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Analyzing travelling salesman problem with new parameters using Ant Colony Optimization

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Abstract: Travelling salesman problem is studied in the field of combinatorial optimization. TSP being heuristic algorithm tries to find minimum distance between given set of cities by traversing each of these cities only once except the starting city. A lot of techniques have been developed to solve TSP like Ant Colony optimization, Genetic algorithms, neural networks etc. Ant Colony optimization (ACO) being a heuristic algorithm attempts to find optimum solution by mimicking ants finding food as a group. Ants release pheromones on their path, concentration of which suggests shortest path to food. Models have been developed to solve ACO with fixed parameters. This paper attempts to analyze and find the best value for the set of parameters like "Exponential Weight", "Heuristic exponential Weight", "Evaporation Rate" for this solution based on no. of iteration and minimum distance traversed.

Keywords: Ant Colony Optimization algorithm, Evaporation Rate, Genetic Algorithm, Travelling Salesman Problem, Heuristic exponential weight.

I. INTRODUCTION

TSP-Travelling Salesman Problem is a problem which is base on the travelling in which the salesman need to visit "n" cities (nodes) by travelling distance (vertexes) to all cites and reaches the starting city, with the minimum cost. TSP can solved with the help of different algorithms such as description method, Tour constructions, Tour improvement, Special cases of the TSP, and Some other heuristic of solving TSP.

Ant Colony Optimization has been involved as the low cost and efficient method for shortest path for travelling. Artificial researcher Marco Dorige described in 1993 a method of heuristically generating "good solutions" to the TSP using a colony called ACS (Ant Colony System). It models behavior observed in real ants to find short paths between food sources and their nest, an emergent behavior resulting from each ant's preference to follow trail pheromones accumulate by other ants. In order to improve the global solving ability and convergence speed, avoid falling into local optimal solution; the basic ant colony optimization (ACO) algorithm is improved to propose an efficient and intelligent ant colony optimization (IMVPACO) algorithm.
Adjustment strategy of pheromones are modify in order to better reflect the quality of the solution based on the increment of pheromone.[1]
This paper tried to study optimum parameters for improved ACO.

II. LITERATURE SURVEY

Khushboo Arora [2] "Better Result for Solving TSP: GA versus ACO(march 2016)". The author had done the comparative studies between GA and ACO. Finally the author shows that Genetic Algorithm gives better result in terms of distance travelled for less number of cities but as the author increases the complexity by increasing the number of cities, ACO proves to give better result than Genetic. While considering Execution time as the factor ACO is also proved to be better.

Ping Duan[1] "Research on an Improved Ant Colony Optimization Algorithm and its Application (2016)." The research studies on the dynamic movement's rule of ants, Improved updating rules of Pheromones, Adaptive Adjustment Strategy of Pheromone, Dynamic Evaporation Factor Strategy, Boundary Symmetric Mutation Strategy.
In the IMVPACO algorithm, the updating rules and adaptive adjustment strategy of pheromones are modifying. It order to provide better quality of the solution based on the increment of pheromone, the author used dynamic evaporation factor strategy to achieve the finer equalization between the decode efficiency and clear up quality, and effectively pass up falling into local optimum for thrilling the convergence speed. The movements rules of the ants are modifying, to make it changeable for large-scale problem solving, optimize the path and better search efficiency.

Richa Bajaj[3] " A Review on Optimization with Ant Colony Algorithm (july 2016)". The Author Studies about the percussion of some control parameters by implementing ACO algorithm. The quality of the solution is compared with

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the optimal solution. The study overcomes the problem of Stagnation and congestion by using Multiple Ant-Colony Optimization. In the improved version, of ACO, Multiple Ant-Colony Optimization can change upon more than one optimal past interfaces are identified as compared to only one path, which are accepted to provide formidable throughput and will be able to examine new and better paths even if the network topologies gets interchanged very frequently. This will assign the traffic of burden link to other preferred links. Hence the throughput of the network is reorganized and the problem of stagnation gets reformed.

