Research on the cooperation method of traffic control and route guidance of local area network

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***Abstract*—The city traffic control system and traffic guidance system are two important subsystems of Intelligent Transportation Systems, also main means of the city traffic management. This paper studies the method of control and guidance system coordination for a specific local area, usually 2-6 signalized intersections, places a detailed analysis from the signal phase changes, guidance information display and other aspects of information to ensure the practical feasibility of the method. This paper presents a systematic approach to ensure interoperability in a variety of state regional road traffic running smoothly and orderly, reduce the incidence of congestion, to avoid further deterioration of the congestion, improving the efficiency of the vehicle access to and pass through the region.**

Keywords-traffic control; traffic guidance; collaborative strategies; guidance follow rate; alternative path

I. INTRODUCTION

The city traffic control system and traffic guidance system are two important subsystems of Intelligent Transportation Systems. Traffic control and traffic guidance were focused on the aspects of time and space for the traffic flow management. The characteristics of urban traffic flow that can not be separated in time and space requires traffic control must be coordinated with the guidance, in order to achieve good management results; Moreover, with the increasing urban traffic congestion and complexity, isolated traffic control and traffic guidance is difficult to deal with the problems of urban transport, resulting in a problem of coordination of control and guidance [1].

At present most of the control and guidance coordination systems are for the regional road network for the large-scale, from a macro point of view. This will ensure optimal traffic throughout the road network, but can not guarantee that each section of road or region is smooth, in particular, can not guarantee that some of the important sections or areas of smooth, such as the city CBD, government and other surrounding areas. This paper studies the method of control and guidance system coordination focused on this phenomenon for a specific local area, usually 2-6 signalized intersections, places a detailed analysis from the signal phase changes, guidance information display and other aspects of information to ensure the practical feasibility of the method.

II. COORDINATION LOGIC

In this paper, the coordination logic of the regional traffic control and guidance as shown below :

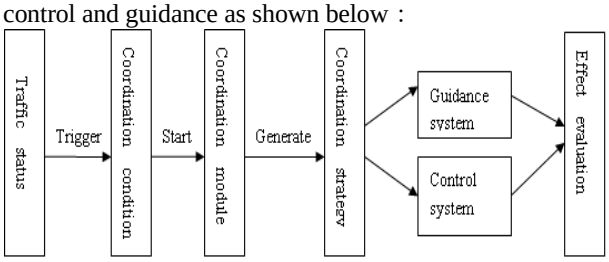

Figure 1. The coordination logic of the regional traffic control and guidance

Prerequisites: set detector at the exit position of guidance screen upstream to detect the road traffic flow; to obtain accurate or more accurate traffic status information, including sections of the average travel time, road traffic entrances and exits traffic flow, the average travel speed; only target area of coordinate area occurs serious congestion, traffic through the other sections have a certain margin; not consider the influence of the guidance road state when guided traffic flow entered it, in other words, the impedance of the alternative path is constant when the coordinate strategy is implementing.

Realizing method: the area status information displayed as pictures released by guide screen, including road congestion, accident information, alternative path through the green arrow in the form of presentation-oriented, in addition, to supporting text in releasing event information, guidance path information and the corresponding changes of guide signal control strategy; the control system is based on the guide demand to increase the green light release time for the guide path direction, while reducing the green light time of entering the crowded area, if the traffic status of the guide path is smooth, it can use coordinate control.

Urban traffic flow system is a complex and time-varying systems, traffic flow in the system can be observed in the state of existing vehicles, according to the characteristics of traffic flow and road congestion, traffic flow can be divided into different states. Our state is divided the traffic flow into four different states: smooth, slight congestion, congestion and blocked. Vehicle guidance systems and road traffic control systems have different functions for road traffic

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network flow in different traffic road network, so should choose a different coordination strategy for different traffic state.

