Study on emergent route guidance strategy on accident occurring section in urban road net

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ABSTRACT

This paper analyses the influence on vehicles after traffic accident happen on urban roads, it is pointed out that accident information is very important to reduce traffic delay and ensure the security of roads. The capacity of the accident point is determined according to the serious degree of the accident. The formula of steady queue is given based on the dynamic law of waiting queue, which is regarded as the gist of circumambulating or not. Dynamic model of travel time on normal roads that share some volume of the road on which accident happened is determined.

KEYWORDS: traffic accident; delay; distribute model; travel time; guidance strategy

1. INTRODUCTION

Traffic demand increases rapidly along with the expanding of cities and the increasing of societal activities. Therefore, traffic jam and accidents happen frequently. Recently, scholars in developed countries use advanced technologies instead of expanding road net to manage modern traffic system (Ritchie, Aldeek). At present, more and more domestic scholars (Zang hua, Shi xiaofa) apply themselves to the study of urban traffic and have achieved some success. In order to improve the emergency dealing capability of traffic managers when traffic accidents happen, route guidance strategy is studied in this paper.

From the latest 1980s', the theory of ITS (Intelligent Transportation System) was put forward, which makes the intelligent traffic management into reality (Martijn, L. Fu). Guiding the traffic flow reasonably after emergency accidents is one of the important parts of ITS. Capacity on the section on which traffic accidents happen reduces after accidents happen. When the traffic demand on the road exceeds the remainder capacity, vehicles queue up upriver the accident point. Travel time increases and some travelers change their route. Route guidance system based on normal situation is not applicable. Capacity of the accident point should be determined based on the analysis of the accident. Optimization route should be selected again.

In the condition of ample information, ATIS (Advanced Traffic Information System) provides real-time traffic information to travelers. The information includes the position and time of the accident, the serious degree and the disposal of the accident. Travelers decide their travel route according to the information achieved and the circumambulate route recommended by the guidance system. Therefore, traffic information helps to lighten the traffic jam by redistributing the traffic flow upriver the accident point.

2. TRAFFIC DISTRIBUTING MODEL WHEN ACCIDENTS HAPPEN

The influence of traffic accident is related to the factors such as the type of the accident, the occurring time, the serious degree, the traffic control and the information distribution. If there is no guidance information, vehicles which are going into the section will run in the vested route. Traffic demand is the same as the formal situation. While the capacity of the accident section is decreased, vehicles wait upriver the accident point and will produce delay. In the condition of ample information, traffic managers estimate the temporary capacity of the section according to the serious degree of the accident. Corresponding guidance strategy will be determined to decrease the delay.

Suppose at time t_0 an accident happen at point *C* on road section l_0. Comparing with the length of the road, the length occupied by the accident is short. The location of the accident can be looked up as a point. Suppose the distance between the point of the accident *C* and the origin of the road *A* is S_1, and the distance between the point of the accident *C* and the destination of the road *B* is S_2. Natural traffic volume of road section l_0 is $\lambda(t)$. The capacity of the accident point is u_0. The capacity and travel time of other circuitous routes are u_k and t_k. All the above is shown in figure 1.

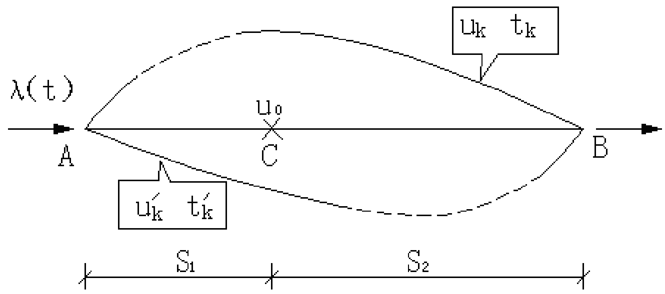

Figure 1.Sketch map of the accident

Traffic managers get the information about the accident through ATIS (Advanced Traffic Information System). The capacity of the accident point u_0 is determined according to the serious degree of the accident. When the accident is very serious, $u_0 = 0$, therefore the point of the accident should be closed. At this time, in order to avoid traffic jam on the road, all the traffic volume running into the section l_0 should select other route. When the accident is not very serious, the capacity of the accident point is observably reduced comparing with normal situation. At this time, traffic managers determine the capacity of the accident point u_0, calculate the delay time and comparing the time with the circuitous time, thus to determine whether the vehicles need to circumambulate other routine. There are two situations as below.