Farah Sarwar[4] "Critical Analysis of Hopfield's Neural Network Model for TSP and its Comparison with Heuristic Algorithm for Shortest Path Computation". The paper studied comparison between the heuristic algorithm and the Hopfield's Neural Network for different number of cities. Neural Network was not able to provide the better optimum solution as compared to heuristic algorithm.

Hashim Ali[5] "Solving Traveling Salesman Problem through Optimization Techniques Using Genetic Algorithm and Ant Colony Optimization(jan 2016)". The paper show the studies of TSP solving with heuristic algorithm such as ACO and Genetic Algorithm and comparatively studies between them on square area(10x10) for the no. of cities. Now a days Genetic Algorithm and Ant Colony Optimization calculated in two scheme a) altering number of iteration, b) altering the number of cites to nodes in solution space as input and keeping other parameters constant. Both techniques provide the optimal solution. In starting for less no. of cities G.A. is better, but the complexity increases when no. of cities Increases, the ACO are better approach to solve it.

Er. Priya Darshni[6] "Implementation of ACO Algorithm for Edge Detection and Sorting Salesman Problem(2010)". The paper represents an Ant Colony Optimization-based technique for image edge detection and also provides solution for the Travelling Salesman Problem. The considered method authorized a pheromone matrix that correspond the edge information at each pixel based on the path formed by ants dispatched on the image. The research achieve the complete ACO algorithm for edge detection of the image, And it also actualized for sorting salesman problem.ACO method solves the ambitious computational problems and chooses compendiary route to solve the problem.

Ivan Brinzina Zuzana Cickova [7] "Solving the Travelling Salesman Problem Using the Ant Colony Optimization (sept 2011)". The research is on TSP using ACO. Study the knock of some control parameters by actualize ACO algorithm. The individuality of the solution is analyze with the optimal solution. It can be achieve that the affirmation of solutions depends on the crowd of ants. The lower number of ants allows the specific to change the path often faster. The greater number of ants in community causes the higher accession of pheromone on edges, and thus an invisible keeps the path with higher concentration of pheromone with a high rise probability.

Zar Chi Su Su Hlaing [8] "Solving Traveling Salesman Problem by Using Improved Ant Colony Optimization Algorithm (dec 2011)". The paper shows the changes in ant colony system, dynamic candidate list strategy, proposed approach a) Dynamic Candidate List Strategy b) heuristic parameter updating based on entropy and mergence of local search solution is proposed. Paper presents an access for solving TSP based on improved Ant Colony Algorithm. An improved interpretation of ACO algorithm based on candidate list strategy and also proposed dynamic heuristic parameter updating establish on degeneration and combine of local search solution is purposed. From the experimental results, the considered system is more capable than the ACS algorithm in terms of association speed and the ability to finding better solutions.

M.M.Manjurul Islam[9] "An Implementation of ACO System for Solving NP-Complete Problem; TSP(Dec 2006)" The research paper suggest the studies ant density, ant quantity, ant cycle on different of rho (0.3 to 0.99) and taking fix value of alpha and beta . Main prospect analysis over simulation in different cities to find best path and time. Also found best performance in various component past prior implemented.

Xue Yang [10] "Application of Improved Ant Colony Optimization Algorithm on Traveling Salesman Problem(2016)". The papers studies about the improved ant colony algorithm for solving TSP, Update Strategy of Information Hormone, Selection of Parameters and Local Optimal Search Strategy. The Author altering the heap of information and seeking for the optimal parameters, it can change up the confluence velocity. The simulation results with a typical TSP problem show that the proposed method can assemble to the global optimal result promptly and speed up the convergence rate.

III. SOLUTION METHODOLOGY

For normal condition we take the value o f Alpha = 1, Beta=1, Rho= 0.05, we execute the Program and gets the following values no. of Iteration (x-axis) Is 59.585, and it takes the time for execution is 180.11 and cost (y-axis) will be 362.43. As no. of iteration, no. of ant and no of cities will be fixed 300, 40 and 20 respectively (fig 1).

