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A Hybrid Method to Solve Travelling Salesman Problem

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ABSTRACT: The Traveling Salesman Problem (TSP) is one of the standard test problems used in performance analysis of discrete optimization algorithms. The Ant Colony Optimization (ACO) algorithm appears among heuristic algorithms used for solving discrete optimization problems. In this study, a new hybrid method is proposed to optimize parameters that affect performance of the ACO algorithm using Particle Swarm Optimization (PSO). In addition, 3-Opt heuristic method is add edto proposed method in order to improve local solutions. The PSO algorithm is used for detecting optimum values of parameters and which are used for city selection operations in the ACO algorithm and determines significance of inter-city pheromone and distances. The 3-Opt algorithm is used for the purpose of improving city selection operations, which could not be improved due to falling in local minimums by the ACO algorithm. The performance of proposed hybrid method is investigated on ten different benchmark problems taken from literature and it is compared to the performance of some well-known algorithms. Experimental results show that the performance of proposed method by using fewer ants than the number of cities for the TSPs is better than the performance of compared methods in most cases in terms of solution quality and robustness.

KEYWORDS: TSP, ACO,PSO,3 Opt

I. INTODUCTION

The Traveling Salesman Problem (TSP) was first formulated as a mathematical problem in 1930and became increasingly popular after 1950. It is one of the most intensively studied problems in optimization even in recent years. The TSP is to find a shortest possible tour that visits each city exactly once for a given list of cities and back to the starting city. The Traveling Salesman Problem (TSP) is one of the standard test problems used in performance analysis of discrete optimization algorithms. TSP is a very important combinatorial optimization problem and is known to be NP-hard. In the TSP, the set of nodes is divided into clusters. Many applications of the TSP exist in many fields. But researches still did not pay enough attention to TSP specific local search and mostly use simple TSP heuristics with basic adaptations. TSP is a well-known NP-hard combinatorial optimization problem. It is used as a benchmark for many optimization methods due to the computational complexity, such as Nearest Neighborhood Search(NNS), Simulated Annealing (SA), Tabu Search (TS), Neural Networks (NN), Ant Colony System(ACS), and Genetic Algorithm (GA). At present, there are many web sites discussing the Traveling Salesman Problem, and have the benchmark in the standard TSPLIB format, suchas burma14, berlin52, where the number behind the name represents the number of cities to be studied. Swarm-inspired optimization has become very popular in recent years. Particle swarm optimization (PSO) and Ant colony optimization (ACO) algorithms have attracted the interest of researchers due to their simplicity, effectiveness and efficiency in solving complex optimization problems. Both ACO and PSO were successfully applied for solving the traveling salesman problem (TSP). Performance of the conventional PSO algorithm for small problems with moderate dimensions and search space is very satisfactory. The 3-Opt algorithm is used for the purpose of improving city selection operations. The Traveling Salesman Problem (TSP) is a well-known combinatorial discrete optimization problem where the salesman attempts to find the shortest tour through cities. This problem has been used in many engineering applications such as the design of hardware devices and radio electronic systems, and computer networks. In the theory of computational complexity, the decision version of the TSP (where, given a length L, the task is to decide whether the graph has any tour shorter than L) belongs to the class of NP-complete problems. Thus, it is possible that the worst-case running time for any algorithm for the TSP increases exponentially with the

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number of cities. For this reason, in recent years some heuristic algorithms have been proposed to solve this problem, which have achieved better results in terms of computational and time complexity.

Grefenstette et al. presented some approaches to the application of Genetic Algorithms (GA) to the TSP . Shi et al. presented a Particle Swarm Optimization(PSO) based algorithm for the TSP . Geng et al. proposed an effective local search algorithm based on Simulated Annealing (SA) and greedy search techniques to solve the TSP. In orderto obtain more accuracy solutions, the proposed algorithm based on the standard SA algorithm adopted the combination of three kinds of mutations with different probabilities during its search.Jolai and Ghanbari presented an improved Artificial Neural Network (ANN) approach for solving the TSP. They employed Hopfield Neural Network and data transformation techniques together to improve accuracy of the results and reach to the optimal tours with less total distances. Pedroet al. proposed a Tabu Search algorithm to solve the TSP.