Situation 1: $u_0 = 0$

When the accident is very serious, the road should be shut. At this time, the traffic volume need to circumambulate is shown as formula (1).

$$\lambda_r = \lambda(t) \qquad (1)$$

Where λ_r is the volume need to circumambulate, and $\lambda(t)$ is the normal volume of the road.

Situation 2: $u_0 \neq 0$

When $u_0 \neq 0$ there remains some capacity on the road. Traffic managers estimate the capacity at the accident point u_0 according to the area occupied by the accident. The serious is the accident, the lower is u_0.

Some time is needed to estimate traffic parameters and select the optimized route after accident happen. The information of the accident is sent off by ATIS. Suppose traffic managers send accident information by ATIS at time t_1.Before the time t_1, travelers are unaware of the accident and the information. The traffic volume on road l_0 is the normal volume when there is no accident, which is represented as λ_0. Therefore, the number of waiting vehicles upriver the accident point at time t_1 is shown as formula (2).

$$L_q(t_1) = (t_1 - t_0)(\lambda_0 - \mu_0) \qquad (2)$$

Where $L_q(t_1)$ is the number of vehicles of the queue upriver the accident point at time t_1, λ_0 is the normal volume on the road, and $t_1 - t_0$ is the lag between the time accident happen and the time when the traffic information is sent off.

At time t_1, travelers get the accident information on road l_0, and travelers who were going into the road reselect their travel route according to the accident information. When the queue is long, more travelers will change their travel route, therefore the number of vehicles upriver the accident decreases and the waiting queue gets short. When the queue is short, a few travelers change their travel route, the number of vehicles upriver the accident point increases and the waiting queue gets long. This is a dynamic course and at last the waiting queue will reach a steady number M .

Steady queue length is determined by the forecasting of traffic delay. If the travelers change the travel route and circumambulate the accident point, the whole travel time is surely prolonged. Suppose the circumambulating time is t_r. If the travelers wait to go through road l_0, the travel time of the road will increase because of the accident delay. Suppose the time of waiting to go through road l_0 is t_d. When $t_r < t_d$, travelers will change their route, and when $t_r > t_d$, travelers will wait to go through road l_0. Because different travelers have different destination, their circumambulating route are not the same. Different travelers have different circumambulating time t_r. In this paper, t_r is the average value of all the possible circumambulating routes. Steady number of the vehicles of the queue is get when the circumambulating time equals the waiting time. Therefore the anticipant value of the number of steady queue is shown in formula (3).

$$M = t_r(\lambda_0 - u_0) \qquad (3)$$

Comparing $L_q(t_1)$ with M, there are two situations.

(1) If $L_q(t_1) > M$,the number of waiting vehicles exceeds the anticipant value of the length of steady queue *M*, the total traffic volume upriver the accident should be redistributed and guided to circumambulate. From time t_1, traffic volume going into road l_0 is zero. The capacity at the accident point is u_0. Therefore the vehicles delayed upriver the accident point will be cleared off until the length of the queue reaches the steady length *M*. Suppose at time t_2 the queue is steady, and the length of queue at any time between t_1 and t_2 is shown as follows.

$$L_q(t) = L_q(t_1) - \mu_0(t - t_1) \quad (4)$$

According to formula (4), the time the queue reaches the steady length can be got.

$$t_2 = \frac{L_q(t_1) - M}{u_0} + t_1 \quad (5)$$

Since time t_2, traffic volume equals u_0 is acceptable to go into road l_0. At this time, traffic volume should be redistributed upriver the accident point is $\lambda_0 - u_0$. Suppose at time t_3 the accident is cleared, the traffic volume that is permitted to go into road l_0 can get back to the normal volume.

