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Evaluating the Performance of Ant Colony Algorithm for the Solution of Constraint Based Traveling Salesman Problem

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ABSTRACT

Soft Computing is the use of inexact solution to computationally hard tasks such as the solution of NP-Complete problems.TSP is a combinatorial optimization problem. In this paper TSP problem has been solved by using ACO. The major drawback of ACO is that it traps in local optima. In order to find an optimal solution for TSP problem the presented paper proposes an improved ACO which produces better result.

Keywords: NP-Hard Problem, Combinatorial optimization, TSP, ACO.

INTRODUCTION

The nature of optimization algorithms can be of two types deterministic or stochastic. To solve optimization problems by using traditional methods require huge computational efforts, and difficult to solve as the problem size increases. This is the reason for using soft computing methods as computationally efficient alternatives to deterministic approach.

Traditional computational methods could model and analyze only relatively simple systems. Now days more Complex systems are big challenges in biology, medicine, the humanities, management sciences and similar fields to solve by using conventional mathematical and analytical methods.

Soft computing techniques look like biological processes more closely than traditional techniques, which are largely based on formal logical systems such as sentential logic and predicate logic, or rely heavily on computer-aided numerical analysis.

Soft computing deals with imprecision, uncertainty, partial truth, and approximation to achieve practicability, robustness and low solution cost. As such it forms the basis of a considerable amount of machine learning techniques. Recent trends tend to involve evolutionary and swarm intelligence based algorithms and bio-inspired computation.

Soft computing techniques are intended to complement each other. Unlike hard computing schemes, which strive for exactness and full truth, soft computing techniques exploit the given tolerance of imprecision, partial truth, and uncertainty for a particular problem.

There are main differences between soft computing and possibility. Possibility is used when we don't have enough information to solve a problem but soft computing is used when we don't have enough information about the problem itself. These kinds of problems originate in the human mind with all its doubts, subjectivity and emotions; an example can be determining a suitable temperature for a room to make people feel comfortable

Components of soft computing include: Machine learning such as(Neural networks ,Perceptron, Support Vector Machines),Fuzzy logic, Evolutionary computation (EC) including: Evolutionary algorithms such as(Genetic algorithms, Memetic algorithms, Genetic programming, Differential evolution, Paddy field algorithm),meta-heuristic and Swarn Intelligence such as(Ant colony optimization, Particle swarn optimization, Simulated Annealing, Tabu search, Firefly algorithm, Cuckoo search),Ideas about Probability including: Bayesian network etc. Soft computing algorithms are stochastic search methods that used to solve optimization problems like TSP.

Traveling Salesman Problem

The travelling salesman problem(TSP) were studied in the 18th century by a mathematician from Ireland named Sir William Rowam Hamilton and by the British mathematician named Thomas Penyngton Kirkman. Travelling salesman problem is one of the most studied problems in optimization. It is an NP-hard combinatorial optimization problem which has various applications such as vehicle routing, job scheduling, machine sequencing, combinatorial data analysis, planning and logistics.

The concept of the travelling salesman problem is if given a set of cities and the distance between each possible pair, the travelling salesman problem is to find the best possible way of visiting all the cities exactly once and returning to the starting point [1]. One has to minimize the distance travelled. If there are n number of cities to be visited, the total number of

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possible routes covering all cities can be given as a set of feasible solutions of the TSP and is given as (*n*-1)!/2.The Travelling salesman problem is classified as symmetric travelling salesman problem, asymmetric travelling salesman problem, and multi travelling salesman problem.

Ant Colony Optimization

The Ant colony optimization is a population based general search technique for the solution of difficult combinatorial problems, which is inspired by the pheromone trail laying behaviour of real ant colonies [2].Ant colony algorithms are one of the most successful examples of swarm intelligent system and have been applied to many types of problems, ranging from the travelling salesman problem, to routing in telecommunications networks.

The ACO is inspired by the food search behaviour of real ants and their ability in finding the optimum paths, they use special chemical 'pheromone' to communication within colonies to find optimum path between the colony and a food source in an environment[3].This mechanism is called 'stigmergy' means indirect communication among the self-organizing agents or actions. When food is located, real Ants initially move randomly from their colony to food. They deposit special chemical 'pheromone' on their path from colony to food. They also deposit some amount of pheromone while returning. Therefore the ants following shortest path return earlier and amount of pheromone on that path is more. So after some time this path has the more traffic because this is the shortest path. The Pheromones is evaporated at certain rate. So, longer paths which are not used by ants are eliminated after sometime. Thus ants using the history in terms of pheromone trail to search shortest path from colonies to their food [2][3].

