OPTIMIZATION OF DELIVERY ROUTES FOR LOGISTICS COMPANY

Manik Koli[1] , Kaushal Yadav[2] , Amrit Jangid[3] , Anurag Ojha[4]

Dr. Akhil Pandey[1], Dr. Vishal Shrivastava[2], Dr. Ekta Soni[3] , Dr. Sangeeta Sharma[4]

Professor[1,2], Assistant Professor[3,4]

[1]B.Tech Scholar , [2]B.Tech Scholar , [3]B.Tech Scholar , [4]B.Tech Scholar

Aritificial Intelligence and Data Science

Arya College Of Engineering and I.T. , Kukas , Jaipur (302028)

Abstract:-

With the current age of e-commerce and international trade, logistics firms have the daunting task of optimizing delivery routes to be more efficient, cost-effective, and customer friendly. This paper provides a comprehensive review of route optimization through existing technology such as machine learning, Geographic Information Systems (GIS), and routing algorithms such as Dijkstra, A*, and Vehicle Routing Problem (VRP) solutions. The paper proposes an architecture for optimizing delivery operations by using real-time traffic information, delivery restrictions, and capacity of the vehicles.

Keywords:- Route optimization, logistics, machine learning, VRP, delivery routes, Dijkstra, A*, real-time traffic

Introduction:-

Logistics companies must synchronize complex operations with the transportation of commodities between various locations within time and resource constraints. Route optimization is critical in minimizing traveling time, decreasing fuel consumption, and maintaining delivery schedules. The current paper discusses various optimization methods and presents a solution framework for route planning.

Optimization methods for logistics delivery routes :-

During the previous periods, the research work on VRP largely centered on the heuristic solution, the majority of which were adjusted from the heuristic solution of TSP. There are mainly two follow-on methods:

(1) Two-stage methods In the first stage, the customer first is allocated to the vehicles irrespective of the sequence of the route. The second phase used the heuristic solution of TSP in determining the routes of the vehicles. The two-stage approach of Fisher and Jaikumar (1981) has not used the geometric approach in determining the grouping at the first stage but to transform the problem to the assignment problem to find the solution. The VRP composite route optimization method used in this paper consists of two phases: in phase one, the shortest distance and path between knots are determined using Dijkstra's Algorithm; in phase two, Clarke and Wright's Savings Algorithm is used to optimize the delivery route, based on the theory of joint distribution. Two algorithms' solution steps are presented as follows:

Dijkstra's Algorithm :- Dijkstra's Algorithm was introduced by Dutch computer scientist E. W. Dijkstra in the year 1959. Dijkstra's Algorithm finds the problem of the shortest distance from one source point to other destination points within the directed graph and it is a method that computes the shortest path after the completion of the weighted consideration. Steps for the calculation of Dijkstra's Algorithm are shown as follows:

Step 1: All the knots in the graph are separated into two sets of S and U: "the visited knots set" are placed in S with the initial condition of null set; "the not-yet-visited knots set" are placed in U with the initial condition of all distribution sites set.

Step 2: Renumber the starting point O (usually the logistics center) as a permanent label and move 957 from U to S. Distribute the starting point's P(O)=NULL, the far travelling cost of starting point L(O)=0, assigning i=O; The far travelling cost of other nodal points j: $L(j)=\infty$. Among them, P(i) is the up-stream nodal point of nodal point i and $\Gamma(i)$ is the set of all i.

Step 3: Update all the knots which is temporary marked in Γ(i): L(j)=min[L(j), L(i)+w(i, j)], if L(i)+w(i, j)

2) Route construction methods

In the route construction methods, each two client will be connected till all clients are assigned to one specific vehicle route. There are mainly two solutions: one is to use the savings criterion to combine the existing routes and the other is to use the insertion cost to insert single client into the vehicle route. C-W Savings Algorithm (Clarke and Wright, 1964) is one of the most well-known heuristic solution for solving VRP, which has two types which are parallel and sequential.

ANALYSIS OF LOGISTICS DISTRIBUTION ROUTE OPTIMIZATION

1. LOGISTICS DISTRIBUTION PATH OPTIMIZATION

Logistics distribution path optimization is a challenging task, primarily in order to tackle the problem of path selection of logistics distribution. Generally, the logistics distribution path optimization problem is required to consider vehicles' carriage capacity, bounded time, transportation cost and other limitations. During actual logistics distribution activities, these components' percentage will be other than above-stated. Therefore, the research of the logistics distribution path optimization problem is also divided into many aspects, and the algorithms used are also various. In selecting the algorithm, we must combine the cost constraint such as distribution capacity and time, and completely consider the problems that are encountered in the real distribution, thereby ensuring that the algorithm can get a good distribution route solution [13-14].

(1.1) Logistics distribution route optimization concept

The rapid growth of our national economy also brings about the leapfrog growth of animal logistics industry, especially the rocket growth of e commerce, which has played an outstanding role in promoting the development of logistics industry.

