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# A VARIATION OF NEAREST NEIGHBOUR ALGORITHM TO SOLVE SYMMETRIC TRAVELING SALESMAN PROBLEM

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## ABSTRACT

*Travelling salesman problem has been occupying as one of the interesting field of research relating to the real life problem which relates Hamiltonian graph. This is world unsolved problem known as NP-Complete problem. In this paper, application of travelling salesman problem in different fields and a variation of nearest neighbour algorithm has been focussed.*

***Keywords:*** Traveling salesman problem, NP-Complete problem, Nearest neighbour algorithm, Heuristic.

## 1: Introduction

The Travelling Salesman Problem[1][2] is a classical combinatorial optimization problem. This is found as NP-complete problem[3]. It is interesting to note that the travelling-salesman problem, which is closely related to the Hamiltonian of a graph .It states that a salesman must visit all the cities, starting his journey from any one city, visiting all other cities exactly once and finally coming to the starting city with least cost. This problem was proposed by two mathematician, Sir William Rowam Hamilton from Irish and Thomas Penyngton Kirkman from British, in early $18^{th}$ century[4]. But this problem became popular among the scientists of different fields from 1930.

There are several variation in Travelling Salesman Problem like symmetric Traveling Salesman Problem, asymmetric Traveling Salesman Problem and multi Traveling Salesman Problem[4], clustered Traveling Salesman Problem, generalized Traveling Salesman Problem[5]. In symmetric travelling salesman problem, distances from vertex $v_i$ to $v_j$ and $v_j$ to $v_i$ are same where $v_i$ and $v_j$ represent cities. Here the salesman finds the shortest path visiting each city exactly once except the starting city. In asymmetric travelling salesman

problem, distances from vertex $v_i$ to $v_j$ and $v_j$ to $v_i$ are not same where $v_i$ and $v_j$ represent cities. Here also the salesman finds the shortest path visiting each city exactly once except the starting city. In multi travelling salesman problem, there are multiple salesman, all salesman may start and end at the same city or they may start from different city and end at their different starting city. All salesmen will find the least cost path visiting all cities exactly once except the starting city. In clustered travelling salesman problem, cities are partitions into some clusters and if clusters are considered like single city it will become like travelling salesman problem. In this case the salesman find the least cost route visiting each city exactly once except the starting city where cities are contiguous in a particular cluster. Clustered Traveling Salesman Problem is modelled as a directed or undirected complete graph.

There are various methods/heuristics algorithms[19] for solving travelling salesman problem, quite a few of them are shortest path algorithm, the simple insertion algorithm, genetic algorithm, the elastic Net method, the simulated annealing algorithm, ant colony algorithm.

This paper is organised in three sections. In section-1, a simple historical approach of traveling salesman problem has been included. Section-2 includes application found in different areas. Section-3 considers a variation of Nearest Neighbour algorithm.

## 2. Application of Travelling Salesman Problem

In 1975 J. K. Lenstra and A. H. G. Rinnooy Kan pointed out formation of traveling salesman problem in the fields such as computer wiring, vehicle routing, clustering and job shop scheduling [6]. They formulated the travelling salesman problem for those four areas and forwarded some technique to solve the problem.

In 2011, Exnar Fiilip and Machac Otakar mentioned numerous application of travelling salesman problem in logistics like distribution of food products from producers to shops, distribution of fuel to petrol stations, distribution of various products from producers or distributors to customers, visits of doctors at patients' home, orbital inspection walks or checkups starting at a certain point and leading through individual checking points etc.[7].

In addition to this, in 2011, Uros Klansek demonstrated how optimal route scheduling can be done by using the solution of travelling salesman problem[8].

Rajesh Matai, Surya Prakash Singh and Murari Lal Mittal[4] considered different area of travelling salesman problems which are related in Drilling of Printed Circuit Board, Overhauling gas turbine engines, X-Ray crystallography, computer wiring, the order picking

problem in warehouses, vehicle routing, mask plotting in PCB production. They also studied the application of multi-travelling salesman problems in the areas of printing press scheduling problem, school bus routing problem, crew scheduling problem, interview scheduling problem, hot rolling scheduling problem, mission planning problem, design of global navigation satellite system surveying networks. The most important area is Drilling of Printed Circuit Boards which prevails in recent research areas of electronics fields.

