Solving Travelling Salesman Problem using Genetic Algorithm by Combining Greedy Approach and Ordered Cross Over

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Abstract— Travelling Salesman Problem (TSP) is a NP problem in graph theory in computer science. It is an optimization problem. Genetic Algorithm GA is an evolutionary algorithm that can solve TSP. In this paper a hybrid crossover technique by combining Ordered Crossover-1 (OX1) and greedy approach is proposed to solve TSP using Genetic Algorithm. The results shows that the proposed algorithm solve TSP in a better way as compared to the existing techniques.

Index Terms— Travelling Salesman Problem, Genetic Algorithm, Cross Over, Ordered Cross Over, Greedy Techniques.

I. INTRODUCTION

Travelling Salesman Problem (TSP) is a NP problem that is easy to describe but difficult to solve. In TSP a salesman have to visit a number of cities such that it must visit every city and each city must be visited only once. The problem is to find the tour the salesman should follow such that the path length should be minimum as compared to other possible routes. Figure-1 shows a simple TSP problem with 5 cities.

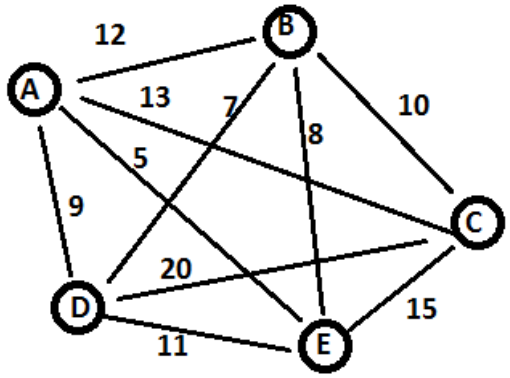

Figure-1 A sample TSP problem of five cities.

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As the number of cities increases then the number of possible tours also increases. If there are 16 cities to be visited then there will be 120 edges in the TSP and possible paths will be 653837184000 which is a very big number. Genetic Algorithm (GA) is an optimization techniques which uses special operators such as selection, reproduction and mutation to solve problems which are difficult to solve by using traditional techniques. The basic genetic algorithm is as follows:

Begin
INITIALIZE population with random solutions;
EVALUATE each candidate;
Repeat
SELECT parents;
RECOMBINE pairs of parents;
MUTATE the resulting children;
EVALUATE children;
SELECT individuals for the next generation;
Until TERMINATING-CONDITION is satisfied
End

II. LITERATURE SURVEY

Yang yi and Qian-sheng Fang [2] shows an im proved genetic algorithm for solving TSP using Handle-C. The author used a hybrid cross over using greedy approach to generate child. The method shows dreastic improvements in finding the solution of TSP. [1] Mei mi et.el. proposed TSP problem by improved differential evolution algorithm. The author proposed a auxiliary operator for mutation process. [3] Shakeel Arshad and Shengxiang Yang proposed an inner over cross over to solve TSP using genetic algorithm. The algorithm works on sub tours found in preveous population and next population will generated in keeping mind these sub tours. [4] Naveen Kumar et.el. proposed a comparative analysis of various cross over operators such as PMX, CX and OX. [5] Jun Li et.el. proposed a multiple TSP problem and its solution based on genetic algorithm. It incoded cities and salesman into two single chromosomes. Then it apply simple city crossover and mutation CCM to solve TSP.

III. ROPOSED WORK

In this paper a new hybrid cross over operator is proposed to generate new children from the parents. The hybrid operator combines the classical OX1 cross over operator and

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greedy approach to generate new children. Ordered cross over OX1 is a cross over operator used to generate new children from two selected parents. To represent travelling salesman problem, permutation encoding is used to represent chromosomes of the population. In permutation encoding every chromosome is a new permutation of all the cities that differ in the order in which cities are visited by the salesman. Here in this example there are 20 cities that are to be visited by the salesman and city-1 is the starting and ending city for the journey. Let two parent,parent-1 and parent-2 that will participate in the ordered cross over as follows:

Parent 1 : 1 13 3 15 8 14 20 12 19 6 7 16 4 18 11 17 5 2 10 9 1

Parent 2 : 1 18 3 19 9 8 13 10 5 17 4 2 12 6 20 16 11 14 15 7 1

Let cross over point is 11th city that is city-7 in parent-1.

Child 1 : 1 13 3 15 8 14 20 12 19 6 7 18 9 10 5 17 4 2 16 11 1

Child2 : 1 13 3 8 19 4 18 17 5 10 9 2 12 6 20 16 11 14 15 7 1

In greedy operation, a chromosome is rearranged according to nearest neighbor first greedy strategy. The distances among the cities are stored in a symmetric matrix. The cell (i,j)th cell in the matrix represent the distance between ith and jth city in the given travelling salesman problem. The distance matrix is generated randomly. The distance matrix is shown in figure – 2.

