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Survey on Ant Colony Optimization Using Travelling Salesman Problem

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ABSTRACT: The ant colony algorithm is an effective method to solve the problem of optimizing shortest path, which is one of the key technologies for navigation and path planning. There is a need for fast traversal algorithms, specifically to find a path from a source to destination with minimum cost. Cost can be distance, time, money, energy, etc. Travelling salesman problem (TSP) is used for combinatorial optimal problem. TSP is the most intensively studied problem in the area of optimization. Ant colony optimization (ACO) is based on the population metaheuristic method that can be used to find approximate solutions to difficult optimization problems. There have been many efforts in the past to provide time efficient solutions for the problem, both exact and approximate. Traveling salesman problem (TSP) belongs to hard problems. Since solving these problems need a lot of time for execution. This paper presents an attempt to decrease execution time using parallelization on multicore processor. To demonstrate the implementation of TSP using ant colony optimization (ACO) and show the comparison between serial and parallel execution, parallelization tool OPENMP was used.

KEYWORDS: Ant colony optimization, Travelling salesman Problem, pheromone update, parallel processing.

I. INTRODUCTION

Ant colony optimization bionics algorithm and was proposed by Italian scholar M.Dorigo and his partners in 1991 [7]. The original idea of ant colony optimization algorithms was developed through observations of the behavior of real ants. Ant colony represents multi-agent system where the behavior of one artificially ant is inspired with the behavior of natural ants. The usage includes classic NP-hard problems and it goes back to routing in computer and telecommunications to data mining. Ants are social insects for which the survival of the colony is more important than survival of individual ants. This has resulted in ants developing highly social behavior and the defense and communication systems which have attracted the attention of many scientists. One of the most interesting ant behavior patterns is the way in which they find food, in particular, the speed and efficiency with which they do it [3]. Ants communicate with one another using stigmergy which is an indirect communication method. The ants communicate with one another by relying on chemical messengers called pheromones. Among their different uses, pheromones are used by ants to mark their territory or signal danger to the colony. For example, ants may use pheromones to mark paths between their nest and a food source. This helps them to easily transport food back to their nest by following a previous route marked by other ants [6]. After the ant colony algorithm proposed, it has been widely concerned by scholars both at home and abroad, and a lot of improved algorithms have been proposed constantly. Such as elite strategy of ant colony algorithm, max-min ant colony algorithm, arrange ant colony algorithm, best-worst ant colony algorithm and so on [8-11]. The basic idea of the algorithm is that only the part of ants walking through the shorter path is allowed to release pheromone and update the total number of ant randomly or fixedly in iterative process.

The remainder of this paper is divided in following sections. Section I will describe briefly about ACO algorithm. Section II will describe about TSP Problem. In section III discussion about proposed system is done. Section IV will review about advantageous features of proposed system.



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II. RELATED WORK

In [1] authors propose it as a viable new approach to stochastic combinatorial optimization. The main characteristics of this model are positive feedback, distributed computation, and the use of a constructive greedy heuristic. We apply the proposed methodology to the classical Traveling Salesman Problem (TSP), and report simulation results. Finally we discuss the salient characteristics-global data structure revision, distributed communication and probabilistic transitions of the AS. In [3] paper introduces the ant colony system (ACS), a distributed algorithm that is applied to the traveling salesman problem (TSP). We study the ACS by running experiments to understand its operation. The results show that the ACS outperforms other nature-inspired algorithms such as simulated annealing and evolutionary computation, and we conclude comparing ACS-3-opt, a version of the ACS augmented with a local search procedure, to some of the best performing algorithms for symmetric and asymmetric TSP's. In [4] this paper we put these algorithms in a common framework by defining the Ant Colony Optimization (ACO) meta-heuristic. A couple of paradigmatic examples of applications of these novel meta-heuristic are given, as well as a brief overview of existing applications. In [5] Based on classical ant algorithm, a method for solving optimization problem with continuous parameters using ant colony algorithm is proposed in this paper. Experimental results in continuous optimization problem show that this method has much higher convergence speed and the disadvantage of classical ant colony algorithm of not being suitable for solving continuous optimization problems is overcome. In [8] authors presents the first rigorous analysis of a simple ACO algorithm called (1 + 1) MMAA (Max-Min ant algorithm) on the TSP. The expected runtime bounds for (1 + 1) MMAA on two TSP instances of complete and non-complete graphs are obtained. The influence of the parameters controlling the relative importance of pheromone trail versus visibility is also analyzed, and their choice is shown to have an impact on the expected runtime. In [12] discuss the Ant Colony Optimization (ACO), which belongs to the group of evolutionary techniques and presents the approach used in the application of ACO to the TSP. We study the impact of some control parameters by implementing this algorithm. The quality of the solution is compared with the optimal solution. In [14] This paper proposes an optimization algorithm to resolve combinatorial optimization problem. Congestion degree in the artificial fish school algorithm is used in ant colony algorithm in this paper. In [15] In this work we study the ACS with heterogeneous ants approach to big dynamic problems. When building solutions ACO algorithms rely in two sources of information static heuristic information about the instance being solved, and dynamic trail information acquired during the execution. In [17] This thesis presents the travelling salesman problem and the application of heuristics in ant colony optimization algorithms. The thesis also discusses the results of an experiment carried out to solve the travelling salesman problem using the ant colony system with different heuristics. An example is focused on heuristics application and comparison.