The research on the optimization of logistics distribution has become increasingly pressing [15-16]. However, the current researches primarily address the small trucks or express brothers. In the city transportation system, the optimal path is solved according to the provided algorithm model. The optimal path generally should consider five conditions [17-19]. The first is the mode of transport, which should consider the modes of transport and the cargo carrying capacity by the transport mode. The optimal selection and allocation of transport mode is one key assumption in transport rationalization. The second is the connection of transportation. Where the transportation begins, goods have to be sorted and loaded. When products are in bulk quantity or type, such work will take a considerable operation time and will increase labor and packaging costs. Therefore, the distribution link will be reduced in the distribution, to reduce the cost. The third is transportation time. In the present logistics, transportation time is becoming more important. There are strict time requirements for distribution of a lot of products, such as perishable fresh food, products that must be delivered within a time limit, etc. Not only is distribution time the call of distribution, but also the simple reflection of the distribution ability of logistics companies, and is closely related to customer satisfaction. Reduction of transportation time is of great importance to the development of logistics companies. How to reduce the delivery time is the key point of logistics distribution path optimization. The fourth is the transportation distance. Compared with the above elements, the transportation distance has gradually less and less impact on the optimization of logistics distribution path in the present accelerated traffic situation. However, the increase of transportation distance will also lead to the increase of uncontrollable factors. Now the high rate of traffic accidents and the increase of road obstructions make the risk cost greatly enhance as the transportation distance becomes longer. Therefore, when we optimize logistics distribution path, we also hope to shorten the transportation distance. The fifth one is the cost of transportation, which is the most important of logistics distribution. Naturally, logistics distribution is an economic activity that pursues the maximum benefits. The transportation cost primarily includes human cost and loss cost. Now the human cost is increasing day by day. This problem can be solved effectively by increasing the effectiveness of work by logistics personnel [20-24]. Depending on some constraints, distribution problems can be categorized roughly as follows: traveling salesman problem (TSP), collection and forwarding problem, path optimization with a time constraint, multi vehicle path optimization, path optimization with constraints on loading capacity, path optimization with constraints of compatibility, etc [25-29]. One portion of the literatures is divided into static path optimization problem SVRP and dynamic path optimization problem DVRP on the basis of treatment methods of changes of logistics distribution factors.

Most of the logistics distribution path optimization problems of today's logistics distribution chains might be regarded as the traveling salesman problem and finding starting and terminal points. The continuous and rapid growth of traffic volume leads to complex and dynamic traffic conditions. Therefore, in the distribution logistics path optimization problem, the research on the logistics path optimization problem with dynamic road conditions has very important research significance and application value.

(1.2) Logistics distribution path optimization In modern logistics distribution, goods are shipped directly to customers from distribution centers or stores. Now, the kind of logistics distribution path optimization is: catching departure and arrival points, selecting optimal routes within the urban transportation network, delivering commodities within shortest time and maximizing distribution efficiency. The specific type is illustrated in Figure 1.

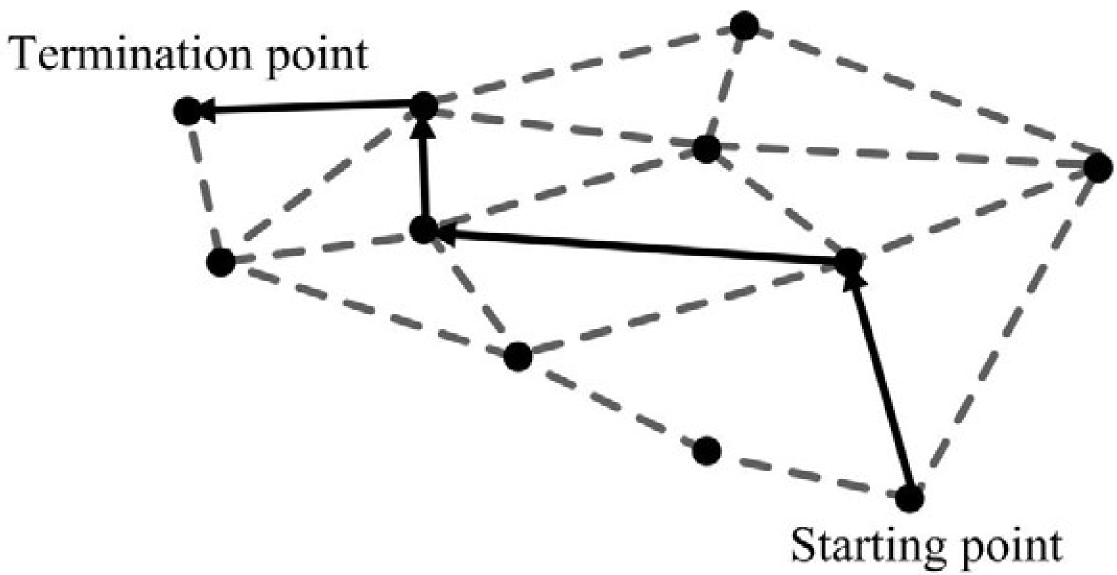

Figure 1 Diagram of starting and ending points of distribution

Distribution vehicles start from the origin, each line is a road section, and nodes are intersections. The optimization is to select the route with the lowest weight value in the urban transportation network to reach the distribution terminal.

