Travelling Salesman Problem Optimization Using Genetic Algorithm

Sahib Singh Juneja[1], Pavi Saraswat[2], Kshitij Singh[3], Jatin Sharma[4], Rana Majumdar[5], Sunil Chowdhary[6]

[1,2,3,4,5,6]*Amity School of Engineering and Technology, Amity University*
[1]*sahibjuneja6005@gmail.com*, [2]*pavisaraswat@gmail.com*, [3]*kshitijsingh1809@gmail.com*, [4]*,jsharma17.js@gmail.com*
[5]*rmajumdar@amity.edu*, [6]*skchowdhary@amity.edu*

Abstract: Optimization problem is which mainly focuses on finding feasible solution out of all possible solutions. Travelling salesman problem belongs to this one. As it is not possible to find its solution in definite polynomial time that is why it is considered as one of the NP- hard problem. This paper utilizes the optimization capability of genetic algorithm to find the feasible solution for TSP. The algorithm starts with the calculation of Euclidean distance between the towns to be visited by the salesman. Initial chromosome pool is generated using value encoding. Then best fit chromosomes are selected by applying roulette wheel selection which then goes through m-point crossover. Now we apply interchange mutation on the offsprings generated before. Now this whole process is repeated until the convergence of genetic algorithm.

Keywords: Travelling Salesman Problem, Genetic Algorithm, Population, Interchange Mutation, Fitness value, m-point Crossover, Roulette wheel selection.

I. INTRODUCTION

The Travelling Salesman problem (TSP) is a combinatorial NP problem [12]. The problem has a salesperson and a set of towns. The sales person has to traverse all the cities initiating from a particular point (example being a head office) and then returning back to the starting city [14]. The purpose of this problem is to minimize the total distance travelled by the salesman. Mathematically traveling salesman problem is formulated as given:

TSP = {(G, s, t): G = (V, E) where G is a complete graph, s is a function

$V \times V \rightarrow Z$, $t \in Z$, G is a graph containing the distance to travel along with the cost which is not greater than t}.

Genetic algorithms (GAs) were successful in order to solve many optimization problems, including Vehicle Routing Problem (VRP), Drilling of printed circuit boards [4], X-Ray crystallography [5], and computer wiring [6] etc. The TSP is a classical graph-theoretical and combinatorial optimization problem [7].Genetic Algorithms (GAs) are flexible heuristic search algorithm that depends on the progressive conclusion of genetics& natural selection. Basically it shows a smart utilization of a random search which is further applied in order to resolve optimization problems. Although randomized, GAs are usually not arbitrary, rather it uses the facts from past to give the correct direction to the search to perform preferable within the given search space. The basic approach of the Genetic Algorithms basically simulates the processes in and of natural systems which is important for growth, which mainly follow the principles of Charles Darwin. As we know in nature, the competition is there among individuals for the resources as there is scarcity of resources which results in the domination of weaker individuals by the fittest ones.

II. GENETIC ALGORITHM

Genetic algorithm process simulates the endurance of the most desirable individual over successive generation to solve a meticulous issue among all the individuals. Every generation in Genetic Algorithm is made up of a number of characters or strings which are alike the chromosome present in the DNA [13]. Any particular sole basically signifies a trace in the search space along with its feasible result. The individuals present in the population then processed by a particular process for evolution.

Genetic Algorithms are based on similarity with the behavior of chromosomes and genetic structure within a population of individuals

A. Genetic Operators

1) Encoding- Encoding is the way of representing individual genes. It can work on string, arrays, trees, lists or any other objects.

2) Selection- Selection gives the best solution at a rate proportional to their relative quality in the population .

3) Crossover- Crossover [11] breaks two different results and then arbitrarily combines their elements to get a unique result. A child result is produced from the two parent results. After the selection process, the population is supplemented with better individuals.

4) Mutation- Mutation randomly perturbs a candidate solution. It acts as the one that recovers the lost genetic

978-1-5386-9346-9/19/$31.00 ©2019 IEEE

materials and also for randomly distributing genetic information.

