

# Algorithm for Finding Shortest Path in All Tours of a TSP Using Pheromone Genetic Factor

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**ABSTRACT:** The shortest path problem is a classical combinatorial optimization problem with countless real-life applications. Numerous algorithms have been proposed to solve the SPP since the classical Dijkstra algorithm, as well as new approaches to improve the algorithms' optimality. But according to the real-world transport conditions, researchers began to study variants of this problem which include the time-dependent SPP and the multimodal networks.

In this paper, we introduce our new pheromone base Genetic property dependent shortest path algorithm for travelling salesman problem. The TSP is to be done efficiently so that it helps in reducing the time for salespersons. There are different techniques that are proposed to solve the problems of TSP.

Through this paper we are going to present the pheromone based Genetic Algorithm that will find all the routes of salesperson as well as it will find the shortest path in every iteration along with its time complexity. A comparison of this Genetic Algorithm based TSP technique is compared with ACO, Improved ACO and proposed algorithms. A result shows that, proposed algorithm will outperform the existing techniques.

**KEYWORDS:** Shortest Path problem, TSP, ACO, Improved ACO, Genetic Pheromone.

## I. INTRODUCTION

The shortest path problem exists in variety of areas. A well known shortest path algorithm is Dijkstra's, also called "label algorithm". Shortest-path computation is a fundamental problem in computer science with applications in diverse areas such as transportation, robotics, network routing, and VLSI design. The problem is to find paths of minimum weight between pairs of nodes in edge weighted graphs, where the weight  $|p|$  of a path  $p$  is defined as the sum of the weights of all edges of  $p$ . The distance between two nodes  $v$  and  $w$  is defined as the minimum weight of a path between  $v$  and  $w$ .

There are two basic versions of the shortest-path problem: in the single-source shortest-path (SSSP) version, given a source node  $s$ , the goal is to find all distances between  $s$  and the other nodes of the graph; in the all-pairs shortest-path (APSP) version, the goal is to compute the distances between all pairs of nodes in the graph. While the SSSP problem can be solved very efficiently in nearly linear time by using Dijkstra algorithm [1], the APSP problem is much harder computationally.

**A. Travelling Salesman Problem:** The Travelling salesman problem (TSP) is a combinatorial optimization problem, and is of great interest to computer scientists and mathematicians. In TSP a salesman begins from his hometown, visits each number of cities just ones and then returns to his home town. The TSP is one of the classes of NP-hard problem and it cannot be worked out optimally in a reasonable time when a large number of cities are involved.

Travelling salesman problem (TSP) is a theoretical mathematical model and has been widely applied in dynamic problems in reality. Most of the existing methods used to model TSP lack a realistic foundation, and cannot provide convenient and polytrophic operations to simulate real-world scenarios. The travelling salesman problem (TSP) [3] is a

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classical combinatorial optimization problem defined in an undirected graph  $G = \{V, A, W\}$ , where  $V = \{1 \dots N\}$  is a set of nodes,  $A = \{(i, j) | i < j\}$  is a set of edges and  $W$  is a symmetrical weight matrix. The optimization objective of a TSP is to find the shortest Hamilton route on  $G$ . Owing to the usefulness in modelling a variety of real world computational problems, TSP applications have been extended to route scheduling [2], machine scheduling and sequencing [3], and some other practical computation problem [4]. Meanwhile, various methods have been proposed and successfully used in solving optimization problems in a static scenario. However, some real problems can be modeled as a TSP is not always static. When considering the situations, such as traffic control and congestion, the actual traversal route and the nodes needed to be visited are variable in different periods, leading to a dynamic TSP (TSP). Similar dynamic scenarios broadly exist in real-world problems, such as the scheduling of school bus for pickup and drop-off students [5] in the case of some students ask for a leave and the postman problem [6] etc.

**B) Ant Colony Optimization:** Ant colony optimization (ACO) is a kind of simulated evolutionary algorithm. It imitates ants' foraging process to find the shortest path, coexists with the characteristics of randomness and heuristic. It is applied successfully to solve combinatorial optimization problems, such as the TSP problem, the job-shop scheduling problem, etc.

