

Modified Greedy Methodology to Solve Travelling Salesperson Problem Using Ant Colony Optimization and Comfort Factor

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Abstract- Travelling Salesperson Problem is a problem where the user has to visit all the cities by using the shortest distance. It is an NP-hard problem in combinatorial optimization, important in operations research and theoretical computer science. TSP is a special case of the travelling purchaser problem. By representing this problem in graphical method we see that it is nothing but a complete graph where user has to visit all the nodes using the shortest distance. Scientist have found that biological ant has an excellent behavior by which they always choose the shortest way between the source and the destination although there are several ways between them. Using these behavior of the biological ant we describe an artificial ant colony capable of solving the traveling salesman problem (TSP). Ants of the artificial colony are able to generate successively shorter feasible tours by using information accumulated in the form of a pheromone trail deposited on the edges of the TSP graph. In this paper we have proposed a new heuristic method by which TSP can be solved.

Index Terms- Ant colony optimization, ant colony system, heuristic function, TSP, Comfort Factor.

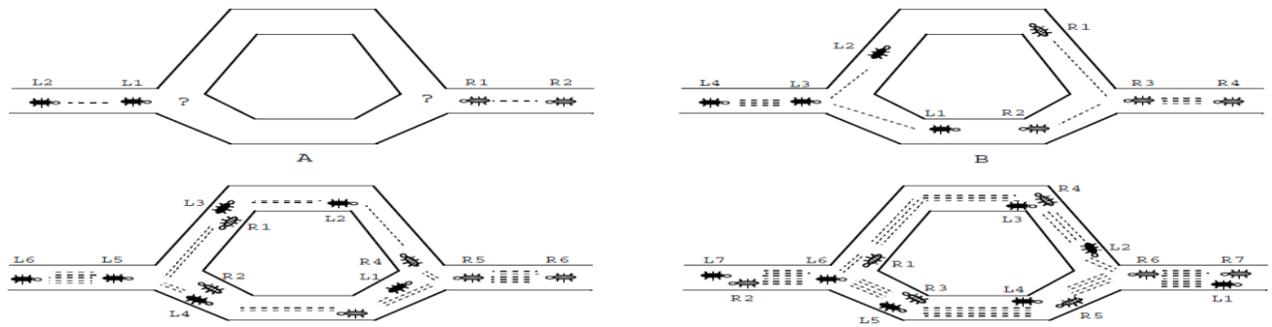
I. INTRODUCTION

Travelling salesperson problem was first formulated in 1930 and is one of the most intensively studied problems in optimization. It is basically an NP-Hard problem where the traveler has to travel all the cities only once and return back to the starting city and has to complete this entire tour in the shortest distance. ACO was first invented by Marco Dorigo and it was totally inspired by the biological behavior of the ants. Scientist have found that biological ant always choose the shortest way between two given points although there may be several ways between these points. Biological ants basically found the shortest path based on the pheromone trail which they deposit on the path during traversal. Pheromone is nothing but a chemical substance which the ant basically use for their communication. Based on this concept we have developed a technique where the shortest path can be founded in TSP. We all know that TSP has already been solved using the general branch

and bound method. The result that we get from it is the optimal solution but the time to solve TSP in this method is not in the polynomial time. Scientist have then proposed this ACO method to solve the TSP where the solution may or may not be optimal but it should be a granted or good solution and the time taken by this method is in polynomial time. But all these methods simply neglected importance of the heuristic value that is nothing but the distance between the vertices of the graph. Another thing that has been completely neglected is the comfort factor. It is not necessary that the path which is the shortest or shorter than the other path should be the most comfortable path. So this new method could be a good choice to find out a preferable short path by considering the heuristic parameter and the comfort factor in the probability function.

II. ARTIFICIAL COLONY OF AGENTS

In this work artificial ants basically work as 'agent' which travel from one node to another node in a TSP graph. It chooses the city to move to using a probabilistic function both of trail accumulated on edges and of a heuristic value, which was chosen here to be a function of the edges length. It is the common tendency of the agents that they move where ever they find the probabilistic function higher. In each iteration at first the values of the probability function is modified. Before invoking the graph the values of the probabilistic function are set. Random function is used to choose the first node of the path in every iteration. Once the starting node is chosen ants follow the ways which has the higher value of the probability. Random function is used for giving the opportunity to explore more ways in the graph. During each traversal they modify the pheromone trail on the edges of the graph. This is termed as "Local pheromone updating". After all the ant finished their solution in a particular colony then the path that has been chosen by most of the ant is consider as the best path for that colony and a amount of pheromone is deposited on that path. This is called as "Global pheromone updating".



