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Ant Colony System based solution of Vehicle Routing Problem with Enhanced Heuristics: A proposed technique

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***Abstract*— Ant colony system is a meta-heuristic that has been applied to various combinatorial optimization problems, including travelling salesman problem and quadratic assignment problem. Ant colony system has some limitations such as pheromone stagnation due to which it does not timely update the heuristic function, which results in not generating the best optimal route of a vehicle. In this paper, we proposed an improved ant colony system with a different heuristic function which is used to solve the vehicle routing problem. VRP is a real-world combinatorial optimization problem of minimizing the total route cost while serving to the customer through different services by visiting the number of stops.**
Keywords— Ant **colony system, Ant colony optimization, NP-hard problem, Heuristic function, Vehicle routing problem**

I. INTRODUCTION

The Vehicle routing problem aims to find a set of tours for a number of vehicles start and end at the depot without exceeding the capacity and pre-defined route length. VRP is a well known NP-hard problem for which it is difficult to find the optimal solution. Genetic algorithm (GA's), Simulated Annealing (SA), Tabu Search and Ant colony optimization (ACO) are the meta-heuristic's which are used to solve the vehicle routing problem. Ant colony optimization methods are the new optimization methods which simulate the food-seeking behavior of ant colonies in nature. Ant colony optimization consists of meta-heuristic optimizations or heuristic which are designed for finding and selecting a lower level procedure, they may provide a sufficiently good solution. Meta-heuristics make some assumptions about the optimization problem being resolved and thus they may be usable for a range a problems. In this paper, we are going to present the new heuristics value which will further be used in the solution of VRP with ant colony system. 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 VRP 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 VRP. Section IV describes the Ant colony system for solving the VRPis a template. The proposed heuristic function for solving VRP is described in section V.

II. THE MODEL OF VRP

VRP was first proposed in 1959 by Dantzig and Ramser. It is such a kind of problem that finds a set of tours for finite number of vehicles from a depot to a lot of customers and return to the depot without exceeding the capacity constraints.

The basic mathematical model of VRP is described as a weighted graph G= (V,E) where "V" represents the set of nodes V= [v_0, v_1,---v_n] and "E" represents the arcs as E= [(v_i, v_j): i≠j]. In this model, v_0 is the depot and the other nodes are the "N" number of customer with a non-negative demand q_i.

Each arc (v_i,v_j) has a value d_{ij} represents the travel distance between the two cities $v_i$and v_j. Each tour starts and ends at the depot v_0, and each node must be visited exactly once, and the quantity of goods contain by vehicle never exceeds the vehicle capacity Q formatting requirements is to use this document as a template and simply type your text into it.

III.THE ACO ALGORITHM

All Ant colony optimization algorithms are meta-heuristic in which a colony of artificial ants co-operate in finding best solutions to discrete optimization problems and communicate with each other by a chemical material called "pheromone", while searching their food. Ants choose their new path through the interaction by pheromone to achieve the purpose of optimization. The ants tend to move to the direction where the strength of pheromone will be high.

Now, let's take a look that how ants search their food with an example suppose there are two ants R and S both start from same source location "D" to find the food "F". There are two different paths P1 and P2 as shown in fig 1.

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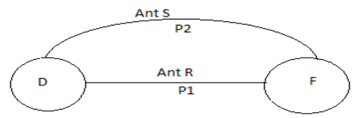

Fig1: Explanation of Ants seeking for food.

The entire document should be in Times New Ant R chooses the path P1, while ant S chooses P2 path. Ant R reaches the destination F first while searching the food as compare to Ant S which follows the path P2. When Ant R get's it way back to the source point "D", S is still on path P2. So during the same period of time the pheromone density on path P1 and P2 differ, path P1 has higher pheromone density than P2. So, the following ants will tend to choose path P1 with high density of pheromone for searching the food at location F. the collective behavior of ants that provide a positive feedback of phenomenon information. As the number of ants walks through the same path, the chances of chosen same path by later ants will be higher than the other paths.

The Ant colony optimization process works on three mechanisms. These are explained as –

A. Selection Mechanism

The selection of the path is based on the amount of information given about that path, greater the amount of information on that path greater is the probability of selecting that path.

B. Update Mechanism

The density of pheromone on each path will increase as the number of ants walks through that path increases, but with the time the density of pheromone will start decreasing due to evaporation.

C. Coordination Mechanism

In the ant colony algorithm the ants work with each other co-operatively to reach their goal and while searching their food the ants communicate to each other using the pheromone trail. This mechanism gives the ant colony algorithm a strong ability to find optimal solution.

IV. ANT COLONY SYSTEM FOR SOLVING VRP

The version of this template is V2. Most of the Ant colony system is the better and improved ACO algorithm than the basic Ant System. The Ant colony system depends upon three main aspects-1) ACS uses a more aggressive action choice rule than As, 2) The pheromone is added only to those moves which belongs to global-best solution 3) when each time an ant moves on a path, it removes some pheromone from that path. The algorithm in their study consists of three phases.

A. Construction

The first phase of the ACS algorithm deals with the tour construction when ant K moves from city I to city j. Ant will choose the city based on two rules. First rule called the pseudorandom proportional rule which is based on exploitation mechanism.

$$J = \begin{cases} \text{argmax}_{l \in N_i^j} \{\tau_{xy}(t)[\eta_{xy}]^\beta\}, & \text{if } q \le q_o \quad (1) \\ J, & \text{otherwise} \end{cases}$$

Where q is the random variable uniformly distributed in [0,1], q_0 ($0 \le q_0 \le 1$) is a parameter and j is a random variable selected according to the probability distribution given by the following formula:-

$$p^k_{ij} = \frac{[\tau_{ij}][\eta_{ij}]^\beta}{\sum_{l \in N_i^k}(x)\,[\tau_{il}(t)]^\alpha [\eta_{il}]^\beta} \quad \text{if } J \in N_i^k \quad (2)$$

Second rule uses exploration mechanism based on the probability distribution used in AS. ACS algorithm applies global pheromone trail update where only one ant (the best-so-far ant) is allowed to add pheromone after all ants finished constructing their tours.

