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Advanced ACO Metaheuristic for Travelling Salesman Problem: A Proposed Technique

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Abstract*: ACO meta-heuristic is an advanced approach of solving the various combinatorial optimization problems with positive feedback. ACO algorithms has some limitations such as pheromone stagnation due to which the optimal result get stuck in local search and give the partial optimised results. To overcome the problem of pheromone stagnation we make two advancements in the ACO algorithm first to use the 2 opt local search method to search local optimal result in less time and second use the new heuristic function which timely update the amount of pheromone with time. The advancements of the ACO algorithm will be implemented on the Travelling salesman problem which is the most famous problem in the operation research and logistics.
***Keywords*: Ant Colony Algorithm, meta-heuristic, travelling salesman problem, combinatorial optimization**

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 behaviour that results is a form of autocatalytic behaviour 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 behaviour 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.

In this paper, we are going to present the new heuristics value which will further be used in the solution of TSP with ant colony algorithm. The proposed technique will overcome the problem of pheromone stagnation which occurs in the earlier heuristic functions in ant colony system. In the section II a brief introduction about TSP is given. Section III describes the main concept of Ant colony algorithm. According to ACO algorithm, we make further research on the process of finding the optimal solution for TSP. Section IV describes the ACO meta-heuristic for solving the TSP. The proposed Advanced ACO Meta heuristic function for solving TSP is described in section V.

II. TRAVELLING SALESMAN PROBLEM

Traveling Salesman Problem is well – known and extensively studied problem which plays an important role in combinatorial optimization and in context of ACO [4]. Since the algorithm Ant System was initially applied on the TSP and has been used later on as a benchmark to test a new idea. TSP is defined as a weighted undirected graph G= (V,E) where V contains set of nodes which represent location to be visited and E is an edge [u,v] € V used to connect two locations u and v. Each weighted edge represents the cost of ranking of that edge while travelling from one location to other. The TSP consists of finding a minimal Hamiltonian Cycle for a complete, weighted and undirected graph with n vertices.

III. ANT COLONY ALGORITHM FOR TSP

Ant Colony Optimization technique is inspired from the real behavior of natural ants [3]. Ants find their way between their colony and their food source in a very smart manner. 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 mostly ants follow the pheromone trail which is already created by previous ants which make this more attractive [6]. But overtime the pheromone trail is starting to delay, it is losing its attractiveness due to time component, pheromone density is very low on the long way, because the pheromone trail is evaporating

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along side. Thus a shorter way has more attractiveness to the workers leading into a kind of optimal path for our graph problem. The Ant colony Optimization has three main parts to solve the TSP-

A. Tour Construction

Initially, we start dropping ants on random vertices in our graph. Each ant is evaluating, selecting the best way for his next move to another vertex.

B. Pheromone Update

The updating of residual information after all the ants finishes their each traversing means amount of pheromone a worker lay while traversing the edge.

C. Cermination

When all the cities are visited and no city is repeated, the circulation will stop and the termination condition is satisfied.

1) Algorithm: Ant colony Optimization for Solving TSP

Initialize all edges
Place each ant randomly on each city
For each iteration
Do While (ant not complete the tour)
For each ant do:
Move ant to next city
End
End
For each ant (tour completed) do
Evaporate pheromones
Apply pheromone update
If (tour done by ant k is shorter than global solution, Update it with local solution)
End
End

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. 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.