Distance Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1:	0	39	36	46	45	40	26	26	36	23	16	22	13	44	38	20	37	30	37	18
2:	39	0	30	27	26	19	14	27	12	33	19	28	33	40	33	47	39	25	34	33
3:	36	30	0	44	30	19	24	25	28	10	15	33	23	38	30	48	31	47	32	16
4:	46	27	44	0	28	40	42	20	25	47	47	15	36	13	34	37	48	33	33	47
5:	45	26	30	28	0	38	44	37	29	16	10	11	49	36	31	43	20	37	25	23
6:	40	19	19	40	38	0	17	16	19	26	21	35	46	35	12	48	47	24	43	12
7:	26	14	24	42	44	17	0	15	32	30	38	16	36	19	15	19	18	32	49	32
8:	26	27	25	20	37	16	15	0	35	43	41	29	24	15	17	43	29	48	16	46
9:	36	12	28	25	29	19	32	35	0	36	20	46	35	35	26	19	35	14	16	25
10:	23	33	10	47	16	26	30	43	36	0	36	19	26	11	27	19	31	45	15	21
11:	16	19	15	47	10	21	38	41	20	36	0	26	31	29	15	14	25	48	39	39
12:	22	28	33	15	11	35	16	29	46	19	26	0	36	35	14	27	38	37	15	10
13:	13	33	23	36	49	46	36	24	35	26	31	36	0	36	25	46	38	41	16	23
14:	44	40	38	13	36	35	19	15	35	11	29	35	36	0	16	28	39	15	12	14
15:	38	33	30	34	31	12	15	17	26	27	15	14	25	16	0	48	30	44	14	31
16:	20	47	48	37	43	48	19	43	19	19	14	27	46	28	48	0	20	42	19	20
17:	37	39	31	48	20	47	18	29	35	31	25	38	38	39	30	20	0	48	29	15
18:	30	25	47	33	37	24	32	48	14	45	48	37	41	15	44	42	48	0	27	36
19:	37	34	32	33	25	43	49	16	16	15	39	15	16	12	14	19	29	27	0	22
20:	18	33	16	47	23	12	32	46	25	21	39	10	23	14	31	20	15	36	22	0

Figure - 2 Distance matrix to store distances between all the cities in TSP.

Let path to perform the greedy operation are as follows

Parent Path :1 12 15 5 11 18 14 2 6 19 20 13 4 8 16 9 3 17 7 10 1

To generate a greedy path we select a portion of 10 cities from the parent path randomly. For this we select a city position randomly and then arrange the next 10 cities using greedy approach.

Let pos=6. So we arrange cities from 14(7th city) to city 9 (16th city) using greedy approach. First we copy the new greedy path from first city to city at pos 6 and from 16th city to last city. For example.

Greedy child = 1 12 15 5 11 18 - - - - - - - 3 17 7 10 1

Then we select the remaining 10 cities according to greedy approach. So we set current city 18 and then find a city which is nearest to city 18 from the remaining cities (14 2 6 19 20 13 4 8 16 9). By using distance matrix we find that city 19 is at minimum distance from city 18 among remaining cities. So we select city 19 after 18. Thus the child will be

Greedy child = 1 12 15 5 11 18 19 - - -- - 3 17 7 10 1

Now we set current city 19 and then find a city which is nearest to city 19 from the remaining cities (14 2 6 20 13 4 8 16 9). By using distance matrix we find that city 9 is at minimum distance from city 19 among remaining cities. So we select city 9 after 19. Thus the child will be

Greedy child = 1 12 15 5 11 18 19 9 - -- - 3 17 7 10 1

We follow the same process till all the remaining cities are not visited. Thus the complete child generated using this approach will be.

Greedy child = 1 12 15 5 11 18 19 9 14 20 13 2 6 16 4 8 3 17 7 10 1

The proposed algorithm to generate child using greedy approach is as follows :

Algorithm : Generate-Greedy-Child (Parent-1,Parent-2,Child)

Input : Parent-1,Parent-2

Output : Child

Step-1 : Select any portion of 10 cities from a parent path starting from a position pos to position pos+10 and copy these in to a list named list_of_remianing_cities.

Step-1 : Copy all cities from first city to city at pos into child.

Step-2 : Select a city at position pos and set it as current_city.

Step-3 : Select next_city from list_of_remianing_cities that is at minimum distance from current_city. Add the next_city in child and remove the next_city from list_of_remaining_cities.

Step-4 : Set current_city = next_city and repeat step-3 until list_of_remianing_cities is not empty.

Step-5 : Return child.