B. Global Pheromone Update

In the ACS only one ant is allowed to add pheromones after completing the iterations. The update is implemented using the following equation:

$$\tau_{i,j} \leftarrow (1\text{-}p)\,\tau_{ij} + \rho\, \Delta\tau_{ij}^{bs}\ ,\ ¥(i,j)€\ \tau^{bs} \qquad (3)$$

C. Local Pheromone Update

ACS algorithm applies local pheromone update which occur each time an ant moves on the arc (i, j) to move from city to city, this process will remove some pheromones from the arc to increase the probability of exploring another path. The local update is implemented using the following rule.

$$\tau_{i,j} \leftarrow (1\text{-}\epsilon)\,\tau_{ij} + \epsilon\tau_0 \qquad (4)$$

Where ϵ, $0<\epsilon<1$, and τ_0 are the two parameters. The value of τ_0 is equal to initial value for the pheromone.

Pseudo-code of ACS for solving VRP

```
Compute Visibility
Initialize pheromone
While (max number of iterations is not reached)
    For each ant i
    Select the next customer to visit from candidate list
    Perform local pheromone trail update
    End for
Perform global pheromone trail update
Save the best route
End while
```

The above mention pseudo-code is of Ant colony system for solving the vehicle routing problem. We implement this pseudo-code in MATLAB to find the optimal result of the sample test cases of the vehicle routing problem. In the below given diagram we show the 21 cities route using the ACS algorithm and the graph is shown in the diagram.

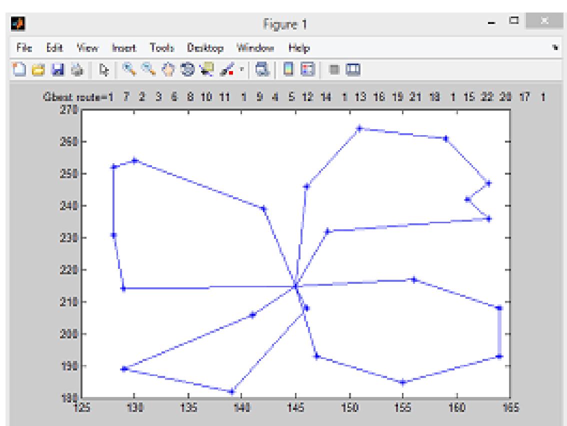

Fig2: The execution of ACS algorithm for solving the VRP

V. PROPOSED ENCHANCED ANT COLONY SYSTEM ALGORITHM FOR SOLVING VRP

Ant colony system 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 ACS algorithm. The proposed enhanced ACs algorithm integrates a new heuristic function that will update the heuristic value every time the ants find a better solution in the iteration and gives more optimal results than the ACS algorithm. After the ant constructs its solution,

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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.

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: $\eta_{i=}\eta_i$ + (δ/ 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. CONCLUSION

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

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REFERENCES

[1] M. M. Alobaedy, "New Heuristic Function in Ant Colony System for the Travelling Salesman Problem," pp. 965–969,2012.
[2] V. Katiyar and M. Ieee, "An Enhanced Ant Colony System for Solving Vehicle Routing Problem with Time Window," vol. 73, no. 12, pp. 27–31, 2013
[3] W. L. Lee, "Real-Life Vehicle Routing with Non-Standard Constraints," vol. I, pp. 3–8, 2013.
[4] M Dorigo , C blumb "Ant colony optimization theory: A survey "Theoretical Computer Science 344 (2005), P. no 243 – 278,Elsevier
[5] M. Birattari, G. Di Caro, M. Dorigo, Toward the formal foundation of ant programming, in: M. Dorigo, G. Di Caro, M. Sampels (Eds.), Ant Algorithms, Proc. ANTS 2002, Third Internet Workshop, Lecture Notes in Computer Science, Vol. 2463, Springer, Berlin, Germany, 2002, pp. 188–201.
[6] C. Blum, Theoretical and Practical Aspects of Ant Colony Optimization, Dissertations in Artificial Intelligence, Vol. 282, Akademische Verlagsgesellschaft Aka GmbH, Berlin, Germany, 2004.
[7] G. Di Caro, M. Dorigo, AntNet: distributed stigmergetic control for communications networks, J. Artif. Intel.Res. 9 (1998)317–365.
[8] M. Caramia, G.F. Italiano, G. Oriolo, A. Pacifici, and A. Perugia. Routing a fleet of vehicles for dynamic combined pick-up and deliveries services. Universit´a di Roma "Tor Vergata", 2002.
[9] AS Tasan, M Gen, " A genetic algorithm based approach to vehicle routing problem with simultaneous pick –up and deliveries." Computers and Industrial engineering, 2012- Elsevier.
[10] B Yu, ZZ yang- "An ant colony optimization model: the period vehicle routing problem with time windows., Transportation Research Part E: Logistics and Transportation Review Volume 47, Issue 2 March 2011, Pages 166-181, Elsevier
[11] AE Rizzoli, R Montemanni, E Lucibello, L.M Gamberdella, "Ant colony optimization for real world routing problems- from theory to applications" Swarm Intelligence 2007, I: 135-151, Springer.
[12] W Dullaert, J K Janssens, K Sorensen and B Vernimmen, "New heuristics for fleet size and mix vehicle routing problem with time windows" Journal of operational research society(2002) 53, 1232-1238.