# CS 214, Lab-3 Report

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## 1 Introduction to the Problem Statement

The Traveling Salesman Problem (TSP) is a well-known optimization problem. It involves finding the shortest possible route that visits a given set of cities and returns to the starting city, visiting each city only once.It is considered NP-hard, meaning that finding the optimal solution becomes increasingly difficult as the number of cities grows.

## 2 Input Format

The input Format is followed as per the given instruction mentioned along with the problem statement.

## 3 Algorithm used

We have used Ant Colony Optimization algorithm for solving the TSP problem.
Why have chosen this algorithm because?
In comparison to traditional optimization methods, such as linear programming or gradient descent(Hill Climbing), ACO is capable of efficiently searching for near-optimal solutions to the TSP even in the presence of large data set with complex constraints. This makes it well-suited for solving the hard problems, where finding the exact optimal solution is not possible.Moreover this has a trim chance of not getting stuck at local optimum as many other traditional algorithms do.

## 4 Ant-Colony Optimization Pseudocodes

A colony of ants is able to produce complex problem solving behaviour through semiotic interactions.It's fascinating how ants find the shortest path between the food source and their nests. They even can get the better path when the environment changes around them. This complex mechanism is because of a simple approach of leaving pheromone trails behind them along the path. In the algorithm we have also built on this idea.

A set of m ants construct tours by greedy approach that moves to next city probabilistic-ally and deposit the pheromone inversely proportion to the cost of the tour.This process is repeated and the best tour found is stored.

```
TSPACO()
    Initialize τij(0) = Δ for all segments i-j in the problem
    repeat
         Construct the tour for each of the m ants
         Remember the best tour when a better one is found
         Update the pheromone levels for each segment τij(t + n)
    until some termination criteria
  return the best tour
```

Figure 1: ACO pseudocode

## 4.1 initialization

We have initialised the pheromone to 0.1 on all the paths and the number of ants equal to total number of cities.The values of number of iterations , $\alpha, \rho, \beta, Q$ are chosen at random based on observation,so that the combination can provide best answer. Following are the definition of parameters :

- $\alpha$ determines the contribution of the pheromones in the probability of choosing the next city for the tour.
- $\beta$ determines the contribution of intercity distances in the probability of choosing the next city for the tour.
- Q is a constant value that determines the update value of the pheromones.
- the pheromone evaporation constant.

## 4.2 selecting the next city

we calculate the probability of selecting the next city( from allowed) using the formula $\tau$ is the pheromone level of the path from city1 to city 2. Here $\eta$ is the reciprocal of distance between city1 and city2 also called as visibility.

$$P_{ij}^{k}(t) = \begin{cases} \dfrac{\left[\tau_{ij}(t)^{\alpha} + [\eta_{ij}]^{\beta}\right]}{\sum\limits_{h \in \text{allowed}_k(t)} \left([\tau_{ih}(t)]^{\alpha} + [\eta_{ih}]^{\beta}\right)} & \text{if } j \in \text{allowed}_k(t) \\ 0 & \text{otherwise} \end{cases}$$

Figure 2: selecting the next city

## 4.3 tour cost

To calculate the total cost of the tour taken

```
for city in tour:
    cost+=distance(city1,city2)
```

distance is being fetched from the given input file.

## 4.4 Update Pheromone

$$\Delta\tau^{k}_{ij}(t.\ t+n) = \begin{cases} Q/L_k & \text{if the } k^{\text{th}} \text{ ant travels on the segment } i-j \\ 0 & \text{otherwise} \end{cases}$$

Figure 3: Updating Pheromone after each iteration

Pheromone levels on the path which the ant follows increases due to the deposition. This is done on based on Q value and the visibility of the path.

### 4.5 Evaporate Pheromone

After each iteration the pheromone gets evaporated as per the formula $(1 - \rho)$pheromone-available. Here $\rho$ is the evaporation constant

## 5 Conclusion

In general, ACO is a metaheuristic algorithm that can be used to find approximate solutions to the TSP problem, that is near-optimal and satisfies the constraints of the problem. The quality of the solution will depend on factors such as the number of ants used, the heuristics employed, the length of the iteration and of-course the input data size.Using a large number of ants can lead to a more accurate solution, but can also increase computational time.
ACO is useful for providing near-optimal solutions in a relatively short amount of time. However, it's important to consider the trade-off between solution quality and computational time when implementing ACO for the TSP problem.

### 5.1 References used as Aid to solve assignment

Book: A First Course in Artificial Intelligence.
Videos: https://youtu.be/ZR2t5qFmxv8