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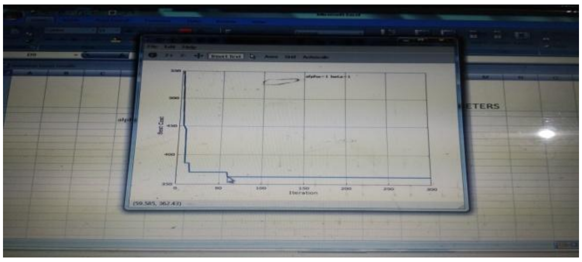

Fig-1: Study of cost and iteration when alpha, beta is 1 and rho is 0.05

Now we have change the parameter values and studies the effect on the graph and also suggest the Better values for min number of iteration and cost.
Let's begin with the values of ALPHA then BETA then RHO respectively with the help of graphs. Now see the effect on the cost, execution time and the no. of iteration when we change the values of Alpha. Other parameter will be fixed such as Beta, Rho, iteration, no. of ants.

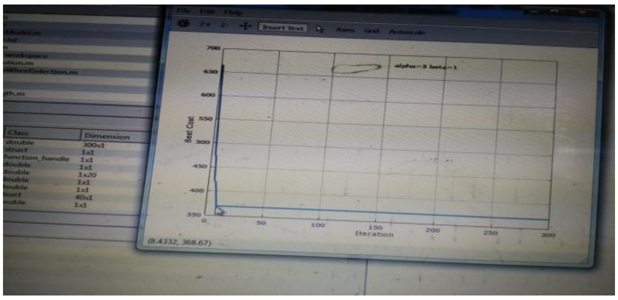

Fig-2: Study of cost and iteration when alpha, is 2

Putting the value of Alpha = 2. The graph provides the Iteration (x-axis) is 11.889 and Cost (y-axis) is 372.9. It also provides 180.29 the execution time (fig 2).

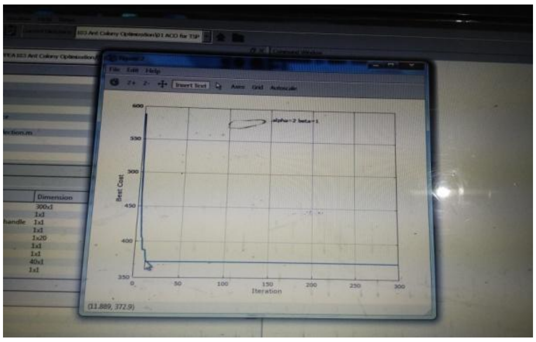

Fig-3: Study of cost and iteration when alpha, is 3
Now substitute the value Alpha = 3 and execute the program the value of iteration is 8.4332 and cost will be 368.67and times taken to execute 180.69 (fig 3).

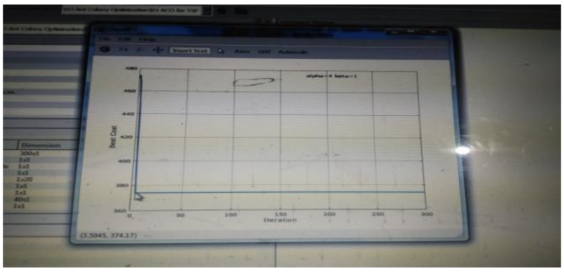

Fig-4: Study of cost and iteration when alpha, is 4

Now put Alpha= 4 and execute the program . We get iteration (x-axis) 03.5945 and with Cost (y-axis) 374.37. The execution time will be 180.72.