III. ANT COLONY OPTIMAZATION ALGORITHM

The fundamental principle of ant colony optimization algorithms is the selection of the path to follow when an ant reaches a fork. Inspired by earlier research results, Goss. The basis for the construction of ant colony optimization algorithms based on observation of the natural environment. The key component of these algorithms is the "artificial" ant model. This ant model is used in solving discrete optimization problems. It has a dual nature. On the one hand, as in its real counterpart, it instinctively attempts to find the optimal solution to a given problem. On the other hand, it also possesses certain characteristics which real ants do not. The model results from applying a set of procedures (a swarm of insects) which are used to solve difficult optimization problems and by adding these additional attributes, is able to more quickly find a near optimal solution. Some algorithms use an additional mechanism which has a general knowledge of the environment and which helps ants find the optimal solution in a shorter period of time.

Ant Colony Optimization (ACO) is a model which was first proposed by Marco Dorigo [3], [6]. It features a metaheuristic used to solve combinatorial optimization problems. In ACO metaheuristics, a final set of artificial ants searches for the optimal solution to a given problem. Each ant constructs the solution or any part of the solution. While searching for the optimal solution, the ants save in their memory all choices made so far. They do this to be able to modify the environment at later times and allow other ants to use the knowledge relating to a given solution. Artificial pheromones are the only means of communication between artificial ants.



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IV. TRAVELLING SALESMAN PROBLEM

Ant colony optimization algorithms are widely applied to solve various transportation problems. One of them is the travelling salesman problem in which the goal is to find the shortest (optimal) route, as in the case of ants searching for the shortest possible path from their colony to a source of food [3]. The Travelling Salesman Problem (TSP) is one of combinatorial optimizations which has been thoroughly studied by various researchers. The definition of this term, viewed as a metric problem, was developed by Vazirani [9].

"Given a complete graph and a non-negative cost function on its edges, the goal is to find the cheapest cycle which visits every vertex exactly once".

Given a set of nodes N , which represent cities and set E of edges connecting all nodes. d_{ij} is the length of the edge $(i,j) \in E$ which represents the distance between city i and city j where $i,j \in N$. The TSP refers to finding the shortest Hamiltonian cycle in the graph $G=(N, E)$. The cycle is defined as the set of edges connecting k nodes, not repeated. The Hamiltonian cycle is the cycle which includes all nodes, which in the case of the TSP is cities.

Each ant either randomly selects the initial city is assigned one in advance. At each step, the ant constructs the solution, selecting the next city. The ant moves along the edges connecting consecutive cities. The route is selected probabilistically and it most often depends on the heuristic value and intensity of pheromone on a given edge. Each ant has a memory where it stores the numbers of all cities it has already visited. This is to avoid selecting cities the ant has already visited when choosing the next node to visit. The search ends when the ant has visited all cities. The pheromone trail is then updated on all edges.