A literature review of ant colony optimization technique is as follows: M.Dorigo et al (1994) proposed a new heuristic called ant system for solving job shop scheduling problem. In this, search task is spread over many simple, loosely interacting agents which can be used to find good solutions [10]. Dorigo and Gambardella (1997) proposed a distributed algorithm ant colony system for solving travelling salesman problem. In this, a group of agents cooperates using an indirect form of communication to find the best solution to the travelling salesman problem. Thomas (1998) proposed ACO based on Max-Min ant system to solve flow shop problem. Max-Min ant system is enhanced by a fast local search procedure to produce high quality solutions to the problem [11]. Bullnheimer et al. (1999) proposed an ant system for solving vehicle routing problem. An ant system is a distributed meta- heuristic that merges an adaptive memory with a local heuristic function to frequently construct solutions of the problems [12]. Talbi et al. (2001) proposed a parallel model of ACO to solve the quadratic assignment problem. The parallel ant colony optimization algorithm has been merged with a local search method that depends on a tabu search [13]. Bell and Mcmullen (2004) proposed an ant colony optimization technique for the vehicle routing problem. It has been proved experimentally that the algorithm is successful in finding a competitive solution technique especially for larger problems [14].Neumann and Witt (2006) proposed an ant colony optimization for minimum spanning tree problem. Solution to the problem is built by a random walk on a so called construction graph. This random walk can be determined by the heuristic information [15]. Yu bin et al. (2009) proposes an ant colony optimization for solving the vehicle routing problem. The proposed algorithm owns a new scheme by modifying the increased pheromone called ant weight strategy and using a mutation operator to solve the vehicle routing problem [16][17]. Zar chi Su Su Hlaing and May Aye Khine (2011) proposed an ACO for solving travelling salesman problem in which, good distribution strategy and information entropy is conducted. Also, it uses local optimization heuristic for solving travelling salesman problem along with the basic ACO and the proposed algorithm shows better performance than ACO algorithm [18].

ACO algorithm is developed to show the behaviour of real ants and is as follows:

Begin ACO procedure generate pheromone trails and other parameters
while(termination criteria not meet)
{ construct solutions update pheromone Trails }
post-process results and output
end ACO procedure

Procedure of ACO is as follows:

An important parameters in ACO are distances between two ants, pheromone update which includes pheromone deposit, and pheromone evaporation. Initially ants start their search for finding food source randomly. An ant selects the next node to be visited by probabilistic equation. When ant k is on node I, the probability of going to node j is given by following equation [4]

$$p_{ij}^{k} = \frac{\left(\tau_{ij}\right)^{\propto}(\eta_{ij})^{\beta}}{\sum_{l\epsilon N_i^k}(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}} \quad if\ j\epsilon N_i^k$$

Where, N_i^k is the adjacent node of k which still not visited by ant i. α is the local pheromone coefficient. β is the heuristic coefficient which controls the amount of contribution problem-specific heuristic information plays in a components probability of selections and η = 1/d which is the inverse of distance between I and j. The total number of ants (m) is commonly set low. The arcs which is used by the most ants and which is the shortest, receives more pheromone and will be used by the ants in future.

Second important function is pheromone update which consists of pheromone deposit and pheromone evaporation. Pheromone values are updated each time an ant travels from one node to another. A first Pheromone value on each arc is decreased by constant factor which is known as pheromone evaporation. Then some amount of pheromone is added to each node which is being traversed by each ant, is known as pheromone deposit. Pheromone evaporation is given by equation follows:

$$\tau_{ij} \leftarrow (1-\rho)\tau_{ij}$$

Where, ρ is the evaporation rate. Each ant drops some amount of pheromone on each node which is known as pheromone deposit and given by following equation.

$$\tau_{ij} \leftarrow \tau_{ij} + \sum_{k=1}^{m} \Delta\tau_{ij}^{k}$$

The calculation of this amount of pheromone is as follows: Where, m is the number of ants, and $\Delta\tau_{ij}^{k}$ is the amount of pheromone drop on k node.

$$\Delta\tau_{ij}^{k} = \begin{cases} \frac{1}{c^k} & if\ arc\ (i,j) belongs\ to\ T^k \\ 0, & otherwise \end{cases}$$

Where C^k is the length of the tour by the K^{th} ant.