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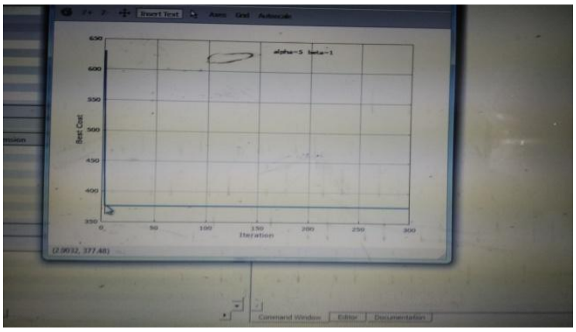

Fig- 5: Study of cost and iteration when alpha, is 5

Now substitute Alpha = 5. And execute the program, the graph provides Iteration (x-axis) 02.9032 With Cost (y-axis) is 377.48 and execution time is 180.49 (fig 5).

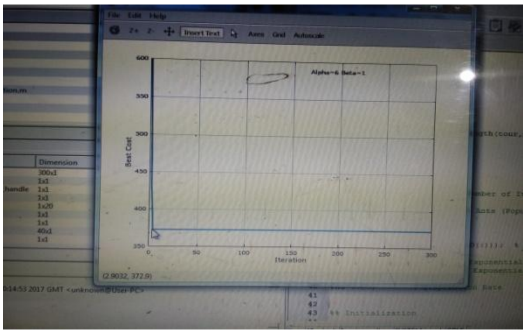

Fig- 6: Study of cost and iteration when alpha, is 6

Putting Alpha = 6, now execute the program we get Iteration (x-axis)is 02.9032,is same as Alpha 5 and the Cost (y-axis)is also approx. same 372.90, also execution time is 180.49 (fig 6).

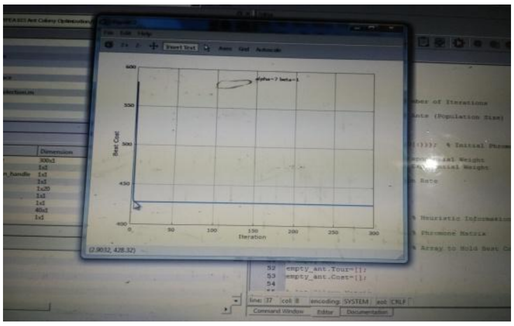

Fig-7: Study of cost and iteration when alpha, is 7

Substitute Alpha = 7 and execute the program and we see Iteration (x-axis) is same 02.9032 but the cost is very high i.e. 428.32 and execution time is almost same 180.61 (fig 7).

alpha	beta	Rho	cost(y axis)	Iteration(x axis)	Time	iteration	cities	No.Ants
1	1	0.05	362.43	59.585	180.11	300	20	40
2	1	0.05	372.90	11.889	180.29	300	20	40
3	1	0.05	368.67	8.4332	180.69	300	20	40
4	1	0.05	372.90	3.5945	180.72	300	20	40
5	1	0.05	377.48	2.9032	181.74	300	20	40
6	1	0.05	372.90	2.9032	180.49	300	20	40
7	1	0.05	428.32	2.9032	180.61	300	20	40

Table 1:- Study of cost, time, and iteration with change of Alpha

Now we have Studies the graph i.e. iteration v/s cost with the increase the value of Beta. From 1to 6 other parameter are fixed such as alpha should be 1. Rho will be 0.05 no. of iteration is 300, 40 is the number of ants and number of cities should be 20.

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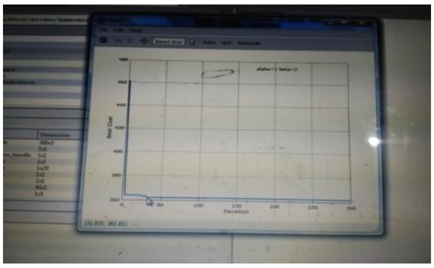

Fig-8: Study of cost and iteration when Beta, is 2

Now we change Beta value is 2 and execute the program the graph show iteration (x axis) Is 31.935. The cost (y axis) be 361, 81 and time of execution 181.82 (fig 8).

