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An Experimental Study of Ant System for Solving Travelling Salesman Problem

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***Abstract*-Ants are a fascinating creature that demonstrates a capability of finding food and bring it back to their nest. The ACO is a type of algorithm that seeks to model the emergent behaviour observed in the ant colonies and utilize this behaviour to solve combinatorial problems. It is based on the co-operation of a complex society of ants through a chemical substance called pheromone. In this paper, we present an implementation of Ant System, the very first algorithm of Ant Colony Optimization in MATLAB to solve Travelling Salesman Problem.**

***Keywords*- ACO- Ant Colony Optimization, TSP- Travelling Salesman Problem, AS- Ant System.**

I. INTRODUCTION.

Ant colony optimization was firstly introduced in early 1990s by Dorigo and his colleagues [1]. ACO models the behaviour of real ant in establishing the shortest path between food sources and nests. Ant can communicate with one another through chemicals called pheromone and acting as memory preservation and guidance for ants in order to come up with shortest paths [2]. Ants deposit a certain amount of pheromone while walking, and each ant probabilistically prefer to follow a direction rich in pheromone [3].In this paper we give an overview of Ant system algorithm for TSP. We first introduce, in section II, the TSP. Section III describes ACO. In Section IV we outline how AS can be applied to TSP. At last, Section V gives experimental results under the MATLAB tool.

II. TRAVELLING SALESMAN PROBLEM

Travelling salesman problem (TSP) is a fundamental and significant optimization problem. Not only is it broadly applicable to a variety of routing and scheduling problem, but it is also usually considered as a standard test-bed for novel algorithmic ideas. Solving the TSP is to find out the shortest or lowest cost Hamiltonian cycle which visits every city exactly once and returns to the starting city [4]. Though it is easy to describe, this problem belongs to a class of NP-hard problem (nondeterministic polynomial hard problem). When the number of designated cities gets large, it becomes extremely difficult and costly to figure out an optimal solution by exact algorithms of TSP. Therefore, a large amount of heuristic algorithms have been developed to effectively discover near-optimal or optimal solutions. An instance of the TSP is given by a weighted graph G= (N, A), where N is the set of nodes (cities) and A is the set weighted arcs between cities

There are several algorithms to solve TSP, among which ACO is a better meta-heuristic algorithm to solve the problem. . The TSP was chosen for many reasons [5]:

- It is a problem to which ACO algorithms are easily applied,
- It is an NP- hard optimization problem,
- It is a standard test- bed for new algorithmic ideas and a good performance on the TSP is often taken as a proof of their usefulness, and
- It is easily understandable, so that the algorithm behaviour is not obscured by too many technicalities.

III. ANT COLONY OPTIMIZATION

Researchers are often trying to mimic nature when solving complex problems; one such example is to mimic the movements of ants [6]. The algorithm is based on the fact that ants are always able to find the shortest path between the nest and the food sources [7], using information of the pheromones previously laid on the ground by other ants in the colony. While an isolated ant moves essentially at random, an ant encountering a previously laid trail can detect it and decide with high probability to follow it, thus reinforcing the trail with its own pheromone. The collective behaviour that emerges is a form of autocatalytic behaviour, where the more are the ants following a trail, the more that trail becomes attractive for being followed.

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IV. ANT SYSTEM FOR TSP

Ant System (AS) can be informally described as follows: A number m of ants is positioned in parallel on m cities. The ants' start state, that is, the start city, can be chosen randomly, and the memory M^k of each ant k is initialized by adding the current start city to the set of already visited cities. Each ant is a simple agent with the following characteristics:

- It chooses the town to go to with a probability that is a function of the town distance and of the amount of trail present on the connecting edge,[1]
- Tabu list disallow the transition to already visited cities.

Once ants have completed a tour they use their memory to evaluate the built solution and to retrace the same tour backward and increase the intensity of the pheromone trails τ_{ij}. In AS all the ants deposit pheromone.

Initially, ants are put on randomly chosen cities. At each construction step, ant k applies a probabilistic action choice rule, called random proportional rule, to decide which city to visit next. The probability with which ant k, currently at city i, chooses to go to city j is

$$\rho^{k}_{ij}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha}\,[\eta_{ij}]^{\beta}}{\sum_{k\,\varepsilon\,\text{allowed}} [\tau_{ik}(t)]^{\alpha}\,[\eta_{ik}]^{\beta}} & \text{if } j \epsilon J_k(i) \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

Where $\eta_{ij=1/}d_{ij,}$, d_{ij} is the distance between cities i and j. In other words, the shorter the distance between two cities i and j,the higher the heuristic value η_{ij}. The role of the parameters α and ,β is the following. If $\alpha = 0$, the closest cities are more likely to be selected. If on the contrary $\beta = 0$, only pheromone amplification is at work.

