Grenze International Journal of Engineering and Technology, June Issue

Route Optimization

Sanket Patil[1], Neeraj Bendkhale[2], Soham Dhore[3], Viraj Gadhave[4] and Sheetal Ahir[5]
[1-4]Student, Department of Computer Engineering, Dr. D.Y. Patil's Ramrao Adik Institute of Technology
[5]Assistant Professor, Department of Computer Engineering, Dr. D.Y. Patil's Ramrao Adik Institute of Technology
Email: {patilsanket8055, neerajbendkhale, sohamdhore3, virajgadhave29}@gmail.com, sheetal.ahir@rait.ac.in

***Abstract*— The majority of businesses deal with the issue of vehicle route optimization on a daily basis. There are numerous locations where deliveries must be completed in a day and within a certain window of time. Thus, time and fuel savings are the companies' top priorities. Therefore, we created an algorithm that would determine the path(s) that the delivery van must take that are the shortest and display them in the form of an image. For an efficient route calculation, this algorithm employs a variety of techniques, including K-means clustering, minimum spanning trees, and the 2-Opt Method.**

***Index Terms*— K- means Clustering, Minimum Spanning Tree, Route Optimization, 2-opt Method**

I. INTRODUCTION

Vehicle Route Optimization is a problem which most of the companies face every day. Many organizations and industries face the challenge of routing their delivery paths. There are many addresses where deliveries have to be made in a day and in a given amount of time. So, the main concern of the companies is to save time as well as fuel. Hence there is a greater need of optimized route.

The process of finding the most resource-effective route is called route optimization. An optimum route would enable the industries to save resources. This would reduce human efforts and eliminate the traditional routing problems [1].

Route Optimization can be done in many different ways taking into consideration of different constraints like capacity constraint, time constraint etc. CVRP is a Vehicle Routing Problem that takes the capacity constraint into consideration [2]. In CVRP, we are provided with a vehicle with limited carrying capacity and it needs to deliver items at various different locations. The main problem here is to deliver the items for minimum cost while never exceeding the vehicle capacity.

Here we have developed an algorithm to solve the Capacitated Vehicle Routing Problem (CVRP). This algorithm uses various Machine Learning techniques to find the best and optimum route. The Machine Learning techniques include K-means Clustering, Minimum Spanning Tree and 2-Opt Method.

At first, we form clusters of different delivery locations that are nearby each other using K-means Clustering. The number of clusters formed are on the basis of vehicle capacity. The number of routes will be equal to the number of clusters formed. The points on the clusters are based on their nearest neighbors.

Minimum Spanning Tree (MST) or Minimum Weight Spanning Tree algorithm is then applied to each cluster. It is a special kind of tree where the weight of route is minimum. For obtaining a minimum spanning tree, several well-known algorithms include Kruskal's algorithm, Prim's algorithm, and Boruvka's algorithm. Here we have used Prim's algorithm as our starting point is fixed.

Grenze ID: 01.GIJET.9.2.93

well-known algorithms include Kruskal's algorithm, Prim's algorithm, and Boruvka's algorithm. Here we have used Prim's algorithm as our starting point is fixed.
We have applied 2-Opt Method on a route that was based on Minimum Spanning Tree. 2-Opt Method uses a special swapping mechanism. The main idea to use 2-Opt Method is to swap the co-ordinates and check for an optimal solution if possible.
Once the optimal solution/route is found, we are displaying it in the form of image using Bing APIs through our web application.
In our algorithm, we have used Geographical Distance for Machine Learning algorithms. Rather actual route distance can be used for the best optimal route.

II. LITERATURE REVIEW

TABLE I. LITERATURE SURVEY OF EXISTING SYSTEM

Sr No	Research Paper Name	Technologies and Methodologies used	Limitations
1	K-Means Clustering and genetic algorithm to solve vehicle routing problem with time windows problem [3].	K-Means method and genetic algorithm are implemented in this research for dealing with the vehicle routing problem using time windows. In order to appropriately cluster data, K-Means is used, and genetic algorithms are used to optimize the root.	Genetic algorithms aim to explore the entire node without returning to previously browsed nodes. They can be quite slow, particularly when compared to other optimization methods [5].
2	Logistics Distribution Route Optimization Based on Genetic Algorithm [4].	The authors utilized a logistic development genetic algorithm, employing a division method to segment the delivery area into genes, and created a practical delivery plan that considers factors such as weight, delivery time, customer value, instrument measurement time, and overall process efficiency. They set weight goals and finds the best way to improve genetic algorithm delivery.	Genetic algorithm can be difficult to optimize and can be time- consuming to run. Additionally, they may not find the global optimum and can be stuck in local optima.

