Research of Method of Regional Route Guidance under Emergencies Based on the Origin-Destination Network

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***Abstract*—When non-early-warning emergencies happen, the main objective of optimal path is the largest number of personnel that evacuated and shortest time required within the incident area. Through the establishment of the origin-destination network model, based on determining the starting and the end of line, make formation of the initial evacuation plan, and generates the evacuation line. Then determine the final route selection through optimized model. Finally, the regional route guidance system in the emergency and evacuation information publishing technology is talked about.**

***Index Terms*—Origin-destination network, route guidance, region, emergencies, weight.**

I. Introduction

When non-early-warning emergencies happen, in order to evacuate personnel trapped to safe areas within the incident area as soon as possible, the choice of the optimal path is taking the route costing shortest time in series of routes created from best evacuation starting point to evacuation transit stations (points) in indirectly affected zone. the main objective of optimal path is the largest number of personnel that evacuated and shortest time required within the incident area. [2]

II. Technical Route

First of all, develop and optimize the pairing of the start and end points of the line, make the planning of the general trend of the line. Because of the main purpose of optimizing the pairing of the start and end points is to determine the direct patronage which is relevant with the direction of the route, so the next step is to optimize the line. Knowing the start and end point of each line, determine the specific direction of each line in order to reach the goal of costing shortest time for passengers.

The overall planning is as following steps:

The first step of the road network is to determine evacuation routes and select the start and end points of routes, and plan evacuation route in the general direction, make the formation of the initial program.

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The second stage: make optimization of evacuation routes of initial program, that is after knowing start and end of each evacuation route in the initial program, determine the specific direction of each line to determine the specific direction of each line in order to reach the goal of costing shortest time for passengers.

III. Generate Origin-Destination Network

A. The Initial Origin-Destination Map

Assume that all routes are connections starting from locations M and end with N which is the destination by vehicle. A point in collection M is in the collection one in N, that is the road up, even if the number of roads between these two points is more than one only counts one line, these two points of the line is composed as a pair of start and end points, the number of lines connected of each point is the number of roads of this point that is intended departure (or arrival).

B. Screening Start and End Points to Get a Feasible Origin-Destination Network

Filtering the routes of start and end points in the figure is based on the existence of the length constraints "non-circuitous route" between the start and end points. The initial origin-destination network being filtered is called a feasible one. Because of the head achievement of evacuation is to get the shortest time for passengers, which need to find one as a straight road. In another words, is looking for a "no-circuitous route".

This route is the a road from the node V_1 to U_1 represented by the sequence of routes, any point of the road is not adjacent with any other points in this road except the pre-order point and the order point of this point, this kind of road called V; For V_1, there exists a "circuitous route" that represented by the sequence of nodes, connecting of the start and end points meets this standard called feasible start and end points.

C. Assignment of Weight

After getting the feasible origin-destination network map, give weighting value to every pair of the start and end points in this network, this weighting value stands for the matching efficiency of the two points weighting value can measure the start and end points on the efficiency of evacuation routes. The overall efficiency of the evacuation line is the shortest time casting and the largest number of passengers being evacuated.

The concrete steps are as follows:

First identify "non-circuitous route" of each pair of start and end points and calculate the direct patronage and

calculate the average direct patronage M_{ij} of each "non-circuitous route", between each pair of start and end points of all circuitous route distance and obtained average distance D_{ij}

Secondly, calculate the weights of each connection according to the formula. $W_{ij} = \frac{M_{ij}}{D_{ij}}$

IV. Determining the Number of The Start Point and End Point

After determining the start and end points of the network model, the next step is optimizing the matching of each pair of points to determine each specific place of departure and destination of the evacuation route under emergencies. The passenger volume of different evacuation routes that can be transported is different, where the optimization goal is the largest number of passengers transported, which is the biggest direct patronage. mathematical programming model of start and end point of the matching problem is:

The objective function：

$$\mathrm{MaxQ} = \sum\sum \mathrm{w_{ij}x_{ij}} \tag{1}$$

Constraints

$$\begin{cases} \sum\sum \mathrm{x_{ij}} = \mathrm{m} \\ \sum \mathrm{F_{ij}} > m \\ 0 < \sum \mathrm{x_{ij}} \le \mathrm{F_i} \end{cases}$$

$$i=1，2，\ldots，n，j=1，2，\ldots，m \tag{2}$$

$$\sum \mathrm{x_{ij}} = 1 \quad \mathrm{x_{ii}} = 0 \text{ or } 1$$

where Q is the overall efficiency of the regional transport network where emergency occurs:

