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A Decision Tree Application for the Development of a Novel Approach to the Traveling Salesman Issue

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Abstract:- The Traveling Salesman Problem (TSP) is a combinatorial problem related to computer science and operations research. There are many methods proposed in the literature to solve TSP with profit and losses. In this classical problem, the objective is to visit a finite number of locations exactly once, one by one, while minimizing the total distance traveled by the connecting links (arcs) needed to reach these sites (nodes). This study presents a new procedure that applies TSP and makes use of the decision tree notion. Anywhere in the TSP network, where n is the total number of places (nodes) in the network, this system ends after n-1 iterations. The method's step-by-step computational criteria make it efficient and readily applicable. To demonstrate the process's validity and efficiency, numerical examples are provided.

Keywords:- *Traveling Salesman Problem (TSP), Minimum Distance Tour, Symmetric TSP, Optimization.*

I. INTRODUCTION

Lot of problems in our daily life can be presented as a network model. Networking is one of the important parts of Operation Research. Minimum spanning tree model is one of the networking models. In this paper, we have worked on TSP using minimum spanning tree model concept The definition of a traveling salesman is a network G, represented as G = (N, L), where N is the set of network nodes and L is the set of network links. The starting position is regarded as the specified node. The salesman must visit each of the N−1 remaining places (nodes) exactly once after starting from the initial location (node) and returning to the designated node while minimizing the connected connection distance. [5-7; 11–13] The network's locations could stand in for nodes, which include, among other things, specific building locations, educational institutions, cities, game parks, mountains, airports, and nations. Roads, railroad tracks, rivers, and water supply connections are all represented by network arcs. There are two types of TSPs: symmetric and non-symmetric.

The TSP is a combinatorial optimization problem. Maximal flow problem (MFP) involves finding a maximal flow among feasible flows in the network. MFP deals with how to design an effective method that helps to calculate the maximal flow that can be sent through the bends of the network from some predefined starting place called the source, to a moment determined designated place called the sink. [1-4] The objective of the MFP is to determine the maximal flow value in any given network.

II. INSPIRATION

There are numerous real-world applications for the challenging combinatorial optimization issue known as the "traveling salesman problem." As tools get better, the TSP has been branching out to create new versions. Numerous methods that have been presented over the past few decades attest to the difficulty of solving the TSP and its modifications. To create hybrid algorithms, it is therefore necessary to continuously creating, altering, and fusing existing algorithms. To solve the TSP, several techniques, like the GA, rely on computer codes. It takes a lot of iterations to compute optimal or nearly optimal tours. This research has been made more difficult by the need to develop simple and clever algorithms that can be used for training as well as for solving the TSP and its variants. Other issues include the need to develop algorithms that can compute alternative optimal tours if the network has one and the requirement to develop algorithms that are not only computer-code-dependent for solving the TSP.

III. MATHEMATICAL MODEL FOR TSP

TSP is a special kind of assignment in which an assign man can visit destined (targeted) locations Mathematically a traveling salesman problem can be stated as follows:

- *Optimize*

$$\sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}x_{ij} \tag{1}$$

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- *Subject to*

$$\left.\begin{array}{l}\sum_{j=1}^{n} x_{ij} = 1, \qquad i = 1,\cdots,n \\ \sum_{i=1}^{n} x_{ij} = 1, \qquad j = 1,\cdots,n \\ x_{ij} = 0 \;\; or \;\; 1, \; i = 1,\cdots,n, \quad j = 1,\cdots,n \\ The\;\; first\;\; and\;\; second\;\; restriction. \end{array}\right\} \tag{2}$$

Where dij is the distance from city i to city j, and xij is to be some positive integer or zero, and the only possible integer is one, so the condition of xij = 0 or 1, is automatically satisfied.

Associated to each traveling salesman problem there is a matrix called distance matrix [dij] where dij is the distance from city i to city j .

IV. PROCEDURE

Consider a set of destinations along with the distance of travel between each pair of them; the traveling salesman problem (TSP) is to find the shortest way of visiting all the destinations and returning to the starting point. The "way of visiting all the destinations" is basically the order in which the assign places (destinations) are visited; the ordering is called a tour or circuit through the assign places (destinations).

This modest-sounding exercise is in fact one of the most powerfully investigated problems in computational mathematics. Its snappy name has unquestionably played a role, but the primary basis for the wide interest is the fact that this easily understood model still eludes a general solution. The simplicity of the TSP, attached with its evident intractability, makes it an ideal platform for developing ideas and techniques to attack computational problems in general. Our primary concern in this paper is to describe a method and computing process that has succeeded in solving a wide range of large-scale instances of the TSP.

