TRAVELLING SALESMAN PROBLEM SOLUTION USING ANT COLONY OPTIMIZATION

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Abstract— This paper presents a solution to travelling salesman problem using an optimization algorithm i.e, Ant colony optimization . ACO is a heuristic algorithm mostly used for finding an optimal path in a graph, and which is inspired by the behavior of ants who look for a path between their colony and a source of food. Hence this algorithm can provide a solution to travelling salesman problem which aims at finding the shortest distance. TSP starts from a city, finds a shortest tour by visiting each city in the graph not more than once and comes back to the same city where it started.

Keywords:- Swarm intelligence, ant colony optimization, travelling salesman problem.

I. INTRODUCTION

Swarm intelligence is used for solving various problems and it is inspired by copying the behaviours of insects or animals. It can be used to solve various problems related to optimization.

Ant colony optimization (ACO) is a type of swarm intelligence technique. ACO is a metaheuristic approach and many combinatorial problems can be solved using ACO.

Ant colony optimization was first found in 1990's.This algorithm follows ants and their behaviour. In this paper, solution to TSP is given using ant colony algorithm.
Ants deposit pheromone trails on the ground while searching for food. Whichever path they take, they lay some amount of pheromone on that path. The other ants follow the path which has more pheromone on it which specify that it is the shortest path as more ants are taking that path. This paper constitutes the following sections. Section II illustrates the origin of ant colony optimization . Section III illustrates basics of ACO. Section IV illustrates algo for ant colony optimization. Section V illustrates the basics of travelling salesman problem. Section VI illustrates ACO algorithm to solve travelling salesman problem. Section VII is about experimental results. Section VIII illustrates conclusion. Section IX illustrates references.

II. THE ORIGIN OF ANT COLONY OPTIMIZATION

ACO(ant colony optimization) was first introduced by Marco Dorigo. He observed the behavior of ants in their colonies. Ants always stay in colonies. They follow the principle of helping in survival of the colonies instead of individual's survival. Ants are very good in searching and exploitation. They generally do complex tasks in a very simple way. They always work in groups. They explore the path between their food and their nestand finally finds the shortest one. Initially, ants wander in their surrounding in a random manner to find food. While wandering, they lay a chemical on the ground which is called pheromone. When an ant find food, it again goes back to its nest by again filling the ground with that pheromone trail. Other ants smell that pheromone trail. And uses the path which contains higher amount of pheromone on the ground as probability of choosing a path is directly proportional to the amount of pheromone deposited on that path.Larger the concentration of pheromone on a path, more is the probability of choosing that path by an ant.

Figure below shows the behavior of ants:-

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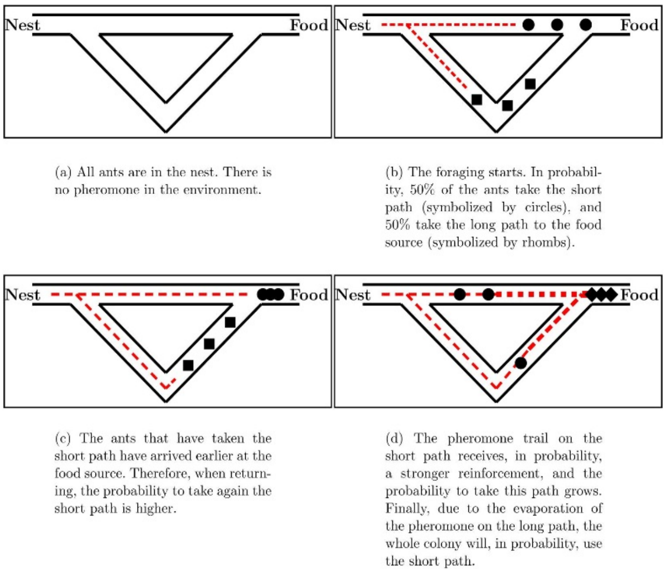

Fig. 1. Behaviour of ants

The above figure shows the behavior of ants and how they find the path which is smaller as compared to other paths between their nest and the food source.

In fig.(a), all the ants are in the nest ,as they have not visited any where in the environment so there is no pheromone on any path.

In fig.(b), ants start exploring the paths and 50% of the ants follow the path as shown by the circles indicated in the figure and the rest 50% follows the path shown by the rhombus.

In fig.(c), the ants which took the path shown by circle reached the food source earlier than the ants which took the other path as shown by rhombus. It means that the path depicted by the circle was the shortest one. So while returning to their home , the chances of ants choosing the same shorter path is more.

In fig.(d), as the ants again took the shorter path while returning home so, the density of pheromone trail will be more on this path.

So the probability for choosing this path by other ants is more in the future as it contains more pheromone trails.

In the next figure as shown below shows the sketch of map ant theory that shows that how group of ants follow the best optimistic path to reach their destination. The other ants follow the path which has more pheromone on it which specify that it is the shortest path as more ants are taking that particular path to reach the food destination.

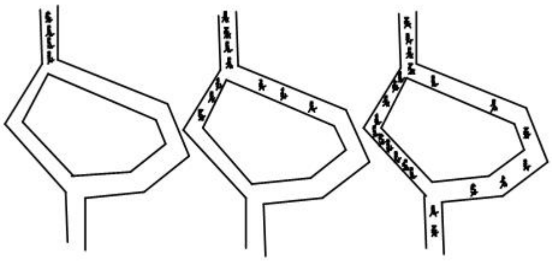

Fig. 2. Sketch map of the ant theory

III. BASICS OF ACO

In ACO, artificial ants are there which are inspired by the real ants. These artificial ants helps in finding solutions that are good globally for the difficult optimization problems. Artificial ants have even more qualities than the ants found in the real world. That's why, articial ants are more capable of solving such difficult problems. Artificial ants help each other by using the information they concurrently write/read on the problem state they visit. Real world ants pheromone starts evaporating over time, because of which they are not able to remember the prior state. Similarly, artificial ants also leave artificial pheromone trail(APT) which is a numeric information. Current state of an ant is represented by this numeric information, that is APT.