Dorigo et al. proposed an Ant System to solve the TSP. Dorigo and Gambardella described an artificial ant colony (ACO) capable of solving the TSP . They demonstrated that the ACO was capable of generating good solutions to both symmetric and asymmetric instances of the TSP. Mavrovouniotis and Yang proposed an ACO framework for dynamic environments . Their framework contains different immigrants schemes, including random immigrants, elitisim-based immigrants, and memory based immigrants. Karabogaand Gorkemli proposed a new Artificial Bee Colony (ABC) algorithm called Combinatorial ABC for the TSP . They showed that the ABC algorithm can be used for combinatorial optimization problems. To solve this problem, hybrid heuristic methods based on Simulated Annealing, PSO, ACO,ABC, ANN, etc. were used.

Bountoux and Feillet proposed a hybrid algorithm to solve the TSP . Their algorithm consists of the ACO algorithm hybridized with local search procedures. They called Dynamic Multi-Dimensional Anamorphic Travelling Ants (DMD-ATA). Tsai et al.presented a metaheuristic approach called ACOMAC algorithm for solving the TSP . They introduced multiple ant clans concept from parallel genetic algorithm to search solution space utilizing various islands to avoid local minima and thus can yield global minimum for solving the TSP. Also, they presented two approaches named the multiple nearest neighbor (NN) and the dual nearest neighbor (DNN) to ACOMAC to enhance large TSPs. Pasti and Castro proposed a meta heuristics for solving the TSP based on a neural network trained using ideas from the immune system . The network was self-organized and the learning algorithm aims at locating one network cell at each position of a city of the TSP instance to be solved. Their network based on a Real valued Antibody Network (RABNET).

Masutti and Castro proposed some modifications on the RABNET-TSP, an immune-inspired self-organizing neural network, for the solution of the TSP Beam-ACO algorithm, which is a hybrid method combining ACO with beam search was usedto solve TSP. Cheng and Mao developed a modified ant algorithm, named Ant Colony System Traveling Salesman Problem with Time Windows (ACS-TSPTW), based on the ACO technique to solve the TSP.

Krohling and Coelho presented an approach based on co-evolutionary PSO for solving the constrained optimization problems as minmax problems . Lin et al. presented an evolutionary neural fuzzy network, designed using the functional-link-based neural fuzzy network and an evolutionary learning algorithm. Their evolutionary learning algorithm was based on a hybrid cooperative PSO and cultural algorithms for prediction problems. Chen and Chien presented a method, called the genetic simulated annealing ant colony system with Particle Swarm Optimization techniques, for solving the TSP. Junqiang and Aijia proposed a Hybrid Ant Colony Algorithm (HACO) which is containing ACO and delete-cross method which is used to speed the convergence of local search is presented for the shortcoming that the convergence speed of ACO isa bit slow. Dong et al. presented an approach, called Cooperative Genetic Ant System (CGAS),combines both GA and ACO together in a cooperative manner to improve the performance of ACO for solving TSP .

Peker et al. proposed for the TSP using the ant colony system and parameter optimization was taken from the Taguchi method. Gunduz and Kiran presented a new hierarchic method based swarm intelligence algorithms for solving well-known TSP. The swarm intelligence algorithms implemented in their study were divided into two types as path construction and path improvement based methods.