On the basis of formation of the distance matrix, the TSPs are classified into two groups—symmetric (STSP) and asymmetric (ATSP). The TSP is symmetric if $d_{ij} = d_{ji}$, for all i, j and asymmetric if not. The TSP is a NP-complete combinatorial optimization problem.

- *Algorithm*

- Step-1: From the given problem construct the distance matrix.
- Step-2: According to the distance matrix create related network.
- Step-3: According to the distance matrix select the minimum distance and the PATH FINDING LOCATION (PFL).
- Step-4: From the rest of the locations select next path by the process min$\{p_{ij}^{d}\}$, i, j = 2,3,⋯n.
- Step-5: Continue this process until connect all the locations.
- Step-6: From the selected locations create a shortest path with concept of Traveling Salesman Problem.

V. NUMERICAL ILLUSTRATIONS

- *Numerical Illustration 1*

We take a look at the 6-node, non-directed network depicted in Figure 1. The home city is node 1, while the intermediate nodes are nodes {2, 3, 4, 5 and 6}.

Table 1 provides the corresponding distance matrix for the network shown in Figure 1.

Table1 Distance Matrix

	1	**2**	**3**	**4**	**5**	**6**
1	∞	11	9	9	15	16
2	11	∞	14	10	10	15
3	9	14	∞	6	13	11
4	9	10	6	∞	9	10
5	15	10	13	9	∞	8
6	16	15	11	10	8	∞

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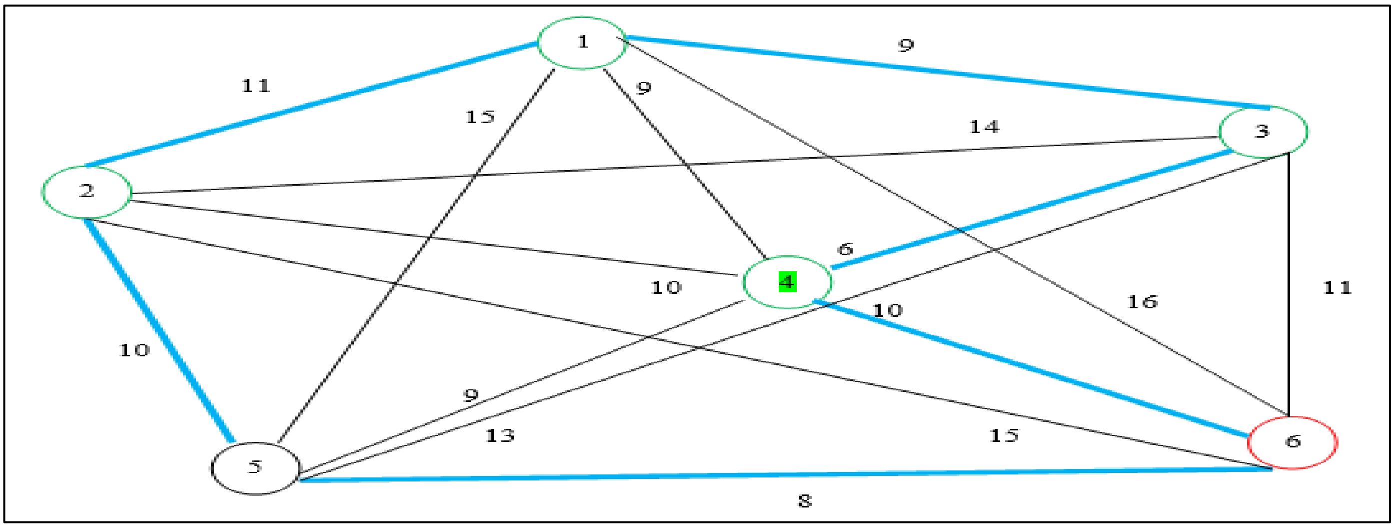

Fig 1 Six-Nodes Network for the Travelling Salesman Problem.

➢ *Algorithm1 A Labeling Method for the Travelling Salesman Problem*

- Step-1: construct distance set.$\{p_{ij}^d\}$= {11,9,9,15,16,14,10, 10,15,6,13,11,9,10,8}. Find minimum distance 6 which is connected from 4 to 3. According to the conception consider node 4 as the initial city.
- Step-2: Remains cites 1,2, 5,6 whose distance set $\{p_{ij}^d\}$= {9,14,10,11}. Find minimum distance 9 which is connected from 3 to 1.
- Find min $\{p_{ij}^d\}$ which is 9 and connected location 3 to 1.
- Step-3: Remains cites 2, 5,6 whose distance set $\{p_{ij}^d\}$= {11,15,16}. Find minimum distance 11 which is connected from 1 to 2. Find min $\{p_{ij}^d\}$ which is 9 and connected location 1 to 2.
- Step-4: Remains cites 5, 6 whose distance set $\{p_{ij}^d\}$= {15, 16}. Find minimum distance 10 which is connected from 2 to 5. After this 5 connected to 6 and 6 connected 4.
- Find min $\{p_{ij}^d\}$ which is 10 and connected location 2 to 5.
- Step-5: According to the connected cites create a link which is considered as a complete tour according to concept of TSP.

