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ANT COLONY OPTIMIZATION FOR OPTIMIZING TRAVELING SALESMAN PROBLEM

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Abstract— **Ant Colony Optimization (ACO) is an optimization technique for designing meta-heuristic algorithms to solve combinatorial optimization problems. The essential trait of ACO algorithms is the combination of a priori information about the structure of a promising solution with posterior information about the structure of previously obtained good solutions. Travelling salesman problem is real-world combinatorial optimization problem which determine the optimal route for travelling salesman. Generally, to provide the efficient vehicle serving to the customer through different services by visiting the number of cities or stops, the VRP follows the Travelling Salesman Problem (TSP), in which each of vehicle visiting a set of cities such that every city is visited by exactly one vehicle only once. In this project I implement the ant colony algorithm on the travelling salesman problem to obtain optimal results.**

Keywords— **Ant Colony Optimization; Travelling Salesman Problem; Ant Colony Algorithm**

I. INTRODUCTION

Ant colony optimization is a meta-heuristic in which a colony of artificial ants cooperates in finding good solutions to difficult discrete optimization problems. Ants use *pheromone trails* to communicate information regarding shortest paths to food. A moving ant lays some pheromone (in varying quantities) on the ground, thus marking a path with a trail of this substance. An isolated ant moves mostly randomly and when it detects a previously laid pheromone trail it can decide, with high probability, to follow it, thus reinforcing the trail with its own pheromone. The collective behavior that results is a form of autocatalytic behavior where the more ants follow a trail, the more attractive for other ants it becomes. The process is thus characterized by a positive feedback loop, where the probability with which an ant chooses a path increases with the number of ants that previously chose the same path. The idea of the ant colony algorithm is to mimic this behavior with "simulated ants" walking around the graph representing the problem to solve. When an ant completes a solution, during the construction phase, the ant evaluates the solution and modifies the trail value on the components used in its solution. This pheromone information will direct the search of the future ants [8].

This Algorithm is a reproduction of the real-life behavior of ants. The ants are quite smart in finding their way between the colonies for food source. A lot of worker “drones” are walking through the near environment and if they find some food, they lay down a pheromone trail (A chemical released by an insect that psychologically affects the behavior of other insects). Some of the other ants still searching for other ways , but the most of them are following the pheromone trail make this more attractive. But over time the pheromone trail is starting to decay, it is losing its attractiveness due to time component, pheromone density is very low on the long way, because the pheromone trail is evaporating along side. Thus a shorter way has higher density of pheromone and has more attractiveness to the workers leading into a kind of optimal path for our graph problem.

II. LITERATURE REVIEW

1. Sourabh joshi, Sarabjit kaur (2015)

Ant colony algorithm is a propelled optimization method which is utilized to take care of combinatorial optimization problems. The significant features of this algorithm are the utilization of mixture of pre-information and post-information for organizing great solutions. Ant colony algorithm is used in this paper for solving the travelling salesman problem of the real set of data and get the optimal results on graphs. This algorithm is an meta-heuristic algorithm in which we used 2-opt local search method for tour construction and roulette wheel selection method for selection of nodes while constructing the route [18].

2. M. Allahviranloo, Y.J. Chow, et.al (2014)

In this paper, the author proposed the three new formulations to account for different optimization strategies under uncertain demand (or utility) level: reliable, robust, and fuzzy selective vehicle routing problems. Three parallel genetic algorithms (PGAs) and a classic genetic algorithm are developed and compared to the deterministic solution. PGAs differ based on their communication strategies and diversity in sub-populations. Results show that a PGA, wherein communication between demes, or subpopulations, occurs in every generation and does not eliminate repeated chromosomes, outperforms other algorithms at the cost of higher computation time. A

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faster variation of PGA is used to solve the non-convex reliable selective VRP, robust selective VRP and the large-scale fuzzy selective VRP, consisting of 200 nodes [1].

3. Charul Dhawan, Maneela, et.al (2014)

In this paper, Author propose an algorithm for solving vehicle routing problem, that is, vehicle routing problem using ACO Meta-heuristic. The author take a scenario of paper delivery van which deliver the question papers to the given number of colleges and the van start and ends its route at university. The core objective is to minimize the number of vans to do the task and find out the best optimal route using Ant Colony Optimization (ACO) [3].

