A survey on travelling salesman problem (TSP) to improve the distance between cities by using Ant colony algorithm

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Abstract— *The travelling salesman problem (TSP) is a nondeterministic Polynomial hard problem in combinatorial optimization studied in theoretical computer science and operations research. And to solve this problem we used two popular meta-heuristics method that used for optimization techniques; the first one is Ant Colony Optimization (ACO), and the second is Genetic Algorithm (GA). In this work, we try to apply both techniques to solve TSP by using the same dataset and compare between them to determine the best one for travelling salesman problem.*

Keyword—*Ant Colony Optimization, Genetic Algorithm, travelling salesman problem, Wireless sensor networks*

I. INTRODUCTION

Due to a recent development in the technology, there is a growth in wireless sensor network which is composed of large figure of homogeneous & heterogeneous sensor nodes which operates in wireless fashion to achieve common objective. Homogeneous nodes are oftenly used over heterogeneous nodes because of less complexity and better

Manageability. Within its radio communication range, each sensor nodes communicates with other nodes.

Nodes can be easily arranged in random or deterministic fashion. Each node contains processing capability and mayhold several types of memory, a power source,and accommodate various sensors and actuators. One or more nodes in the network will aid as sink (node) which exchange information with the user either directly or by the way of existing wired networks. Peer-to-peer networking protocols support a mesh-like relation to transfer retransfersdata between the thousands of nodes in a multi-hop fashion. The flexible mesh architectureenvisioned dynamically adapts to support introduction of new nodes or allow existing nodes to expand to cover a larger geographic region.

The ideal wireless sensor is networked, robust and scalable, fault tolerance, consumes very less power, smart and software programmable, efficient, capable of fast data acquisition, reliable and accurate over long term, cost little to purchase and required no real maintenance.

Wireless sensor networks have gained worldwide attention in recent years, particularly with the Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. These smart sensors are small with a limited processing and computing resources, and they are expensive as compared to traditional sensors. These nodes are capable of sense, measure, and gather information from the environment and, based on that information, some local decision process; they are allowed to transmit the sensed data to the user.

These tiny nodes aresmall in size compromises of sensing, data processing &communicating components. The position of all these tiny nodes need not be absolute; this not only gives random placement but also means that protocols of sensor networks and its algorithms must possess self-organizing abilities in inaccessible areas. These communicating components are integrated on a single or multiple boards, & packaged in a few cubic inches.

A WSN usually consists of tens to thousands of such nodes that communicate through wireless channels for information sharing and cooperative processing. WSNs can be deployed on a global scale for environmental monitoring and natural study, over a battle field for militarysurveillance. The onboard sensors then start to collect acoustic, seismic, infrared or magnetic information. About the environment, using either event driven working or continuousmodes. Location and positioning information can also be obtained through the local positioning algorithms or global positioning system (GPS). This information gathered across the network and appropriately processed to construct a global view of the monitoring phenomena or objects. The basic philosophy behind WSNs is, while the capability of each individual sensor node is limited, the aggregate power of an entire network is sufficient for the required target. In a typical scenario, users can retrieve information of interest from a WSN by injecting queries & gathering results from the so-called base stations (or sink nodes), which behave as aninterface between users & the network. In this way, WSNs can be considered as distributed database. It is also envisioned that sensor networks will ultimately be connected to the Internet, through which sharing of global information becomes feasible.

Recent advancement in micro-electro-mechanicalsystems (MEMS) technology, wireless communications and digital electronics have started the progress of low-cost, low-power, multifunctionalsensor nodes that are small in size andcommunicate untethered in short distances. These small sensor nodes, which compromise of sensing, dataprocessing, and communicating components, leverage the concept of sensor networks based oncollaborative effort of a large number of nodes. A WSN typically has somewhat little infrastructure. It compromisesof a number of sensor nodes (few tens to thousands) working together to test a region to obtain data aboutthe environment. There are two kinds of WSNs: structuredand unstructured. An unstructured WSN is one that includesa thick collection of sensor nodes. Sensor nodesmay be distributed in an ad hoc mannerinto the field. Oncedistributed, the network is left unattended to perform supervisingand informing functions. In an unstructured WSN, networkmaintenance such as managing connectivity anddetecting failures is difficult since there are so many nodes.In a structured WSN, all or few of the sensor nodes are deployedin a pre-planned manner.The benefit of a structurenetwork is that fewer nodes can be deployed withlower network maintenance and management cost. Fewernodes can be distributed now since nodes are placed at specificlocations to provide coverage while ad hoc deploymentcan have uncovered regions.

