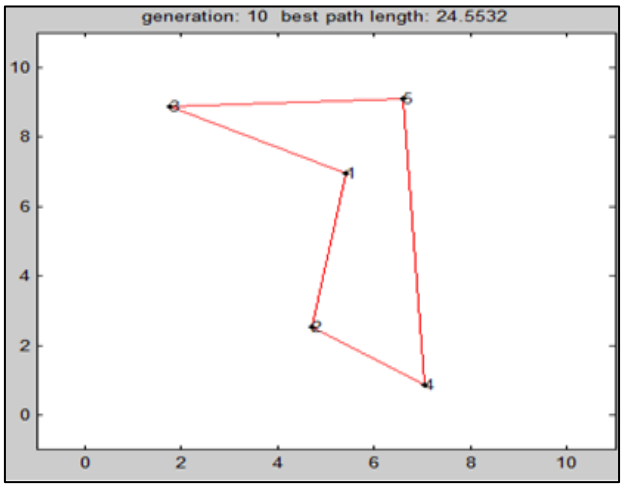

Fig. 5: Best Path

Fig. 6: Path on Google Map

G. Observation & Analysis

Given a two distance matrix as shown in Table 2 and Table 3, with random coordinates it is observed that the highly optimal path is generated when the coordinated values are close to each other.

City	1	2	3	4	5
1	0	5.8933	5.7802	9.2343	6.5674
2	5.8933	0	7.7894	4.8336	8.6143
3	5.7802	7.7894	0	9.8393	8.5619
4	9.2343	4.8336	9.8393	0	2.7254
5	6.5674	8.6143	8.5619	2.7254	0

Table 2: Distance Matrix 1

City	1	2	3	4	5
1	0	4.4531	4.1502	6.2789	2.4564
2	4.4531	0	6.9994	2.8626	6.8143
3	4.1502	6.9994	0	9.5985	4.8619
4	6.2789	2.8626	9.5985	0	8.2254
5	2.4564	6.8143	4.8619	8.2254	0

Table 3: Distance Matrix 2

The optimal path or the chromosome value also depends upon the generation value. The more the generation value higher the mutation and crossover. And also higher is the optimal path.

V. CONCLUSION

This paper highlights the use of Travelling Salesman Problem which is a NP-hard problem and cannot be exactly solved in polynomial time, so as to find an optimal result. The use of Genetic Algorithm promises to solve this problem more effectively than other optimization algorithm. This is due to its robustness in nature. Genetic algorithm has the best combinational techniques which are crossover and mutation which is based on natural selection. Travelling Salesman Problem is one of the hardest problem in NP-complete. The implementation work is done to achieve the required aoutput using MATLAB.

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