In the early 1990s, the Italy scholar Macro Dorigo proposed an ant colony algorithm by imitating ants' foraging process to find the shortest path [7]. Compared to other optimization methods, the ACO has a number of advantages which contribute to its wide use. Some of the key advantages of ACO include: (a) It does not need the calculation of derivatives.

(b) The knowledge of good solutions is retained by all ants.

(c) The ants in the colony share information.

Moreover, ACO is less sensitive to the nature of the objective function, and hence it can be used for various objective functions [8]. Then it is applied successfully to solve combinatorial optimization problems, such as the TSP problem, the job-shop scheduling problem, etc. TSP, simply speaking, is one salesman starts and ends at the same city, with all cities being visited once and only once, and the path length required as short as possible. TSP problem is a classic combinatorial optimization problem, and the study of TSP can be used for other reference. To solve TSP, the simplest method is enumerating all possible solutions, and obtain optimal path by comparing [9]. For  $n$  cities, the time complexity is  $(n-1)!$ , which is a large amount of engineering calculation. Because of ACO's numbers of advantages, it has played a critical role in solving TSP problem [10].

**C) Ant System for the TSP:** In the TSP is given a completely connected, undirected graph  $G = (V, E)$  with edge-weights. The nodes  $V$  of this graph represent the cities, and the edge weights represent the distances between the cities. The goal is to find a closed path in  $G$  that contains each node exactly once (henceforth called a tour) and whose length is minimal. Thus, the search space  $S$  consists of all tours in  $G$ . The objective function value  $f(s)$  of a tour  $s \in S$  is defined as the sum of the edge-weights of the edges that are in  $s$ . The TSP can be modelled in many different ways as a discrete optimization problem. The most common model consists of a binary decision variable  $X_e$  for each edge in  $G$ . If in a solution  $X_e = 1$ , then edge  $e$  is part of the tour that is defined by the solution.

Concerning the AS approach, the edges of the given TSP graph can be considered solution components, i.e., for each  $e_{i,j}$  is introduced a pheromone value  $\tau_{i,j}$ . The task of each ant consists in the construction of a feasible TSP solution, i.e., a feasible tour. In other words, the notion of task of an ant changes from "choosing a path from the nest to the food source" to "constructing a feasible solution to the tackled optimization problem". Note that with this change of task, the notions of nest and food source lose their meaning. Each ant constructs a solution as follows. First, one of the nodes of the TSP graph is randomly chosen as start node. Then, the ant builds a tour in the TSP graph by moving in each construction step from its current node (i.e., the city in which she is located) to another node which she has not visited yet. At each step the traversed edge is added to the solution under construction. When no unvisited nodes are left the ant closes the tour by moving from her current node to the node in which she started the solution construction. This way of constructing a solution implies that an ant has a memory  $T$  to store the already visited nodes.

In practical application, ACO has some the limitations.

(a) It is easily trapped into local optimum. (b) It takes long executing time finding optimal result.

These limit the use of popularization and application of the algorithm.

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## II. RELATED WORK

Travelling Salesman Problem (TSP) is a well known NP-hard problem in combinatorial optimization which was first studied in the 1930s by Karl Menger in Vienna and Harvard. Dynamic Travelling Salesman Problem is an extension of the traditional TSP which involves dynamic-cost allocation between the cities. This may include, but is not limited to, inclusion and exclusion of certain cities at any given time. It was proposed by Parfaits [11] in 1988. DTSP is widely applicable in real-time scenarios than TSP but is arguably more difficult to solve. Usually, the algorithms used to solve Static TSP turn out to be inefficient for DTSP.

