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Implementation of Travelling Salesman Problem Using ant Colony Optimization

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ABSTRACT
Within the Artificial Intelligence community, there is great need for fast and accurate traversal algorithms, specifically those that find a path from a start to goal with minimum cost. Cost can be distance, time, money, energy, etc. Travelling salesman problem (TSP) is a combinatorial optimization problem. TSP is the most intensively studied problem in the area of optimization. Ant colony optimization (ACO) is a population-based metaheuristic that can be used to find approximate solutions to difficult optimization problems. There have been many efforts in the past to provide time efficient solutions for the problem, both exact and approximate. This paper demonstrates the implementation of TSP using ant colony optimization(ACO).The solution to this problem enjoys wide applicability in a variety of practical fields.TSP in its purest form has several applications such as planning, logistics, and manufacture of microchips, military and traffic.
KEYWORDS: Ant colony optimization, Metaheuristic, Travelling salesman Problem, pheromone update, Hamiltonian cycles

I. LITERATURE REVIEW:

The Travelling Salesman Problem (TSP) is a problem in combinatorial optimization. Given a list of cities and their pair wise distances, the task is to find a shortest possible tour that visits each city exactly once.

It is one of the most intensively studied problems in optimization. The problem was first defined in the 1800s by the Irish mathematician W.R. Hamilton and the British mathematician Thomas Kirkman.It was, however, first formulated as a mathematical problem only in 1930 by Karl Menger.The name *Travelling Salesman Problem* was introduced by American HasslerWhiteney. The origin of TSP lies with Hamilton's Icosian Game, which was a recreational puzzle based on finding a Hamiltonian cycle.Richard M. Karp showed in 1972 that the Hamiltonian cycle problem was NP-complete, which implies the NP-hardness of TSP. This supplied a mathematical explanation for the apparent computational difficulty of finding optimal tours.

Travelling Salesman Problem can be analyzed using traditional techniques like Branch-Bound algorithm.

II. INTRODUCTION:

The travelling salesman problem (TSP) is the problem of finding a shortest closed tour which visits all the cities in a given set. Travelling salesman problem (TSP) is one of the well-known and extensively studied problems indiscrete or combinational optimization and asks for the shortest roundtrip of minimal total cost visiting each given city (node) exactly once. Now days these traditional methods are not adaptive to real time. So as to make it dynamic, artificial intelligence techniques like Genetic algorithm, Neural Network, Ant Colony Optimization(ACO) and Particle Swarm Intelligence can be used.Ant colony optimization (ACO) belongs to the group of meta heuristic methods.

The proposed approach exploits a number of ants, which move on the paths driven by the local variation.This research paper demonstrates the use of ant colony optimizationtechnique in The Travelling Salesman Problem. It is simulated in MATLAB and results have been discussed accordingly.

A. TRAVELLING SALESMAN PROBLEM

TSP is an NP-hard problem and it is so easy to describe and so difficult to solve.

The definition of a TSP is: given *N* cities, if a salesman starting from his home city is to visit each city exactly once and then return home, find the order of a tour such that the total distances (cost) travelled is minimum.The data consist of weights assigned to the edges of a finite complete graph, and the objective is to find a Hamiltonian cycle, a cycle passing through all the vertices, of the graph while having the minimum total weight.

In the TSP context, Hamiltonian cycles are commonly called tours.

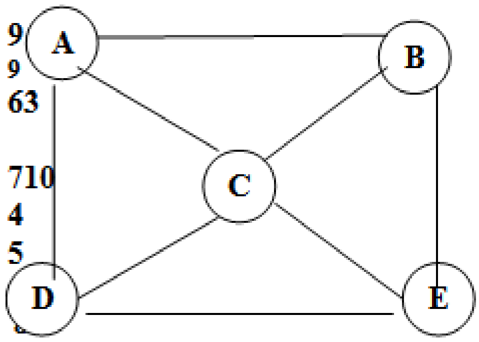


Fig. 1. The tour with A=>B =>C =>E =>D => A is the optimal tour

Different instances of the TSP are also divided into different classes based on the arrangement of distance between the cities or the type of graph in concern. In the Symmetric TSP, the distance between two cities is the same in each direction, forming an undirected graph.This symmetry halves the number of possible solutions. In the Asymmetric TSP, paths may not exist in both directions or the distances might be different, forming a directed graph.Hence, the number of tours in the ATSP and STSP on n vertices (cities) is (n-1)! and (n-1)!/2, respectively.