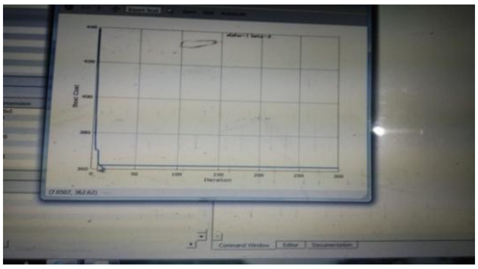

Fig-9 : Study of cost and iteration when Beta, is 3

Putting Beta = 3 and execute the program we get iteration 07.0507 on x axis and with Cost (y-axis is) 362.62. The execution time will be 180.64. (fig 9).

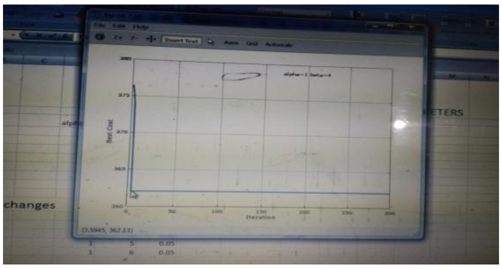

Fig-10: Study of cost and iteration when Beta, is 4

Now substitute Beta value is 4 and execute the program the graph show iteration (x axis) Is 3.5945. The cost (y axis) be 362.13 and time of execution 180.49. (fig 10).

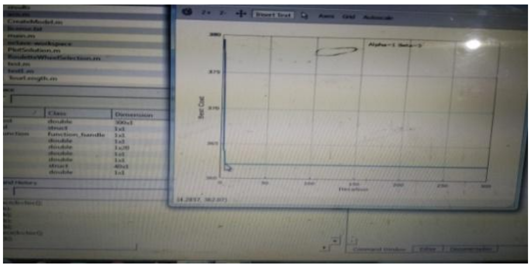

Fig-11: Study of cost and iteration when Beta, is 5

Now put Beta = 5 and execute the program we get iteration 04.2857 on x axis and with Cost (y-axis) 362.07. The execution time will be 180.85 (fig 11).

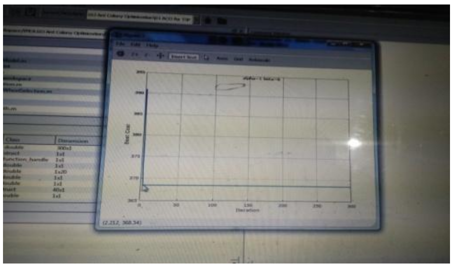

Fig-12: Study of cost and iteration when Beta, is 6

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Lastly put Beta = 6 and execute the program we get iteration 02.212 on x axis and with Cost (y-axis) 368.54. The execution time will be 180.39 (fig 12).

Alpha	Beta	Rho	Cost (y-axis)	Iteration (x axis)	Time	Iteration	Cities	No.Ants
1	2	0.05	361.81	31.935	181.82	300	20	40
1	3	0.05	362.62	7.0507	180.64	300	20	40
1	4	0.05	362.13	3.5945	180.49	300	20	40
1	5	0.05	362.06	4.2857	180.85	300	20	40
1	6	0.05	368.54	2.212	180.39	300	20	40

Table 2:- Study of cost, iteration and Time with change of Beta

Finally we are going to study the graph i.e iteration v/s cost with the increase the value of RHO. From 0.10to 0.70, other parameter are fixed such as alpha should be 1. Beta will be 1. No of iteration is 300, and the number of ants are 40 and number of cities should be 20.

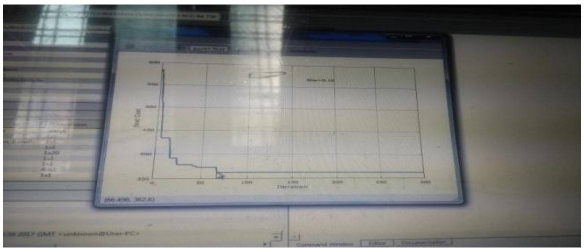

Fig-13: Study of cost and iteration when rho, is 0.10

Finally we going to change RHO value0.10 and execute the program the graph show iteration (x axis) Is 66.498. The cost (y axis) be 362.60 and time of execution 208.95 (fig 13).