➢ *Numerical Illustration 2:*

Issue with Alternative Optimal Tours in TSP Figure 2 shows a network with five nodes, which is used to illustrate how the suggested method can identify an alternate, optimal tour. In Table 2, the appropriate distance matrix is displayed. The home city is regarded as Node 1.

Table 2 Distance Matrix

	1	**2**	**3**	**4**	**5**
1	∞	10	10	7	8
2	10	∞	3	7	12
3	10	3	∞	11	8
4	7	7	11	∞	4
5	8	12	8	4	∞

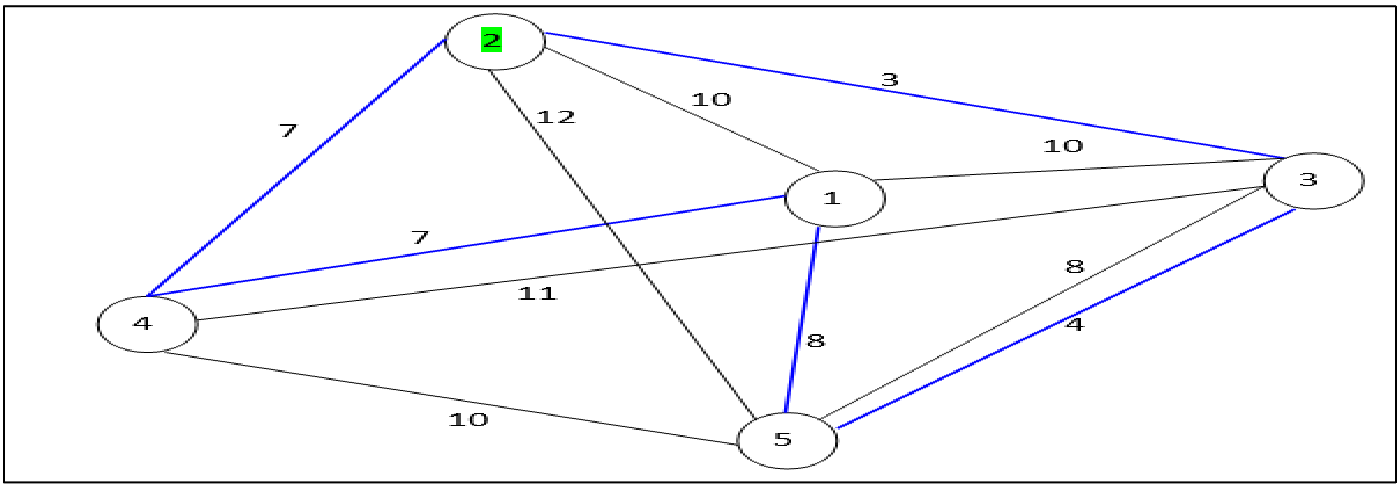

Fig 2 Optimal TSP Tours.

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Optimal tours are given by 1→4→5→3→2→1 or 1→5→4→2→3→1, which give a total distance of 32 units. Figure 2 shows the optimal tours on the network.

- *Merits:*

In this section we analyze the performance of the ALTERNATING ALGORITHM to obtain an shortest tour on concept of TSP and then show that the algorithm performs within the restrictions to gain the optimal result. Here mainly reduce the total distance as well as cost. This is very effective for production industry and traveling sector.

To obtain an upper bound on the length of the Dubins vehicle while executing the ALTERNATING ALGORITHM, we first obtain an upper bound on the optimal point-to-point problem for the Dubins vehicle.

VI. LIMITATIONS

This is very easy process to find out the required tour. It is executed properly for small size of TSP but for large scale TSP needs long duration. If it is possible this concept to converting a computerize programming then it is very effective to find a solution of assign TSP.