III. PROPOSED WORK

A. Route Optimization

Route optimization refers to the procedure of identifying the route that utilizes resources and costs in the most efficient manner. An optimum route would enable the industries to save resources. This would reduce human efforts and eliminate the traditional routing problems. Route optimization is a more intricate process than just finding the shortest distance between two points. It requires considering all pertinent factors such as the quantity and placement of necessary stops on the route, optimal access to each stop, and the number of turns or intersections on the route.

B. K-means Clustering

The K-Means Clustering algorithm is an unsupervised learning technique utilized in data science and machine learning to address clustering issues. The K-Means Clustering algorithm is iterative in nature, and partitions an unlabeled dataset into k distinct clusters in a manner such that each datapoint is assigned to only one cluster, based on its similar properties. The K-Means Clustering algorithm is based on centroids, where each cluster is linked to a centroid. The primary objective of this technique is to minimize the total distance between data points and their corresponding clusters. The K-Means Clustering algorithm accepts an unlabeled dataset as input, partitions it into k distinct clusters, and iteratively repeats this process until the optimal clustering is achieved. However, the value of k must be predetermined in this technique [6].
The K-Means Clustering algorithm is primarily responsible for performing two tasks:
1.Identifying the optimal number of K centroids or center points via an iterative procedure.
2.Assigning each data point to its nearest K-center, thereby generating clusters consisting of data points that are closest to each respective centroid.
As a result of the clustering process, each cluster will contain data points that exhibit commonalities with each other, while also being distinct from the other clusters.

C. Minimum Spanning Tree

A spanning tree is defined as a sub-graph of an undirected connected graph, which will include all the vertices of the graph with a minimum possible number of edges. If a vertex is missed, then it will not be a spanning tree. Minimum spanning tree has many applications in the design of networks.

In the context of a spanning tree, the cost refers to the total weight of all the edges present in the tree. There can be many different spanning trees. Minimum spanning tree is defined as the spanning tree where the cost is minimum among all the spanning trees. There can be many minimum spanning trees [7].

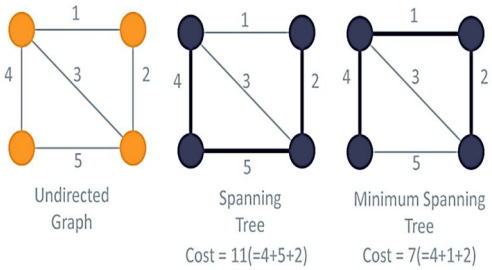

Figure 1. Minimum Spanning Tree

D. Prim's Algorithm

Prim's Algorithm uses Greedy approach to find the minimum spanning tree. In Prim's Algorithm, we always grow the spanning tree from a starting position. Unlike an edge in Kruskal's, we tend to add vertex to the growing spanning tree in Prim's. In Prim's Algorithm, we will start with any arbitrary node and mark it and it does not matter which one we select. In each of the iteration, we will mark a new vertex which is adjacent to the one that we have already marked. As a greedy algorithm, Prim's algorithm selects the cheapest edge and marks the vertex [8].

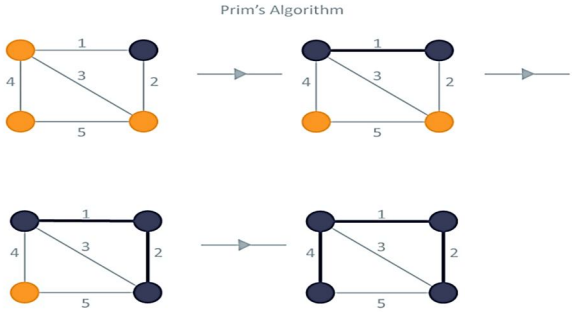

Figure 2. Prim's Algorithm

E. 2-Opt Method

The 2-opt algorithm is defined as a simple local search method with a special swapping mechanism which works as its heuristic. The main idea behind the 2-opt method is considered as to remove path crossing in each neighborhood of cities. The 2-opt can be implemented very easily and is executed fast. The 2-opt method converges fast because it is deterministic in contrary to the SA method. This method is very similar to other heuristic search algorithms but it does not guarantee the finding of the global optimum [9].

For this project we have used Python Django web framework which enables rapid development of secure and maintainable websites. Thus, makes it easier to divide the functions in different apps within the project.

IV. METHODOLOGY

A. Tools and Technology Used

1. HTML: It is used to develop structure of every web page in our website. It is also used to add content and generate links.