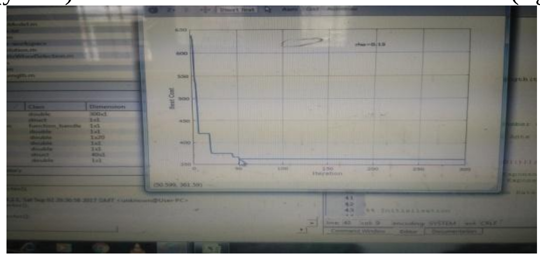

Fig-14: Study of cost and iteration when rho, is 0.15

Now put Rho =0.15 and execute the program we get iteration 50.599 on x axis and Cost on (y-axis) is 361.59 the execution time will be 204.65 (fig 14).

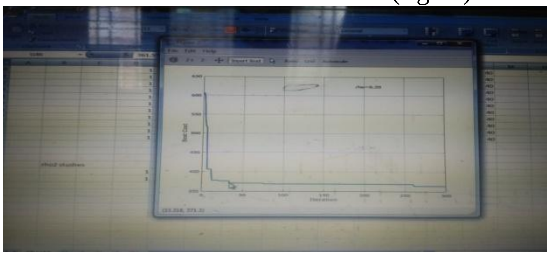

Fig-15: Study of cost and iteration when rho, is 0.20

Now substitute Rho is 0.20 and execute the program the graph show iteration (x axis) Is 33.318. The cost (y axis) be 371.30 and time of execution 202.13 (fig 15).

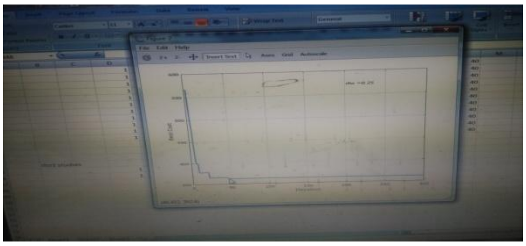

Fig-16: Study of cost and iteration when rho, is 0.25

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We substitute RHO value is 0.25 and execute the program the graph show iteration (x axis) Is 46.452. The cost (y axis) is 362.6 and time of execution is 204.05 (fig 16).

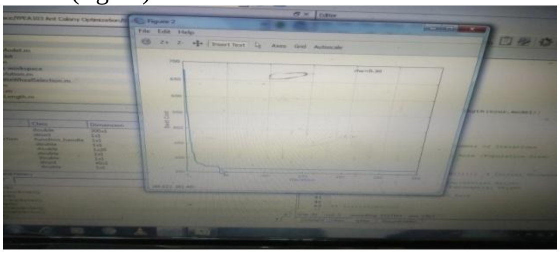

Fig.17 Study of cost and iteration when rho, is 0.30

Now put Rho =0.30 and execute the program we get iteration 40.922 on x axis and Cost on (y-axis) is 361.46 and the execution time will be 202.95 (fig 17).

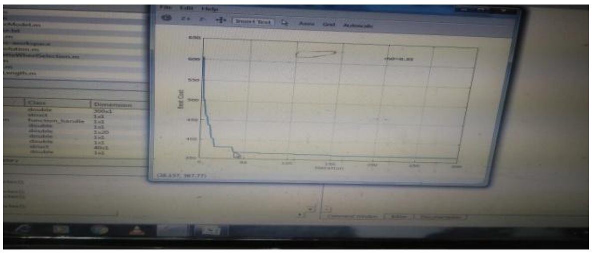

Fig.18 Study of cost and iteration when rho, is 0.35

Now substitute Rho is 0.35 and execute the program the graph show iteration (x axis)is 38.157 the cost (y axis) be 367.77 and time of execution 203.64 (fig 18).