The path construction based method (Ant Colony Optimization-ACO) that produced good solutions have taken more time to achieve a good solution and also, the path improvement based technique (Artificial Bee Colony ABC) that quickly produced results have not achieved a good solution in a reasonable time. Therefore, their hierarchic method which consists of ACO-ABC was proposed to achieve a good solution in a reasonable time. ACO was used to provide better initial solution for ABC that use path improvement technique in order to achieve to optimal or near optimal solution. In this study, a new hybrid method was suggested, which optimizes parameters that affect performance of the ACO algorithm through PSO and reduces the probability of falling in local minimum with the 3-Opt algorithm. Better

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results were achieved with the suggested method compared to other studies in the literature by using fewer ants than the number of cities for the TSPs.

II. METHODOLOGIES

1.1 Ant Colony Optimization (ACO) Algorithm

The ant colony algorithm is an algorithm for finding optimal paths that is based on the behavior of ants searching for food. At first, the ants wander randomly. When an ant finds a source of food, it walks back to the colony leaving ”markers” (pheromones) that show the path has food.

When other ants come across the markers, they are likely to follow the path with a certain probability. If they do, they then populate the path with their own markers as they bring the food back. As more ants find the path, it gets stronger until there are a couple streams of ants traveling to various food sources near the colony. Because the ants drop pheromones every time they bring food, shorter paths are more likely to be stronger, hence optimizing the ”solution.” In the meantime, some ants are still randomly scouting for closer food sources.

A similar approach can be used find near-optimal solution to the traveling salesman problem. Once the food source is depleted, the route is no longer populated with pheromones and slowly decays. Because the ant-colony works on a very dynamic system, the ant colony algorithm works very well in graphs with changing topologies. Examples of such systems include computer networks ,and artificial intelligence simulations of workers.

1.2 Particle Swarm Optimization (PSO) Algorithm

Inspired by the flocking and schooling patterns of birds and fish, Particle Swarm Optimization (PSO) was invented by Russell Eberhart and James Kennedy in 1995. Originally, these two started out developing computer software simulations of birds flocking around food sources, then later realized how well their algorithms worked on optimization problems. Particle Swarm Optimization might sound complicated, but it’s really a very simple algorithm. Over a number of iterations, a group of variables have their values adjusted closer to the member whose value is closest to the target at any given moment. Imagine a flock of birds circling over an area where they can smell a hidden source of food. The one who is closest to the food chirps the loudest and the other birds swing around in his direction. If any of the other circling birds comes closer to the target than the first, it chirps louder and the others veer over toward him.This tightening pattern continues until one of the birds happens upon the food. It’s an algorithm that’s easy and simple to implement.

1.3 3 Opt Algorithm

3-Opt is a simple local search algorithm for solving the TSP in optimization. 3-Opt algorithm is a special case of the k-opt algorithm. In this algorithm, 3-Opt analysis involves deleting three connections (or edges) in a network (or tour), reconnecting the network in all other possible ways, and then evaluating each reconnection method to find the optimum one. This process is then repeated for a different set of three connections . In this way, there are edges in the graph and edges overlapped in the tour are created on the graph. This leads to increasing lengths of tour. Using replacements for three edges in the specified nodes determines the length of the best tour. To reduce the length of the best tour, different algorithms such as GA, PSO, ACO and ABC are presented.

1.4 Hybrid method (PSO-ACO-3 Opt)

In general, the number of ants is taken as equal to the number of cities for the solution of the TSPs via ACO. Increasing the number of ants also increases the calculation complexity.

In this study, a hybrid method is proposed that is based on the PSO, ACO and 3-Opt algorithms in order to improve solution performance of the TSPs. At first, ants are randomly distributed to cities. Then, pheromones are assigned to all inter-city routes as much as the amount calculated.

All ants complete their first tours only by taking intercity distances into account. Tour lengths are determined for all ants and the pheromone update is realized. Values of parameters α and β are determined by using the PSO. Objective function of the PSO algorithm is the tour length. $gbest_{ant}$ represents parameters α and β, which yield the shortest tour length for each ant in the PSO algorithm. Ant route and parameters that provide the shortest tour length are accepted as the solution of the system. Pheromone update is achieved by using routes of all ants. When the number of iterations designated for the ACO algorithm is reached, the stage of the PSO–ACO has been completed.