2. CSS: Colors, fonts, background and all the styling is done with the help of external CSS. Navigation bars, photos are also added through CSS.
3. Python: It is used as a programming language for developing backend logics.
4. Django: It is a python web framework which we used for developing backend and to link databases.
5. Visual Studio Code: It is used as a coding platform for us. All the group members can edit the code at the same time and work efficiently on VS Code. Also, its Emmet Abbreviations help to code faster and in proper format.
6. PyCharm: It is our coding platform for Python Django.
7. Google Chrome: We have used Google Chrome Developer options when we were styling the web pages. Also, as a web browser it is used to view the website.

B. Synthesis and Flowchart

At first, we will take the input from the user in desire format. And then find the coordinates from the geopy library and finally User has to enter the capacity of the vehicle and the starting point (latitude and longitude).
It will first remove the co-ordinates whose loads are greater than the capacity of the vehicle. Then after it will calculate the number of clusters. Further clustering will be done for two times for doing the best centroid selection. After getting the best centroid the clustering will done in by considering capacity constraint.
Once we get clusters then we run the minimum spanning tree algorithm (Prim's algorithm) on each cluster, and get the minimum spanning tree in each cluster. Minimum spanning tree is further used for finding the route out of it.
After the route is formed from minimum spanning tree, we perform the 2-opt algorithm performing the swapping the co-ordinates and comparing it with previous route, and do the changes in main route accordingly to get beat route. Best route will most optimized route will minimum route distance.
After we have done with the best route optimizer will display it on web-app in form of the static image. It will also display the route distance of each route and total route distance.