This APT among individual ants helps the rest of the ants in finding the global optimal solution efficiently. A probabilistic decision policy helps artificial ants to move from one problem state to adjacent problem state. This decision policy is a function of artificial pheromone trail. This decision policy doesn't use any look a head mechanism, it takes decision on the basis of local information .Exact definition of state, adjacency, and decision policy are problem specific.

IV. THE ANT COLONY OPTIMIZATION METAHEURISTICS

In this, idea of ACO metaheuristic is provided. To solve given ACO problem, firstly a set C of solution components is derived. Then, a set of pheromone values are defined these pheromone values are called as pheromone model. This model is the main component of ACO. The pheromone values $\tau i \in T$ are usually associated to solution components.

Following steps are used to solve optimization problem used ACO:-

- A model i.e, model of Pheromone is used to construct candidate solutions.
- Pheromone values are modified using these candidate solutions to obtain solutions of better quality.

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Then, the update for pheromone is concentrated in the areas of search space where high quality solutions are there.

Algorithm1.*Ant colony optimization(ACO) Algorihtm*
Until conditions for termination not found repeat
ActivitiesSchedule
ConstructAntSolution() {seeAlgorithm2}
UpdatePheromone()
DaemonActions() {optional}

end ActivitiesSchedule
end while

The description for this algorithm is given below.

In this algorithm, this while loop is controlling the run time of ACO algorithm.In each iteration the three algorithmic components ConstructAntSolution(), UpdatePheromone(), and DaemonActions()—gathered in the ActivitiesSchedule construct—must be scheduled.

These three components i.e, ConstructAntSolution(), UpdatePheromone(), and DaemonActions() are described below:-

Algorithm2.*Procedure* ConstructAntSolution() of **Algorithm1**
l=()
Find*N(l)*
While*N(l)* = ∅ **repeat**
c ← ChooseFrom(N(l))
l← increase l by adding solution component c
Determine *N(l)*
end while

V. TRAVELLING SALESMAN PROBLEM

Travelling salesman is a type of problem that gives a solution to a problem by finding the path which is the shortest one by visiting all the cities in a given set. Here we will consider all those cities on which a path or edge exists between each pair of cities, that is , we could say that TSP graph should be completely connected. TSP

This problem is very well known and captivating problem in the field of combinatorial optimization that has the capability to attract many problem solvers. This problem is relatively very simple to solve yet a very challenging task in operational research. This problem also comes under optimization problem where we find the shortest path. It was first introduced in 1930 by Merrill Flood and since then it has become very popular.

In TSP, there may be any number of cities given initially, generally N cities.A sales person starts from a city, i.e, his home city, and returns to his home again by visiting all other cities exactly once. He visits the cities in such a way that distance travelled by the person through out the journey is the minimum. TSP falls under the category of NP hard problem i.e, it can be described very easily but a very difficult problem while solving. Representation of TSP can be made by a complete graph G=(N,E) which must be weighted. Here the set of n cities are represented by N and E represents the set of edges(paths) fully connecting all cities.

Dij denotes how far the city i is from city j.dij can be described by the formulae:-

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

Many engineering applications involve the use of travelling salesman problem. Design of hardware devices, radio electronic devices also involve travelling salesman problem.

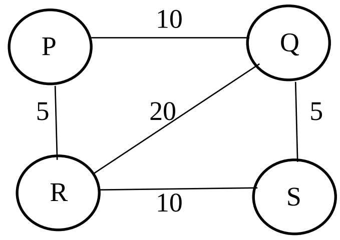

Fig3. Graph representing travelling salesman problem

VI. ACO ALGORITHM TO SOLVE TRAVELLING SALESMAN PROBLEM

Procedure TSP can be solved using following ACO algorithm

Initially Set parameters as well as initialize the pheromone trails

Loop /* each loop is called an iteration during this level*/
Each node is occupied by an ant initially (each node has at least one ant)

For k=1 to m **do /*at this level each loop is called a step */**
Here, a different route is followed by each ant

Repeat
Select node j to be visited next (ant should not visit the next node) according to
A local updating rule(2) is applied

Until ant k has completed a tour
End for
Tour can be improved by applying Local search (2-opt, 2.5 opt)
Compute entropy value of current pheromone trails entropy value can be computed by applying a A global updating rule(3)
the heuristic parameter is updated
Until End_condition
End

VII. CONCLUSION

In this paper, solution to travelling salesman problem is provided using ACO. ACO follows the real world ants. In this paper, It is presented that how ants actually find their food in the real world using chemicals called pheromone trails. An ACO algorithm is given, i.e, how artificial ants, using artificial pheromone trails, find the shortest path in a graph. A description about the travelling salesman problem is also presented here. Then, an ACO is given to provide solution to Travelling salesman problem.

VIII. FUTURE WORK

This paper provides a solution to travelling salesman problem using ACO. In the future, travelling salesman problem can be solved using other algorithms also. The effectiveness of various algors that provides a solution to travelling salesman can be compared to find that which algorithm is efficient enough or which algorithm solves TSP problem more quickly and efficiently.

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