Different diameter holes are required in printed circuit board to connect conductor on one layer with a conductor on another layer. Using the drilling machine each time making a hole and then changing the diameter of the drill for two different diameter holes is a time consuming process. Instead of changing the diameter of the drilling machine each time, first one diameter hole for all locations and then changing the diameter for the second diameter hole for all locations can be made. This drilling problem can be viewed as a series of travelling salesman problem, one for each hole diameter, where cities are referred to initial position & set of all holes that can be made with the same drill. The distance between two cities is given by the time it takes to move the drilling head from one position to the other hole. Here travel time for machine head to be reduced[9-10].

Besides ,during gas turbine engines of aircraft overhauling to guarantee a uniform gas flow through the turbines there are nozzles-guide vane assemblies located[11]. Such an assembly consists of number of nozzle guide vans affix about its circumference. All these vans have their own characteristics and placing the vans at correct position substantial benefits like reducing vibration, increasing uniformity of flow and reducing fuel consumption can be achieved. Placing the vans in the best possible way can be modelled as a travelling salesman problem with a special objective function.

The X-Ray crystallography, used for analysing the crystalline structure of materials an X-ray diffractometer is used to obtain information about the crystalline material structure[12-13]. A detector measures the intensity of X-ray reflections of the crystal from various positions. In some experiment thousands of thousands positions have to be realized. Here the problem is in what sequence the different positions are to be considered so that the total positioning time can be reduced. This order of sequencing of positioning can be modelled as a travelling salesman problem.

Again in Computer wiring, the Computer interface consists of a number of modules and on each module several pins are located. The position of each module has been determined in advanced and a given subset of pins has to be interconnected by wires. In view of possible future changes or connection and of small size of pin if maximum two wires are

connected to a pin, connecting all the pins a Hamiltonian circuit can be obtained. Here the problem is to find the minimum Hamiltonian circuits which can lead to a traveling salesman problem.

On the other hand the position of the modules has not been determined in advanced, in this case determining the position of the pins and then connecting the all subset of pins by wires in such a way that it will reduce the wire length will lead to more complex Traveling Salesman Problem.

The order picking problem in warehouses problem which arises in warehouses can be explained as follows: Suppose an order is received to supply some subset of items which are stored in warehouse. Here one vehicle has to collect all the subset of items from different location of the warehouse. This problem can be modelled as a traveling salesman problem considering the different locations as cities and the distances between two locations as length or cost. The aim is to find a shortest path reducing the pickup time for different subset of items.

In Vehicle routing problem, in a town telephone boxes have been installed and a technical crew has to visit each telephone box once or twice a week to empty the coin box and repair the telephone box as on necessary. Here the problem is to minimise the number of days in which all boxes can be emptied and to minimize the total distance travelled.

A similar type of another problem is to empty the postal mail boxes located at different location of a city suppose at one hour interval by trucks. Here the problem is to minimize the number of trucks and to minimize the distanced travelled by each truck.

Both the problems can be constructed as a traveling salesman problem maintaining time constraints as well as number of vehicles [6].

Mask plotting in PCB production, explained that Photographic mask of a printed circuit board is done by a mechanical plotting device. The plotter moves a lens over a photosensitive coated glass plate and the shutter may be opened or closed to expose specific parts of the plate. Different types of apertures are available to generate various structures on the board. Two types of structures have to be considered. A line is exposed on the plate by moving the closed shutter to one endpoint of the line, then opening the shutter and moving it to the other endpoint of the line and then the shutter is closed. A point type structure is generated by moving to the position of that point then opening the shutter just to make a short flash and then closing it again. Modelling of the plotter control problem leads to a problem which is more complicated than traveling salesman problem. A real world application in the actual production environment is reported [9].

Apart from the above Travelling Salesman Problem has many applications such as very large scale integration(VLSI) design [14], rearrangement clustering [15], predicting protein function [16] etc. TSP plays a very important role in the development, testing and demonstration of new optimization techniques.

