Modified Ant System Solving TSP Problem

Renu Jangra, Ramesh Kait

Abstract: ACO is applied on various combinatorial optimization problems. One among them is Travelling Salesman Problem. Generally, the fundamental ACO has the disadvantage of the entrapment in the local minimum and stagnation problem. In this paper, we proposed the algorithm named modified ant system (MAS) to resolve the above problems by modifying the pheromone update equation which results in better overall searching ability and also give better optimal solution earlier than AS. The comparison is done between basic ant system and modified ant system on different TSP problem instances. The proposed algorithm illustrates the less cost\length of the tour taken by ants to discover the shortest pathway.

Index Terms: Ant System (AS), Modified Ant System (MAS), Pheromone, Ant Colony Optimization (ACO).

I. INTRODUCTION

Swarm intellect is a quite innovative way to solve the difficulty that are based on and takes motivation from the societal events of insects, birds, and animals. The researchers work in the computer area is interested in to build the algorithms that are based on the insect natural behavior. The common combinatorial optimization problems take place in the fields of engineering, commerce, medicine or industry. The problems of this category are very difficult to answer in practice. In computer science, these problems are known as NP-hard, which means that there is not any algorithm exists which executes these problems in the polynomial time. Many methods and techniques use the base of ant colony among which the mainly considered and successful is the all-purpose principle optimization practice identified as ant colony optimization. ACO is the modern meta-heuristic that locate the straight trail by using the searching deeds of ants [1]. ACO uses the concept of pheromone present on the route and the real activities of ants group. The ants discharge, a chemical substance, pheromone on the path when they search for food. They can identify the path where the concentration of pheromone is more and then, choose the path according to its pheromone concentration. Ultimately, all the ants will select the shortest path from the nest to the foodstuff.

Ant System (AS): The initial ACO algorithm, termed Ant System that firstly solves the Traveling Salesman problem created by Dorigo and Colony in the year 1991.

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. AS have two phases: construction of solution and update of pheromone. The pheromone update is done when each and every ant have completed their solution construction and is done in following ways.

Firstly, to implement the vanishing rate of pheromone, the value of pheromone on all the arcs is decrement by a fixed rate. The pheromone value of the path that ants pass through during their tour is added to the pheromone present on the arcs [2].

Construction of the Solution: Initially, ants are placed in random cities. An ant 'k' applies a random proportional rule to select the next destination city where they want to visit next. Currently, ant 'k' presents in city f and wish to move in city g with the probability specified by the rule given below:

$$p^k_{f,g} = \frac{\left[\tau_{f,g}\right]^{\alpha}\left[\eta_{f,g}\right]^{\beta}}{\sum_{l}^{N_f^k}\left[\tau_{f,l}\right]\left[\eta_{f,l}\right]^{\beta}} \quad \text{if} \quad j \in N_f^k$$

Where, $\eta_{f,g} = 1/d_{f,g}$ is the heuristic value of the city/node g from city/node f. $d_{f,g}$ is the length between cities/nodes f and j. $\tau_{f,g}$ is the amount of pheromone on the route that connects cities. α is the constraint that regulates the pheromone on the trail. β is a constraint that contains heuristic information.

Pheromone update:

The pheromone evaporation equation is specified by

$\tau_{f,g} \leftarrow (1-\rho)\tau_{f,g}$, where $0 < \rho \le 1$ (2)

ρ is used to evade the unnecessary formation of the pheromone on the route. During creation of the path, if an arc is not selected by ants then their corresponding pheromone value is diminishing exponentially as the iteration count varies.

After the evaporation, all the ants will leave pheromone on those paths that they have traversed during the visit:

$$\tau_{f,g} \leftarrow \tau_{f,g} + \sum_{k=1}^{m} \Delta\tau^k_{f,g} \ , \quad \forall (f,g) \in L \quad (3)$$

where $\Delta\tau^k_{f,g}$ is the total of pheromone that ant 'k' puts down on the arc which they traversed. It is represented by: $\Delta\tau^k_{f,g} = 1/C_k$, if the arc $(f,g) \in T^k$, if not, then zero where C_k is the end to end distance of trip T_k assemble by the k_{th} ant and is

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calculated by adding up the length of the arc belonging to T_k. In broad, the arcs that are followed by more ants and form the short tour collect more pheromone on the path and these arcs are most probable to be preferred by the ants in further iterations.

II. LITERATURE SURVEY

M. M. Manjurul Islam et al.[3] discovered the methodology that they applied to the Travelling Salesman Problem. They discuss how to set the model and how to select the parameter. Also, made the comparison with tabu search and apply the results of simulation on variety of cities to discover the best tour and less time.

Z. F. Jun and G. Wei [4] proposed an algorithm named meeting ACO that merges pairs of searching ants jointly to expand the diversification of the search. A threshold constant is applied to make the algorithm function normally.

