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A Novel Approach To Solve Tsp Using Ant Colony Optimization

Jyoti Garg[1], Renu Singla[2]

M.Tech Student, Dept. of CSE, SRCEM, Palwal, India[1]

Assistant Prof., Dept. of CSE, SRCEM, Palwal, India[2]

ABSTRACT: Travelling salesman problem (TSP) is a routing problem, which is a sub-problem of many application domains such as transportation, network communication. In this paper, we propose a novel methodology which solves the problem ACO algorithm has defined with well distribution strategy in which total search space area is partition into P numbers of hyper-cubic quadrants where P is the dimension of total search space is updating ant colony optimization heuristic parameter that improve the performance When solving TSP. From experimental Results, we can see that proposed algorithm is giving better showing than other standard algorithms.

KEYWORDS: pheromone, global minima, ant colony optimization, travelling salesman problem, NACO.

I. INTRODUCTION

In recent years, many research works have been dedicated to ant colony optimization (ACO) techniques in different areas.Ant colony optimization is applied to define various combinatorial optimization problems such as Travelling Salesman Problem (TSP) Vehicle Routing Problem (VRP) etc.We proposed a new optimization algorithm (ACO) based on ant colony optimization to solve travelling salesman problems for both continuous and discrete function. This ACO algorithm uses number of ants, number of iterations, dimensions, lower pheromone limit and upper pheromone limit. Total search space is divided in P numbers of hyper-cubic quadrants. Here P is the Search space dimension. Each ant covers the path as the number of iterations. We arrange coordinates according to the distance from the source. Novel approach is use ant colony optimization system pheromones update to find out the shortest path from source node to the destination node. After predefined number of iterations to find global minima from source node to destination node.Ant colony optimization system use pheromones upgrade to find out the Minimum shortest path from source node to the destination node. After the data set from TSPLIB (http://elib.zib.de/pub/mp-testdata/tsp/tsplib/tsplib.html) and we assume that the TSP graph is completely connected TSP is defined as: If P cities are given and a salesman starts from his home city has to visit each city exactly once and then return to his home city, TSP has to find out the order of the tour such that total travelled distance (costs) is minimum. Cost can be taken as time, money, distance, energy or a combination of two or more factors. In this paper, we assume that Euclidean distance is the distance between two cities. The distance between two city i and j is d(i,j) = d(i,j)= $\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$. TSP is to solve a tour that minimizes the objective function S: S =$\sum d(i,j)$.

Ants are made to walk over two branches of equal length. At the start, ants were left free to move between the nest and the food source and the percentage of ants that chose one or the other of the two branches were observed over time. The outcome was that although in the initial phase random choices occurred, eventually all the ants used the same branch. The reason can be explained as follows. When a trial starts there is no pheromone on the two branches. Hence, the ants do not have a preference and they select with the same probability any of the branches. Yet, because of random fluctuations, a few more ants will select one branch over the other. Because ants deposit pheromone while walking, a larger number of ants on a branch results in a larger amount of pheromone on that branch; this larger amount of pheromone in turn stimulates more ants to choose that branch again, and so on until finally the ants converge to one single path. This auto catalytic or positive feedback process is, in fact, an example of a self-organizing behaviour of ant.

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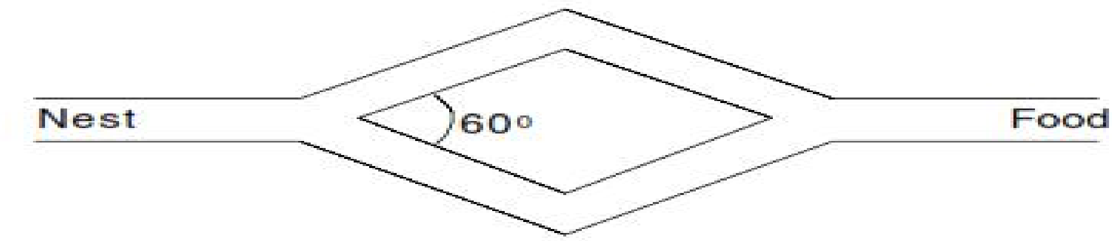