- *Economic Impact*

The discovery of a unique method for the Traveling Salesman Problem (TSP) using decision tree applications has important economic consequences. Businesses can save significantly on logistics and transportation by optimizing route planning and lowering travel expenditures. Improved route selection efficiency can result in lower fuel consumption, operating costs, and environmental effects. These developments benefit industries such as shipping, delivery services, and supply chain management by increasing productivity and profitability. Furthermore, a more efficient approach to TSP can boost economic growth by encouraging innovation, opening up new market opportunities, and promoting more sustainable corporate practices.

- *Biological Impact*

The biological impact of applying a decision tree approach to the Traveling Salesman Problem (TSP) can be observed in areas like bioinformatics and ecology. Decision trees can optimize routes for sequencing DNA, reducing the time and computational resources needed. In ecology, efficient route planning can minimize the energy expenditure and environmental disruption caused by fieldwork, such as tracking animal movements or conducting surveys. By improving logistical efficiency, decision tree applications can indirectly contribute to the conservation of biodiversity and natural resources, highlighting the importance of computational methods in biological research and environmental management.

VII. CONCLUSIONS AND FUTURE WORK

In this study, we introduce a labeling method that can be used for the computation of the ideal TSP tour. To find the optimal solution for a given network with K nodes, the approach iterates K−1 times. Given a network with M optimal solutions, the technique can calculate all M optimum solutions after K−1 iterations. The approach is adaptable since it can be used to resolve TSP issues that are symmetric or asymmetric. This strong and straightforward algorithm has a decreasing computational complexity as the number of iterations increases; hence, when the number of iterations approaches K−1, fewer operations are needed for each iteration. We showcased two numerical instances to illustrate the effectiveness of the approach. When compared to the other ways, the method produced better results. The approach is made in a way that makes it suitable for instructional use. Additional research will involve a comparison examination with other approaches now in use and the creation of software for the proposed method to enable computational trials using huge issue instances.

REFERENCES

[1]. Mallick, K.K., Khan, A.R., Ahmed, M.M., Arefin, Md.S. and Uddin, Md.S. (2016) Modified EDMONDSKARP Algorithm to Solve Maximum Flow Problems. Open Journal of Applied Sciences, Vol. 6, pp.131-140

[2]. Khan, Md.A., Rashid, A., Khan, A.R. and Uddin, Md.S. (2013) An Innovative Approach for Solving Maximal-Flow Problems, Journal of Physical Sciences, Vol. 17, pp. 143-154.

[3]. Ahmed, F., Khan, Md.A., Khan, A.R., Ahmed, S.S. and Uddin, Md.S. (2014) An Efficient Algorithm for Finding Maximum Flow in a Network-Flow. Journal of Physical Sciences, Vol. 19, pp. 41-50.

[4]. Akter, D., Uddin, M. S. and Shami F. A. 2021. Modification of EDMONDS –KARP algorithm for solving maximum flow problem, international journal of innovation and applied studies, Vol. 31, No. 4, pp. 703 -711.

[5]. S.Mandal and M.Pal, A sequential algorithm to solve next-to-shortest path problem on circular-arc graphs, Journal of Physical Sciences, 10 (2006) 201- 217.

[6]. M.Bazarra and J.Jarvis, Linear Programming and Network Flows, John Wiley & Sons, 1977.

[7]. J.Edmonds and R.M.Karp, Theoretical improvements in algorithmic efficiency for network flow problems, Journal of the ACM, 19(2) (1972) 248-264.

[8]. L.R.Ford and D.R.Fulkerson, Maximal flow through a network, Canadian Journal of Mathematics, 8 (1956) 399-404.

[9]. D.R.Fulkerson and G.B.Dantzig, Computation of maximum flow in network, Naval Research Logistics Quarterly, 2 (1955) 277-283.

[10]. V.A.Goldberg and R.E.Tarjan, A new approach to the maximum-flow problem, Journal of the ACM, 35(4) (1988) 921-940.

[11]. 11.Jayanth Kumar, T. and Purusotham, S., 2018. The degree constrained kcardinality minimum spanning tree problem: a Lexi-search algorithm. Decision Science Letters, 7(3), pp.301–310.

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[12]. Kumar Amit, Gupta Anil "Assignment And Travelling Salesman Problems With Coefficient As LR Parameters," Int.Journal Of Applied Science And Engineering, Vol.10, No.3, Pp155-170. 2012.

[13]. Z. H. Ahmed, A Sequential Constructive Sampling and Related Approaches to Combinatorial Optimization, Ph.D. thesis, Tezpur University, Assam, India, 2000. 18 Mathematical Problems in Engineering.

[14]. C. P. Ravikumar, "Solving larege-scale travelling salesperson problems on parallel machines,"Microprocessors and Microsystems, vol. 16, no. 3, pp. 149–158, 1992.