Hong-biao Mei et al [5] proposed an improved version of AS called An Ant Adaptive Dynamic Ant System (ADAS) with the modification in the pheromone update rule and the probability/transition rule. Through the help of simulation result, they showed the better solution that solves the conflict between stagnation problem and the convergence speed.

Y. Zhang et al. [6] proposed a changed Ant System Algorithm worked on PPL (Parallel Pattern Library) to explain TSP by combining PPL parallel programming with equation of pheromone update of the Ant-System algorithm. The proposed algorithm generates an innovative method to diminish pheromone update with the help of three different pheromone update method that results in healthier overall searching skill, higher convergence speed; and a variety of solutions than the traditional ACO algorithm.

Z.C.S.S Hlaing and M.A. Khine [7] proposed an improved Ant System Algorithm focus on two things (i) candidate set approach is assumed to quick convergence speed. (ii) Performance is improved by using entropy in heuristic parameter vibrant update rule in solving TSP.

A. Paul and S. Mukhopadhyay [8] proposed a better Ant System (IAS) and build up a fresh outline of modeling with the attributes of basic Adaptive Filters. They resolve the critical deficiency of local optima and the sluggish convergence speed by means of the belongings of Least Mean Square algorithm in the update of pheromone to trace the finest smallest tour duration.

A. Bajpai and R. Yadav [9] introduced a partitioning procedure stands on the partition and overcome policy for the traveling salesman problem. They partitioned the difficulty into smaller problems, apply the ant colony algorithm with the candidate list approach and local optimization on each sub problems, then merge the associated problems to get the high-quality solution by recovering the discovery competence of the ants.

Abdulqader M. Mohsen [10] proposed a hybrid ACO algorithm that solves the traveling salesman problem using the advantages of ACO. The ant's population range is increased from time to time by using the mutation operator and properly uses the available search area by applying the local search.

Y. Yan et al. [12] made the changes in the existing Ant System algorithm and design a proposed algorithm. They apply alternation in the solution construction of tour and pheromone update policies to attain better equilibrium between intensification and diversification during the search criteria. The quality of the new algorithm is experienced in arbitrarily created data and recognized obtainable data. The analyzed outcomes specify the proposed amendment is efficient and resourceful for the TSP and viable with Ant Colony System, Max-Min Ant System, and Artificial Bee Colony Meta-Heuristic.

K.S. Mohammed [13] planned an algorithm that based on the pheromone value and the distance between the cities.
The author assured that the new approach of finding the shortest path and the optimal solution is better than the existing one.

III MODIFIED ANT SYSTEM (MAS):

In ant colony optimization (ACO) algorithms, an ant uses pheromone for conversation with other ants. Typically, this indirect communiqué of ants show the way of stagnation behavior, in which the ants track the similar route from earlier phases. The reason of the problem to develop is the large quantity of pheromone formation on the path which induces other ants to follow the related equivalent path again and again. Due to this, the populace gets fascinated in the local most advantageous solution that is hard to break and get out from this [11]. An evaporation rule will be attached with the pheromones, which will lessen the possibility of poor quality solutions in which a constant\fixed quantity of pheromone is deducted from all the trails. These practices allow the population to eliminate the terrible conclusion that made in earlier tours and avoid the infinite growth of pheromone which possibly resulting in early convergence in the direction of a suboptimal solution area. This system, therefore, favors in the exploration of the search space. The proposed modified ant system solves the problem of stagnation and local optimum solution. This is done by modifying the evaporation rule and the pheromone update rule. The evaporation rule shown in equation 2 is now modified and given by

$\tau_{f,g} \leftarrow (1-\rho)\tau_{f,g}/n$, where n as a parameter represents the count of cities\ nodes\ dimension and $0 < \rho \leq 1$

And equation 3 is modified and given by

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$$\tau_{f,g} \leftarrow \tau_{f,g} + s\sum_{k=1}^{m}\Delta\tau_{f,g}^{k}, \forall(f,g)\in L$$

where $s = 1/\rho$.

III. EXPERIMENT ANALYSIS

The modified Ant system algorithm is executed on TSP problem instance berlin52.tsp of 52 cities. The different graphs show the comparison between AS and MAS results in less cost\length of the tour in case of MAS than AS based on parameter setting as $\alpha = \beta = 1$ till Fig. 3. Other parameter values depend on the type of comparison. In Fig.1 the parameter number of ants (m) is initialized with value 150 and iteration with 100. On different values of rho (ρ), the cost\length of MAS is less than AS. In Fig.2 the parameter ρ is initialized with value 0.05 and iteration with 100. On different values of the number of ants (m), the cost\length of MAS is less than AS. In Fig.3 the parameter ρ is set with value 0.05 and number of ants (m) with 100. On different values of iterations, the cost\length of MAS is less than AS. In Fig.4 the parameter ρ is initialized with 0.05 and number of ants (m) and iteration with 100. On diverse values of combination of α and β, the cost\length of MAS is less than AS.