The arising field of wireless sensor networks concentrates sensing, computation, and communication into a single diminutive device. Through advanced mesh networking protocols, these devices create a sea of connectivity that extends the reach of cyberspace out into the physical world. As water flows to fill every room of a sunken ship, themes networking connectivity will seek out and exploit any feasible communication path by hopping data from node to node in search of its destination. While the capabilities of any idiosyncratic device are negligible, the creation of hundreds of devices offers radical new technological possibilities butthere are a lot of technological challenges that must be overcome before DSNs can be used for today's increasinglycomplex information collecting tasks.

II. TECHNIQUES OR METHODS

A. Ant Colony Optimization (ACO)

Ant Colony Optimization (ACO) is a technique for designing metaheuristic algorithms for combinatorial optimization problems. The first algorithm which can be identified within this framework was presented in year 1991 and, since then,many diverse variants of the basic principle have been reported in the literature.An important trait of ACO algorithms is the combination of a priori informationabout the structure of a promising solution with a posteriori information about thestructure of previously obtained good solutions.

The characteristic of ACO algorithms is their explicit use of elements of earliersolutions. In fact, they drive a constructive low-level solution, as GRASP does, but including it in a population framework and randomizing the constructionin a Monte Carlo way. A Monte Carlo combination of various solution elementsis suggested also by Genetic Algorithms, but in case of ACO the probabilitydistribution is explicitly defined by previously obtained solution components

Ant colony optimization, which was introduced in the early 1990s a novel technique for solving hard combinatorial optimization problems, finds itself presently atthis point of its life cycle. With this article we cover a survey on theoretical results on ant colonyoptimization. First, we reviewsome convergence results. Then we cover relations between ant colony optimization algorithms and other approximate methods for optimization. Finally, we concentrate on some research efforts directed at gaining a deeper understanding of the behavior of ant colony optimization algorithms.

Ant colony optimization (ACO) was introduced by the Italian scholar, M. Dorito and colleagues. It is a novel meta-heuristic technique that has been successfully applied in solving various problems in combinatorial optimization. To create the shortest path from food sources to nests, ACO algorithm helps in modeling the behavior of real ants. The ants assemble pheromone trail while walking and all other ants prefer to follow a path where the amount of pheromone is rich. When an ant searches a food source, it carries it back to the nest and starts depositing the chemical. Other ants will begin to choose a shorter path between food source and their nest, where there is higher quantity of pheromone. This ant foraging behavior can solve ACO problems.

One of the problem is defined as to visit "n" cities, beginning andending with the same city, visiting each city once and making the tour with the lowest cost, this cost can be expressed in terms of time or distance, i.e., travel a minimum of kilometers or perform a tour in the shortest time possible. More formally, the TSP can be represented by a complete weighted graph G= (N, A) with N being the set of nodes representing the cities, and A being the set of arcs. Each arc (i, j) A is assigned a value (length), which is the distance between cities i and j, with i,j**i**nn. In the general study of an asymmetric TSP, the distance between a set of a node i,j is supported on the direction of traversingthe arc, that is, there is at least one arc (i, j).The ACO algorithmTraveling Salesman Problem (TSP) is a well-known and a typical non-deterministic polynomial complete problem which is difficult to solve and easy to describe. It asks for the shortest path of minimum total cost visiting each given city only once. The main task of TSP is to find the Hamiltoniancycle with the least weight for a graph where a Hamiltonian cycle is a closed path which visits each of the cities (nodes) of the graph exactly once. TSP is a problem where ACO algorithms can be easily applied. It is easy to understand and is often used to validate certain algorithm by making an easy comparison with other algorithms.

B. Traveling Salesman Problem

The Traveling Salesman Problem can be represented by a complete weighted graph G=(N,E), where N denominate the set of nodes representing cities, and E denominate the set of edges or arcs connecting all the cities. Each arc (i,j) ∈E is assigned a cost(value or length) dij, that describes difference between cities i and j with (i, j) ∈N .To select the path that has minimum total cost for all feasible permutations of N cities is a direct method for solving problem. The permutations are very large in number for even 40 cities. Each and everyrepresented in 2n different ways for symmetrical TSP. Since all the possible ways for the permutation of n numbers is n!.