Yan Cao and Jun Zhang presented Rs-ACS algorithm to solve Travelling Salesman Problem using Pheromone matrix update rule [12]. The proposed model contains two environmental changes, weight change and dimension change. In dimension change some nodes are removed temporarily from the solution space because the salesman did not want to visit the nodes in future. Recently, biogeography-based optimization algorithms are interested by researchers to find approximate solutions for optimization problems. BBG is a new heuristic algorithm proposed by D. Simon [13] in 2008. The BBG algorithm draws inspiration from the mechanism of species mutation and migration and is employed to solve the optimization problems. The solutions of optimization problems or "islands" in BBG are analogous to the habitat in biogeography. The High Suitability Index (HSI) is used for evaluating the goodness of the islands. Which mean that the habitat having a high HSI value is considered a good island and the best islands are islands having the most species? The features of a habitat are called Suitability Index Variables (SIVs).

The mutation and migration operators are very important and strongly affect the algorithm's performance in BBG. With these operators, problem solutions can communicate with one another. Thus, the problem solutions in BBG algorithm have higher flexibility in terms of individual communication in comparison with some other classical meta-heuristic methods and also show a better performance when compared with other evolutionary algorithms [14]. Huynh Thi Thanh Binh and Pham Dinh Thanh Presented Biogeography-based on optimization algorithm (BBO) is a new evolution algorithm inspired by the science of biogeography and designed based on the migration strategy of animals [15]. According to investigations and analysis on this algorithm, BBO has great success in numerous optimization problems and it has been used in different types of applications. In BBO, the migration operator is an important operator which is able to efficiently share the good information among solutions.

In the work proposed by Fozia Hanif Khan in Solving TSP [16]. The main purpose of this study is to propose a new representation method of chromosomes using binary matrix and new fittest criteria to be used as method for finding the optimal solution for TSP. The concept of the proposed method is taken from genetic algorithm of artificial intelligence as a basic ingredient which has been used as search algorithm to find the near-optimal solutions. We introduces additional improvements, providing an algorithm for symmetric as well as Asymmetric TSP, here we are implementing the new fittest criteria as well as new representation of asymmetric matrix and improving our solution by applying the crossover and mutation again and again in order to get the optimal solution.

In the work proposed by Zakir H. Ahmed Genetic Algorithm for the TSP using Sequential Constructive Crossover Operator [17] develops a new crossover operator, Sequential Constructive crossover for a genetic algorithm that generates high quality solutions to the Travelling Salesman Problem (TSP). Genetic algorithms (GAs) are based essentially on mimicking the survival of the fittest among the Species generated by random changes in the gene-structure of the chromosomes in the evolutionary biology. To apply GA for any optimization problem, one has to think a way for encoding solutions as feasible chromosomes so that the crossovers of feasible chromosomes result in feasible chromosomes. For the TSP, solution is typically represented by chromosome of length as the number of nodes in the problem.

K-Means algorithm is one of the major algorithms of clustering analysis and a kind of clustering algorithm based on partitioning. K-Means randomly chooses k points as the initial clustering centers and adjusts each center step by step based on distances of vertices to their center. In order to reduce the complexity of TSP and solve the large scale TSPs efficiently, [18] presents a bi-level genetic algorithm with clustering (BLGA-C). First, BLGA-C uses a clustering

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method to divide a large scale TSP into several sub-problems; each sub-problem corresponds to a cluster. K-Means clustering method is adopted. All these clusters can be handled parallelly. Then, we need to select two nearest vertices between two clusters, and determine which edges will be deleted from the shortest Hamiltonian cycle for each cluster, and which edges will be linked for combining two adjacent clusters into one.

In the field of Shortest Path Problem (TSP), there has been a lot of innovation. In our literature survey, we went through some dominant method used in recent research for solving Travelling Salesman Problem and compared them. Also we explained the various factors on the basis of which we will further develop our new algorithm. Hence, it forms a conspicuous part of our research work. Crucially, there will be a great usage of Novel mechanism in the field of finding shortest route. We evaluate the above mentioned theories and try to propose an appropriate user verification system in the next section.

### III. PROPOSED METHOD

Many research has been done to find the good parameters for Ant Colony Optimization problems, but very little research has been done in ACO, as to find how the pheromone factors will affect the optimal solution, how the ACO pheromone works and what space the parameters will be selected from so that the algorithm work efficiently and effectively. This paper is concerned with the space parameters of pheromone system. The space parameter in the proposed algorithm is increased by using Genetic Property. It is very difficult to find shortest path by applying ACO when the search space is very less. Through our work we are going to enhance the working of Pheromone system in ACO.