Advantages of ACO are as follows:

ACO algorithm is strong and easy to accommodate of other algorithms[6].There are some limitations of ACO. Ant colony algorithms can solve optimization problems successfully, but It get stuck in the local optimal solution, since the ACO updates the pheromone according to the current best path [5].

Experimental Results

In this section, we are implementing Ant Colony (ACO) algorithm for solving travelling salesman problem for different cities by using different datasets. The GUI User Interface of Ant Colony (ACO) algorithm is developed by using Java NetBeans IDE 6.5.1 and it is executed through GUI user interface on Windows 8 platform, Core i3 processor 2.13 Ghz with 2.0 GB RAM.

To illustrate the proposed Algorithm, a travelling salesman problem is solved by using GUI Interface of ACO Algorithm. To make clear, algorithm of the proposed method is also given. The results are better to understand and apply to find optimal solution of travelling salesman problems occurring in real life situations. In **the table -1** the results are shown.

Table-1: Experimental Results of Ant Colony (ACO) Algorithm.

No .of Cities	Travel Distance		No. Of Iteration	Mut Rate	Evap Factor
	Best	Worst			
10	2.608	3.40	10000	0.3	0.1
12	2.933	3.791	10000	0.3	0.1
15	3.313	4.28	10000	0.3	0.1
18	3.729	5.25	10000	0.3	0.1
20	3.958	5.50	10000	0.3	0.1
25	4.443	5.837	10000	0.3	0.1
30	4.637	6.33	10000	0.3	0.1
40	6..436	8.022	10000	0.3	0.1
50	7.022	8.268	10000	0.3	0.1
75	9.123	10.75	10000	0.3	0.1

Graphical representation of Results for Ant Colony(ACO) Algorithm for different cities are shown in the following figures.

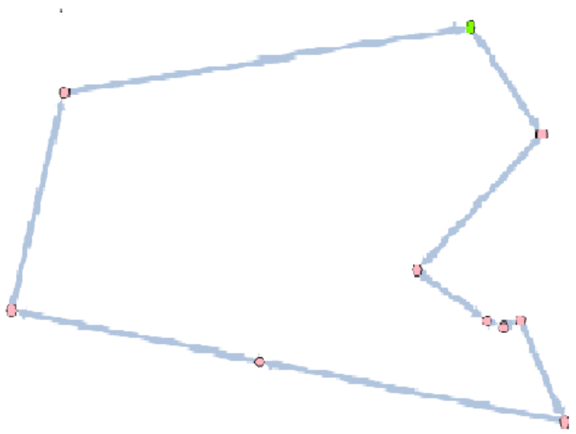

Fig.1: Symmetric Path of 10 Cities

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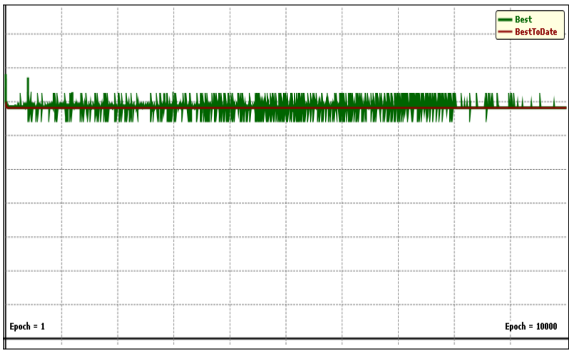