TSP is used to find a routing of a salesman who starts from a home location, visits an inflicted set of cities and returns to the original location in such a way that the total distance travelled is minimized and each city is visited exactly once. This problem is known to be NP-hard, and cannot be calculated exactly in polynomial time.A lot of exact and heuristic algorithms have been developed in the field of operations research (OR) to solve this problem. TSP is solved very easily when there is less number of cities, but as the quantum of cities increases it is very hard to workout, as large amount of computation time is required. The numbers of areas where TSP can be used very effectively are military and traffic. Another approach is to use genetic algorithm to solve TSP because of its robustness and flexibility. Some typical applications of TSP include vehicle routing, computer wiring, piercing wallpaper and job sequencing. The main usefulness in statistics is combinatorial data calculus, e.g., reordering rows and columns of data matrices or identifying clusters .

The idea behind ant algorithms is to adapt and use their communication style which has been proven to be excellent in nature, rather than truly imitate the behavior of real ants. Artificial ants can then be seen and described as communicating agents sharing some traits of the real ants, but also incorporating other traits for which there is no parallel in nature. The overall characteristics are what makes them fit to solve problems, if not optimally, at least by finding very good conclusions. A real foraging ant spends all its life travelling between its nest and some food source. It does not then come as an aback that the first problem solved with an ant algorithm, known as Ant System (AS), was the Travelling SalesmanProblem (TSP), a well-known combinatorial problem, where the shortest route (path) that visits exactly once each city of a given class of cities, beginning and ending at the aforementioned city, is to be found.

The very good results that were being achieved with ant algorithms pointed to the broadening of the definition of *path* therefore allowing for the use of this method to solve other problems. Some adaptations of the algorithm had to take place, resulting in the so called Ant Colony Optimization meta-heuristic, which is based on the ant system. The symbolic definition of the ACO meta-heuristic, as a series of generic guidelines that could be very easily adapted to almost all types of combinatorial optimization problems, allowed a lift up in the use of this methodology and in the number of researchers and publications in an area. From that time, ACO procedures have been applied to solve a broad set of problems, including: Network Flow Problems, Network Design Problems, Facility Location Problems, Transportation Problems,Santos Covering Problems , Location Problems , just to mention but a few in the area of combinatorial optimization. Excitingly enough, although the TSP was the first problem to be solved by the AS and ACO met heuristics.

III. RELATED WORK

Ant colony optimization (ACO) is a heuristicalgorithm which has been proven a successful technique and applied to a number of combinatorial optimization problems and is taken as one of the high performance computing methods for Traveling salesman problem (TSP). TSP is one of the mostfamous combinatorial optimization (CO) problems and which has wide application background. ACO has excellent search capability for optimization problems,however it is one of thecomputational bottlenecks that the ACO algorithm costs toomuch time to convergence and traps in local optima in order to find an optimal solution for TSP problems. This paper proposes an improved ant colony optimization algorithm withtwo highlights. First, candidate set strategy has beenadapted to rapid convergence speed. Secondly, a dynamic updating rule for heuristic parameter based on entropy to improve the performance in solving TSP. Algorithms are checked onbenchmark problems from TSPLIB and test results are presented. In our detailed analysis, the proposed algorithm has better performance than the conventional ACO algorithm and the turn out results of the proposed algorithms are found to be satisfactory.

We describe an artificial ant colony capable of solving the traveling salesman problem (TSP).Ants of the artificial colony are able to generate successively shorter feasible tours by using formation accumulated in the form of a pheromone trail deposited on the edges of the TSP
Graph. Computer simulations demonstrate that the artificial ant colony is capable of generatinggood solutions to both symmetric and asymmetric points of the TSP. The method is anexample, like neural networks, and growingcomputation,of thesuccessful use of a natural symbol to design an optimization algorithm

Ant algorithms are a recently developed, population-based approach which has been successfully applied to several *NP*-hard combinatorialoptimization problems. As the definition of name suggests, analgorithms have been influenced by the behavior of real ant colonies,particularly,by their foraging behavior. One of the main aspects of ant algorithms is theindirect communication of a colony of agents, called (artificial) ants, based onpheromone trails (pheromones are also used by real ants for communication).The (artificial) pheromone trails are a kind of distributed numeric informationwhich is modified by the ants to reject their experience while solvinga particular problem. Recently, the Ant Colony Optimization (ACO) meta-heuristichas been proposed which provides a unifying framework for most
Applications of ant algorithms to combinatorial optimization problems.In particular, all the ant algorithms applied to the TSP perfectlyinto the ACO meta-heuristic and, therefore, we can call these algorithms asACO algorithms.