Figure:- Double Bridge Experiment: Branches having equal length

II RELATED WORK

In [2] authors used multiobjective EA, i.e., MOEA/D-ACO. Following other MOEA/D-like algorithms, MOEA/D-ACO decomposes a multiobjective optimization problem into a number of single-objective optimization problems. Each ant (i.e., agent) is responsible for solving one sub problem. All the ants are divided into a few groups, and each ant has several neighboring ants .An ant group maintains a pheromone matrix, and an individual ant has a heuristic information matrix [3]. Authors used a novel swarm intelligence optimization method which integrates bacterial foraging optimization (BFO) with quantum computing, called quantum bacterial foraging optimization (QBFO) algorithm .In [4] Heterogeneous Ant Colony Optimization (HACO) algorithm to solve the global path planning problem for autonomous mobile robot in the previous paper. The HACO algorithm was modified and optimized to solve the global path planning problem unlike the conventional ACO algorithm which was proposed to solve the Traveling Salesman Problem (TSP) or Quadratic Assignment Problem (QAP). In [5] authors improved efficient programming approach for solving the proposed problem with an analogy, the way ant colonies function has suggested the definition of a new computational paradigm, which we call Ant colony optimization technique. The existing proposal is a single processor-scheduling problem in which the sum of values of all jobs is maximized and also presents a new pheromone updating strategy which is used to optimize ACO (Ant Colony Optimization) technique in solving the Traveling Salesman Problem. The value of a job is characterized by a stepwise no increasing function with one or more moments at which the changes of job value occur.In [6] Author used Multi-Objective concept to solve the Traveling Salesman Problem (TSP). The traveling salesman problem is defined as an NP-hard problem. The resolution of this kind of problem is based firstly on exact methods and after that is based on single objective based methods as Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO). Firstly, a short description of the Multi-objective Particles swarm optimization (MOPSO) is given as an efficient technique to use for many real problems.In [7] authors considered two new variants of AS-PSO (Ant Supervised by Particle Swarm optimization) meta-heuristic are proposed and applied to a classical travelling salesman benchmark problem. The new variants are Fuzzy-AS-PSO and Simplified AS-PSO (S-AS-PSO). AS-PSO is a hierarchical meta-heuristic based on the ant colony optimisation (ACO) and particle swarm optimization (PSO), in which ACO is the heuristic and PSO is the meta-heuristic.

III PROPOSED WORK

The problem is considered in this thesis is to find out “TSP Solution Using a Novel Approach of Ant Colony Optimization”. The objective of this work is to apply this new method in Travelling Salesman Problem. We have to find out x_{opt} that belongs to P.

This thesis has proposed an efficient ant colony optimization function namely technique for optimizing mathematical functions. The search process of the optimization approach is directed towards the region of hypercube in a multidimensional space where the amount of pheromone deposited is maximum after predefined number of iterations. The entire search area is initially divided into N number of hyper cubic quadrants where N is the dimension of search space. Then the pheromone level of each quadrant is measured. Now the search jumps to the new region of highest

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pheromone level and restarts the search process in the new region. However the search area of new region is reduced compared to the previous search area. Thus the search advances and jumps to a new search space with reduced search area in several stages until the algorithm is terminated. The space of the new search region is smaller than the previous hyper-cubic search area. The reduction of search space is done along all dimensions. The space is reduced in multiple stages with progress of the search process. If the search space is reduced slowly, then the possibility to come out of local optima and the convergence possibility to the global optimum is increased. On the other hand if the search space is reduced faster then there is a possibility to miss the global optimum since the process has no back tracking capabilities.

A. **Functional optimization using Novel Approach of ACO**

Global optimization problem can be stated as a pair of (p, f) where S is the subset of R and f: S --> R is an real valued function in N dimension. We have to find out a point x_{opt} that belongs to P on R such that value of $f(x_{opt})$ is global optimum on P. We have to find out x_{opt} that belongs to P as per the following:

$\forall$X that is subset of P: $f(x_{opt}) <= f(x)$………………(1)

Where f is bounded but may not be continuous.

Initially this algorithm starts searching to find out the global optimum in the entire search area. The entire search space i.e. multi-dimension space is divided into a number of quadrants based on dimension of the problem where each quadrant will be taken as hypercube. The partitioning of the search space is necessary to measure the level of pheromones in each partition. If dimension of the problem is denoted by N then we will calculate number of quadrants as:

q=N ………………………………(2)

This method runs for certain number of iterations, I_k and when it completes I_k iterations then it will measure the level of pheromones in every quadrant. This measurement is directed towards the searching of the quadrants having maximum pheromone value. We take p as the pheromone value deposited in each iteration and p is defined as p=1/N.
This technique runs in multiple stages iteratively and in that we find the quadrant in each iteration in which the best pheromone value of that iteration lies. Then the pheromone level p_j of j^{th} quadrant i.e., for corresponding quadrant has increased by 1/N in each iteration. When this optimization method completes I_k iterations, then it calculates the deposited amount of pheromone p_j in each quadrant. If the deposited pheromone amount p_m of m^{th} quadrant (1<=m<=N) is maximum, then search will move towards that m^{th} quadrant. The space area for search is being re-defined and ant population is regenerated again. Now, this will start in a new search space area and it continues for I_k times until it is being transferred to another new space area by considering the highest pheromone value. This optimization method finally terminates when it complete its I_{max} iterations.