Fig.2: Chart of 10 Cities

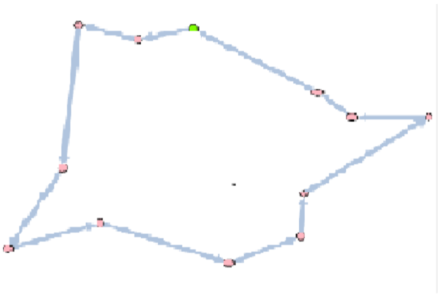

Fig.3: Symmetric Path of 12 Cities

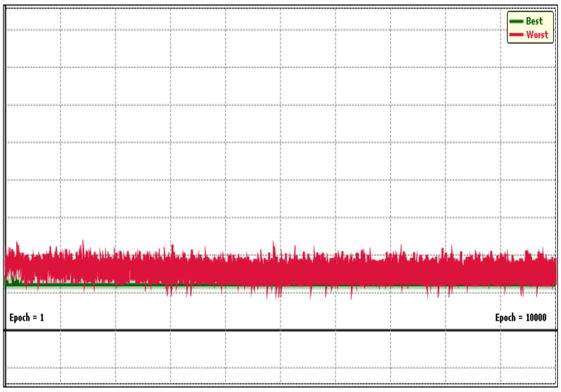

Fig.4: Chart of 12Cities

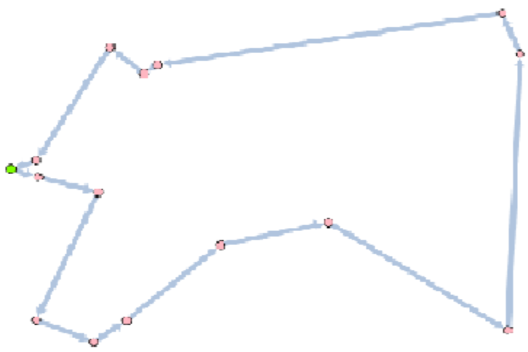

Fig.5: Symmetric Path of 15 Cities

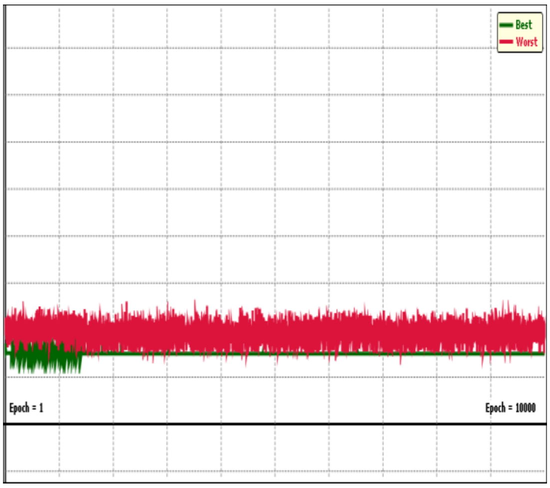

Fig.6: Chart of 15 Cities

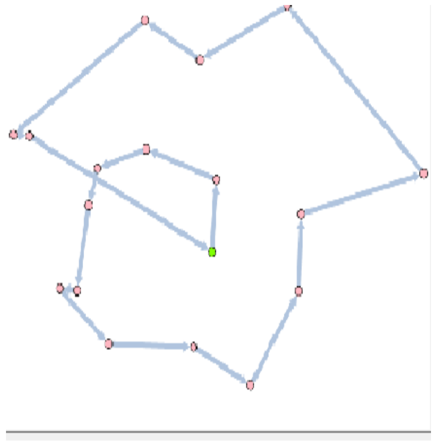

Fig7: Symmetric Path of18 Cities

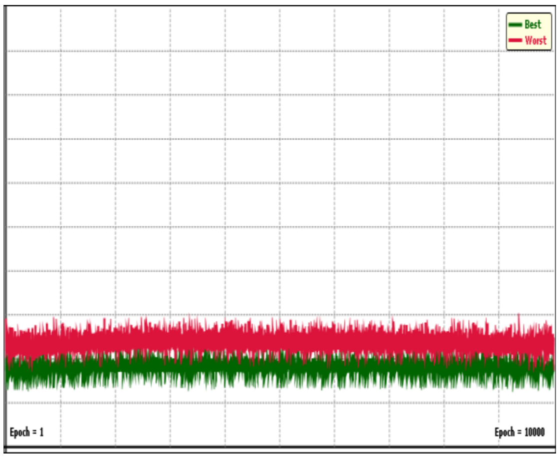

Fig.8: Chart of 18 Cities

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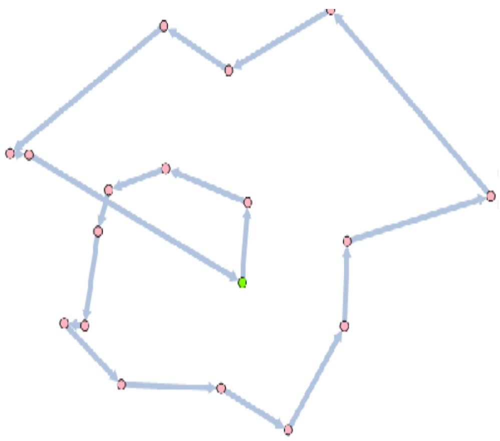