A complete weighted graph G= (N, E) can be used to represent a TSP, where N is the set of n cities and E is the set of edges (paths) fully connecting all cities. Each edge *(i,j)∈E* is assigned a cost *dij*, which is the distance between cities i and j. *dij*can be defined in the Euclidean space and is given as follows:

$$dij = \sqrt{(xi - xj)^2 + (yi - yj)^2}$$

The most popular practical application of TSP are regular distribution of goods or resources, finding of the shortest of costumer servicing route, planning bus lines etc., but also in the areas that have nothing to do with travel routes.

B.ANT COLONY OPTIMIZATION

The base of ACO is to simulate the real behaviour of ants in nature. An ant colony provides indirect communication with the help of pheromones, which ants excrete. Pheromones are chemical substances which attract other ants searching for food.

The attractiveness of a given path depends on the quantity of pheromones that the ant feels. Pheromones excretion is governed by some rules and has not always the same intensity therefore changes with time. The quantity of pheromones depends on the attractiveness of the route. The use of more attractive route ensures that the ant excrete more pheromones on its way back and so that path is more also attractive for other ants. The characteristic of pheromones is evaporation.

C.ACO MODEL

Ant System was first introduced and applied to TSP.Initially, *m* artificial ants are placed on randomly selected cities.

- At each time step they move to new cities and modify the pheromone trail on the edges used – this is known as *local trail updating*.
- When all the ants have completed a tour the ant that made the shortest tour modifies the edges belonging to its tour –known as *global trail updating*– by adding an amount of pheromone trail that is inversely proportional to the tour length.

An ant k currently at city i choose to move to city j by applying the following probabilistic transition rule:

The probability rule between two nodes i and j, called Pseudo-Random-Proportional Action Choice Rule, depends on two factors: the heuristic and metaheuristic.

$$p_{ij} = \frac{[\tau_{ij}]^\alpha [\eta_{ij}]^\beta}{\sum_{h \in s} [\tau_{ij}]^\alpha [\eta_{ij}]^\beta} \quad \text{-----------(1)}$$

where τ is the pheromone, η is the inverse of the distance between the two cities, q is a random variable uniformly distributed over [0, 1], q0 is a tunable parameter in the interval [0, 1], and J belongs to the candidate list and is selected based on the above probabilistic rule.

Each ant modifies the environment in two different ways, Dorigo (1999)[4]:

A*. *Local trail updating: As the agent moves between cities it updates the amount of pheromone on the edge by the eq (4):

$$\tau_{ij}(t) = (1-\rho).\tau_{ij}(t-1) + \rho.\tau_0 \quad \text{--------(2)}$$

where, ρ is the evaporation constant. The value τ_0 is the initial value of pheromone trails and can be calculated as

$$\tau_0 = (n.L_{nn})^{-1} \quad \text{-----------(3)}$$

where, n is the number of cities and L the length of the tour produced by one of the construction heuristics.

B. *Global trail updating:* When all agents have completed a tour the agent that finds the shortest route updates the edges in its path using the following equation:

$$\tau_{ij}(t) = (1-\rho).\tau_{ij}(t-1) + \frac{\rho}{L^+} \quad \text{---------(4)}$$

where, $L^+$is the length of the best tour generated by one of the agents.

Fig. 2 shows a pseudo code of the general procedure in an Ant Colony Optimization metaheuristic.

Set parameters, initialize pheromone trails
While termination conditions not met do
Construct Ant Solutions
Apply Local Search (optional)
Update Pheromones
end while

III. RESULTS

A. **By considering five cities and five ants**

- **INPUT(DISTANCE VS CITIES)**

Fig.3 shows the distances between various cities.This graph represents number of cities by "X AXIS" and distances between cities by "Y AXIS".

This research paper has considered that number of ants is equal to the number of cities.

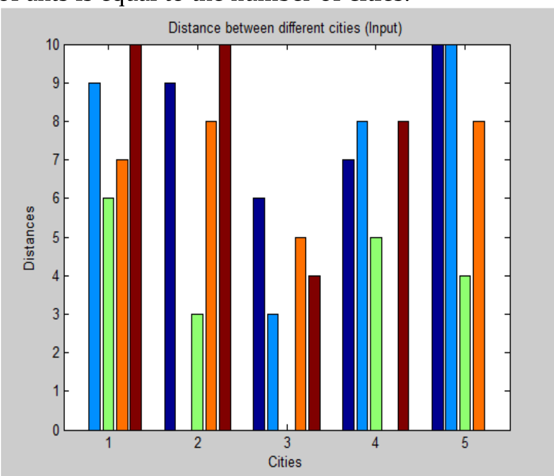


Fig.3

- **OUTPUT1 (OPTIMAL TOURS VS ITERATIONS)**

Fig.4 has been plotted by considering no.of ants and no. of cities equals to 5.Here "X-AXIS" represents the no.of iterations and "Y-AXIS" represents optimal tours for each iterations.