III. ACS

Agents or artificial ants play an important role in ACS. In ACS, artificial ants follow the route which has richer pheromone density. The pheromone is updated based on the local and global pheromone update rules. In the ACS algorithm, ants apply exploitation and exploration mechanisms when they select the next city to move to. The global update is calculated based on the quality of the best tour so far while local update applies the evaporation concept. But ACS basically suffers from a deficiency in the heuristic function update. ACS focuses only on the pheromone update rules and completely neglects the values between the edges that is the heuristic value. ACS uses this heuristic value in the probability function to choose the next node. This heuristic part is not updated throughout the process. This is a contradiction of the process. The term heuristic comes from Greek which means "To Discover". Therefore, some modification is required in the ACS so that this heuristic value is updated every time a colony finds a good solution. This also helps to rise the value of the probability function and as a result the ant takes less time to choose the path.

IV. COMFORT FACTOR

In this work, we have implemented another factor named the comfort factor along with the probability distribution factor and the heuristic factor. Research for solving the TSP in polynomial time is going on for so many days. But in most of the research works, the scientists have completely neglected the length of the path value between the nodes. One other thing that has been totally neglected is the comfort factor. It is always not necessary that the shortest path should be the most comfortable path. More number of breaks in the path, more it becomes uncomfortable. In this approach, we have also taken the comfort factor into consideration. More number of junction nodes in the path, less is the comfort. But in the travelling salesperson problem, the ant or the artificial agents have to traverse the entire path. But during choosing the path for the first time, it takes more time than choosing the path for the next time. Because as the pheromone level rises, the probabilistic function also rises. So it becomes more comfortable for the ant to choose the path for the second time rather than choosing for the first time. By adding the comfort factor in the probabilistic function, we are sending a message to the next colony of artificial agents that the previous colony has already found a suitable way. So more and more ants will be attracted to that way. If the next colony ants choose the previous way that is already chosen by the previous colony ants,

then the time taken in this case will be shorter than the previous one. The comfort factor will play a part in the probabilistic function that the ant will use for choosing the path. Here μ is nothing but the inverse of the path length; we use this parameter because path length is a very important factor in case of TSP.

Comfort Function

Step 0: for each path chosen by a colony, do step 1 to 2

Step 1: if path i ($i = 1, 2, n$) is falls in the best tour, do step 2

Step 2: $\mu_i = \mu_i + \xi/\alpha$

Where α is the path length.

Where ξ (Comfort_Factor) is some value between (0-10)

End

V. GREEDY ACS WITH COMFORT FACTOR

Ants will be randomly distributed over the graph. Ants choose their ways on a random basis. After choosing the first node based on the probability function, they choose the next node. The probability function is totally based on the concentration of the pheromone and the inverse of the distance between the nodes that is called the heuristic function. After each colony makes a solution, local pheromone update is done. After the local pheromone modification is done, the path that is followed by most of the ants is chosen as the best path for that colony. Global pheromone update has been done on that particular path that has been chosen by most of the ants. After that, a counter is assigned to that path. If for the next time that path is again considered as the global best path in the upcoming iteration, that counter is increased. After that, the comfort function is fired. This comfort factor will rise the value of the probability function when the second colony of ant will start their tour. As the value of the probability factor rises, so the next colony of ant will take less time to choose that path. When all the colonies have finished their traversal, the path which has the highest counter value is considered as the best path for all the colonies.

Algorithm

Step 1: Initialize Ant array, Map array, Path array, initialize counter

Step 2: Set pheromone array

Step 3: Create ant in the Ant array.

Step 4: Set the no of colonies

While (Iteration < The no of colonies)

Do

While (Each of the ant don't traversed through a path)

Do step 4-10

Step 4: Each ant use random function to chose the starting node

Step 5: Each ant use probability function to choose the next node

Step 6: local pheromone update done after each ant complete the tour

Step 7: Select the path that has been traversed by highest no of ants

Step 8: Apply global pheromone update on that path

Step 9: Increase the counter for that path

Step10: **Apply Comfort_factor_function**

End-While

Step 11: Start iteration for next colony

End-While (Outer)