Fig.9: Symmetric Path of 25Cities

Fig.10: Chart of 25 Cities

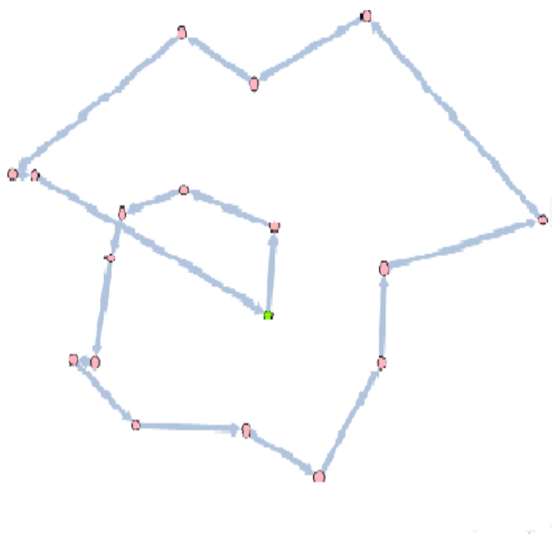

Fig.11: Symmetric Path of 30 Cities

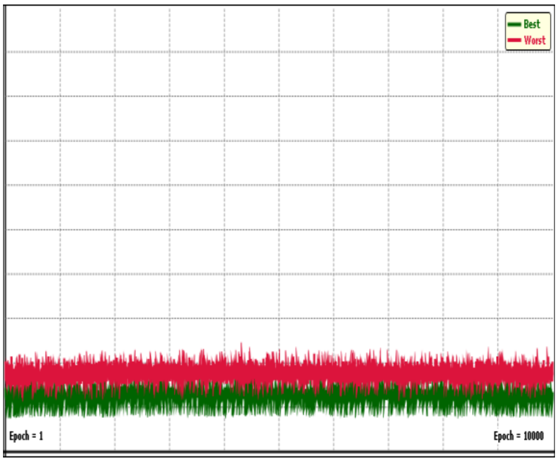

Fig.12: Chart of 30 Cities

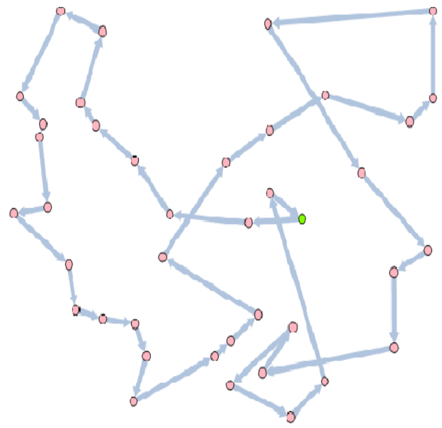

Fig.13: Symmetric Path of 40 Cities

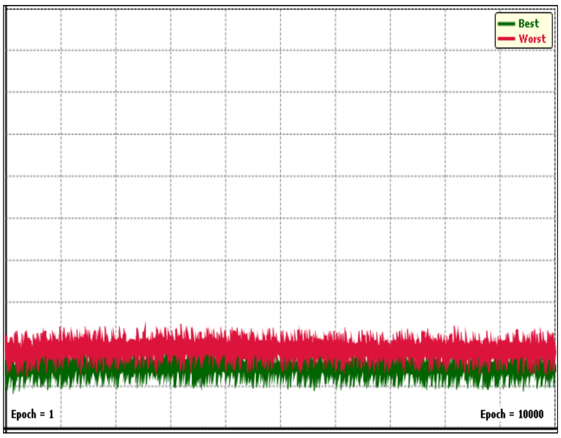

Fig.14: Chart of 40 Cities

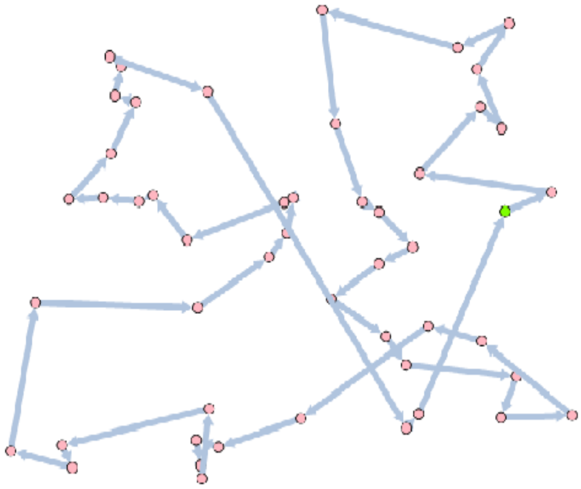

Fig.15: Symmetric Path of 50 Cities

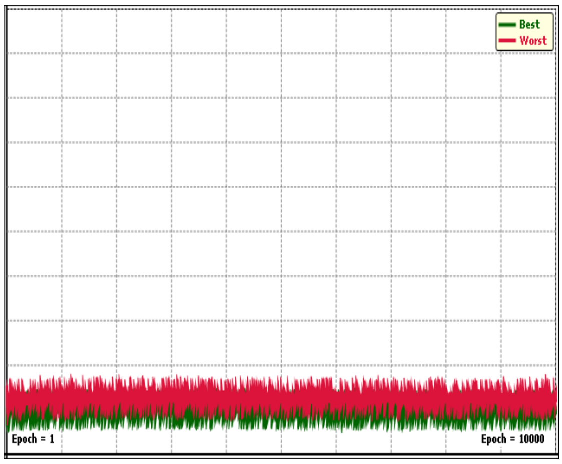

Fig.16: Chart of 75 Cities

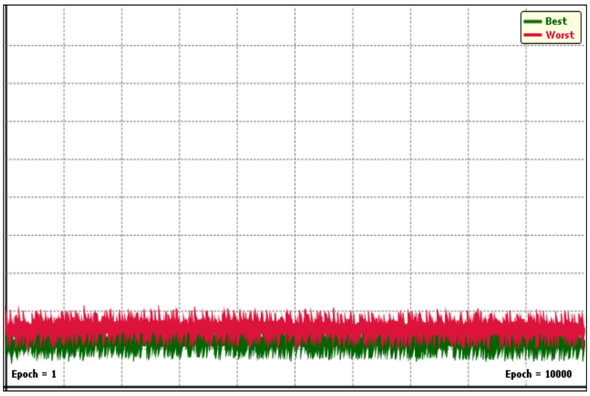

Fig.16: Chart of 50 Cities

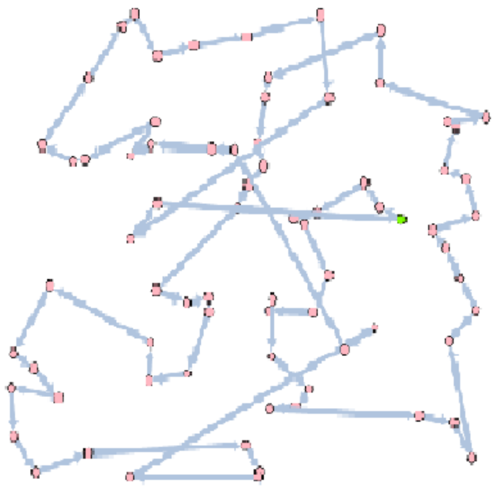

Fig.16: Symmetric Path of 75 Cities

Conclusion and future scope:

In This paper we presented a view of most widely used optimization algorithm technique namely ACO. ACO is the process used by ants to forage food source. They use pheromone trail deposition /evaporation technique to map their way. Results section shows the experimental results obtained on standard randomly generated TSP problems. The experimental results shows that the ACO algorithm has competitive potential for solving discrete real world optimization problems. The result obtained shows that how the various cities are visited in different iterations . It also shows that how the various parameters varies when the number of cities get changed.

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