B. Genetic Algorithm Method Flow

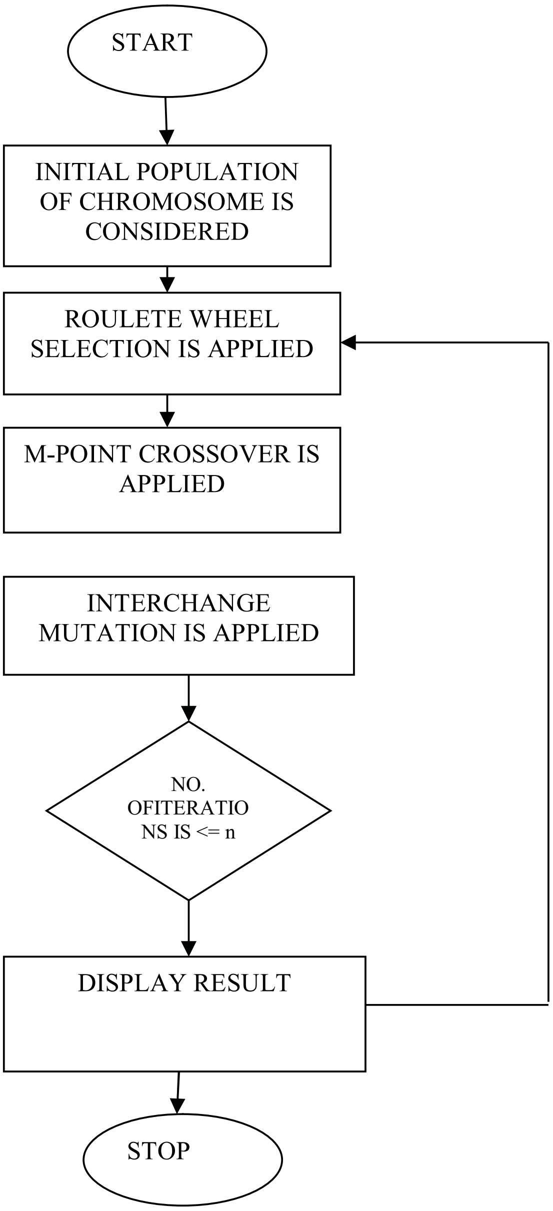

Fig. 1. Method flow of genetic algorithm

III. TRAVELLING SALESMAN PROBLEM

The travelling salesman problem is a famous optimization problem [1] requiring the least total distant Hamiltonian cycle. It is NP-hard problem [2] because there is no algorithm available to find its solution in polynomial time. The minimum expected time for obtaining optimal solution is exponential [8]. We can represent TSP as an undirected weighted graph in which each vertex is representing the city to be travelled and the distance amongst cities is represented by the edges connecting the city vertices [8]. The distance calculation between the is can be done using multiple distance formulas

like City block, Canberra distance, Hamming distance, Euclidean distance and many more, here we have used Euclidean distance function(d) for calculating distance between any two cities having the coordinate (x1, y1) and (x2, y2) is given in equation 1 [9].

$$d=\sqrt{|x1-x2|^2+|y1-y2|^2} \qquad (1)$$

IV. IMPLEMENTATION

The algorithmic rule is tested on a collection of total 5 issues taken from the literature. The operating of the GA has already been described on a tangle of twenty cities within the succeeding part. The coordinates of twenty cities has been given in figure 3.