III. ANT COLONY OPTIMIZATION

Ant colony optimization is a meta-heuristic in which a colony of artificial ants cooperates in finding good solutions to difficult discrete optimization problems. Ants use *pheromone trails* to communicate information regarding shortest paths to food. A moving ant lays some pheromone (in varying quantities) on the ground, thus marking a path with a trail of this substance. An isolated ant moves mostly randomly and when it detects a previously laid pheromone trail it can decide, with high probability, to follow it, thus reinforcing the trail with its own pheromone. The collective behavior that results is a form of autocatalytic behavior where the more ants follow a trail, the more attractive for other ants it becomes. The process is thus characterized by a positive feedback loop, where the probability with which an ant chooses a path increases with the number of ants that previously chose the same path. The idea of the ant colony algorithm is to mimic this behavior with "simulated ants" walking around the graph representing the problem to solve. When an ant completes a solution, during the construction phase, the ant evaluates the solution and modifies the trail value on the components used in its solution. This pheromone information will direct the search of the future ants.
This Algorithm is a reproduction of the real-life behavior of ants. The ants are quite smart in finding their way between the colonies for food source. A lot of worker "drones" are walking through the near environment and if they find some food, they lay down a pheromone trail (A chemical released by an insect that psychologically affects the behavior of other insects). Some of the other ants still searching for other ways , but the most of them are following the pheromone trail make this more attractive. But over time the pheromone trail is starting to decay, it is losing its attractiveness due to time component, pheromone density is very low on the long way, because the pheromone trail is evaporating along side. Thus a shorter way has higher density of pheromone and has more attractiveness to the workers leading into a kind of optimal path for our graph problem. Generally speaking about the algorithm there are four main parts:-
1) Tour Construction:

Initially for our TSP problem , we are dropping ants on random vertices in our graph. Each ant is going to evaluate best way for his next move to another vertex based on this formula:

$$\rho^k_{xy} = \begin{cases} \dfrac{[\tau_{xy}(t)]^\alpha [\eta_{xy}]^\beta}{\sum_{\mu \in J_k(x)} [\tau_{x\mu}(t)]^\alpha [\eta_{x\mu}]^\beta} & \text{if } y \in J_{k(x)} \\ 0 & \text{otherwise} \end{cases}$$

Its about the probability "ρ" for a worker(ant) called "k" to move to the vertex described by "xy". The variable called"τ" is the amount of pheromone deposited on the edge of the "xy" . It gets raised to the power of"α" which is a heuristic parameter describing how greedy the algorithm is in finding its path across the graph. This is going to be multiplied by apriori knowledge of how "good " the edge is . This is the case the inverted distance is: 1/distance (1/xy) between the city x and y. and the raised to the power of"β" is also a heuristic parameter describing how fast the ants are going to select their path and everything calculated until , now gets divided by the summation of every possible solution.The record of cities from where the ant k passes is kept in the tabu list ($tabu_k$).

2).Pheromone Update:
The next thing is updating the residual information after all the ants finish their each traversing means how much pheromone does a worker lay while traversing the edges. This is going to be described by the following formula:

$$\tau_{xy}(t+n) = (1-\rho)^* \tau_{xy}(t) + \Delta\tau_{xy}(t) \qquad (2)$$

$$\text{where } \Delta\tau_{xy}(t) = \sum_{k=1}^{m} \Delta\tau_{xy}^{k}(t) \qquad (3)$$

"τ" is the absolute pheromone amount which gets deposited for worker(ant) "k" on the edge"xy". "ρ" refers to the pheromone volatization coefficent and (1-ρ) represents the decay of pheromone ranges between 0-1.

These get represented by the current amount of deposited pheromone and just add the new pheromone to it ($\Delta\tau_{xy}^k(t)$).
In the ant cycle model, $\Delta\tau_{xy}^k(t)$ is equitation to:

$$\Delta\tau_{xy}^{k} = \begin{cases} Q/L_k & \text{if ant k uses edge xy in its tour} \\ 0 & \text{Otherwise} \end{cases} \qquad (4)$$

"Q" is the pheromone strength and heuristic parameter as well, divided by the distance (L_k), the ant took to get to this edge. If this is negative, we just return 0.
3).Terminating Condition
If the terminating condition is satisfied i.e all the cities are visited and no city is repeated, the circulation will stop. Compare all the best solution previously updated in the tabu

list ($tabu_k$) for every iteration and find the optimal solution, otherwise empty the tabu list and continues the iteration.

A. Ant Colony algorithm –

The ACO is introduced in the form of an algorithm that was theoretically studied. It works as follows. At each iteration ants probabilistically construct solutions to the combinatorial optimization problem under consideration, exploiting a given pheromone model [9]. Then optionally a local search procedure is applied to the constructed solutions. The following are the steps:-

1) Initialize Pheromone - At the start of the algorithm the pheromone values are all initialized to a constant value.

2) Construct Solution – The basic ingredient of any ACO algorithm is a constructive heuristic for probabilistically constructing solutions. A constructive heuristic assembles solutions as sequences of elements from the finite set of solution components. A solution starts with an empty partial solution and then at each construction step the current partial solution is extended by adding a feasible solution component.