After each ant completes its tour, the pheromone amount on each path will be adjusted according to equation

$$\tau_{ij}(t+1)= (1-\rho).\tau_{ij}(t)+\Delta\tau_{ij} \qquad (2)$$

where ρ is a coefficient such that $(1-\rho)$ represents the evaporation of trail

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau^{k}_{ij} \qquad (3)$$

$$\Delta\tau^{k}_{ij} = \begin{cases} Q/L_k & \text{if } (i,j) \epsilon \text{ tour done by ant } k \\ 0 & \text{otherwise} \end{cases} \qquad (4)\ [8]$$

(1-p) is the pheromone decay parameter (0<p<1) where it represents the trail evaporation when the ant chooses a city and decides to move. m is the number of ants, L_k the length of the tour performed by ant k and Q is an arbitrary constant.

V. RESULT

We execute AS on city dataset from TSPLIB under the MATLAB tool. We have 16 city and 29 city problem. The initial data set is given as:

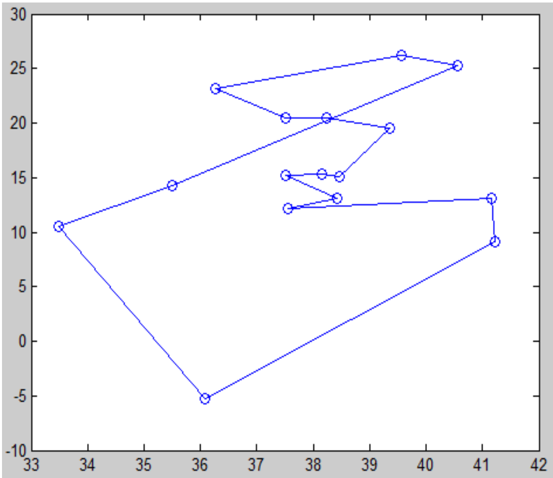

Figure 1 .16 city problem

The result of 16 city dataset is given below

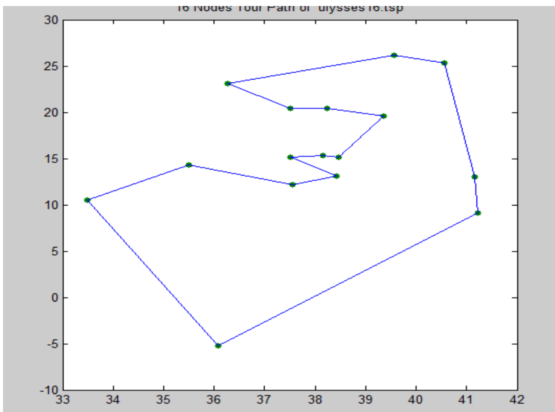

Figure 2: 16 city dataset result

The initial data set of 29 city is given below

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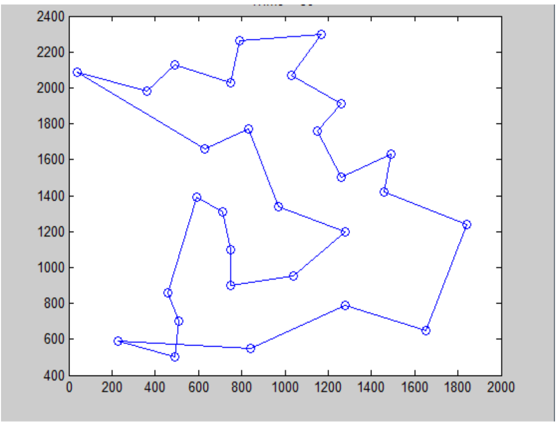

Figure 3: 29 city problem

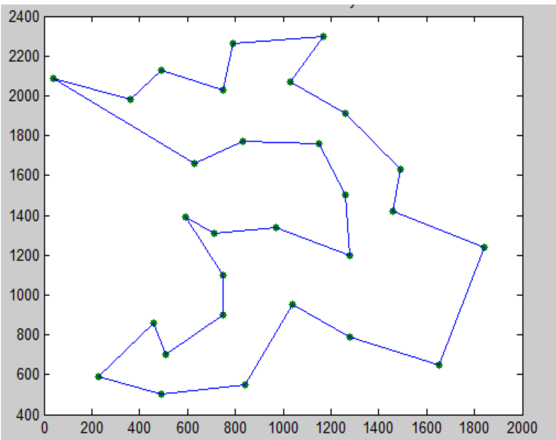

Figure 4: 29 city dataset result

VI. CONCLUSION

This Paper presents an approach for solving travelling salesman problem based on first ant colony algorithm known as ant system. This algorithm combines the features of classical ant colony optimization technique with swarm intelligence to form a model which is an artificial system designed to perform task of finding shortest path. The experimental results show the good optimization capability of ACO.

VII. REFERENCES

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