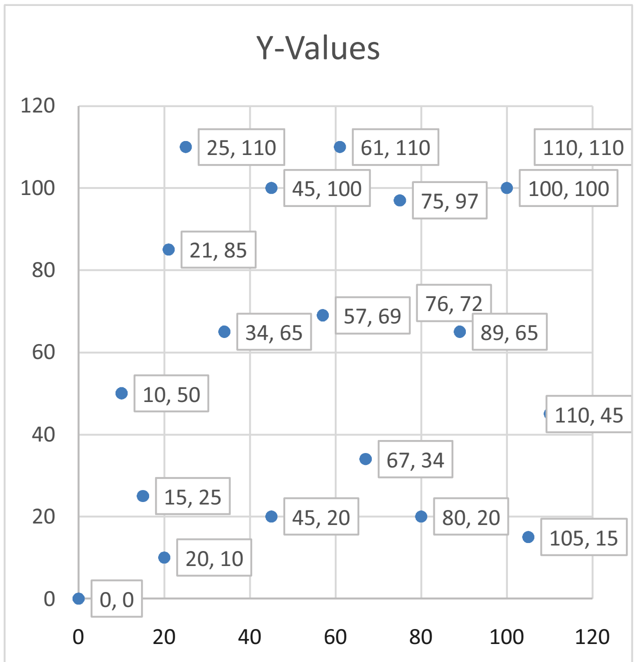

Fig. 2. Co ordinates of 20 towns

The distance matrix of the matter has been provided in the first table. We normally assumed the distance-matrix to be symmetric; thus, the fraction on top of the most diagonal contains all necessary data. the gap between the cities is taken into account to be parallel i.e. if the employee moves from town one to town two than the gap is same if he moves from town two to town one that’s why 1/2 the matrix is empty. The data on top of the crosswise is sufficient to seek out the gap amidst totally dissimilar cities. The primary column and row shows the city:

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P 10	P 11	P 12	P 13	P 14	P 15	P 16	P 17	P 18	P 19	P 20
P1	0	22	49	29	51	82	89	75	105	73	110	88	126	110	123	141	113	119	156	106
P2		0	27	16	41	61	70	53	84	57	88	75	108	93	103	120	100	97	135	85
P3			0	30	46	35	50	26	61	46	63	69	91	80	83	97	92	70	111	60
P4				0	25	65	61	53	77	44	84	60	97	81	94	113	86	97	127	91
P5					0	76	51	59	70	28	80	37	79	61	80	103	62	100	117	101
P6						0	54	19	52	64	46	88	92	87	77	82	105	39	95	25
P7							0	36	10	23	32	39	41	33	33	53	52	58	67	72
P8								0	39	45	38	69	76	70	64	74	87	44	87	42
P9									0	43	15	57	41	42	25	37	64	43	51	64
P10										0	55	24	52	37	52	75	46	79	88	91
P11											0	71	53	56	35	37	78	29	50	52
P12												0	47	28	55	80	25	98	92	109
P13													0	19	19	40	36	81	49	105
P14														0	30	55	92	85	66	104
P15															0	25	52	63	37	87
P16																0	76	56	14	85
P17																	0	107	85	125
P18																		0	65	30
P19																			0	95
P20																				0

A. Initial Population

The earliest populace of chromosomes is made arbitrarily by working on distinctive arbitrary range generator to operate in Matlab. The earliest populace shaped is given in the succeeding section. The populace consists of 10 chromosomes, wherever every one signifies the succession within which cities have to be compelled to be traversed and every sequence exemplifies the amount allotted to a town. Section A to E explains varied genetic operators exercised to the earliest populace to get the best outcome.

Set of chroosomes used are as follows:

Chromosome 1:2 0 3 5 7 9 5 3 7 9 5 2 1 5 8 8 3 9 0 3
Chromosome 2:6 7 3 4 8 3 1 3 5 7 9 6 5 4 3 8 4 3 7 4
Chromosome 3:8 5 4 6 8 3 1 3 9 8 0 5 2 1 8 5 7 0 4 3
Chromosome 4:3 5 7 2 0 9 5 0 6 2 1 6 8 0 5 8 4 7 2 1
Chromosome 5:5 6 7 2 4 7 4 9 0 5 3 0 6 7 4 9 0 3 1 2
Chromosome 6:2 5 4 7 8 9 4 7 0 1 3 2 9 0 7 5 2 5 0 1
Chromosome 7:3 6 7 3 2 4 6 8 9 0 7 2 8 3 7 1 4 0 5 8
Chromosome 8:4 6 2 8 4 7 9 0 3 2 0 6 3 0 6 3 9 4 8 4
Chromosome 9:1 3 2 5 6 3 8 3 9 0 5 7 8 3 6 9 0 0 2 9
Chromosome 10:4 5 7 7 3 2 6 9 0 8 6 6 0 3 5 2 4 1 3 7

B. Fitness Value

The fitness function is the measure to decide the best chromosome among the various available offspring. The fitness criteria for TSP chromosome is the distance among the cities.[10].

$$\text{fitness calculated}_{\text{chromosome}} = \sum_{z=1}^{\text{city count}} z_i \qquad (2)$$

City count = total number of cities ; zi = distance between two cities.