3) Local Search – A local search procedure may be applied for improving the solutions constructed by the ants. The use of such a procedure is optimal; through experimentally it has been observed that, if available, its use improves the algorithm's overall performance.

4) Global Pheromone Update – The aim of applying global pheromone update is to increase the pheromone values on solution components that have been found in high quality solutions and save that as the best optimal solution. Should be typeset in boldface italic and capitalize the first letter of the first word only.

B. Travelling Salesman Problem –

The problem of finding an optimal path between "n" number cities is known as Travelling Salesman Problem. The TSP is a most significant problem first posed by Irish mathematician W.R Hamilton in the nineteenth century [12]. This problem is also intensely studied in operations research and other areas since 1930. Formally, TSP can be represented by complete weighted Graph, G=(V,E) in which V represents set of n vertices and E represents a set of bi- directional edges between V_i, V_j€ V , form a Hamiltonian cycle which minimizes $\sum^{n}_{i=0} W_{i,j}$, where $W_{i,j}$ is used to represent an edge weight between two vertices V_i and V_j.

IV. Experiment and Result

While going for the implementation part, we solve the travelling salesman problem taking different input node values and check the whether the result shown by the ACO algorithm are more optimal than the nearest neighbor algorithm which is a heuristic approach used earlier to solve vehicle routing problem. We perform different experiments taking different set of value and compute their results with both the ant colony optimization and nearest neighbor algorithm such that we can easily analyze which is best approach to find optimal results.

The ACO algorithm is implemented in the MATLAB tool in which all the test and experiments are performed on the data set of travelling salesman problem using Ant colony optimization technique. To show that the results generated by ACO algorithm gives more optimal result than Nearest neighbor algorithm we compare their results using the same data set for both the techniques.

In this experiment we have taken the data set 100 of nodes where and compute its results using the Ant colony optimization. During the execution time as we increase the number of number of iterations it gives more optimal results.

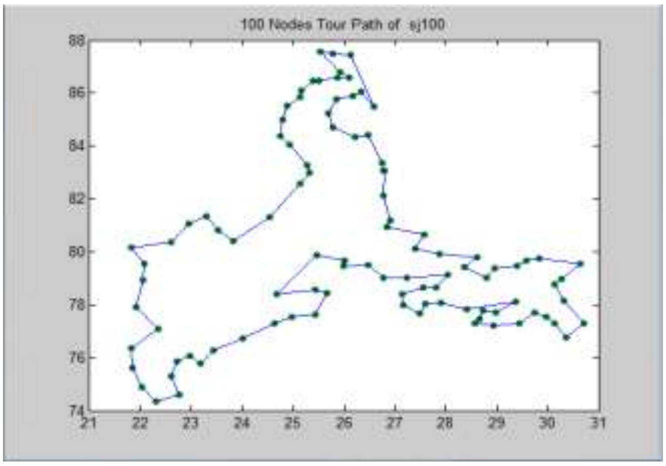

Fig. 1. shows the graphical representation by the ACO algorithm for 100 nodes of tsp

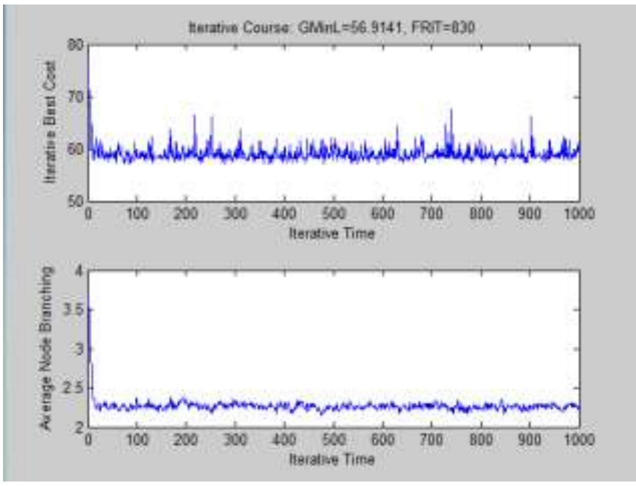

Fig. 2. shows the graph of optimal solution with respect to number of iterations

V. CONCLUSION

ACO algorithm is implemented in MATLAB and the results obtained by ACO algorithm are compared with the nearest neighbor algorithm and the results show that the ACO is better techniques than nearest neighbor for finding the optimal solution of the travelling salesman problem. This techniques avoid being get trapped in the local optimal solution, hence generates the global optimal solution. This technique can also help us to find the best optimal solution from the generated solutions for the given problem. This technique can be enhanced by adding such constraints in the ACO algorithm such that it can generate more specific and optimal result for the given problem.

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