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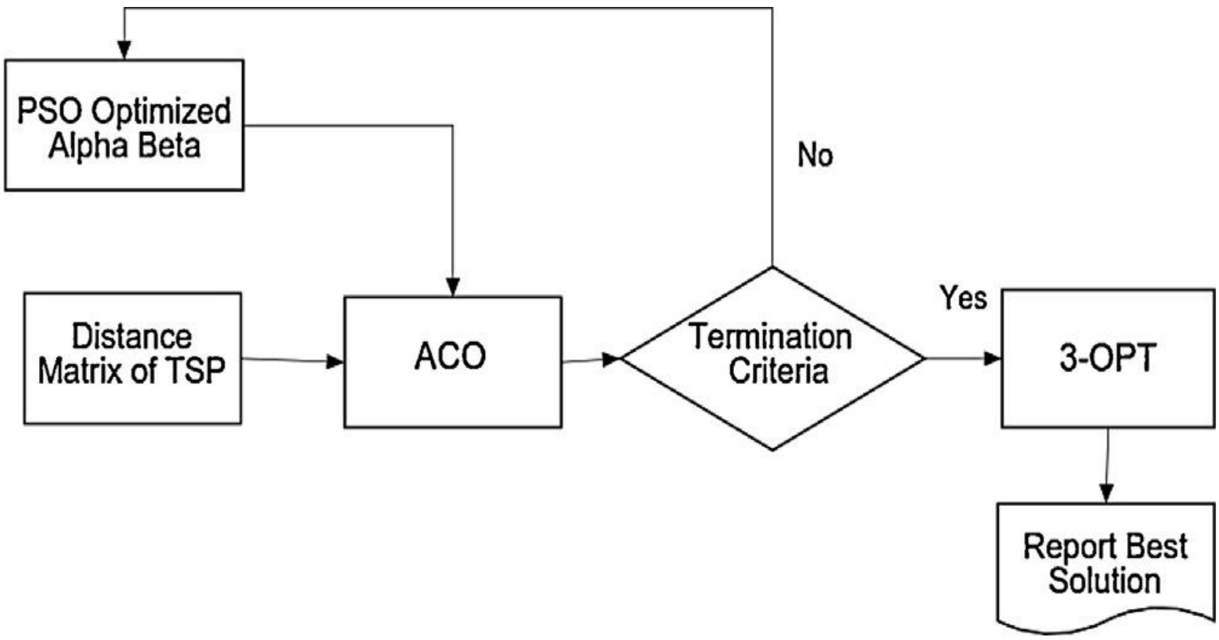
The 3-Opt algorithm is applied after the stage of the PSO–ACO for not falling in local optimum. In our proposed method, a solution is developed by applying the 3-Opt algorithm to the best solution.

Flowchart of Proposed System:



III. EXPERIMENT RESULTS

The best tour length is mentioned in the table below :

Data Set	No.of Ants=10	No.of Ants=20	No.of Ants=30	No.of Ants=No.of City
Eil51	441.35	442	434.2	432.9
Berlin52	8196	7536	8160	7536
Eilon76	572.25	560.25	563.25	549

IV. CONCLUSION

In this study, a new hybrid method based on the PSO, ACO and 3-Opt algorithms is proposed in order to solve the TSPs. In this method, the PSO is used for determining parameters α and β which affected performance of the ACO, and the 3-Opt is used for getting rid of the local solution found the ACO algorithm. The performance of this proposed method is investigated by taking into consideration average route length on three different datasets taken from TSPLIB. The effects of the different number of ants in the ACO are also analyzed in this present study. As seen from the

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experimental results, performance of the proposed method is getting better depended on the fewer number of ants. From the results obtained in this work, it can be concluded that the performance of the proposed method is better than or similar to performance of compared methods.

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