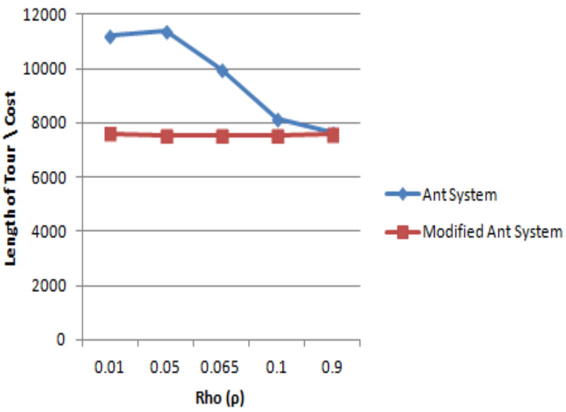

Fig.1 Comparison of Length/Cost between AS and MAS based on different values of rho.

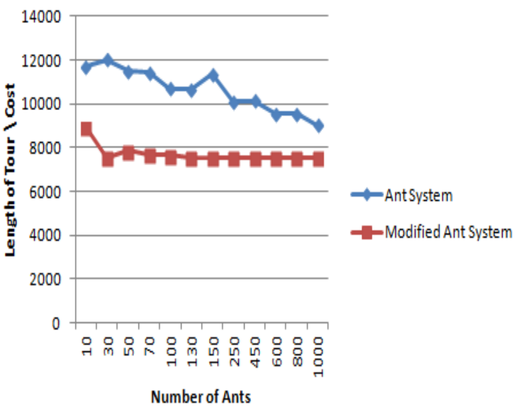

Fig. 2 Evaluation of Length/Cost between AS and MAS based on different values of the number of ants.

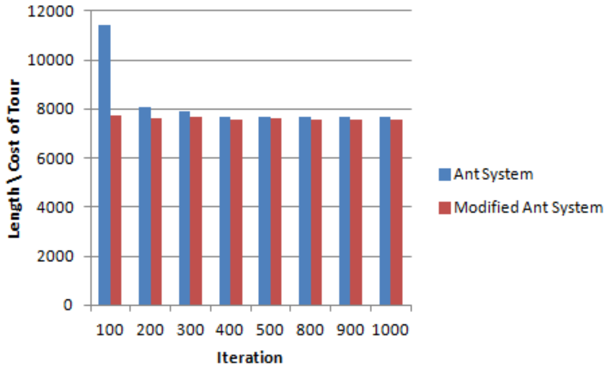

Fig.3 Evaluation of Cost/Length between AS and MAS based on different values of the iteration.

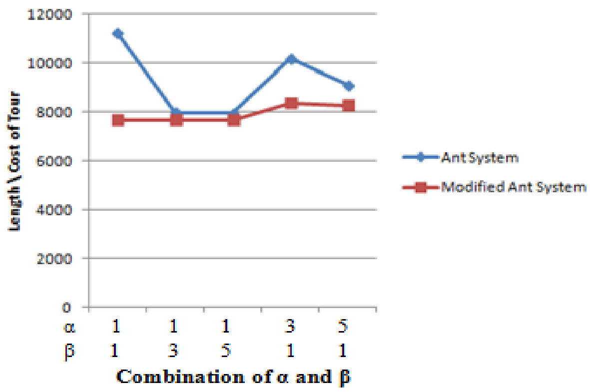

Fig.4 According to different arrangement made in values of α and β comparison of Cost/Length between AS and MAS. Table 1 depicts the cost\length of visit done by ants to find the shortest path in case of AS and MAS on different problem instances of TSP. The experiment is taken by setting the parameter as follows: $\alpha = \beta = 1$, ρ = 0.05, m = 100, iteration=1000.

Problem Instance	Ant System (AS)	Modified Ant System (MAS)
ulysses22.tsp	75.3984	75.2832
att48.tsp	34838.8978	34715.1208
st70.tsp	717.3565	705.2688
gr96.tsp	545.322	545.0088
ch150.tsp	6893.4878	6659.9964
d198.tsp	17677.4109	17562.6009

Table 1: Comparison based on length\cost of tour between AS and MAS on different problem instances of TSP

IV. CONCLUSION

In the paper, we proposed the algorithm modified ant system to crack the problem of local minima and stagnation occurs in a basic ant system by modifying the pheromone update equation. By removing the problems, the MAS can give better overall searching ability and also give better optimal solution earlier as compared to AS. The comparison is also shown in graphs in terms of length\cost of a tour done between ant system and modified ant system using Matlab on TSP problem instance berlin52. The comparison is also done on other TSP

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problem instances shown in the table. The modified ant system results better in all comparisons in terms of length\cost. In the future, work can be done on the other ACO algorithm by using the different parameters.

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