The above algorithm is used to generate child using greedy approach of nearest neighbor first. The proposed genetic algorithm using a hybrid of OX1 cross over and greedy operator is as follows:

Algorithm : Genetic Algorithm for solving travelling salesman problem using hybrid of Ordered Cross Over -1 (OX1) and greedy cross over operator.

Step-1: Generate a random initial_population of chromosomes using permutation encoding.

Step-2: Calculate fitness (Path Length) of every chromosome of initial_population.
Step-3: Repeat step-4 to step-7 for given number of generations (iterations).
Step-4: Select parents from initial_population using random selection for cross over.
Step-5: Perform ordered cross over OX1 and Greedy_Cross_Over to generate children from parents.
Step-6: Calculate fitness of all newly generated children of step 4. Add newly generated children in initial_population.
Step-7: Sort combined population initial_population + new_children by path length and select best chromosomes for next_population. Set initial_population = next_population and go to step-4.
Step-8: Stop

IV. RESULT ANALYSIS

In this work the classical OX1 cross over operator is combined with greedy cross over operator. After implementing the classical OX1 operator and new combined (OX1 and greedy) following results have been found.

Table 1 Path length of best path using existing work and proposed new work

Iteration Count	Path length of best path using OX1 (Existing Work)	Path length of best path using Combined OX1 and Greedy cross over operation (Proposed Work)
1	764	630
2	764	630
3	758	616
4	758	613
5	691	595
6	691	595
7	681	572
8	681	551
9	681	551
10	681	551
20	662	540
30	662	540
40	627	540
50	623	540

It has been observed that path length of best path is 623 using existing OX1 cross over and 540 using proposed approach.

The path length is 83 unit less using proposed work as compared to existing work (623-540=83). So path length of best path is 15% better than the existing work.(83 is 15% of 540). So our work is 15% better than the existing work. Figure 5.8 shows a graphical comparison between two techniques.

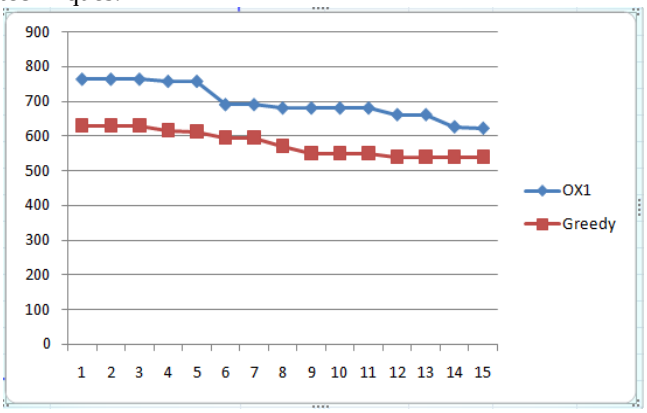

Figure - 3 Graphical comparison of existing work and proposed work.

V. CONCLUSION AND FUTURE WORK

Genetic algorithm is an evolutionary algorithm that can solve an optimization problem such as TSP. Selection, cross over and mutation are the GA operators that controls the working of genetic algorithm. Greedy approach can also be used to optimize the performance of the cross over operator to generate children in genetic algorithms. This work conclude that Ordered Cross Over -1 (OX1) and greedy approach can be combined to improve the performance of genetic algorithm to solve TSP. In future some well known TSP problems such as as Oliver30, eil51, eil76 can also be solved using the proposed cross over operator.

REFERENCES

[1] Mei Mi et.el. , "An Improved Differential Evolution Algorithm for TSP Problem", 2010 International Conference on Intelligent Computation Technology and Automation, 978-0-7695-4077-1/10 $26.00 © 2010 IEEE
[2] Yang yi and Qian-sheng Fang, "The Improved Hybrid Genetic Algorithmfor Solving TSP Based on Handel-C", 20IO 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE), 978-1-4244-6542-2/$26.00 © 2010 IEEE
[3] Shakeel Arshad et.el. "A Hybrid Genetic Algorithm and Inver Over Approach for the Travelling Salesman Problem", Engineering and Physical Sciences Research Council (EPSRC) of the United Kingdom under Grant EP/E060722/1. 978-1-4244-8126-2/10/$26.00 ©2010 IEEE
[4] Naveen Kumar et.el. ," A Comparative Analysis of PMX, CX and OX Crossover operators for solving Travelling Salesman Problem" , International Journal of Latest Research in Science and Technology ISSN (Online):2278-5299 Vol.1,Issue 2 :Page No.98-101 , July .August (2012)
[5] Jun Li et.el. ," A New Multiple Traveling Salesman Problem and its Genetic Algorithm-based Solution", 2013 IEEE International Conference on Systems, Man, and Cybernetics, 978-1-4799-0652-9/13 $31.00 © 2013 IEEE

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