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Analysis and Comparison Among Ant System; Ant Colony System and Max-Min Ant System With Different Parameters Setting

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Abstract:-**Ant colony optimization is a victorious technique to resolve complicated combinatorial optimized problems. Subsequent Ant System; the primary ACO algorithm, the tremendous number of algorithmic variations have been deployed that illustrate appreciably superior performance on a broad variety of optimized problems. In this paper, we present the basic modifications in Ant Colony System -ACS and Max-Min Ant System -MMAS with respect to Ant System -AS. Also, compare the result of these three algorithms based on different parameter adjustments.**

Keywords:-Ant Colony Optimization; Ant System; Ant Colony System; Max-Min Ant System.

I. INTRODUCTION

Being a popular meta-heuristic ACO, originated at the start of the 1990's, encouraged by the concept of real ants that utilize pheromones as intermediate for communication with other ants. Ant System (AS) is the first ACO algorithm. After that several other algorithms also proposed that showed the improved performance over AS. The major algorithmic enhancement included Ant Colony System; MAX–MIN Ant System; Rank-based Ant System; and a many more. First Ant Colony Algorithm was proposed by M. Dorigo, A. Colorniant V. Mahiezzo in year 1991, this algorithm based on the simulation and is a advanced process of the genuine ant wanders in searching of foodstuff. During calculation process of the ant-colony algorithm, the message of ant colony is transferred or guided to other ants through the control of information quantity left onto the paths. The movement of ants in ant-colony shows that the path followed by ants is most informative path [1]. The research study shows that the path which has well-built amount of information is always nearer to the most favorable path. When the ants move in search of food, at the start, their journey is in the region of their nest in an arbitrary manner. During their move, ants leave a pheromone, a chemical substance, on the land. Ants can feel the aroma of pheromone. When ants select the path where they have to go next, they have a tendency to choose, in probability, the paths having large quantity of pheromone [2]. Our paper is structured as follows. Section II describes the author's findings related to the work and concise basic about the ant system; ant colony system; and max-min ant system. Section III illustrates the experimental study results present through graphs. At last, Section IV illustrates the conclusion of this paper.

II. LITERATURE SURVEY

Leslie Perez Caceres, et.al [3] observed the act of various ACO - algorithms beneath a limited cost of 1000 evaluations. They done this act by using the default parameter adjustments from the literature study and adjust the parameter for the limited budget parameter settings adjusted for the limited-budget scenario. They also compare the performance of the ACO tuning algorithms in case of limited-budget that directs the search through the ACO algorithms using replacement modeling techniques. The proposed ACO variants with improvements over Ant System will be considered. Thomas Stutzle , et.al[8][9] introduced the enhanced version of Ant System called Max-Min Ant System, by improving the local search heuristics by generating good initial tour. Also, they show the result for the problems of TSP having instances in symmetric and asymmetric form. Holger H.Hoos, et.al [10] presented Max-Min Ant System with several modifications to AS (a) to find the greatest solution during the search to achieve the high-quality solution. (b) To keep away from the premature convergence of the ant's search, they gave the proper reason of the changes with the help of computational learning of MMAS and shown the results that all the modifications that are done, are important for getting the best performance. James Morris-King [11] presented an overview of ACO and its variants in solving TSP. They also observe several accepted ant-systems algorithm and calculate approximately the performance with each other and also against the other combinatorial troubles. Finally, they study other areas where AS principles are looking efficient. Amilkar Puris, et.al [12] proposed a new two-stage PTS-ACO to improve the quality of solution of ACO algorithms. In this paper a new approach is introduced, the pheromone trails attained in the first step are used to direct the ant's exploration in the second step of the

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explore process. Marco Dorigo [13] proposed the methodology to the TSP and show details of simulation results with parameter choice and the early setup of the model. They also contrast it with simulated annealing and tabu search using TSP. Yara Khaluf, et.al[14] proposed a modified version of Ant Colony System that solve the edge detection problem that is a is a elementary method in image processing, machine, and computer vision. These modified algorithms solve the stagnation problem. Benjamin Lammel, et.al [15] solved the Travelling Salesman Region Problem by talk about the control of the parameters/factors of the Ant Colony Optimization algorithm. The parameters are explained properly so that they can be used to evaluate the best solutions. Wenjiao Ban,et.al [16] proposed an algorithm PGA – MMAS that use GA and MMAS that is capable of executing the multi-join for query processing, also has a vital task in improving the task of distributed database. NAVTEJ SINGH GHUMMAN, et.al[17] proposed an improved Max-Min to balance the total load **(**CPU load-memory capacity-delay or network load**)** of a cloud system. They illustrate the comparison between improved max min and the proposed new hybrid improved Max-Min an approach that centered on the total time of process and cost of processing.

TABLE 1. ANT COLONY ALGORITHMS

ALGORITHM	AUTHORS	YEAR
ANT SYSTEM(AS)[4]	DORIGO ET AL.	1991
ANT COLONY SYSTEM[5]	DORIGO& GAMBARDELLA	1996
MAX-MIN AS[6][7]	STUTZLE & HOOS	1996

The key difference among Ant System, Ant Colony System, and Max-Min Ant System are the way pheromone is updated and the way pheromone trails are managed.

