An Efficient Solution that Integrates Travelling Salesman Problem with Ant Colony Optimization Technique for Warehouse Management and Shipment

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Abstract - With the advent of e-commerce websites and a huge number of products that are introduced to the market on a day to day basis. It is difficult to collect these products and deliver them to the customer on time. Travelling salesman problem along with ant colony optimization can be a solution to solve this problem. A simple model is proposed and the approach has been demonstrated theoretically.

Keywords - Swarm Intelligence, Ant Colony Optimization Technique, Travelling Salesman Problem.

I. INTRODUCTION

Swarm intelligence is a concept of artificial intelligence where there is a demonstration of collective or individual behaviour of social animals. These social animals include ant colonies, bird flocking, fish schooling, bee colonies etc. Natural systems have made it possible to solve many types of problems such as NP-hard decision problems. One such NP-hard decision problem is the Travelling Salesman Problem.

The Hamiltonian cycle is an important concept that is associated with the travelling salesman problem. It is represented as a path in an undirected graph or a directed graph that can visit each vertex only once. This path restricts the traveller to visit every city more than once. Thereby in travelling salesman problem when a list of cities and the distance among the cities have been assigned, the traveller can choose the shortest route with respect to the Hamiltonian cycle. Thereby it is an NP-hard decision problem.

Ant colony optimization algorithm can be solved with the help of the travelling salesman problem. Ants are an important part of biodiversity in nature. Artificial ants are inspired by the collective and collaborative behaviour of real ants. Ant colony optimization is a probabilistic technique used for solving problems in the field of computer science and operational analysis. It can be used for solving many combinational optimization problems. It is also stated as a successful technique in solving computational problems since it reduces the complexity of a given graph thereby finding the shortest path to reach the solution. The Travelling salesman problem, on the other hand, is an example of the combinational optimization problem where it is difficult to find the exact solution for a given set of cities. The collaboration of these two techniques has been proven to give good result in finding the shortest path and thereby these techniques have been implemented in this paper to obtain the desired result.

II. ANT COLONY OPTIMIZATION TECHNIQUE

In ant colony optimization algorithm, a single ant is considered to be a computational agent and is iteratively used to construct the desired solution set for a problem. The solution states are considered to be intermediate solutions. When a transition takes place i.e. when an ant changes from one state to another state it corresponds to give intermediate solutions. Each ant computes a feasible set of solutions from the present state to another state in a given iteration with respect to some given criteria. The criteria is the attractiveness of the move, with the help of heuristic property, the desirable move can be indicated; by this means the trail level of another move will help to indicate how proficient it is to make the present move. The trail levels are updated consistently when all ants complete their respective solution. After the update is done, with the increasing or the decreasing levels of trails the corresponding moves are considered as a good move or bad move. By this means the optimal solution can be found and the shortest path can be obtained. At every iteration, the ant moves from a to b state in order to get solutions for the transition states corresponding to an intermediate solution k which computes a feasible set of Ak(a) expansions of the current state in every iteration and proceeds to one of the probable states.

Problem - Given n number of cities, the aim is to obtain the shortest path travelledto all the cities and visiting every node only once. Let us consider a graph that is complete, $d_{ab}$is theEuclidean distance from the city a to b.

Where

m is the given number of ants.

$\tau_{ab}$is the intensity factor of pheromone on the route (a,b) in time t.

$\eta_{ab}$is the visibility factor based on the heuristic value declared by $1/d_{a.b.}$

$(1-\rho)$ is the evaporation factor where ρ is constant for the process.

$tabu_k$ is the progressively growing vector of the cities that have previously visited by the k^{th} ant.

AntS iteration-every ant provides one city in addition to create the route.

AntS cycle- consists of n iterations, for all ants to finish their routes.
Where AntS indicates the Ant System.

Pheromone Deposition -

$\tau_{ab}(t+n)=\rho.\tau_{ab}(t)+\Delta\tau_{ab}$

$\Delta\tau_{ab}=\sum_k \Delta\tau_{ab}^k$

Q/L_k if k^{th} ant used theedge(a,b).

$\Delta\tau_{ab}^k=$

Otherwise 0.

Where,

$\Delta\tau_{ab}^k$ is the total amount of pheromone that can be deposited on the edge(a,b) by the k^{th} ant within a given time interval (t, t+n).

Q is a constant value.

L_k is the length of the obtained route that is constructed by the k^{th} ant.