V. PROPOSED METHOD

The Ant colony Optimization has three main parts to solve the TSP:

A. Tour Construction

Initially, we start dropping ants on random vertices in our graph. Each ant is evaluating, selecting the best way for his next move to another vertex.

B. Pheromone Update

The updating of residual information after all the ants finishes their each traversing means amount of pheromone a worker lay while traversing the edge [9].

C. Termination Condition

When all the cities are visited and no city is repeated, the circulation will stop and the termination condition is satisfied.

Proposed method use the ACO, which was necessary to project virtual ants. The properties of ACO help virtual ants to scan the graph and find the shortest tour. These virtuals do not continuously, they move in jumps, which means that, after a time unit, they will always be in another graph node. In the next tour, the ant decides on the base of pheromones rates. Just because the property of pheromone evaporation, pheromones on shortest edges are stronger, because of the fact that the ant goes across these edges faster. Based on these facts we can mathematically describe the behaviour of the virtual ants.

Working:

M ants search for a solution and have the following characteristics:

- They select the city which they choose to visit with probability dependent on the distance of a given city and intensity of pheromone.
- They do not select cities they have already visited (as a result, after n steps, each ant will find the correct solution).
- Upon completion of the tour, the ant deposits pheromone on each edge along which it has moved.

Each ant in time t selects the city to visit and stays there for $t+1$ time. Therefore, if the iteration is defined as the movement of m ants taking place in time $(t, t+1)$, then after n iterations (also referred to as cycles) each ant finds the solution to the problem. Pheromone is then updated:



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$$\tau_{ij(t+n)} = \rho \cdot \tau_{ij(t)} + \Delta\tau_{ij}$$

where ρ , is the coefficient presented in the form of $(1-p)$ which may be interpreted as pheromone evaporation between t to $t+n$.

The algorithm uses the visibility (attractiveness) of city j from city i ($\eta_{ij} = 1/d_{ij}$). This value is not modified like pheromone trails which are modified according to equation. The probability with which the ant located in city i selects city j is described by the following formula.

$$P_{in}^k(t) = \frac{[\tau_{ik}(t)]^\alpha \cdot [\eta_{ij}]^\beta}{\sum_{j \in N_k} [\tau_{ik}(t)]^\alpha \cdot [\eta_{ij}]^\beta}$$

where set $N_k = \{N \setminus \text{tab}_k\}$, i.e. the set of the cities which have not yet been visited and $\alpha > 0$ and $\beta > 0$ are parameters which can be used to modify the importance of the pheromone trails and attractiveness of the city, respectively.

The algorithm pattern is as follows:

- In the initial time ($t=0$) the initialization stage takes place - m ants are randomly assigned to cities; the initial value of pheromone is set on each edge $\tau_{ij}(0)$.
 - Each ant moves from city i to city j with probability dependent on:
 - o Pheromone trails - corresponding to the number of ants which have already selected a given edge.
 - o Attractiveness of the city - nearer cities are better than these located further away.
 - After n iterations all ants finish their search for the solution and their list tab_k is full - the route length L_k is then calculated using the list and the values τ_{ij} are updated.
 - The shortest route is saved ($m \times L_k$, $k = 1, 2, \dots, m$) and all lists tab_k are cleared.
- This process is repeated until either the loop counter, defined before starting the program, does not hit the maximum number of cycles or until ants select the same route. In such cases stagnation occurs as ants are no longer able to search for alternative solutions.

VI. ADVANTAGE OF PROPOSED METHOD

Using the ACO for TSP problem it helps to give the positive feedback for the accounts of rapid discovery of the best solution. The distributed computation gives the premature convergence. For the larger problems it give the best results. The greedy heuristics helps to find the acceptable solution in the early stages of the search process. It give the collective iteration of the population of the agents.

VII. CONCLUSION

The goal of this paper presentation was to demonstrate the usefulness of ant colony optimization algorithms applied to solving Travelling Salesman Problem. The high role of proper heuristic was underlined. In this paper we first study the ant system algorithm which is existing system for our proposed work. We overcome the disadvantage of ant system by solving the problem of TSP by using the Ant Colony Optimization Algorithm for large number of cities with good solution and performed it sequential.

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