B. **Algorithmic representation**

STEP 1: Start with iteration i=1, ants population and other parameters like pheromone, dimensions etc;
STEP 2: After initializing, Divide the search space area into N number of quadrants.
STEP 3: Then find out the quadrant where best solution lies in each iteration. Then increase pheromone value of that quadrant by 1/N.
STEP 4: Find out the quadrant q_m that is having highest amount of deposited pheromone after completion of I_k iterations.
STEP 5: Redefine space area by eliminating the quadrant q_m. Again start this process after moving the search into new search space that is smaller in size.
STEP 6: Increase $I=I + I_k$ untill $I <= I_{max,}$ go to STEP 2.
STEP 7: Exit.

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IV . PROPOSED ALGORITHM

A. Algorithm for TSP tour construction

STEP 1: Initialize all of the co-ordinates.
STEP 2: Then initialize starting node/position.
STEP 3: Then Calculate the distance from start node to all neighbor nodes.
STEP 4: Sort all of the nodes by taking their distance from source node.
STEP 5: Dimension of each nodes are again initialized
STEP 6: Apply this technique for each of the sorted coordinates/nodes.
STEP 7: Then find out the node that is having lowest global minima.
STEP 8: The coordinate that has lowest global minima is taken as the new source
STEP 9: new Search space is reduced as the previous node is being eliminated.
STEP 10:Go STEP 3.
STEP11: Stop.

V. SIMULATION RESULT

The simulation studies involve the tour construct with 51 nodes as shown in Fig.1. In Figure-5.1, all the nodes are given and in Figure-5.2, we start from a node (x_i , y_i) and moving towards a node that is having lowest value of global minima. By doing so iteratively a tour is build for TSP. We can calculate cost of this tour by the summation of all the global minimum value of two connected nodes.

The performance of this novel approach optimization algorithm on a set of nodes is examined to find how the construction of tour using NACO is efficient than another algorithms. In this, we have considered a set of 50 ants (population of ants). We have assumed that the upper limit of pheromone is +10 and lower limit of pheromone is -10. We have selected the path that has lowest amount of global minima from a source node to all the neighbouring nodes. We add that path to our solution. We complete this tour by doing this procedure iteratively.