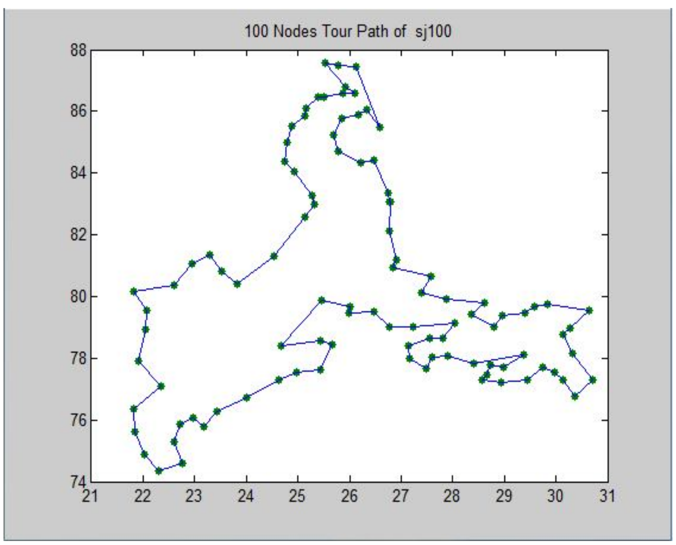

Fig1 shows the execution by the ACO algorithm for 100 nodes of tsp

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IV. ACO META HEURISTIC FOR SOLVING TSP

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 main feature in AS algorithm is that for every iteration the values of pheromone get updated and will generate a solution itself. The pheromone τ_{ij}, associates the edge which join two cities i and j and is updated by the equation:

$$\tau_{ij} \longleftarrow (1-\rho) \cdot \tau_{ij} + \sum m^{k}=1 \, \Delta \tau_{ij}^{k} \qquad (1)$$

Where "ρ" represents the rate of evaporation, m represents the ants, and $\Delta \tau^{k}ij$ is the pheromone deposited on edge (i,j).

$$\Delta \tau_{ij}^{k} = \begin{cases} Q/L_k & \text{ant k is used for edge (i,j)} \\ 0 & \text{otherwise,} \end{cases} \qquad (2)$$

Where "Q" is a constant value and "L_k" represents the tour length for an ant k.

While the tour is constructed, ants select the city which is next visited using a random values generated mechanism. The probability of finding paths is calculated by formula:

$$\rho^{k}_{i} = \begin{cases} \dfrac{\tau^{\alpha}_{ij} \cdot \eta^{\beta}_{ij}}{\sum C_{il} \epsilon N(S^{p}) \tau^{\alpha}_{il} \, \eta^{\beta}_{il}} & \text{if } C_{ij} \epsilon N(S^{p}) \\ 0 & \text{otherwise} \end{cases} \qquad (3)$$

Where $N(S^{p})$ is the set of feasible components that is edges (i, l), where "l" is the city had not been visited by the ant k . The parameter α and β are the two constants which are used to control the pheromone versus the heuristic information value generated while calculating the probability using the above defined formula, η_{ij} is represented as :

$$\eta_{ij} = 1/d_{ij} \qquad (4)$$

Where d_{ij}, represents the value of distance between cities.

V. PROPOSED ADVANCED ACO META-HEURISTIC FOR TSP

Ant colony algorithm suffers from pheromone stagnation problem when all ants congregate quickly on one sub-optimal solution. To remove the stagnation problem occurred in the Ant colony system algorithm we proposed an enhanced version of ACO algorithm. The proposed algorithm integrates a new heuristic function with the 2 opt local search method that will update the heuristic value every time the ants find a better solution in the iteration and gives more optimal results than the ACO algorithm. After the ant constructs its solution a global update process will be applied for updating of the best so far solution. This event wills the environment for the next coming iteration. A function would be generated at this moment to reflect this change and hence new information will be applied to the best so far edge or tour.

A. Pseudo-Code for New Heuristic Function

Step0: for each path in the best tour do step 1 to 2
Step 1: if path i (i=1, 2,n) is not updated before do step 2
Step3: $\eta i = \eta i + (\delta/$ best so far tour)
//δ is parameter from (0-10)
End.

After applying the new heuristic function, the values of heuristics will change according to the quality of best optimal solution. As we found the best solution, it will increase the heuristic value and vice-versa. The parameter δ will reflect the influence of updating value that should be applied to heuristic value.

VI. CONCLUSIONS

The proposed ACO metaheuristic will prove to give better optimal results as compared to the earlier Ant Colony algorithm. This advanced ACO algorithm avoid being get trapped in the local optimal solution, hence generates the global optimal solution. This new ACO algorithm will produce more optimal solution as it also overcome the problem of pheromone stagnation which is caused in earlier ACO algorithm due to which the algorithm cannot provide timely updating of ants.