## 3. Nearest neighbour algorithm

In nearest neighbour algorithm, the salesman starting at any randomly selected city repeatedly visits the nearest city until all cities have been visited [17]. Complexity of this algorithm is $O(N^2 \log_2(N))$, where N is the number of cities to be visited [18]. This algorithm quickly generates a short tour, but not the optimal one usually.

### 3.1 Variation of Symmetric Traveling Salesman Problem

When Traveling salesman problem is modelled as a complete undirected graph and weight of each edge is given, then we can classify the complete graph as follows.

Non-Repeated-Weight-From-Same-Vertex-Complete Graph: In a complete graph if there is no repeated weight from the same vertex, then such a complete graph is called Non-Repeated-Weight-from-same-vertex.

Non-Repeated-Weight-From-Different-Vertex-Complete Graph: In a complete graph if there is no repeated weight from different vertex, then such a complete graph is called Non-Repeated-Weight-from-different-vertex.

Non-Repeated-Weight-Complete Graph: In a complete graph if there is no repeated weight either from the same vertex or from different vertex, then such a complete graph is called Non-Repeated-Weight.

Repeated-Weight-Complete Graph: In a complete graph if there is repeated weight from the same vertex and there is repeated weight from different vertices, then such a complete graph is called Repeated-Weight-Complete Graph.

### 3.2. **A variation of nearest neighbour algorithm**

Instead of randomly selecting a vertex and then applying nearest neighbour algorithm, if we apply nearest neighbour algorithm from each city and in case of repeated edge (i.e. same length between cities), if each repeated path is considered separately then the result of the algorithm will be improved.

### 3.3 Experimental Results:

Example 1: The cost matrix of a graph is as shown in table 1.

**TABLE-1**

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| A | - | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| B | 1 | - | 8 | 9 | 10 | 11 | 12 | 13 |
| C | 2 | 8 | - | 20 | 19 | 18 | 17 | 16 |
| D | 3 | 9 | 20 | - | 21 | 22 | 23 | 24 |
| E | 4 | 10 | 19 | 21 | - | 30 | 25 | 26 |
| F | 5 | 11 | 18 | 22 | 30 | - | 27 | 28 |
| G | 6 | 12 | 17 | 23 | 25 | 27 | - | 31 |
| H | 7 | 13 | 16 | 24 | 26 | 28 | 31 | - |

Applying the algorithm four shortest paths are found as follows –

A→ B→ C → H→ D → E → G → F → A and cost is 127.

B→ A→ C → H→ D → E → G → F → B and cost is 127.

E→ A→ B → C→ H → D → F → G → E and cost is 127.

F→ A→ B → C → H → D → E → G → F and cost is 127.

Example 2: The cost matrix of a graph is as shown in table 2.

**TABLE-2**

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| A | - | 2 | 4 | 8 | 16 | 32 | 64 | 128 | 12 | 24 |
| B | 2 | - | 3 | 6 | 13 | 26 | 52 | 62 | 72 | 82 |
| C | 4 | 3 | - | 1 | 11 | 21 | 31 | 41 | 51 | 61 |
| D | 8 | 6 | 1 | - | 5 | 10 | 15 | 20 | 25 | 30 |
| E | 16 | 13 | 11 | 5 | - | 7 | 14 | 28 | 56 | 17 |
| F | 32 | 26 | 21 | 10 | 7 | - | 18 | 19 | 22 | 23 |
| G | 64 | 52 | 31 | 15 | 14 | 18 | - | 40 | 50 | 60 |
| H | 128 | 62 | 41 | 20 | 28 | 19 | 40 | - | 34 | 17 |
| I | 12 | 72 | 51 | 25 | 56 | 22 | 50 | 34 | - | 19 |
| J | 24 | 82 | 61 | 30 | 17 | 23 | 60 | 17 | 19 | - |

Applying the algorithm the least cost route is

D→ C→ B → A→ I → J → H → F → E → G → D and cost is 109.

### 3.4 Conclusions

This paper only has covered some areas where the application of traveling salesman problem can be used. This problem is not yet solved completely. This works help for researcher in getting more information on it so that they can think new ideas and can develop new methods on it for solution.

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