Step 12: Apply Greedy Function

Step 13: Chose the path that has largest counter value

End-Procedure

Consider the following complete graph :-

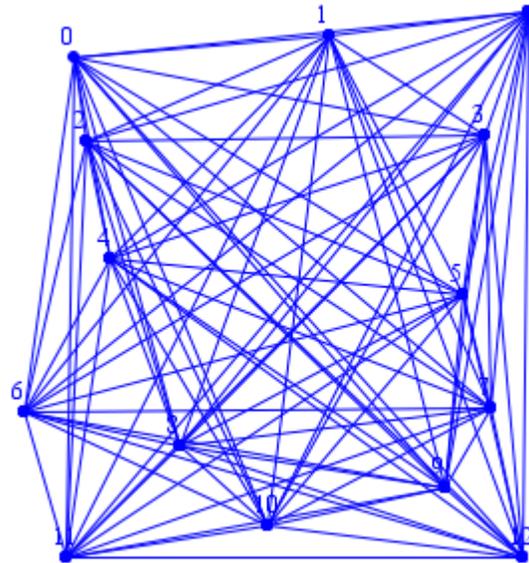


Fig:1

VI. EXPERIMENT AND RESULTS

Two scenarios has been considered in our work. During choosing the path random function are used for giving the agents freedom to discover new ways between the vertices of the graph. The path that has been traversed by most of the ants is chosen as the best solution for that colony. But that solution will only be considered as the best solution if it is shorter than the other solution. Results has been found that the best solution always have shorter length than the other solution . The procedure is explained below with the help of an example

Result of The First Iteration

Ants	Path	Path Length
0	2-->0-->1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->	1000
1	1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->	932
2	3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13	995
3	6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->10-->8-->11	985
4	7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->	1002
5	0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1	932
6	13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->	960
7	9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->	1008

8	3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13	995
9	3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13	995

Path Traversed By Most Of The Ants : 3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13--> Distance:- 995

Shortest Path Chosen By The Ants :- 3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13--> Distance:- 995

Result Of The Second Iteration

Ants	Path	Path Length
0	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
1	10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->	1001
2	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008
3	9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->	1008
4	7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->	1014
5	2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->	1018
6	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008
7	8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->	981
8	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
9	10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->	1001

Path Traversed By Most Of The Ants : 12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9--> Distance :- 1008

Shortest Path Chosen By The Ants :- 3--->5--->7--->9--->12--->10--->8--->11--->6--->4--->2--->0--->1--->13---> Distance:- 995

Result Of The Third Iteration

Ants	Path	Path Length
0	8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->10	1001
1	7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->	1002
2	5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3	980
3	0-->1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->	1018
4	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008
5	2-->0-->1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->	1000
6	6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->	985
7	1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->	932
8	7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5	1002
9	8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->10-->	1001

Path Traversed By Most Of The Ants:- 12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9--> Distance:- 1008

Shortest Path Chosen By The Ants :- 3--->5--->7--->9--->12--->10--->8--->11--->6--->4--->2--->0--->1--->13---> Distance:- 995

Result of The Fourth Iteration

Ants	Path	Path Length
0	3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13	995
1	2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->	1018
2	7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->	1014
3	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
4	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
5	13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->	995
6	10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->	1001
7	1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13	960
8	4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->	1000
9	10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->	1001

Path Traversed By Most Of The Ants:- 6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4--> Distance:-972

Shortest Path Chosen By The Ants :- 6--->11--->8--->10--->12--->9--->7--->5--->3--->13--->1--->0--->2--->4---> Distance:-972

Result of The Fifth Iteration

Ants	Path	Path Length
0	10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->	932
1	10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->	932
2	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008
3	9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->	1008
4	1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->0	932
5	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008
6	4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->	1000
7	8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->	981
8	7-->9-->12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->	1002
9	1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13	960

Path Traversed By Most Of The Ants:- 10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12--> Distance is 932

Shortest Path Chosen By The Ants 10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12--> Distance is 932

Result Of The Sixth Iteration

Ants	Path	Path Length
0	10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->	932
1	10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->	1001
2	4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->	1000
3	1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13	960
4	7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->	1014
5	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
6	1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13	960
7	0-->1-->13-->3-->5-->7-->9-->12-->10-->8-->11-->6-->4-->2-->	1018
8	7-->5-->3-->13-->1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->	1014
9	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008

Path Traversed By Most Of The Ants: 1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13

Distance:-960

Shortest Path Chosen By The Ants 10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->12-->

Distance is 932

VII. DISCUSSION & CONCLUSION

From above result it is clear that in each iteration the path that has been traversed by most of the ants is consider as the best solution(local) for that colony but then its path length is compared and checked that whether it is shorter than the previous global best solution or not . If it is shorter than the previous global best solution then it is consider as the new global best solution and the global pheromone update function as well as the heuristic function is fired on that path. We have taken 200 iteration of the given graph and it is found that at the end of the iteration among all the paths that has been chosen by the ants the shortest path is consider as the global best solution in most of the cases.

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REFERENCES

- [1] R. Wankar, Grid computing with Globus: An overview and research challenges,International Journal ComputerScience and Applications, vol. 5(3), 2008,pp. 56-69.
- [2] F. Magoules, J. Pan, K. A. Tan andA. Kumar, Introduction to grid computing. Boca Raton, FL: Taylor & Francis Group, 2009
- [3] S.C.Lin, and E.Yen, Grid Computing(International Symposium on Grid Computing. New York, USA: Springer, 2009.

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