IJCSN International Journal of Computer Science and Network, Volume 3, Issue 3,June 2014 **Impact Factor – 0.274**
ISSN (Online) : 2277-5420
www.IJCSN.org

Advanced Heuristic Technique for Solving Travelling Salesperson Problem Using Ant Colony Optimization

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Abstract- Travelling Salesperson Problem is a problem where the user have 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 have to visit all the nodes using the shortest distance. Scientist have found that biological ant have 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**.**

Keywords - *Ant colony optimization, ant colony system, heuristic function.,TSP.*

1. 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 have to travel all the cities only once and return back to the starting city and have 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. So this new method could be a good choice to find out a preferable short path by considering the heuristic parameter in the probability function.

2. 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 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".

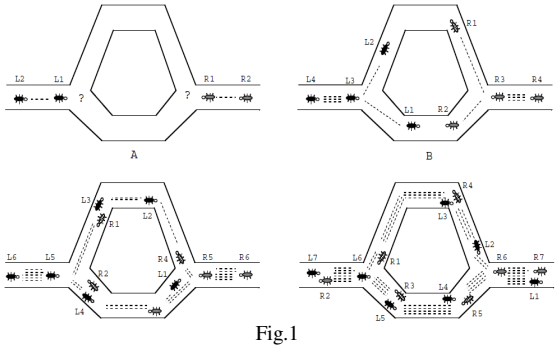

Fig.1

3. ACS

Agents or artificial ants plays important role in ACS. In ACS artificial ants follows the route which has richer pheromone density. The pheromone are updates based on the local and global pheromone update rules. In 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 evaporation concept. But the ACS basically suffers from a deficiency in the heuristic function update. ACS focuses only on the pheromone update rules and completely neglect 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 required in the ACS so this heuristic value is updated every time a colony found a good solution. This also helps to rise the value of the probability function and as a result the ant takes lesser time to chose the path.4.

4. Updated Heuristic Function

Up gradation of the ACS has been proposed by many scientist in their studies. In their studies they proposed many ideas to enhance the performance of ACS. But most of the researchers only concentrate on the pheromone function and totally neglected the heuristic value. In general it can be showed that TSP is nothing but a complete graph consisting of set of edges and vertices. Ant starting from a particular node needed to be guided that which path it should follow if multiple option is there. Scientist proposed a probability factor to attract more and more ants on the most desirable path. This probability factor depends mostly on two factors pheromone concentration (τ) and inverse of the path length (μ) between the vertices. Inverse of the path length that is basically consider as the heuristic value is taken because that will rise the value of the probability function for the shortest path. The new heuristic function will update the heuristic value every time a colony of ants find a solution in the iteration. This is basically done to change the status of the graph when it will be again given as input to the next colony. Each time a colony finds out a solution the global pheromone update is done to attract more and more ants to that particular path in the next iteration. Pseudo code for the new heuristic function is

Step0: for each path chosen by a colony do step 1 to 2
Step1: if path i (i = 1, 2, n)is falls n the best tour
do step 2
Step2: $\mu i = \mu i + £$
Where £ is some value between (0-10)
End

By applying this function, the heuristic values will change according to the quality of the best-so far solution. This change will be reflected in the graph. So the ant took less time to chose the path and it become possible to rise the value of the probability function that help the ant to chose the desire path. The modification that is done in the algorithm is the new heuristic function after the global pheromone update.

Procedure Modified_ACS
Initialize parameters
While (each colony does not create the solution) do
Construct Ants Solutions
Apply Local Pheromone Update
End – While
Choose the path through which most ant has traversed
If (New AntPath better than Global Best Solution)Global Best Solution = New Ant Solution
Apply Global Pheromone Update
Apply New Heuristic Function
End – Procedure

5. Modified ACS

Ant will be randomly distributed over the graph. Ant chose the their ways on random basis. After choosing the first node based on the probability function they chose the

next node. The probability function is totally based on 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 updation 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 . The path is then compared with the previous best solution if the solution is better than the previous one then the current solution is chosen as the best solution and global pheromone modification is done on the path. After the global pheromone modification the new heuristic function is fired on the best solution. Due to this function the value of the probability function rises and the ant find easy to choose that path again during the next iteration.

Procedure
Step 1:Initilize Ant array,Map array,Path array
Step 2: Set pheromone array
Step 3: Create ant in the Ant array.
While(Each of the ant don't traversed through a path)
Do step 4-11
Step 4:Each ant use random function to chose the starting node
Step 5:Each ant use probability function to chose 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: If(this solution is better than the previous solution)
Do Step 9
Step 9:Global Best Solution=New ant solotuion
Step 10:Apply Global Pheromone update
Step 11: Apply Heuristic update
End-While
End-Procedure

6. 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

Consider the following complete graph :-

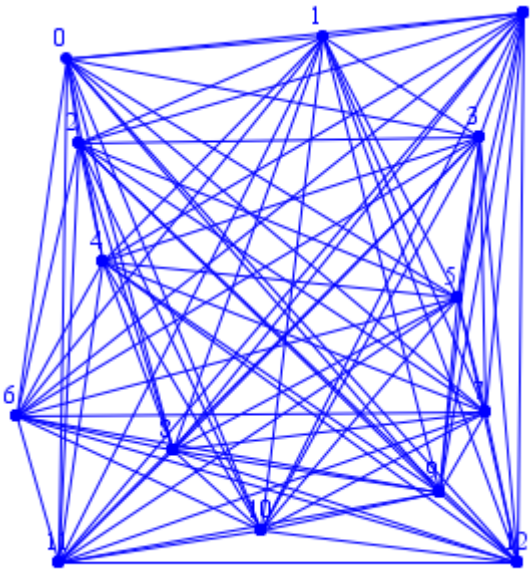

Fig:2

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 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 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 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 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 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

8. 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.

Acknowledgments

At first I want to thank my mentor Mr Kaushik Banerjee for giving me an excellent opportunity to work with him. I want to thank him again for his excellent guidance towards my work. I gratefully acknowledge Prof Himadri Nath Saha for his valuable guidance; support to set my goal and the valuable advice for the way to achieve the goal,without his suggestions, this thesis would not been possible. Last but not the least, I deeply express my gratitude to my parents who had struggled a lot in life right from my childhood to bring me to the position what I am now.I dedicate this thesis to them.. . .

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.