ρ, value must be lesser than 1,(recommended is 0.5) otherwise it would accumulate unboundedly.

$\tau_{ab}(0)$ is set to obtain small values that are positive.

Probabilistic Decision Making - It compromises two factors**:**

- The visibility factor prefers closer cities compared to the far away cities.
- The intensity of the pheromone deposited will consider those edges that were frequently used.

A Probability of adding a link in their-j route where $j\in\{N\text{-}tabu_k\}$ into a route is given by,

$[\tau_{ab}(t)]^{\alpha}[\eta_{ab}]^{\beta}$

$\sum_l[\tau_{ab}(t)]^{\alpha}[\eta_{ab}]^{\beta}$

, if value of $j\in\{N\text{-}tabu_k\}P_{ab}^k(t)$

Otherwise 0.

Where,

$l \in \{ N\text{-}tabu_k \}$ and value of α and value of β define the relative importance of the pheromone deposited and the visibility factor.

Algorithm –

1. Initialization:

- When time: t=0
- The number of cycles are: NC=0
- Pheromone is given as:τab(t)=c
- Initial positioning of ants m to n number of cities.

2. Initialization of number tabu lists.

3. Ant's action

- Each ant consecutively builds its route
- Calculates the length of the routes Lk for all ants k ∈ (1,.....m)
- Updates the shortest route that is found
- Calculates the valueΔτabk and update τab(t+n)

4. Increment discrete time value

- t = t+n , NC = NC+1

5. if (NC < NCmaxiumum) then goes to step 2 else stop.

Implementation of ACO with TSP -

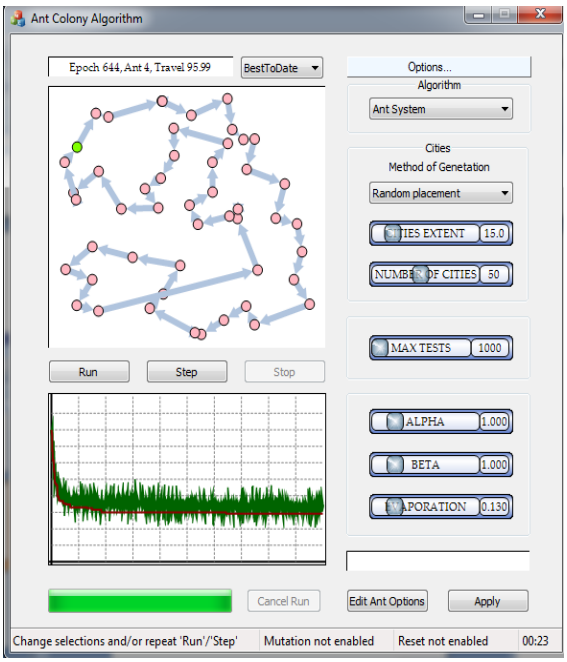

Figure 1:The best to date tour is obtained by Ant4.

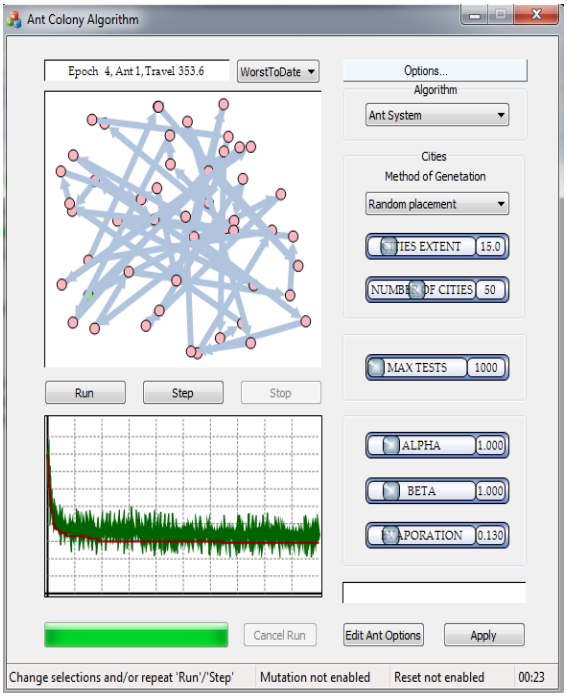

Figure 2:The worst to date tour is obtained by Ant7;

fig 1 and fig 2 cited from"https://www.codeproject.com-Articles-644067""Applying-Ant-Colony-Optimization-Algorithms-to-Solutions".

