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A Greedy Methodology to Solve Travelling Salesperson Problem Using Ant Colony Optimization

[1]Wrishin Sarkar, [2]Himadri Nath Saha, [3]Arpita Ghosh

[1, 2, 3]Computer Science & Engineering, West Bengal University of Technology, Kolkata, West Bengal, India

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 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 this 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 greedy method by which TSP can be solved.***

Keywords: Ant colony optimization, ant colony system, greedy 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 has 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 uses 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.

2. Artificial 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".

3. Modern ACS

Agents or artificial ants plays important role in ACS. In ACS artificial ants follows the route which has richer pheromone density. The pheromone is 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. We have seen that ACS uses the greedy the approach for choosing the path but it neglects that approach during the final selection of the path. The new greedy function chooses that path which has been selected for the most of the time in several colonies. This approach has been totally influenced by the biological behavior of the ant. In nature we see that the path that has been chosen by most of the ant is considered to be the best path. Same approach has been used here but we have used several colonies for getting more accurate results.

4. The Greedy Approach

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. The greedy approach has already been used in ACS in terms of pheromone concentration. 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 considered as the heuristic value is taken because that will raise the value of the probability function for the shortest path. In this greedy approach the path that has been chosen by most of the ants in their during their traversal in their respective colonies is considered to be the best path in that particular colony. The greedy function at the last of the algorithm calculates which path has been chosen for the most of the time in several colonies. That path is considered to be the best path for all the colonies.

5. Modified Greedy 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. Global pheromone updation has been done on that particular path that has been chosen by most of the ant. 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. When all the colonies has finished their traversal the path which has the highest counter value is consider as the best path for all the colonies.

Procedure

Step 1: Initilize 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 4-9
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
End-While
Step 10: Start iteration for next colony
End-While (Outer)
Step 11: Apply Greedy Function
Step 12: Chose the path that has largest counter value
End-Procedure

6. Experiment and Results

ACO is an algorithm that has been inspired by the biological behavior of the ant. In nature we always see that biological ant always follow the greedy method for choosing their ways. In this procedure we have used that property of the biological ant. Since it is quite natural that in the probabilistic function as there are two parameters the concentration of the pheromone and the inverse of the path length and we are using multiplication of these two parameters two calculate the probability , the value of the probability always rise for the path that has the shorter path length. Since the ant use greedy approach to choose the way, it is quite natural that most of the time they will be attracted to the shorter way. The procedure is explained below with the help of an example.

Consider the following complete graph:

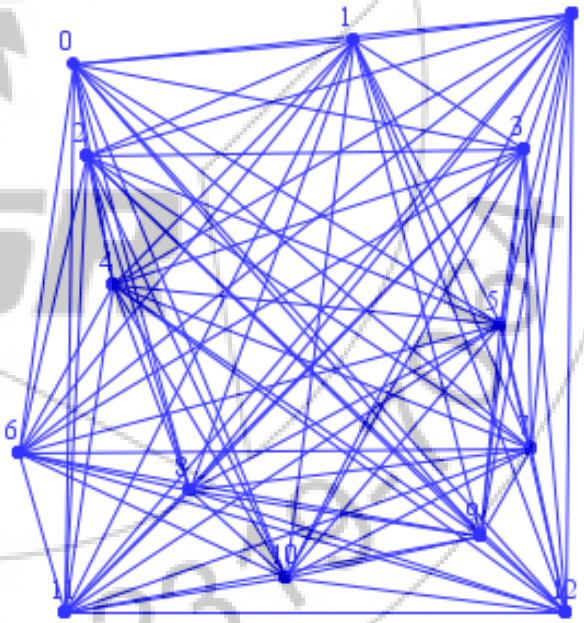

Figure 1

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

Counter value for the path having path_length 995 is - > 1

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
Counter value for the path having path_length 1008 is - > 1

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	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
6	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
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:- 6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->
Distance: - 972

Counter value for the path having path_length 972 is - > 1

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	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
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
Counter value for the path having path_length 972 is - > 2

Result of the Fifth Iteration

Ants	*Path*	*Path Length*
0	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
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	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
5	12-->10-->8-->11-->6-->4-->2-->0-->1-->13-->3-->5-->7-->9-->	1008
6	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
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:- 6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4--> Distance is 972
Counter value for the path having path_length 972 is - > 3

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	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
3	1-->0-->2-->4-->6-->11-->8-->10-->12-->9-->7-->5-->3-->13	960
4	6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->	972
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: 6-->11-->8-->10-->12-->9-->7-->5-->3-->13-->1-->0-->2-->4-->
Distance: 972

Counter value for the path having path_length 972 is - > 4

7. Discussion and 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 after that global pheromone has been updated on that path and the counter value increased. If that path is again selected by most of the ants in the next colony iteration then again the counter is increased and so on. We will see that in most of the cases the ant chooses the shorter way and sometimes the shortest. Our solution in this algorithm does not always guarantee that the solution that we get will be always the optimum solution. But the solution should be a good solution. We have taken 200 iteration of the above graph and found that the path having path length 972 achieved a counter value of 60 and it is considered as the solution of the algorithm in greedy approach.

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