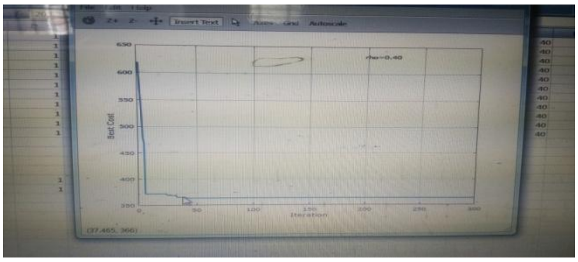

Fig.19 Study of cost and iteration when rho, is 0.40

We substitute RHO value is 0.40 and execute the program the graph show iteration (x axis) Is 37. 465. The cost (y axis) is 366 and time of execution is 202.87 (fig 19).

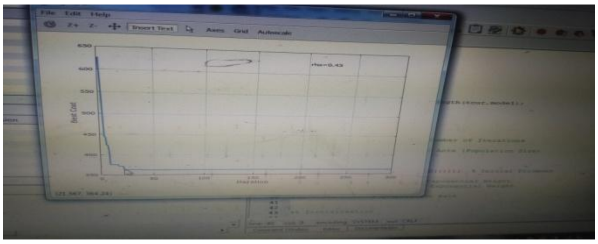

Fig-20: Study of cost and iteration when rho, is 0.45

Now put Rho =0.45 and execute the program we will get iteration 21.567 on x axis and Cost on (y-axis) is 364.24 and the execution time will be 202.89 (fig 20).

Fig-21: Study of cost and iteration when rho, is 0.50

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Now substitute Rho is 0.50 and execute the program the graph show iteration (x axis) Is 18.802 the cost (y axis) be 366 and time of execution 202.87 (fig 21).

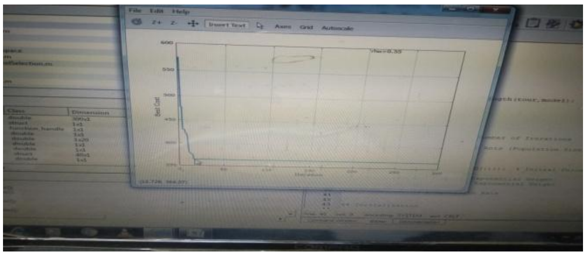

Fig-22: Study of cost and iteration when rho, is 0.55

Now put Rho =0.55 and execute the program we will get iteration 16.786 on x axis and Cost on (y-axis) is 364.07 and the execution time will be 201.44 (fig 22).

Fig-23: Study of cost and iteration when rho, is 0.60

Now substitute Rho is 0.60 and execute the program the graph show iteration (x axis) Is 14.654 the cost (y axis) be 369.5 and time of execution 203.52 (fig 23)

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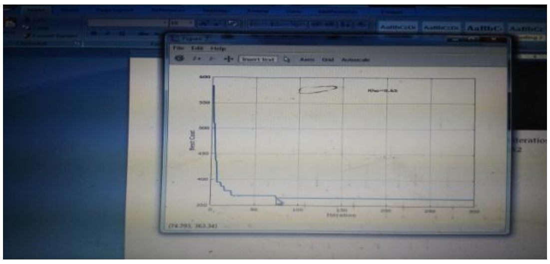

Fig-24: Study of cost and iteration when rho, is 0.65

Now put Rho =0.65 and execute the program we will get iteration74.793 on x axis and Cost on (y-axis) is 363.34 and the execution time will be 202.79 (fig 24)

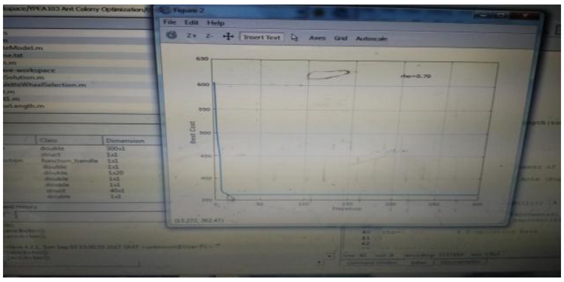

Fig-25: Study of cost and iteration when rho, is 0.70

We substitute Rho value is 0.70 and execute the program the graph show iteration (x axis) Is 13. 272. The cost (y axis) is 362.47 and time of execution is 186.05 (fig 25).

