SC205

Solving Travelling salesman problem using Ant Colony Optimization

202101197 , 202101174 , 202101184 , 202101162

I. Motivation and Application

As we all know that how largely transportation and courier services are going nowadays. With this the price of fuels are also increasing. And people are also demanding on time services. For making transportation faster there are many possible ways. Like one is increasing speed of vehicles which is risky and obviously not a good option to a certain level. The another option is to use shorter and correct estimated paths for travelling. Also if we talk about salesman problem then definitely salesman have to traverse multiple places. If he do visit this places in correct order then it is quite fast and effective way. Nowadays online business and services also growing increasingly. So for that also if we make such product which gives shortest traversing path for the selected places then it is very helpful. Such kind of products already exist which solve the TSP using different ways.

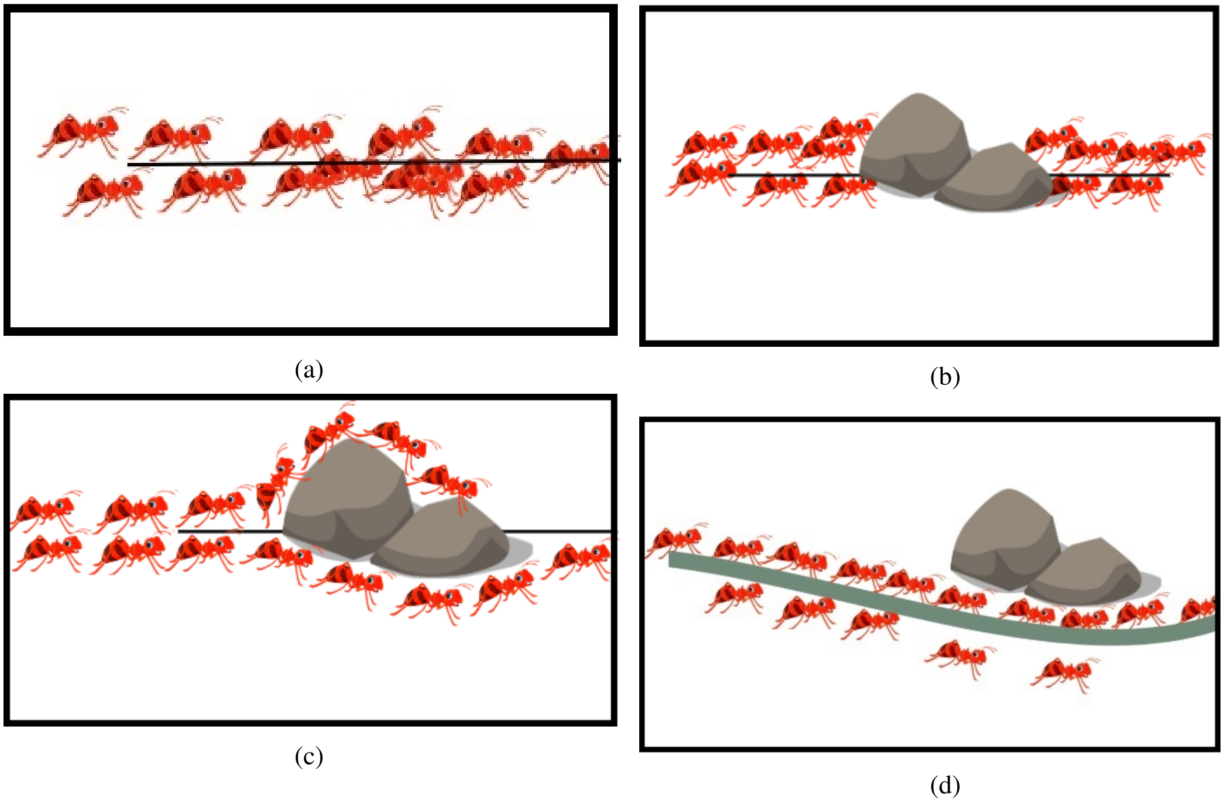
II. INTRODUCTION

The Traveling Salesman problem is one of the most well-known NP-hard problems. It is an algorithmic problem that involves determining the shortest root for a given set of points and places that a traveler must visit all at once before returning to their starting point. Simply put, we must determine the shortest path between the given set of cities based on their distances from one another. Sometimes the term ”traveling salesperson problem” is used to refer to the issue. The salesman makes an effort to travel as little as possible, both in terms of cost and distance. The answer can be discovered in a variety of ways using various algorithms and methods. Utilizing the Ant Colony Optimization Algorithm is one of the best methods. This algorithm quickly generates a short route successfully.