ACO uses three models called ant-quantity system, ant-density system and ant-cycle system, separately to update the pheromone values. This pheromone communicates only indirectly by laying pheromone in the environment. The more pheromone a particular part of the environment contains, the more desirable that part of the environment becomes to the ants. This is how the ants find solutions.

The ACS pheromone system consists of two rules; one rule is called local pheromone update rule and the other rule is called global pheromone update rule, and is applied after all ants have finished constructing a solution. These rules have different purposes. The purpose of the local pheromone update rule is to make “the visited edges less and less attractive as they are visited by ants, indirectly favouring the exploration of not yet visited edges. As a consequence, ants tend not to converge to a common path”. The purpose of the global pheromone update rule is to encourage ants “to search for paths in the vicinity of the best tour found so far”. Here, in this thesis, we look at the Global pheromone update rule, for the TSP.

**A) Proposed Algorithm:** Existing Improved ACO algorithm has some limitations:

a) The best route i.e. next city (j) is found by using pheromone parameter  $\alpha$ . The value of  $\alpha$  has been selected in between 0 and 1. If the value of  $\alpha$  becomes zero, the algorithm will only work for local minimum. It will not work for global minimum i.e. the algorithm will not work for longest distance or large solution space. To overcome the problem, a proper selection method of  $\alpha$  is required.

b) It uses a roulette algorithm to find the better route. The roulette algorithm works upon selecting a random value and it is based on exceptions. Results generated by this algorithm cannot be guaranteed and is based on+ luck by chance policy.

To overcome the above limitations we propose a new algorithm that will work global optimal solutions and will always gives the best results.

The global pheromone update rule is give by:

$$\tau_{ij}^u(t) = (1-p) \cdot \tau_{ij} + P * \tau_0 \dots\dots\dots(4)$$

Where  $\tau_{ij}(t)$  is the amount of pheromone on the edge (i, j) at time t;  $p$  is a parameter governing pheromone decay such that  $0 < p < 1$ ; and  $\tau_0$  is the initial value of pheromone on all edges.

To select the value of a set S of 10 random numbers are generated. These random numbers are sorted in non-decreasing order and are stored in an array.

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A higher pheromone values represents a dense route that helps ants to search the next path fastly and lower ones represents weak value that reduces the searching process. The Pseudo code of proposed algorithm is given below:

Algorithm Genetic ACO ( )

```
{  
Step 1: Select Value of pheromone between 0 and 1 and store in A [N].  
Step 2: Find the best pheromone by using following rule:  
a) Find the best pheromone from randomly selected by sorting in non-decreasing order.  
b) For k=N to 0 do  
c) Apply crossover with the best to produce the multiple copies.  
c) Say parent1= A [0] and parent2= A [1] (the best found)  
    B=A [0] +A [1];  
    Return B (every time best Pheromone is returned)  
d) Collect the remaining unused pheromone to get a new pheromone.  
e) Repeat step a until we end up with the new city.  
}
```

The pheromone crossover product rule will produce best pheromone at every step which will result in fast searching by travelling salesman problem. The above algorithm will always selects the large value pheromone that increases the searching rate and the chance of getting the shortest path. This reduces the limitations of roulette algorithm where winning is always luck by chance i.e. if lower value selected than the shortest path selection process will not give proper result and also it will take longer time. It will only work for local solution i.e. when numbers of cities will increases the algorithm will not give good results. By applying the crossover in between pheromones ,the pheromones gets denser and increase s the probability of finding the next city and reduces the time. The proposed algorithm overcomes the limitations of existing algorithms.

