CS 312: Artificial Intelligence Laboratory

Lab 4 report

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- **Introduction:**

The objective of this task is to find the best (shortest) tour (visiting all cities exactly once and returning to the origin city) in a given amount of time with a given a set of cities (coordinates) and distances between them, viz. **Traveling Salesman Problem**.

- **Methodology (Ant Colony Optimization):**

Ants build solutions to TSP by moving on the problem graph from one city to another until they complete a tour. During an iteration of the ACO algorithm each ant builds a tour executing one step for each node (city).

For each ant, transitions from one city to another depend on:

1. Whether or not the city has been visited.
2. The heuristic desirability ("visibility") of connected cities.
3. The amount of pheromone trail on the edge connecting two cities.

Probability of ant k, currently at city i, choosing a next city j is given by,

$$P_{ij}^{k}(t) = \begin{cases} \frac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{s=Allowed_k} \tau_{is}^{\alpha}(t)\eta_{is}^{\beta}(t)} & \text{if } j \in Allowed_k(t) \\ 0 & \text{Otherwise} \end{cases}$$

$Allowed_k$: feasible neighbourhood of ant k when being at city i, which are the set of cities that ant k has not visited yet.

$\tau_{ij}(t)$: Intensity of pheromone w.r.t. time.

$\eta_{ij}(t)$: visibility of city j from i.

η_{ij} = $1/d_{ij}$: heuristic value that gives more priority to closer city

d_{ij} : length of arc (i, j)

α, β : hyper-parameters

α = 0, β > 1: the closest city is selected

α > 1, β = 0: only pheromone is used

$\tau_{ij}(t+n)$ = $\rho\tau_{ij}(t)$ + $\Delta\tau_{ij}(t, t+n)$, where ρ is evaporation rate.

$$\Delta\tau_{ij}(t, t+n) = \sum_{k=1}^{m} \Delta\tau_{ij}^{k}(t, t+n)$$

Where τ_{ij}^{k} = Q/L_k , if ant k visits city j from i, and 0 otherwise.

Cost = sum (edges) = L_k for k^{th} ant, where L_k = cost generated by ant k.

- **Pseudocode:**

TSP-ACO()

Initialise τ_{ij} (0) to a small value for all segments $i - j$ in the problem

while termination condition is satisfied:

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 τ_{ij} $(t + n)$

while end

return best tour

- ## <u>Conclusion and Iterative Improvements:</u>

- In ACO, Artificial ants use a probability determined by pheromones and visibility to choose a good path with less cost, that tends to be closer to a min-cost solution (in smaller cases).

- ACO can find best solutions on smaller problems.

- ACO has little chance to get stuck in a local optimum.

- On larger problems, it converges to good solutions, but not the global optimum.

- We tweaked values of α, β, ρ to get a better tour, with lesser cost. Our outputs for euc_100 and noneuc_100 were 1613 and 5394 respectively. But these may from one run to another due to probabilistic reasons.