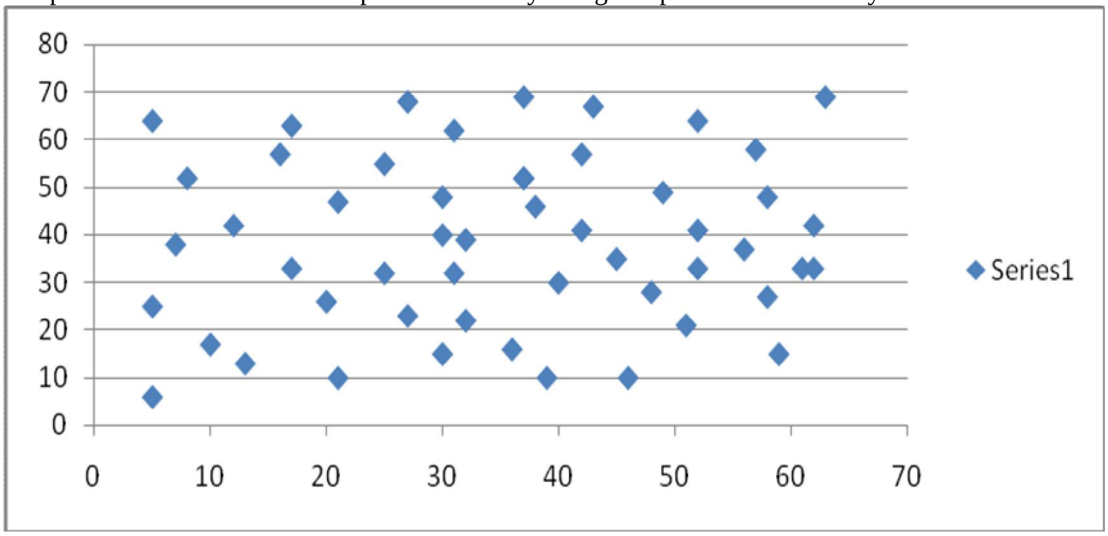

Figure 5.1: Graphical Representation of EIL51 in space

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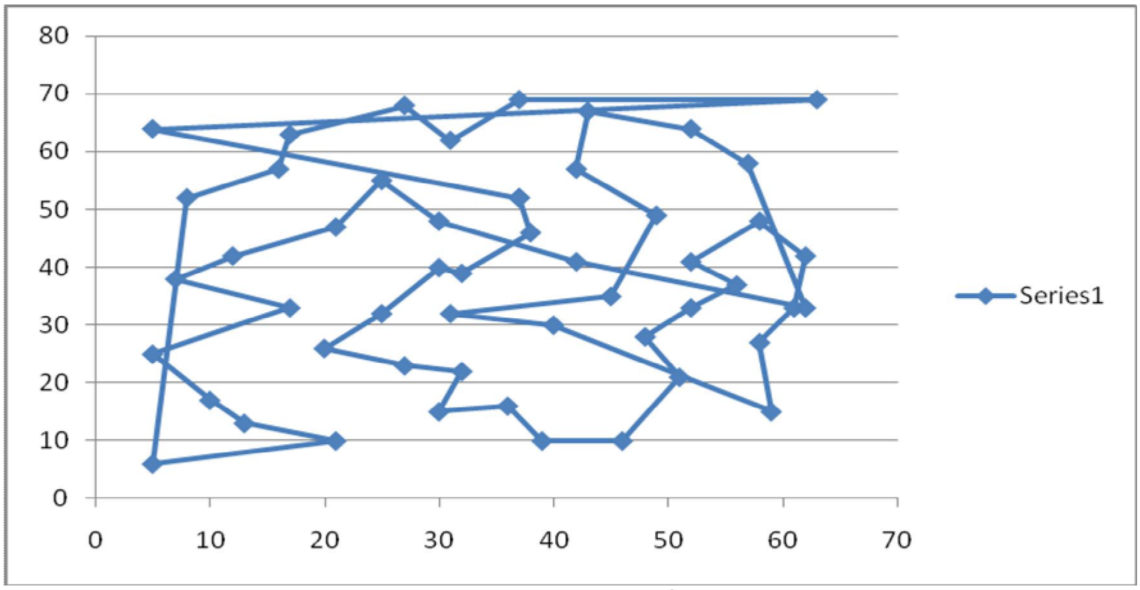

Figure 5.2 Tour constructions for EIL51

VI. COMPARISON WITH ALGORITHM

Here, the performance of Dimensional ACO technique to solve TSP has been evaluated to find out how new ACO is efficient.

In this setup we have considered 50 as the population size of ants. In this algorithm novel approach ACO was run 50 times and average of the 50 optimum results has tabulated.

TABLE I shows the best result, relative error and running time. In this, “Best” is taken as the best result of 10 times run and “Optimal” is taken from TSP lib whereas “Error” is calculated as (“Average”-“Optimal”)/ “Optimal” and “time” is taken as system time to complete the task and is measured in milliseconds. In this experiment we take all the test cases from TSPLIB (http://elib.zib.de/pub/mp-testdata/tsp/tsplib/tsplib.html).

As shown in these tables that Dimensional ACO is more efficient than other algorithms It can get the solutions easily and have faster convergence as it takes relatively less time to get the optimum result.

EIL51 Optimal=427	ACO	MST-ACO	PSO without C3	NACO
Best	426	426	441	427
Error	1.6	0.04	9.96	0.0039
Time(ms)	5128	781	3867	3351

TABLE-1 (EIL51)

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VII CONCLUSION AND FUTURE WORK

Simulation results shows that TSP solution using new ACO method is capable of providing improved performance as compared to other TSP solution/Optimization techniques. This algorithm helps avoid stagnation and improve performance. It has been seen that the solutions of new ACO technique depends on the number of ants. Less number of ants allows changing the path much faster. The higher number of ants causes the higher deposition of pheromones on edges, and hence an individual keeps a path having higher concentration of pheromones with high probability.

This proposed work in this thesis is having a lot of potential for further research in the area of tour construction using different paradigm making the work more versatile and flexible. The research can be extended in the area of routing as this algorithm has taken consideration of dimension which plays a very powerful role to construct the tour. Also the proposed work can be further studied by observing different parameter variations and inclusion of some dynamic problems which can adjust the parameter values to the values optimal for specific situation.

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BIOGRAPHY

Jyoti Garg is a MTECH Student in CSE, SRCEM, Palwal, MDU university, , India

Ms. Renu Singla is working as Assistant Professor at Department of CSE, SRCEM, Palwal , MDU University ,India