### 3.3.3 Proposed algorithm for finding shortest path:

Algorithm TSP Proposed (City Info, p, i, j, k)

```
{  
I represent initial point represents final point of city and k represents total visited city.  
Input: City info, Ants number, p. (Assign some values).  
Step I: Initialization, the initial population of candidate solutions is usually generated randomly across the search space in between S.  
Step II: Select a random number between 0 and 1.  
Step III: while i> 0 and j>0 do  
Step IV: while j< Iteration time do  
IF q< random number (Between 0 and 1)  
Choose city where the transition probability is max.  
Set q= Genetic ACO ( )  
Else  
     $\tau_{i,j}^{\alpha}(t) = (1-p) \cdot \tau_{i,j} + P * \tau_0$   
    0, otherwise  
End IF.  
}
```

## IV. EXPERIMENTAL SETTINGS AND RESULTS

In theory, the theoretical definition of the convergence of the ACO is that, the route ants choose is not change or most of ants choose the same one during one iteration. In practical applications, due to the introduction of many random factors, it is difficult to achieve that state in the case of reasonable design. So in practice, as long as the proportion of

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the pheromone on a certain path is relatively large, or we don't find a better solution during certain iterations, the algorithm can be considered as reach to a convergence state.

In solving TSP problem, the implementations of the measure of pheromone values are the important parameters of the algorithm. The best result is responded from system corresponding to appropriate set of parameter value of  $\tau^{k, ij}(t+1)$  and the range of them have remark achievements.

The experimentation was deployed on Windows 7 OS, Intel Core i7-6700 (3.4Ghz , 8M Cache) processor, 16GB DDR3L. We used Open JDK Java 8 environment and Netbeans to implement the proposed algorithm.

The performance of the system is evaluated by criteria such as total length of route from starting point to destination, and time that is used for algorithm processing. The dataset graph29 stores the parameter values for constructing the graph in every iteration for finding shortest path. A total of 100 iterations are performed to check for shortest path. Further the results are tested for different iterations and at every iteration the proposed algorithm performs the better results. The results are checked with using three genetic operators OX, CX and PMX. Theses operators are added to the library of Netbeans folder. Table

ALGORITHM	ACO (Distance)	IMPROVED ACO ALGORITHM (Distance)	PROPOSED ALGORITHM (Distance)
NO. OF GRAPH			
50	4375.56	5219.58	3800.47
100	4183.45	3821.05	3601.30

Table 1: Showing average distance for 50 and 100 graphs.

Results shows that the proposed algorithm performs better for large values i.e. it perform better with global solution.

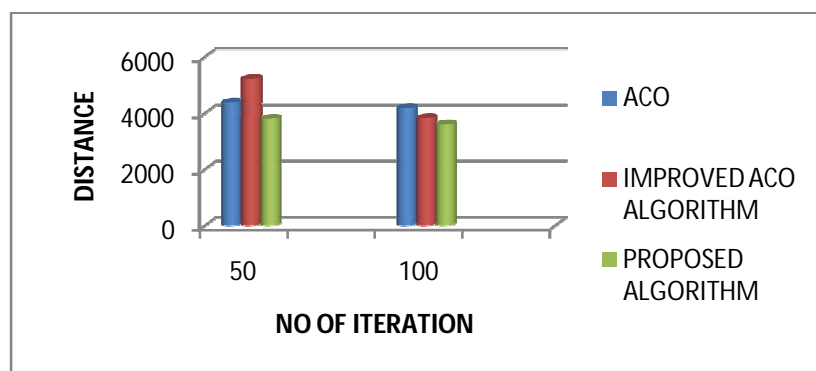


Figure 1 Comparison of Algorithms.

### V. CONCLUSION AND FUTURE WORK

Issue of Shortest path is one of the main issues for TSP. Through this thesis we investigate the limitation of pheromone update rule and proposed a new algorithm based on Genetic property that will help in finding the best route for travelling salesman problem. The proposed algorithm performs better for Global optimum solution i.e. it works well when the size of path will be large. It may also be helpful for real time application to find the shortest path. In ACO algorithm most of the research has focused on reducing the shortest path with less concentration on pheromone factor. This research mainly focuses on improving the range of Pheromone value and always predicting the best route.