From the analysis above, when $L_q(t_1) > M$, the traffic volume that should change the travel route upriver the accident point, in other words, the volume needs to be redistributed at different periods t_0 t_2, t_2 t_3 and after t_3 are λ_0, $\lambda_0 - u_0$ and 0.

(2) If $L_q(t_1) < M$, the number of waiting vehicles doesn't reach the anticipant value of the length of steady queue *M*, at this time. Waiting upriver the accident will be efficient comparing with circumambulating. At this time, no vehicles need to circumambulate. All the traffic volume of normal condition should be permitted to go into road l_0. Suppose at time t_2 the queue is steady, and the length of queue at any time between t_1 and t_2 is as follows.

$$t_2 = \frac{M}{\lambda_0 - u_0} + t_0 \quad (6)$$

Since time t_2, traffic volume equals u_0 is acceptable to go into road l_0. The remained volume λ_0-u_0 should be redistributed upriver the accident point. Suppose at time t_3 the accident is cleared, the traffic volume that is going into road l_0 can get back to the normal volume.

From the analysis above, when $L_q(t_1) < M$, the traffic volume that should change the travel route upriver the accident point, in other words, the volume needs to be redistributed at different periods t_0 t_2, t_2 t_3 and after t_3 are 0, $\lambda_0 - u_0$ and 0.

3. AMEND OF THE TRAVEL TIME AFTER THE REDISTRIBUTION OF TRAFFIC VOLUME

The travel time of the road is related to the factors such as traffic density, the capacity, length of the road, signal control and the interaction of vehicles. After accident happening, traffic volume is redistributed upriver the accident point, and only traffic volume of all the factors is changed, the other factors are as the same as the normal situation.

The total travel time of a road is composed of three parts, which are the driving time of the road $T_k^{(r)}$, the waiting time at the downriver cross $T_k^{(q)}$ and the time going through the cross $T_k^{(c)}$. The formulas are as follows.

$$T_k = \theta_k^{(t)} L_k / (Q_k^{(t)} L_e) \quad 7$$

$$T_k^q = 1/(g_k^{(t)} C_k - Q_k^{(t)}) \quad 8$$

$$T_k^{(c)} = 1/ g_k^{(t)} C_k \quad 9$$

$$T_k = T_k^{(r)} + T_k^{(q)} + T_k^{(c)} \quad 10$$

Where T_k is the total travel time on road *k*. $\theta_k^{(t)}$ is the occupy rate of time on road *k* during time period *t*, L_k is the length of the road *k*, $Q_k^{(t)}$ is the traffic volume of road *k* after volume redistribution, L_e is a constant, $g_k^{(t)}$ is the green rate of the downriver cross of road *k*, and C_k is the capacity of the cross.

Travel time of every road after accident happen can be calculated according to the formulas above. Traffic managers suggest new travel route according to the dynamic travel time of the roads. When the accident is eliminated, the capacity of the road get right, and at this time the travel time of the road should be calculated by the normal traffic volume.

4. CONCLUSIONS

Not only the travel time of the road on which accident happen increases but also the travel time of other roads upriver the accident point increases because of sharing the traffic volume of the accident road. Distributing the traffic volume waiting upriver the accident point and the volume going into the accident road in time is an efficient method to decrease traffic delay. The dynamic situation of traffic volume on accident road is studied in this paper. Traffic volume needs to circumambulate is determined in different period of time and the model of travel time of the road after redistributing the volume is given. How to balance the utility of each traveler and the utility of the whole traffic system needs to be studied in the future.

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