A. Ant System (AS)

Originally, three diverse variations of AS were proposed called ant-density(AD), ant quantity(AQ) and ant-cycle (AC) (Dorigo et al., 1991a; Colorni,Dorigo, & Maniezzo, 1992a; Dorigo, 1992). In ant-density(AD) and ant-quantity(AQ), update of pheromone is done when an ant travel from one city to next city. But, in case of ant-cycle (AC), the update of pheromone is done only when all the ants had build the tours and a function is set for tour quality as the total of pheromone amount deposited by each ant. Due to good performance of ant-cycle, ACO variants are build on the same concept. AS algorithm contains two parts. (1) First; is solution/tour construction by ants and second is pheromone update. Tour Construction: Primarily, ants are put on randomly chosen cities deciding the next city based on random proportional rule[4].Pheromone update: Pheromone value is updated only after when all ants completed their tour construction. The quantity of pheromone value placed by ants in completion of one tour highly depend on the count of ants and the length/distance of the tour covered by ants by means of any of the nearest neighbor heuristics approach.

B. MAX–MIN Ant System (MMAS)

As compare to Ant System, four different changes are launched in MMAS. (i) The presentation of Ant System algorithm can be made better by allowing the best-ant only to update the pheromone trails in each cycle. This approach has a shortcoming called early stagnation that creates problem in further tour improvements. When the problem of stagnation occurs, the pheromone trails on some arcs are so high because of the ants will build the corresponding tour forever means again & again. In MMAS, the best ant is only allowed to update\modify the trails. (ii) Stagnation problem is to be resolved by introducing explicit maximum (τ_{max}) and minimum (τ_{min}) trail strengths on the arcs, hence the name MAX-MIN Ant System [8]. The decision of selecting the maximum and minimum trail limits is done according to a problem that is used and calculated by geometric series. Also, the decision of selecting limits has some to follow [9]. (iii) Initialization of pheromone is equal to the higher pheromone trail bound having small rate of evaporation which raise the finding of tours at the initiation of the search. (iv) The value of pheromone is reinitialized every time when the system moves towards the stagnation problem or with the number of successive iterations, when no improved path is revealed [4].After the completion of ant's tour, pheromone trail value is updated. The ant which has authority to insert pheromone is any between the best-so-far ant and the iteration-best ant.

C. Ant Colony System (ACS)

As compare to Ant System, three different changes are introduced in ACS. First, the probability rule used to find the path to move in next city is different from AS and replace by aggressive (forceful) action choice rule. Second, the process of deposition and evaporation of pheromone is only applicable on the arcs that are belonging to best--so-far ant's tour. Third, ants eliminate some pheromone on the arc that they use to travel from one place to other place to raise the examination of other substitute paths.

In Table 2: α as a factor\parameter that choose the control of the pheromone trail; β as a factor or parameter reveals the value of heuristic information ($\eta_{i,j}$) in the probability function given below, where $\eta_{i,j}=1/d_{i,j}$ and $d_{i,j}$ represents the distance between cities/places i and j. ρ is used to keep away from the limitless buildup of pheromone trail and m is the quantity of ants. In our experimental learning of the different ACO algorithms for solving the TSP problem has recognized the parameter settings that show good outcomes and performance, as depicted in the below given table.

TABLE 2. PARAMETER VALUES

Algorithm	α	β	ρ	m
AS	1,3,5,7,9	1,3,5	0.05	Acc. to problem instance
MMAS	1,3,5,7,9	1,3,5	0.05	Between 10 to 60 (varies with iterations)
ACS	1,3,5,7,9	1,3,5	0.05	Between 10 to 60

Probability function is given by equation:

$$p_{i,j}^{k} = \frac{[\tau_{i,j}]^{\alpha}\,[\eta_{i,j}]^{\beta}}{\sum_{l} \in N_i^{k}\ [\tau_{i,j}]^{\alpha}\,[\eta_{i,j}]^{\beta}}, \quad \text{if } j \in N_i^{k}$$

Where, $\tau_{i,j}$ = concentration of pheromone trail linking cities i and j, $\eta_{i,j}$ = visibility of the city/place j from city/place i.

III. EXPERIMENT ANALYSIS

In Fig. 1 The comparison is done on basis of parameter setting α = β = 1, ρ=0.05 in MMAS, AS and ACS. But, in MMAS m varies with respect to a number of iteration, in ACS m=30 and in AS m=16.The comparison shows the variation in execution time of three algorithms, when iterations vary. In Fig. 2 The parameter setting α = β = 1,ρ =0.65, m varies with respect to number of iteration in MMAS ,in AS α = β =1,ρ =0.05, m=20 and in AS α =1, β =5,ρ = 0.65, m=29. The comparison shows the cost/length of ant's tour on varying iterations. In Fig. 3 the parameter settings are α = β = 1, ρ =0.05, Iteration = 100 in all three algorithms. The comparison shows the execution time of three algorithms when a number of ants vary. In Fig. 4 the parameter settings are α = β = 1, ρ =0.05, Iteration = 100 in all three algorithms. The comparison shows the cost/length of ant's tour, when a number of ants varies. In Fig 5, the comparison shows the cost/length of ant's tour on varying combinations of α and β.