X_{ij} equals 1 means that point i and could be matched, it's a pair of start and end point; equals to 0, which means point i and j cannot be paired;

W_{ij} for the efficiency of the line while point i and j point are matching. Mainly contains information about the total direct patronage;

F_{ij} the max number of routes connected to site i, $i \in I$; n is the number of the place of departure from collection U; m is the number of the place of destination sites from collection V.

V. Model Solution Steps

1) Set the two networks M and N, M is the origin-destination network, the network of the N is empty.
2) Set the initial weighing value for point of each vertex in M network. The right point in the set of vertices of U is $d(u) = \mathrm{F_u}$, and the right of points in V is $d(v)$ = the degree of the point.
3) Have the points which $d(v) = 1$ and its U point and its connected edges (u, v.) joined in network N; delete the edges and v point in network M, $d(u)$ minus 1.
4) In the M network, delete points which $d(u) = 0$ and even the edges connected . Repeat steps 3 and 4 until all $d(v) = 1$ point, and even the edge (u, v) the have been added to the N network. If the set of edges M network is empty set, go to step (6); otherwise go to the next step.
5) After deleting some edges and point, expand the network $M' = (U', Y, ', R', W')$ to a weighing graph. When the absolute value of $U' \neq V'$, each point in the collection U increases F_u-1 points, then we get $\mathrm{U}' = \sum \mathrm{F_u}$. If $\mathrm{F_u} > V'$, points in collection V' increases $F_u - V'$, then $U' \neq V'$. Figure after the addition of new vertices and then add some edge so that a new graph was created, and to make the weight of new edges is 0, getting a weighing graph M'.
6) Solving the edge with biggest right in this graph, connection of this edge can be one pair of solutions, and remove edges that its right may be 0.
7) Join the edges (i, j) that $X_{ij} \neq 0$ into collection N, delete all the others.
8) When the edge set of collection M is the empty set, N is the final obtained by matching start and end point.

VI. Create Intended Route

Using exploratory generation algorithm to generate the initial program of intended route, the specific steps of the algorithm are as follows:

1) Treat starting point as the root node, find all nodes adjacent to the starting point as a second layer of nodes, establish several new lines from the start and the second layer nodes, the second layer of nodes is equal to the number of lines Record the length of each line, and take a line for the current line.
2) Find out all other nodes that adjacent to the last node of the current line to determine whether these nodes adjacent to the other nodes in addition to the last node, if adjacent, delete the node. To determine the remaining number of nodes, if it's zero, it means that the line does not reach the finish point, delete the line and go to ⑤; if not zero, put the remaining arbitrary node into the current line, the other nodes into the new line, and record the length of each line.
3) Check if road length is greater than the maximum allowable road length, if so, than delete the sections and go to 5) less than or equal to the next step.
4) Judge the current section of the last node is the end, if not then go to 2)continue to seek other nodes in the circuit; if so, continue to the next.
5) Determine whether the current line as the last line, if so, then above lines is the request line set; if not, set the next one line as the current line, and determine whether the last node of the current section is the end node. If it is, go to 3), otherwise, go to 2).

Generate initial program of lines

Now we have formed three groups of possible lines, as follows:

First group: set of R_{KH} which contains all possible lines

between start and end point (*KH*):

$$R_{KH} = (r^1_{KH}, r^2_{KH}, \ldots, r^3_{KH}, \ldots, r^1_{KH}) \ ;$$

$$r^5_{KH} = (K \ldots, l \ldots, H)$$

Second group: set of R_{KH} which contains all possible lines between start and end point (*KY*):

$$R_{KY} = (r^1_{KY}, r^2_{KY}, \ldots, r^3_{KY}, \ldots, r^1_{KY}) \ ;$$

$$r^5_{KH} = (K \ldots, \ l \ldots, \ Y)$$

Third group: set of R_{KH} which contains all possible lines between start and end point (*HY*):