This graph has been plotted by considering no.of iterations equals to 10. Since in maximum iterations the output is 31,so this paper has considered optimal output equals to 31.

- **OUTPUT2(BEST TOUR)**

Fig.5 shows the minimum path length having considered between various cities.

So the output, that is optimal tour is from city2 - city3 - city5 - city4 - city 1.

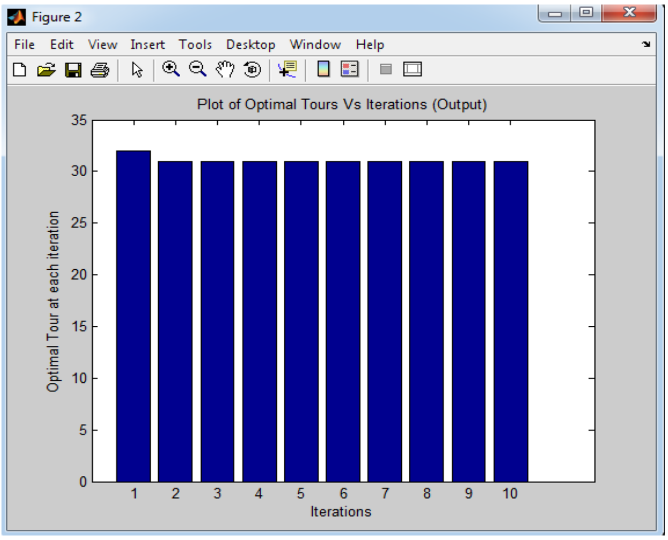


Fig.4

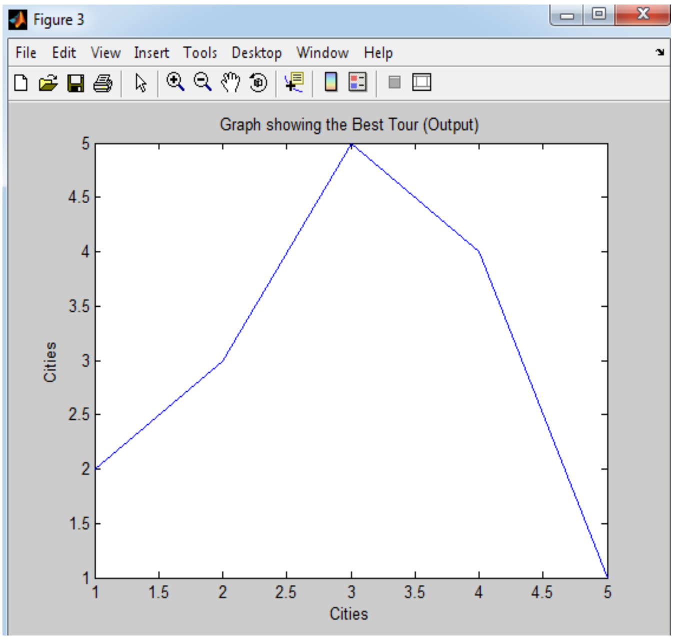
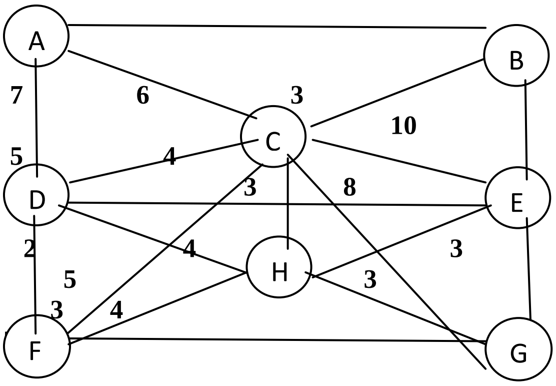


Fig.5

TABLE-1

No of Ants	**No of Cities**	**Iterations**	**Best Tour**	**Best Length**
10	**10**	**1**	**[2 3 5 4 1]**	**32**
20	**20**	**2**	**[2 3 5 4 1]**	**31**
30	**30**	**3**	**[2 3 5 4 1]**	**31**
40	**40**	**4**	**[2 3 5 4 1]**	**31**
50	**50**	**5**	**[2 3 5 4 1]**	**31**
60	**60**	**6**	**[2 3 5 4 1]**	**31**
70	**70**	**7**	**[2 3 5 4 1]**	**31**
80	**80**	**8**	**[2 3 5 4 1]**	**31**
90	**90**	**9**	**[2 3 5 4 1]**	**31**
100	**100**	**10**	**[2 3 5 4 1]**	**31**