We first introduce, in Section 3, the Ant Colony Optimization. How it is work ? In section 4, We discussed mathematical terms and procedures that are used in solving this problem. Then after we have implemented the procedure in section 5 and Also discussed how we implemented the code.

III. ANT COLONY OPTIMIZATION

Real ants are able to find the shortest route from the food source to the nest without the aid of clues. Also, they are able to adapt to changes in the environment, for example to find a new short route where the old one is no longer possible due to a new obstacle Consider Fig.1: ants move in a straight line connecting a food source. in their nest. It is known that the main mechanisms for ants to form and maintain the pheromone line are. Ants absorb a certain amount of pheromone as they travel, and each ant prefers to follow a rich direction with pheromones. This basic behavior of real ants can be used to explain how they can find the shortest route to reconnect a broken line after the sudden appearance of an unexpected obstacle disrupts the original path .In fact, once an obstacle has arisen, those ants just before the obstacle cannot continue to follow the pheromone path and therefore have to choose between right or left turns. In this case, we would expect one ant to pick a right turn and the other to turn left. It is interesting to note that those ants who prefer, fortunately, the shorter route around the barrier will rebuild the disturbed pheromone path compared to those who prefer the longer route. Thus, the shorter route will receive a larger amount of pheromones each time and a larger number of ants will choose the shorter route. Thanks to this positive response process, all ants will quickly choose the shortest route. Which shows in the last figure. The most interesting feature of this autocatalytic process is that finding the shortest path around the barrier appears to be an emerging asset of interaction between the shape of the obstacle and the ant-distributed behavior: obstacles on their long side rather than on their short side causing the pheromone to accumulate rapidly on the short side. It is a favorite of the ants on the high pheromone trail which makes this accumulation fast on the short road. Now we will show how the same process can be done in a simulated world inhabited by artificial ants trying to solve the problem of a traveling merchant. The traveling merchant problem (TSP) is the problem of getting a short closed trip to visit all the cities with a given set. In this article we will limit the attention of TSPs where cities are on the plane and the path (edge) is located between the two cities (i.e., the TSP graph is fully connected).



(a) (b) (c) (d)

Fig. 1

IV. MATHEMATICS AND PROCEDURE

For this Experiment, the concept of discrete maths is widely use. As we use the Algorithm. Also for faster and efficient work we use divide and conquers approach here. Here each edge (i,j)∈ E is assigned to a cost d_{ij},which is the distance between cities i and j.d$_{ij}$ can be defined in the Euclidean space and is given as in below equation.

$$d_{ij} = \sqrt{(x_i - xi)^2 - (y_i - yi)^2} \tag{1}$$

One best solution for this problem is to select a rout which use a less number of permutations for N cities.Here every rout can be perform in 2n different ways.

Since there are n! possible ways to permute n numbers, the size of the search space is then $|S|$=n!÷(2n) = (n-1)!÷ 2

The ant colony system (ACS) is different from the ant system in three aspects: first is the state transition rule which provide the balance between exploration of new edges and exploitation of priory.Second is the local pheromone updating rule is the global updating rule is applied only to edges which belong to the best ant tour.

$$S = \begin{cases} arg\ max_{u \in j_k(r)}[[\tau(r,u)]^{\alpha}.[\eta(r,u))]^{\beta}] \text{ if } q \leq q_0 \\ \text{S ,otherwise \ (biased exploitation)} \end{cases} \tag{2}$$

In this method we encounter two types of situation. First is during the traversing of the paths by ants and another situation occurs when the ant will reach at the location(here it is food). So according to these two conditions they have different pheromone level. We design a system in a way that during the traversal time all the ants were permitted to update the pheromone level, which is general pheromone level update rule. But at the end when one of the ant will reach the exact location then it only has power to update the pheromone level. We call that situation as Global Pheromone update rule.