$$R_{KY} = (r^1_{HY}, r^2_{HY}, \ldots, r^3_{HY}, \ldots, r^1_{HY}) \ ;$$

$$r^5_{HY} = (H \ldots, \ l \ldots, \ Y)$$

Fourth group: set of R_{KH} which contains all possible lines between start and end point (*BH*):

$$R_{BH} = (r^1_{BH}, r^2_{BH}, \ldots, r^3_{BH}, \ldots, r^1_{BH}) \ ;$$

$$r^5_{BH} = (B \ldots, \ l \ldots, \ H)$$

VII. Model Optimization

For the main objective of the shortest time and largest number of personnel in evacuation from the emergency service area within the region, establish mathematical model:

$$\min T = \sum T_{ij} Q_{ij} / \sum Q_{ij} \qquad (3)$$

where: Q_{ij} refers the amount of vehicle travel from i point to j: *i, j* is any two nodes within the traffic region; the T_{ij} refers travel time, the time it takes the shortest path from *i* to *j*.

A. Constraints

Select a line between each pair from the end points and establish constraints;

The choice of the evacuation line from one pair of start and end point $K_{ij} \leq B_{ij}$ (line overlapping coefficient on this section);

i, j is any two nodes adjacent in traffic areas; the initial K_{ij} value is zero, when *i* and *j* belong to one line, K_{ij} plus 1.

B. Model Solution Steps

According to the actual situation of the emergency road network, the specific model solution steps are as follows:

1) Using "brute-force" method lists each combination program;
2) Delete unconnected programs. "Connected" is determined by if the condition for each node in the graph has a road up to;
3) Check if each program meets the constraints, and delete the program does not satisfy the constraints;
4) At last, get feasible solution both satisfy all constraints and cost the minimum total travel time.

VIII. Regional Emergency Route Guidance System

Route guidance under emergencies is based on real-time dynamic traffic assignment, using the advanced information technology, electronic control technology, data communication technology and computer processing techniques which are combined in regional traffic management system, and establish a full range of real-time, accurate, and efficient regional route guidance system. Through this system, road network conditions information can be provided to the driver of the vehicle, achieve real-time optimal driving path selection and real-time navigation, and can effectively avoid the occurrence of traffic congestion and prevent traffic congestion, reduce length of time stay on the road, evacuate the vehicles from emergency area as soon as possible, and ultimately to achieve a balanced distribution of traffic flow on the section of the network.

The main function of the route guidance system based on emergency is, through analysis of real-time traffic data, to predict the future trend of the traffic conditions, to produce the best real-time traffic control strategies, to mitigate or avoid a large number of evacuation vehicles at the same time to seize the same road resources causing local traffic congestion, ensure the free flow of traffic.

IX. Composition of the Regional Route Guidance System

Regional route guidance system mainly includes traffic information acquisition and processing system, vehicle positioning system, traffic information services system, driving routes optimization system.

A. Traffic Information Acquisition and Processing System

Regional route guidance system is, through capturing real-time data and sending traffic information in a timely manner, guiding traffic flow and reasonable distribution so as to achieve efficient utilization of the road network in an active traffic control. Traffic flow guidance system work properly relies on its accuracy and timeliness of traffic information which relies on traffic information acquisition and processing system.

B. Vehicle Positioning System

Vehicle location subsystem is to determine the exact location of the vehicle in the road network.

C. Traffic Information Services System

Traffic information services system can host computing dynamic traffic information (including the forecast traffic information) in a timely manner sent to the public through a variety of media.

D. Driving Directions Optimize System

Traffic route optimization system is based on the input of the destination and the vehicle positioning system determining the vehicle position in the network and travel, combined with traffic information collection and processing system, give the optimized routes.

X. Route Guidance Information Publishing Technology Based On Traffic Emergency

Route guidance information publishing system is different from the general traffic information and route guidance information publishing system should pay more attention to induce real-time information, efficiency and accuracy in the case of the occurrence of traffic emergencies.

Route guidance information publishing system is divided into two parts; one is released for internal information use by traffic management personnel, mainly through the traffic management network. The other part is for the majority of the traffic participants, providing real-time traffic information to guide vehicle evacuation, vehicles from other sections avoid the incident point, change the opposite direction. There are many means of diverse services for the traffic participants, such as VMS, the Internet, mobile phone text messages, voice inquiries, radio stations and GPS positioning receiver on-board terminals.

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