Scientific literature is prolific both on exact and on heuristic solution methods developed to solveoptimization problems. Although the previous methods have anindisputable theoretical value
When it comes to solve large realistic combinatorial optimization problems they are usually associated with large and even prohibitive running times. Heuristic methods, do not guarantee todetermine a global optimal solution for a problem but are usually able to find a good solutionrapidly, might be a local optimum, and require less computational resources. Ant Colony Optimization (ACO) algorithms belong to a class of heuristics based on the behavior of nature ants.These algorithm has been used to solve many combinatorialoptimization problems and

havebeen known to outperform other popular heuristics such as Genetic Algorithms. Now, webelieve that the number of ACO based algorithms will continue to grow for a long time. Thecontribution of this work is to help the reader with a sort of consultation guide for developing ACO algorithms, by presenting a collection of various approaches that can be found inliterature, concerning the ACO building blocks.

The today's work deals with approaches to control the parameters of Ant Colony Optimization (ACO) algorithms for the Traveling Salesman Problem (TSP). The TSP is acombinatorial optimization problem. It is concerned with a salesman that require to plan atour on which he visits a given set of N cities before returning to his starting point.The goal is to end the order in which he should visit the cities so that the overall length ofthe tour is minimized. Some of the practical applications of the TSP exist, such as tour planningfor packet delivery services.Many popular methods to solve the TSP model it as a graph problem. The nodes in the graph denote the cities, which the salesman needs to visit and the edges correspondto the available connections. The edges are assigned weightdijthat corresponds to thedistance between the two neighboring citiesI andj. To simplify the model, the graph isfully connected and the salesman is obliged to visit every city exactly once. As the presentwork deals with the symmetric TSP, the edges in this type of graph are undirected, i.e., the distancethat needs to be traveled to get from city
to cityjis the same as in the opposite direction.In terms of graph theory, ending the salesman's optimal tour corresponds to ending theshortest Hamilton cycle in the graph.The TSP is of particular interest in an optimization context because it is a NP-hardproblem, i.e., there is no optimization technique that generally solves it in polynomial time. Therefore, large TSP instances are typically solved using heuristic approaches, i.e.methods that derive rather good solutions within a relatively short amount of time, butwhich do not guarantee the optimality of the returned result.This is where Ant Colony Optimization comes into play. ACO algorithms are heuristicmethods that mimic the foraging behavior of real ants. When a real ant ends a foodsource, it will determine the desirability of using this food source, which may be impactedby the amount of food that was found or its distance to the nest. While traveling back tothe nest, the ant marks its way with a chemical known as pheromone. For some real antspecies, the amount of deposited pheromone depends on the desirability of using the foodsource.Whenever another ant explores the region around the nest on its search for food, thetrail it chooses will be biased towards directions in which it senses a lot of pheromone onthe ground. Over time, this eventually leads to more and more ants using the promisingpaths and depositing additional pheromone on them. Should the reserves at a popular foodsource get deposited over time, the natural evaporation of the chemical gives the pheromonetrails the chance to adapt to the new situation.It should be noted that the ants do not communicate directly. The only way theyexchange information is by depositing pheromone on promising trails. This type of communication by means of physical modifications of the environment is called stigmergy.

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IV. Conclusion

In this paper the first step is determining the best number of iteration for Ant Colony Optimization to have the optimized solution. It is necessary to evaluate the relation between costs, alpha, and beta and how these parameters effect on best number of iterations and evaporations coefficient. For Genetic Algorithm, we need to select the best value for chromosome population, crossover, and mutation probabilities. But still at this time the Genetic Algorithm is better than Ant Colony Optimization for TSP.

REFERENCES

I.F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, Wireless sensor networks: a survey,ELSEVIER, vol 393–422 ,2002

Marco Dorigo and Christian Blum, Ant colony optimization theory: A survey,ELSEVIER, 243 – 278, 2005.

Neha Rathi, Jyoti Saraswat, Partha Pratim and Bhattacharya, A review on routing protocols for application in wireless sensor networks, International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.5, September 2012

Xiao-Fan Zhou and Rong-Long Wang,Self-Evolving Ant Colony Optimization and its Application to Sraveling Salesman Problem,International Journal of Innovative Computing, Information and ControlICIC International Vol8, Number 12, December 2012

Inderpal Singh and Jaskiran kaur, A Survey on Ant Colony Optimization, International Journal of Computer Science & Engineering Technology (IJCSET), Vol. 4 No. 06, Jun 2013 713