we can define general pheromone level using below equation:

$$\tau(r,s) = (1-p).\tau(r,s) + p.\Delta\tau_0 \tag{3}$$

where

$$\Delta\tau_0 = \big(1/L_{mn}.n\big) \tag{4}$$

similarly for global rule,

$$\tau(r,s) = (1-p).\tau(r,s) + p.\Delta\tau(r,s) \tag{5}$$

$$\Delta\tau(r,s) = \begin{cases} 1/L_{gb}, if(r,s) \in shortestpath \\ 0, otherwise \end{cases} \tag{6}$$

so using these calculation now we able to form the solution in algorithm.

V. Implementation Procedure

A. *Ant colony optimization Pseudocode:*

Procedure **AntColonyOptimization**

take necessary parameters and cities as input

while (termination condition not met) **do**

construct solution

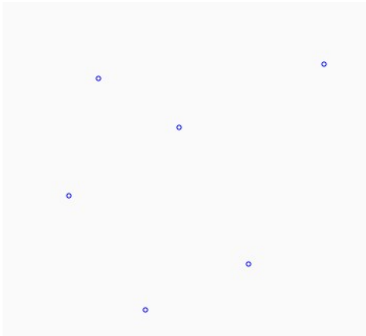
Apply local search

update pheromone

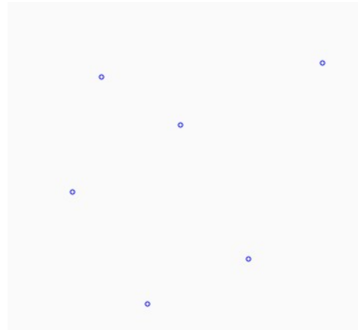
end while

end AntColonyOptimization

B. *The progression of pheromone trails laid by ants while solving the Traveling Salesman Problem:*

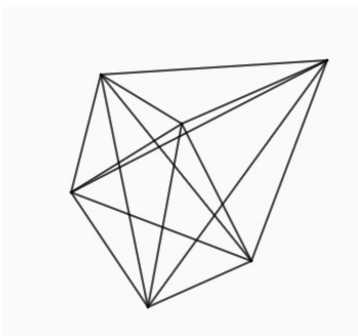


(a) Pheromones: 0

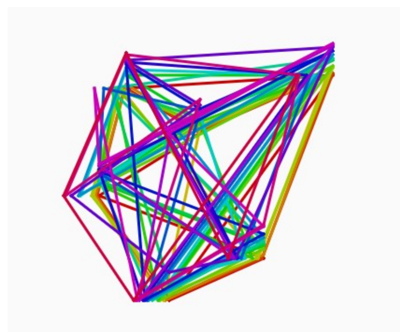


(b) Ants: 0

Fig. 2:



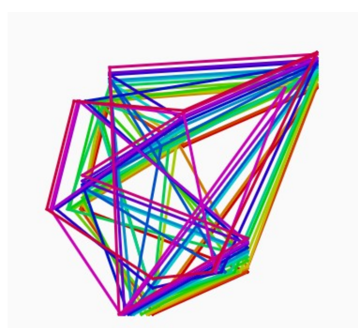
(a) Pheromones: 1



(b) Ants: 1

Fig. 3:

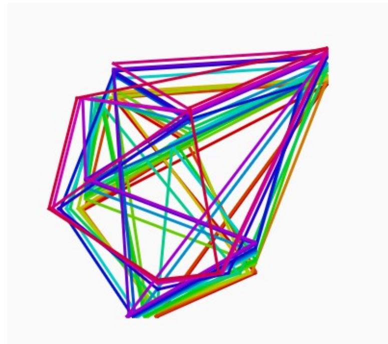
(a) Pheromones: 2



(b) Ants: 2

Fig. 4:

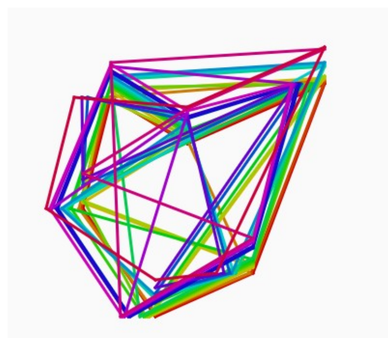
(a) Pheromones: 3



(b) Ants: 3

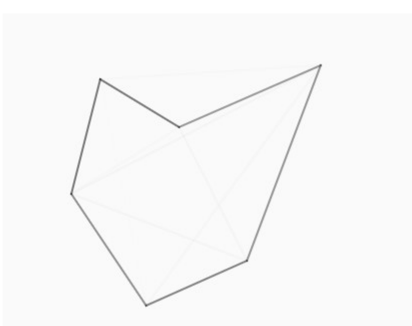
Fig. 5:

(a) Pheromones: 4

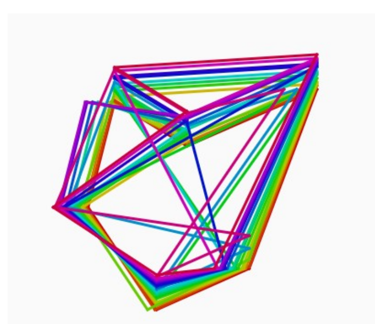


(b) Ants: 4

Fig. 6:

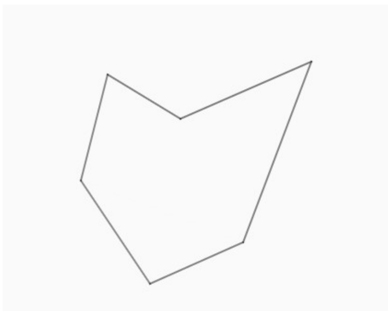


(a) Pheromones: 5

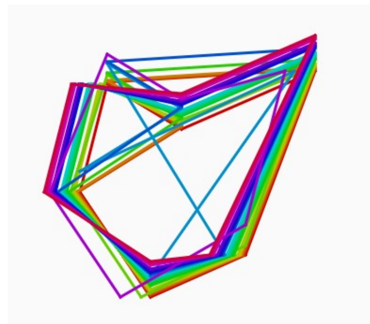


(b) Ants: 5

Fig. 7:

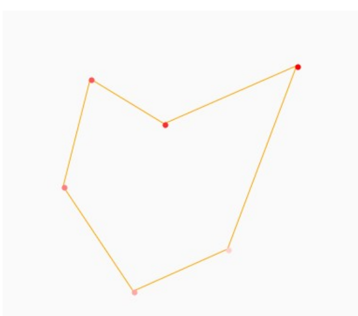


(a) Pheromones: 6

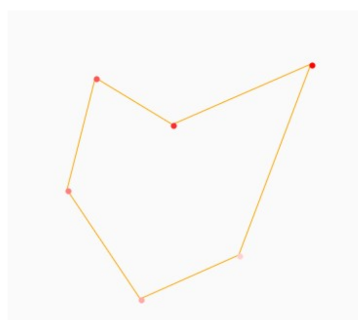


(b) Ants: 6

Fig. 8:



(a) Pheromones: 7



(b) Ants: 7

Fig. 9:

C. *ACO Code Implementation:*

- User have to enter City's position and name of the city are taken as an input of the code.
- Then using the graph theory with the help of matrix.Then that code show the graph in form of matrix.
- Then program will calculate the pheromones with the help of the equation which shows in the above part. And they release every time a new ant and check the pheromones level. Then pheromones are updating every time and best pheromones will be chosen. Equation (3) has been used in the implementation of this function.
- Equation (6) is used for the function to find the shortest path. It will Find best solution through selection method. This steps are continue repeated: Generating ant population, Calculating fitness values associated with each ant, Finding best solution through selection methods, Updating pheromones.
- After these steps are terminated, we will get the shortest route.

VI. CONCLUSION

This Project is really helpful for saving time and fuel with effective path choosing. We implement the natural process in ants to an application for solving TSP. This project may helpful for transport and courier companies. It will defiantly help them to improve profit as well.

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