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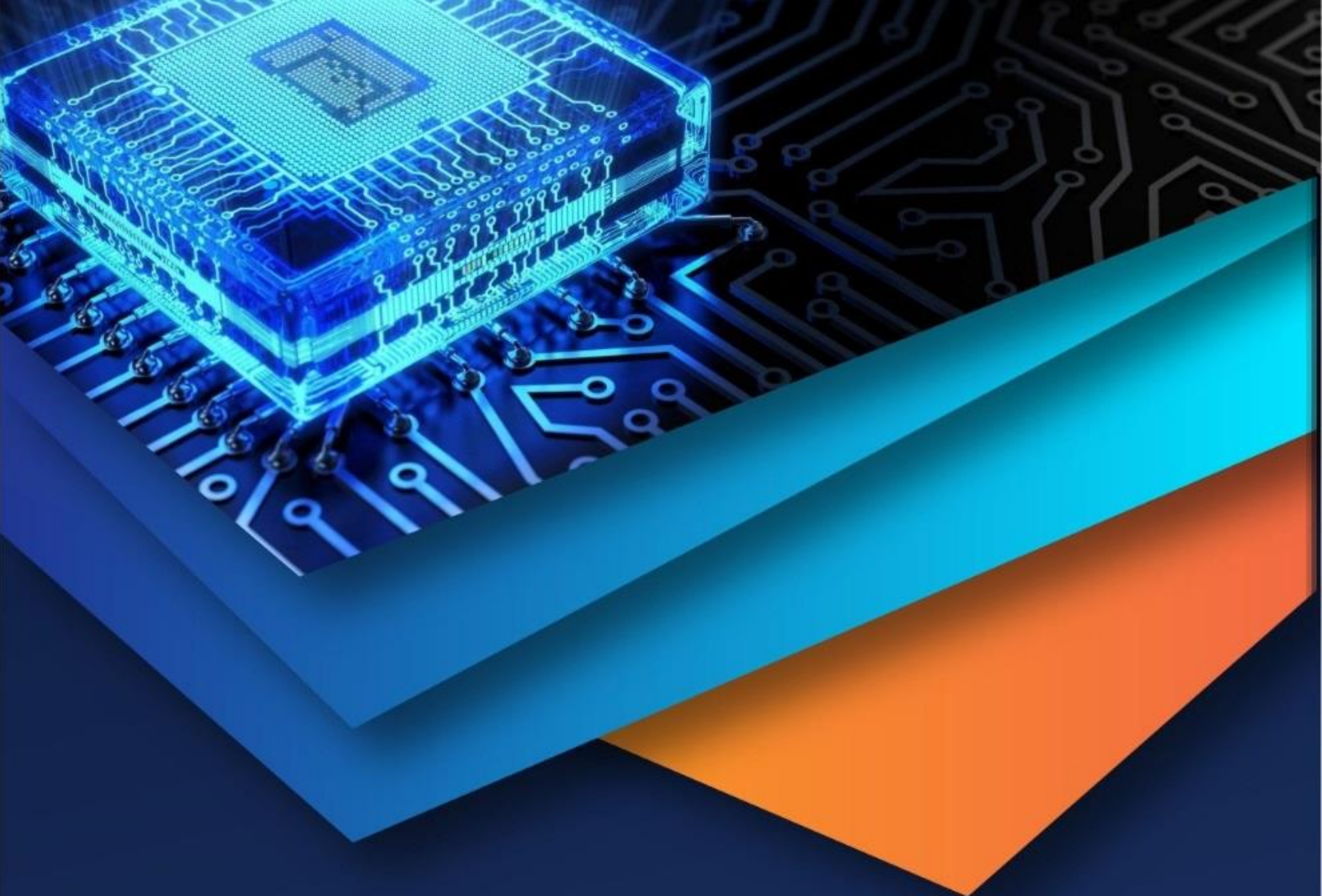

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