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In future more studies are required in improving the pheromone values that will help to reduce the distance between two cities. However, each algorithm has its own limitations and cannot be universally accepted to perform well on all optimization problems. Hence, in future work, it is intended to further improve the performance of this algorithm and apply it to various other practical problems.

## REFERENCES

- [1]. E.W. Dijkstra, A note on two problems in connexion with graphs, Number. Math. (1999) 269–271.
- [2]. K. Savla, E. Frazzoli, and F. Bullo, “Travelling salesperson problems for the dubins vehicle,” IEEE Trans. Autom. Control. vol.53, no.6, pp.1378-1391, Jul.2008.
- [3]. G. Gutin and A. Punnen, “The travelling salesman problem and its variations,” Combinatorial Optimization, vol.4, no.2, pp. 193-25, May 2007.
- [4]. S. S. Ray, S. Bandyopadhyay, and S. K. Pal, “Gene ordering in partitive clustering using microarray expressions,” J. Biosci., vol. 32, no. 5, pp. 1019–1025, Aug. 2007.
- [5]. R. M. Newton and W. H. Thomas, “Bus routing in a multi school system,” Computers & Operations Research, vol. 1, no. 2, pp. 213- 222, Aug. 1974.
- [6]. C. Cook, D. A. Schoenfeld, and R. L. Wainwright, “Finding rural postman tours,” in Proceedings of ACM symposium on Applied Computing, Mar. 1998, pp. 318–326.
- [7]. A. Colomi, M. Dorigo, V. Maniezzo et al., “Distributed optimization by ant colonies,” in Proceedings of the first European conference on artificial life, vol. 142.Paris, France, 1991, pp. 134–142.
- [8]. X. Wang, T.-M. Choi, H. Liu, and X. Yue, “Novel ant colony optimization methods for simplifying solution construction in vehicle routing problems.”
- [9]. I. Chaari, A. Koubaa, H. Bennaceur, S. Trigui, and K. Al-Shalfan, “smartpath: A hybrid aco-ga algorithm for robot path planning,” in 2012 IEEE Congress on Evolutionary Computation. IEEE, 2012, pp. 1–8.
- [10]. B. Zhang, X. Sun, L. Gao, and L. Yang, “End member extraction of hyper spectral remote sensing images based on the ant colony optimization (aco) algorithm,” IEEE transactions on geo science and remote sensing, vol. 49, no. 7, pp. 2635–2646, 2011.
- [11]. H. N. Psaraftis, “Vehicle routing: Methods and studies,” Dynamic Vehicle Routing Problems. North Holland, Amsterdam, the Netherlands, pp. 223–248, 1988.
- [12]. Yan Cao and Jun Zhang, “Dynamic Swarm Intelligence to solve TSP using Reuse strategy”, IEEE- 2016.
- [13]. W. Guo, M. Chen, L. Wang, Y. Mao, and Q. Wu, “A survey of biogeography-based optimization,” Neural Computing and Applications, pp. 1-18, 2016.
- [14]. J. Lin, “A hybrid discrete biogeography-based optimization for the permutation flow shop scheduling problem,” International Journal of Production Research, pp. 1-10, 2015.
- [15]. Huynh Thi Thanh Binh and Pham Dinh Thanh, “New Migration Operator in Biogeography-based Optimization for Solving Travelling Salesman Problem”, IEEE 2016.
- [16]. Fozia Hanif Khan, Nasiruddin Khan, SyedInayaTullah, And Shaikh Tajuddin Nizami, “Solving TSP problem by using Genetic Algorithm”, International Journal of Basic &Applied Sciences IJBAS Vol: 9 No: 10
- [17]. Zakir H. Ahmed , “Genetic Algorithm for the TSP using Sequential Constructive Crossover Operator” International Journal of Biometrics & Bioinformatics (IJBB) Volume (3): Issue (6)
- [18]. Yan-yan TAN, Li-zhuang TAN, Guo-xiao YUN, Wei ZHENG, “Bi-level Genetic Algorithm with Clustering for Large Scale Travelling Salesman Problems” IEEE 2016.