III. SUGGESTED MODEL

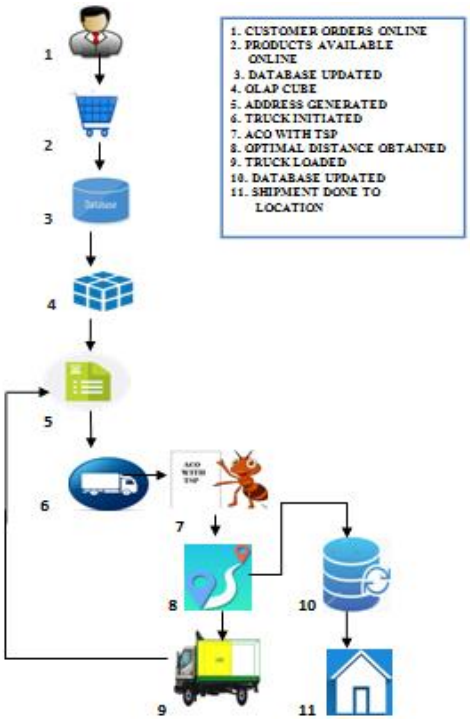

Figure 3: Shipment Workflow

Online shopping has become an important factor in every individual's life. E-commerce has created a path-breaking history where the customer with the help of the web browser can easily buy products from the retailer on the desired website. The process of customer buying products from the user is called the Business to Customer online shopping. The shoppers generally use a search engine in the website to find the desired product, once the customer has decided to buy the product online, the customer gives the concerned details such as email address, mobile number, and address of delivery and completes the payment with either cash on delivery or online payment using a card. Now the details of the customer are stored in a database such as MYSQL or ORACLE.

After which the Analysis of data takes place by the data analyst. Now OLAP (Online Analytical Processing) can be done. It is used for multidimensional analysis of querying in computing. It is an important part of business intelligence that consists of a relational database which can be useful for the process of business reporting for the purpose of sales and management reporting. It is also helpful in analyzing multiple databases such as relational databases, navigational databases and hierarchical databases which reduces the execution time.

Data can have a number of dimensions. In a multidimensional dataset, the cube is shorthand. To make the process more feasible we can use OLAP cube which is a multidimensional array of dataset this can also be called as the hypercube if the dimensions of the cube are greater than 3. Conceptual straightforward operations can facilitate analysis; this can be done by representing data in form of a cube which has hierarchical levels of dimensions. Learning and productivity can be enhanced by visualization of the aligned data. Some of the common operations which are related to the OLAP cube can be performed. These operations are used for the visualization of data that are slice and dice, drill down, pivot and roll up. By using these different operations, a list can be generated.

With respect to the suggested model the user can order the products from an online website, the details of the order are stored in the database, later analysis is done by the data analyst with respect to data such as order date, order id, product type, customer name and customer id which can be retrieved from the database. Later with help of OLAP cube, a list containing the products and the address of the warehouse can be generated. Thereafter, the truck driver can use the ant colony with travelling salesman algorithm to obtain the optimal distance to reach the location of the warehouse, collect the products, load it in the truck and a message is sent to the manager. Now the database administrator updates the database, sends a delivery initiated message to the customer, the customer's address is obtained with respect to the location. A generated list is given to the truck driver where with the help of ant colony with travelling salesman algorithm, the product is shipped to the location of the customer.

IV. CONCLUSION

There are some algorithms like A* algorithm and Dijkstra algorithm which can be used to find the shortest path but this suggested model is useful for collecting the products from the warehouse and thereafter delivering these products to the customer's residence. OLAP cube gives the three-dimensional view of the database which gives additional functionality to the entire model. Thereby this model can be used since time can be saved for delivering the goods and also the cost of hiring many vehicles for delivering the products can be reduced. The complexity of the graph is also reduced since many warehouses are located in different locations across the city. This approach thereby has been theoretically demonstrated and can be practically applied. Since the ant colony optimization technique with the TSP has provided feasible solutions to many real-time problems.

V. FUTURE ENHANCEMENT

This model has been demonstrated with only ant system algorithm along with travelling salesman problem but there are many more ant colony algorithms such as the "Elitist Ant System", "Max-min Ant System", "Ant Colony System" and "Rank-Based Ant System". These algorithms can be associated with the TSP in the suggested model to obtain the optimal solutions and also obtain the desired route to reach the destination.

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