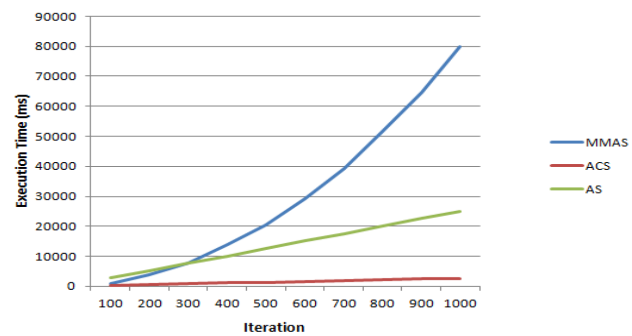

Fig.1 According to number of iterations the comparison of execution time of MMAS, ACS, and AS

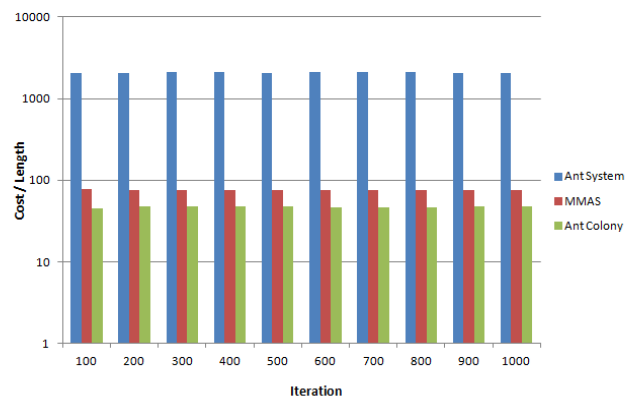

Fig.2 According to number of iterations the comparison of Cost/Length of MMAS, ACS, and AS

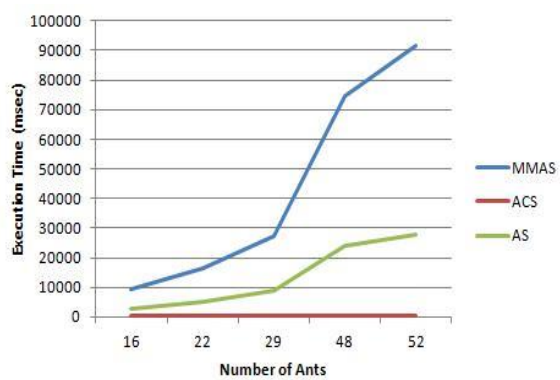

Fig.3 According to number of ants the comparison of execution time of MMAS, ACS, and AS

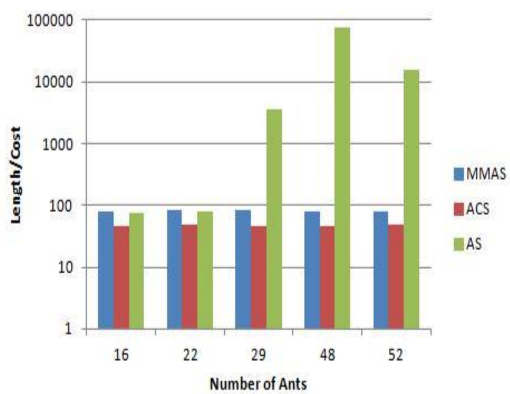

Fig. 4 According to a number of ants the comparison of Cost/Length of MMAS, ACS, and AS.

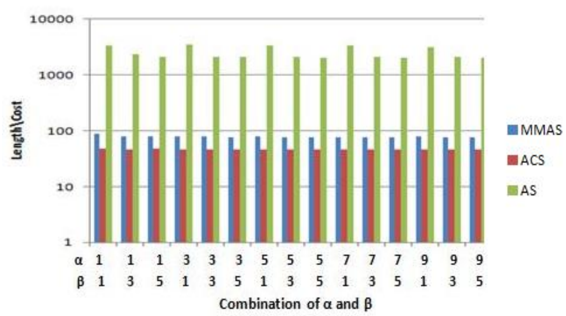

Fig .5 According to combination of α and β the comparison of length/cost of MMAS, ACS, and AS

IV. CONCLUSION

ACO is a one of the best metaheuristic optimization problem-solving method. In this paper, we discuss the three variants of ACO. We can analyze and compare the three variants based on different parameters setting. Algorithms show different behavior depend on the setting of parameters like a number of ants(m), iterations, a parameter that decide the relative control or weight of the pheromone trail(α), parameter to show visibility when choosing the route (β), a parameter that avoids unlimited accumulation of pheromone trail (ρ).In our analysis, ant colony system results better among three with respect to other algorithms in following ways. When a count of ants and iterations increases, the cost of a route taken by ants and time taken is less in ACS. ACS is also better in terms of length of route covered by ants when calculating against a combination of α and β. In future, researchers can also analyze the ACO variants on other parameter values, may show different behavior and results

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