2. COMPLEXITY OF LOGISTICS DISTRIBUTION ROUTE OPTIMIZATION

In recent years, there have been tremendous changes in the way, conditions and requirements of logistics distribution in India, such as the intelligent management of new logistics, the evolution of logistics transportation equipment, increased customer demands for logistics distribution standards and more complex traffic conditions.

It also creates new requirements for the algorithm of logistics distribution path optimization.

Classical algorithm only is existing mainly in today's logistics path optimization path distribution path in main: a single mode solution, research about changing path of path optimization is not precise enough, and a path of distribution is unable to adjust flexibly once traffic states have been transformed [30].

(2.1) Complex degree of changing road condition Complexity in road condition will seriously influence traffic on road in most of accidents. For example, accidents, road construction, building infrastructure, abnormal weather, holidays and other events will reduce the capacity of the road or render the road impassable. These events are not taken into account or treated by the classical algorithm.

The process is simple and rough, and the precision of calculation for the influence value on the road condition is very low. In route optimization, congestion and section gradient are taken into account, and the equivalent consumption is transformed to a flat road of a given length, which is optimized by the traditional algorithm [31-33]. There is also a logistics distribution route optimization algorithm through travel time prediction by the historical average method applied to predict the road travel time [34-35]. Processing these algorithms is simple and the complexity of the road conditions is not fully taken care of.

(2.2) Logistics distribution complexity In actual logistics distribution link, distributing driver in distributing process, the principal reference for route selection relies on experience in the past or other colleagues' suggestion, which can deliver goods quickly and efficiently [36]. Or in large logistics companies, provide traffic flow advisory service to drivers through smart logistics software. These measures have had a satisfactory impact while used in real practice, but some problems do exist. Drivers must spend too much time to get familiar with the road in a new distribution area, which severely affects the efficiency of distribution.

And hearing others' experience cannot guarantee the right and timely decision in the complex road. Additionally, it is difficult for the distribution personnel to understand and comprehend the enormous and new information such as the surging logistics business volume and the enlarging service area, the enormous construction of cities and the new planning of road construction. The enormous distribution network of logistics is difficult to memorize.

Literature Review

Traditional solutions to the VRP include traditional heuristic approaches and commercial logistics packages. But none of them have scalability or real-time update capabilities in most of them. Metaheuristic techniques such as Genetic Algorithms (GA), Ant Colony Optimization (ACO), and machine learning-based techniques have produced promising results over the past few years. Our approach is a progression of those with real-time updating and state-of-the-art visualization tool.

Meathodology

1. **Data Collection :-** Data are gathered from GPS-equipped vehicles, past delivery history, traffic APIs (e.g., Google Maps API), and warehouse management systems.
2. **Preprocessing :-**Data is normalized and cleaned to identify unique delivery points, remove anomalies, and normalize formats.

3. **Route Optimization Algorithms**
    - **Dijkstra's Algorithm:** Used to obtain the shortest distance between two nodes.
    - **A Search Algorithm*:** Uses heuristics to improve Dijkstra's algorithm.

- **Vehicle Routing Problem (VRP):** Optimized using Clarke-Wright savings algorithm and metaheuristics like genetic algorithms.

4. **Machine Learning Integration :-** Machine learning models predict delivery time, traffic, and estimate delay. Clustering techniques (e.g., K-means) are used to regionally cluster delivery points.

5. **Implementation Tools** :- Python, PostgreSQL, Flask (web portal), and libraries such as Scikit-learn, NetworkX, and Folium for visualizations.

Results and Discussion

The proposed system was tested with a data set of a mid-sized logistics company. Implementation led to 25% reduction in the total delivery time and 15% reduction in the fuel consumption. The route planning module performed efficiently with real-time traffic information and dynamically adjusted routes.

Conclusion

Route optimization is crucial for maximum logistics performance. By integrating conventional routing algorithms with machine learning and GIS, logistics companies can significantly boost their service efficiency. Future developments include adding drone-based delivery as well as enhancing prediction models through the use of deep learning techniques.

References

1. Dantzig, G.B., & Ramser, J.H. (1959). The truck dispatching problem. Management Science.

2. Bellman, R. (1958). On a routing problem. Quarterly of Applied Mathematics.

3. Google Maps Platform Documentation. https://developers.google.com/maps

4. Mitchell, T. (1997). Machine Learning. McGraw-Hill.

5. Dorigo, M., & Stützle, T. (2004). Ant Colony Optimization. MIT Press.