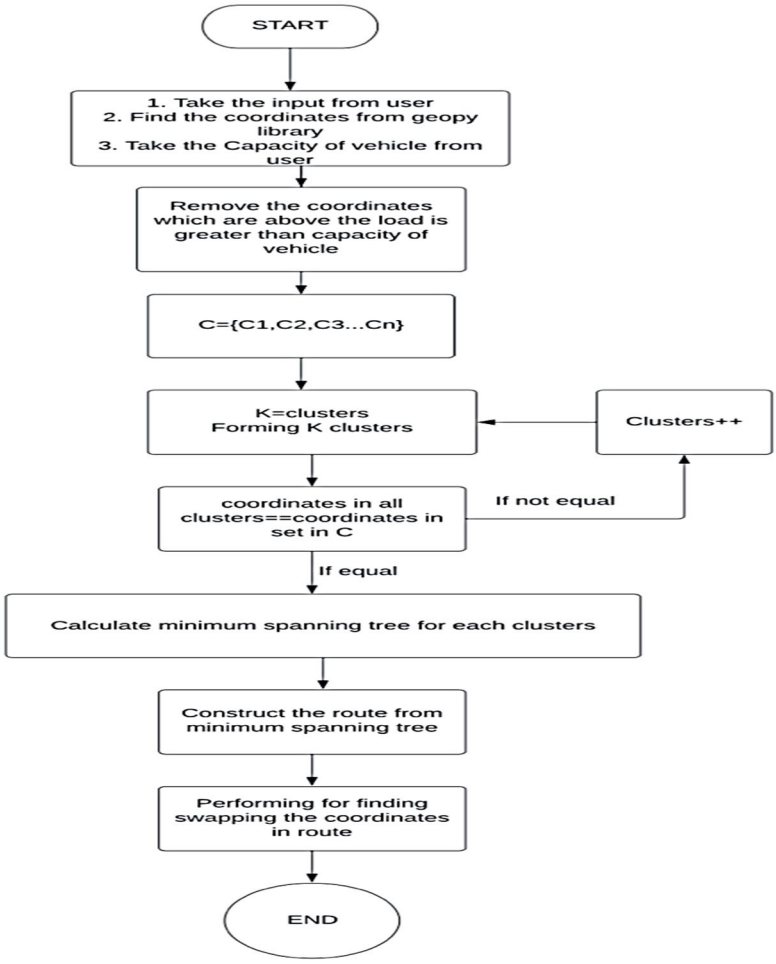

Figure 3. Flowchart of System Design

V. Results And Discussion

Figure 4. Home page of system

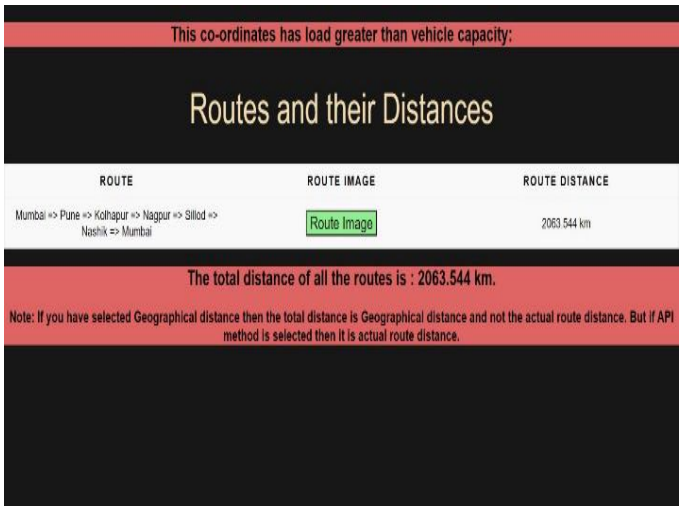

Figure 5. Routes and their distances

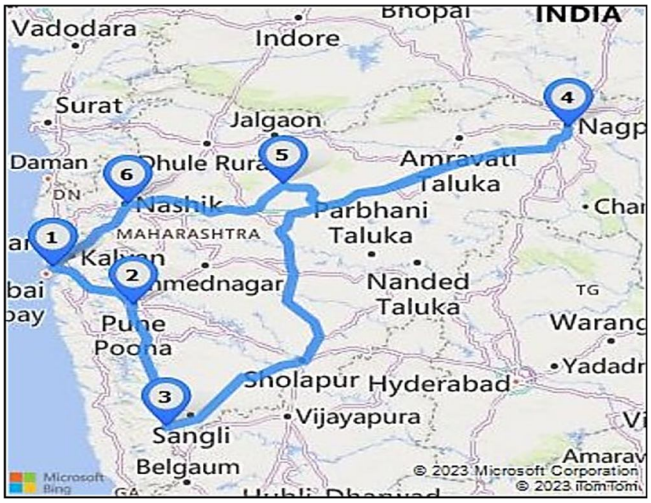

Figure 6. Optimized Routes

VI. Conclusion

Our project has demonstrated the immense potential of route optimization in benefiting businesses and industries. By implementing the proposed Prims algorithm, we have achieved outstanding performance results that surpass those of other methods. The significant reduction in planning time, up to 70%, coupled with cost savings on fuel and driver wages, highlights the practical advantages of route optimization. These findings pave the way for the widespread adoption of our proposed method in real-world applications. We are optimistic that the implementation of the Prims algorithm will bring substantial improvements and efficiencies to various industries, offering a valuable tool for optimizing routes and enhancing overall operational performance.

References

[1] Zafar, Kashif & Baig, Abdul & Bukhari, Nabeel & Halim, Zahid. (2011). Route Planning and Optimization of Route Using Simulated Ant Agent System.. Journal of Circuits, Systems, and Computers. 20. 457-478. 10.1142/S0218126611007396.

[2] Ralphs, Ted & Kopman, L. & Pulleyblank, William & Trotter, L.E.. (2003). On the Capacitated Vehicle Routing Problem. Mathematical Programming. 94. 343-359. 10.1007/s10107-002-0323-0.

[3] Alfiyatin, Adyan & Mahmudy, Wayan & Anggodo, Yusuf Priyo. (2018). K-Means Clustering and Genetic Algorithm to Solve Vehicle Routing Problem with Time Windows Problem. Indonesian Journal of Electrical Engineering and Computer Science. 11. 462. 10.11591/ijeecs.v11.i2.pp462-468. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[4] Xin L, Xu P, Manyi G. Logistics Distribution Route Optimization Based on Genetic Algorithm. Comput Intell Neurosci. 2022;2022:8468438. Published 2022 Jul 6. doi:10.1155/2022/8468438C. Sutcliffe, J. Board: Optimal solution of a vehicle routing problem: Transporting mentally handicapped adults to an adult training centre, Journal of the Operational Research Society 41, 61–67 (1990).

[5] Furqan, Mhd & Sitompul, Opim & Mawengkang, Herman & Siahaan, Andysah Putera Utama & Donni Lesmana Siahaan, Muhammad & Wanayumini, & Nasution, Nazaruddin. (2018). A Review of Prim and Genetic Algorithms in Finding and Determining Routes on Connected Weighted Graphs. International Journal of Civil Engineering and Technology. 9. 1755-1765.

[6] Li, Youguo & Wu, Haiyan. (2012). A Clustering Method Based on K-Means Algorithm. Physics Procedia. 25. 1104-1109. 10.1016/j.phpro.2012.03.206.

[7] Khan, Afsana & Aesha, Afrida & Sarker, Juthi. (2019). A New Algorithmic Approach to Finding Minimum Spanning Tree. 10.1109/CEEICT.2018.8628095.

[8] Kinyua, Charles. (2015). Prims Algorithm and its Application in the Design of University LAN Networks. International Journal of Advance Research in Computer Science and Management Studies. 3. 131.

[9] Karagül, Kenan & Aydemir, Erdal & Tokat, Sezai. (2016). Using 2-Opt based evolution strategy for travelling salesman problem. An International Journal of Optimization and Control: Theories & Applications (IJOCTA). 6. 103-113. 10.11121/ijocta.01.2016.00268.