B. **By considering With eight Citiesand eight ants**



- **INPUT:(DISTANCE VS CITIES)**

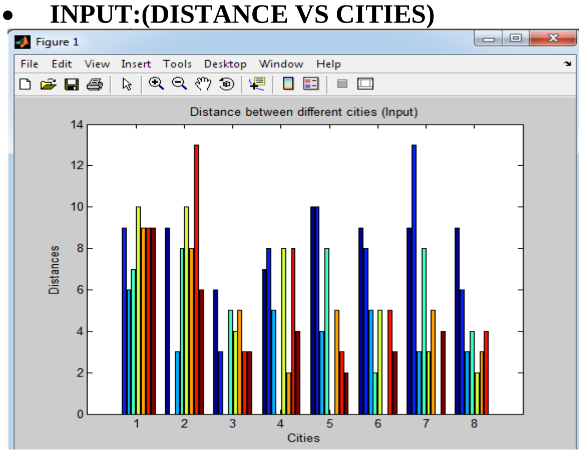


Fig.6

OUTPUT 1: (OPTIMAL TOURS VS ITERATIONS)

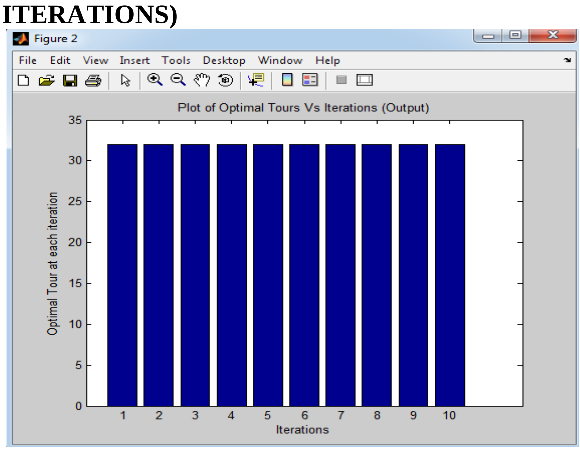


Fig.7

OUTPUT 2: (BEST TOUR)

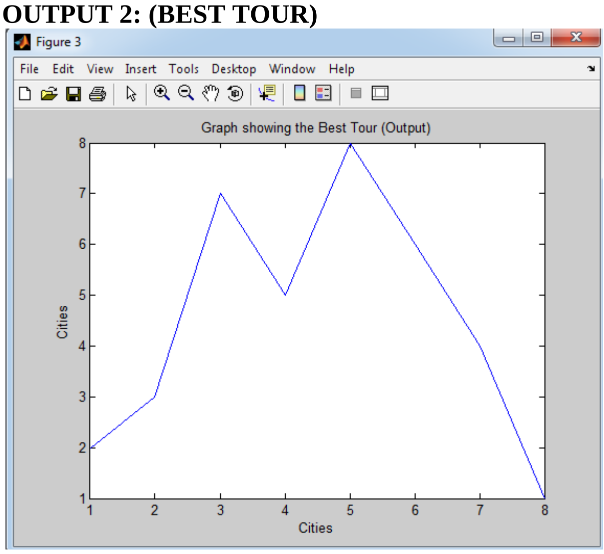


Fig.8

IV. CONCLUSION

This paper presents an approach for solving travelling salesman problem based on ant colony algorithm.It can be concluded that the quality of solutions depends on the number of ants. The lower number of ants allows the individual to change the path much faster. The higher number of ants in population causes the higher accumulation of pheromone on edges, and thus an individual keeps the path with higher concentration of pheromone with a high probability.

The great advantage over the use of exact methods is that ACO algorithm provides relatively good results by a comparatively low number of iterations, and is therefore able to find an acceptable solution in a short time interval. Therefore it is useable for solving problems occurring in practical applications.

The experimental results and performance comparison showed that the proposed system is more useful in terms of convergence speed and the ability to finding better solutions.

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large amount of computation time is required. The numbers of fields where TSP can be used very effectively are. It appears as a sub-problem in many areas, such as DNA sequencing .In real time scenario, in transportation-based graphs, the edge weights can changeconstantly when they are based on the time to traverse the roadway they represent.