C. Selection

Selection is required to choose the chromosome out of all possible chromosomes which is having fitness value least in amount. In this work, the roulette wheel selection method has been used by applying a method which is sorting on the basis of the fitness value.

D. Crossover

M-Point crossover or we can say multiple point crossovers is exercised on the multiple doublet of chromosomes which then creates a new chromosomes which will be having improved fitness value. In multiple-point (m-point) crossover, arbitrarily total number of m positions in the chromosomes is selected and then the replacement of the gene takes place with each other in the pair of chromosomes.

E. Mutation

Evolution is performed to basically create a new generation of chromosomes. In this paper interchange mutation is applied for performing the mutation operation. In the method of interchange mutation, arbitrarily two genes are selected from a single chromosome and then the values are swapped between them.

F. Termination and Result

After carrying out the total number of repetitions on the chromosomes the finest course will be achieved as the output and the process of traversing the cities will be concluded. The minimum distance of the tour achieved is 552 for 20 cities as given in figure 3, starting city is (0, 0).

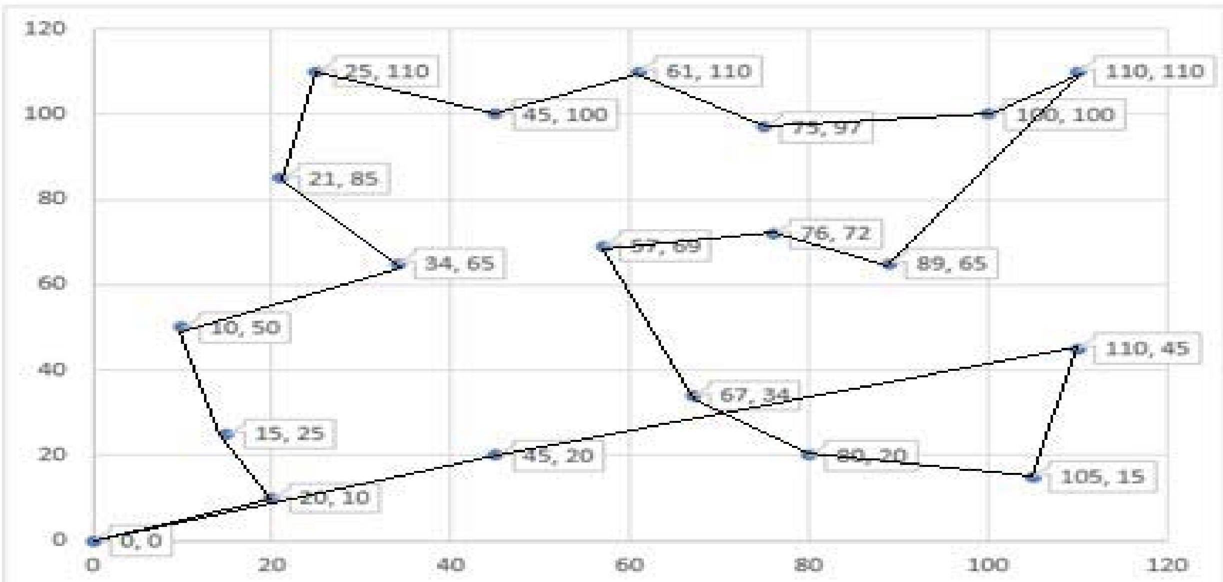

Fig. 3. Best Path From City (0,0)

V. RESULTS AND ANALYSIS

In this paper, 5 numbers of problems have been resolved applying the proposed technique which is genetic algorithm. Both the best and the worst outcomes achieved are given briefly in table 2. The similar table which is table 2 also denotes the best finest known path as the output of the problems present in literature part of the paper. After exploring the outputs and examining the outcome , the conclusion is that GA is a swift and optimal algorithm to achieve the best outcome as the output of the algorithm:

TABLE II: Results obtained by proposed technique for different problems

No. of Cities	Best Path	Worst Path	Best Known Path
20	552	1823	552
26	937	1141	937
42	792	1250	699
45	867	1125	860
50	976	1527	967

VI. CONCLUSION AND IMPLICATION FOR FUTURE WORK

Heuristic methods and genetic approaches are the most appropriate ways to solve the travelling salesman problem. Multiple optimal solutions can be obtained for this problem by using various combinations of selection, crossover and mutation techniques. We have surveyed many approaches and many combinations of genetic operators for this problem and the used combination of genetic operators in this paper is the optimized one among them. For future extension of this work we can use multiple combinations of hybrid genetic operators. The approach used can be operated in diverse network optimization problems like vehicle navigation routing model, task scheduling models, Chinese postman problem and logistic networks.

REFERENCES

[1] Dwivedi, Taruna Chauhan, Sanu Saxena and Princie Agrawal, “Travelling Salesman Problem using Genetic Algorithm”, International Journal of Computer Applications(IJCA), 2012, pp. 25-30.

[2] Naveen kumar, Karambir and Rajiv Kumar, “A Genetic Algorithm Approach To Study Travelling Salesman Problem”, Journal of Global Research in Computer Science, 2012, Vol. 3, No. (3).

[3] Adewole Philip, AkinwaleAdioTaofiki and OtunbanowoKehinde, “A Genetic Algorithm for Solving Travelling Salesman Problem”, International Journal of Advanced Computer Science and Applications, 2011, Vol. (2), No. (1).

[4] Grötschel, M.; M. Jünger , G. Reinelt (1991), “Optimal Control of Plotting and Drilling Machines: A Case Study”, Mathematical Methods of Operations Research, Vol. 35, No. 1, (January, 1991), pp.61-84.

[5] Bland, R.E., D.E Shallcross (1989),” Large traveling salesman problem arising from experiments in X-ray crystallography: a preliminary report on computation”,Operations Research Letters, Vol. 8(3), pp. 125-128.

[6] Lenstra, J.K, RinnooyKan, A.H.G. (1975),” Some simple applications of the traveling salesman problem”, Operational Research Quarterly, Vol. 26, pp. 717–33.

[7] E. L. Lawler, J. K. Lenstra, D. B. Shmoys, The Traveling Salesman Problem: A Guided Tour of Combinatorial Optimization, NY: Wiley-Interscience,New York, 1985.Y.

[8] Ivan BrezinaJr.,ZuzanaCickova, “Solving the Travelling Salesman Problem using the Ant colony Optimization”, Management Information Systems, 2011, Vol. (6), No. (4).

[9] ButhainahFahran, Al-Dulaimi, and Hamza A. Ali, “Enhanced Traveling Salesman Problem Solving by Genetic Algorithm Technique (TSPGA)”, World Academy of Science, Engineering and Technology, 2008, Vol. (14).

[10] Milena Karova,VassilSmarkov,StoyanPenev,” Genetic operators crossover and mutation in solving the TSP problem”, International Conference on Computer Systems and Technologies - CompSysTech’ 2005.

[11] G. Syswerda, “Schedule Optimization Using Genetic Algorithms”, Davis, L. (Ed), Handbook of genetic algorithms, Van Nostrand Reinhold, New York, 1991,pp.332-349.

[12] E. L. Lawler, J. K. Lenstra, D. B. Shmoys, The Traveling Salesman Problem: A Guided Tour of Combinatorial Optimization, NY: Wiley-Interscience,New York, 1985.

[13] A. Simões, E. Costa, Using genetic algorithms to deal with dynamic environments: a comparative study of several approaches based on promoting diversity, The Proceedings of the Genetic and Evolutionary Computation Conference, San Francisco, CA: Morgan Kaufmann, New York, 2002.

[14] G.Gutin, AP.Punnen," The Travelling Salesman Problem and Its Variations", Kluwer Academic Publishers, 2004.

[15] H. Shah-Hosseini, 'The Time Adaptive Self-Organizing Map is a Neural Network Based on Artificial Immune System in Neural Networks", 2006. IJCNN, pp. 1007- 1014.