Alpha	Beta	Rho	Cost (y Axis)	Iteration (x axis)	Time	Iteration	Cities	No. Ants
1	1	0.10	362.6	66.498	208.95	300	20	40
1	1	0.15	361.59	50.599	204.65	300	20	40
1	1	0.20	371.3	33.318	202.13	300	20	40
1	1	0.25	362.6	46.452	204.05	300	20	40
1	1	0.30	361.46	40.922	202.95	300	20	40
1	1	0.35	367.77	38.157	203.34	300	20	40
1	1	0.40	366	37.465	202.87	300	20	40
1	1	0.45	364.24	21.567	202.89	300	20	40
1	1	0.50	366	18.802	202.87	300	20	40
1	1	0.55	364.07	16.786	201.44	300	20	40
1	1	0.60	369.5	14.654	203.52	300	20	40
1	1	0.65	363.34	74.793	202.79	300	20	40
1	1	0.70	362.47	13.272	186.05	300	20	40

Table 3:- Study of cost, iteration and Time with change of Rho 4.

IV. RESULT

This paper helps in finding best possible parameters to solve TSP with ACO.

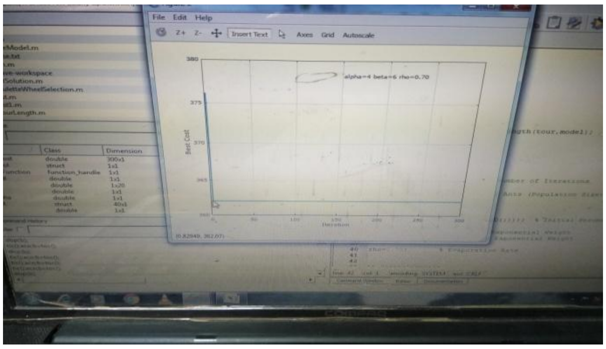

Fig-26: Study of cost and iteration when alpha is 4 beta is 6 and rho is 0.70

We also modified the ACO program to calculate the execution time of the program.

Alpha	Beta	Rho	Cost (Y-axis)	Iteration (X-axis)	Time	Iteration	Cities	No.Ants
4	6	0.7	362.07	0.8294	179.84	300	20	40

Table 4:- Study of cost, iteration and Time with final values

Finally we take all the better parameter from Alpha, Beta, Rho i.e. Alpha =4, BETA=6 and Rho=0.70.The Graph shows iterations (x axis) is 0.8294 and the cost will be 362.07.It takes 179.84 execution time (fig 26).

V. CONCLUSION

It is evident that ACO is better than Genetic algorithm, neural networks and other heuristic and non heuristic methods for both static and dynamic configurations. ACO becomes even better on increasing no. of ants. In improved ACO modeling parameter constants like exponential weight, heuristic exponential weight, and evaporation constant are fixed.

In this study, we have arrived at parameters shown in table no 4 in result section, while running our program on Intel Pentium PC. When alpha is 1, beta is 1, and rho is 0.5 then we observed the values of iteration are 59.585, cost is 362.46 and time of execution will be 180.11. After final studies of all the parameter, we suggest alpha is 4, beta is 6, and rho is 0.70. We get the cost 362.07; iteration is 0.8294 ant execution time will be 179.84 which is better than the previous results.
Although cost/distance travelled remains approximately same the execution time will and no. of iterations to get optimal result reduces significantly. Hence we propose parameters in table no 4, to execute the program.

In Future more complex set of parameters can be studied for more no. of cities. Further Execution time with more no. of cities can be studied to justify/find best parameters for ACO to solve TSP. The execution time and no of iteration to achieve saturation point can also vary with the hardware and software capabilities of the system. Although same has not been studied or verified.

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BIOGRAPHIES

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