A. Coordination strategy for traffic state of smooth

At night and off-peak traffic flow is small, the traffic demand is less than the traffic capacity, the interaction between vehicles can be ignored, the speed of movement of each vehicle are desired, smooth road in the state, we believe that for the smooth state of the main road the average speed should not less than 30km/h. In the state of smooth, although the management of the road has reached the target, but still need to manage and control traffic flow. The most important task this time is to determine the status of the road traffic and the status changes based on the detector to detect the traffic flow parameters. Once detected abnormal traffic state of road, immediately take the appropriate measures to prevent the deterioration of traffic state. At this time traffic volume is very small, the effect of traffic management has been very good. Coordination goal should be to minimize costs. Therefore, coordination should be used stand-alone, with only for information and basic data sharing, not for strategic interaction. This can greatly simplify the complexity of the two systems, improve processing speed and computing time, with minimal cost to obtain the best result [2] .

B. Coordination strategy for traffic state of slight congestion

As traffic demand increases, the free flow of road traffic flow became chaotic, longer time to reach the destination, the traffic state change from smooth into slight congestion, average speed of main road is 20 ~ 30km/h. At the state of slight congestion, control and guidance synergistic effect plays a vital role. If the coordination effect is good, even the flow increases, can also ensure the smooth flow of road traffic; if the coordination effect is not good, with the increase in traffic, the road will soon be in a crowded state. Therefore, the goal under slightly congestion is to evacuate traffic as soon as possible, avoid the occurrence of the state of congestion, to ensure the balanced distribution of the traffic flow of the road network. Slight congestion state is the best time for coordination to realizing functions, the coordination effect of this state directly affected the state of the entire road traffic network [2] .

C. Coordination strategy for traffic state of congestion

If the coordination of the traffic flow is not well managed at the state of slight congestion, traffic flow will inevitably enter the state of congestion. Traffic congestion is a phenomenon that the road traffic demand exceeds capacity and the excess traffic stay on the road formatted a waiting queue. When congestion occurs, average speed pass through of the main road is 10 ~ 20km/h. When the congestion occurs, the main task of traffic management is to solve the traffic congestion in the shortest time. So the goal for coordination at this status is to evacuate occurred congestion, and guide other vehicles to avoid the congestion bottleneck areas, to ensure the total vehicle travel time is minimum time. At this status, the coordination model should more counted on guidance [2].

D. Coordination strategy for traffic state of congestion

The congestion that talking about here is for a coordinate sub-block area, or for the entire road network in all the roads are crowded, this situation rarely occurs. If often happens, that shows the city's road infrastructure is inadequate. The regional road network in the case of blocking, because the entire area has been in nearly saturated or supersaturated state, in this case that only relying on regional traffic control system is unable to alleviate traffic congestion. At this status need to hand the control to the traffic signal control system - a wide range of strategic traffic control system, from a wide range of strategic traffic control system from the larger context of comprehensive coordination of traffic flow and control [2] .

III. The Key Parameter Calculation

Coordination module that is, when the traffic status developed to a certain degree and trigger conditions of coordination by co-start coordination module; Coordination module by detecting the current state of the regional traffic signal control and regional traffic flow parameters, calculate the dynamic OD demand and guidance demand and if congestion drift does not occur is sure, then calculate the congested roads or regional alternative paths to develop guidance release program while the program signal control system with guidance program changes in signal phase turn on time. In other words, it is generate control and guidance coordination strategies to achieve scattered crowded flow, balance traffic distribution, reduce the regional average travel time for the purpose. Coordination module process is shown in Figure 2.

A. Trigger conditions

In this paper, the status index as a coordination module trigger conditions, different traffic status index threshold trigger traffic coordination of different strategies.

Definition: Road traffic status index $s_{ij}(t_k, t_{k+1})$ (road traffic impedance coefficient $r_{ij}(t_k, t_{k+1})$) for collecting a certain road area l_{ij} at the k data sample collecting period $[t_k, t_{k+1}]$ the average travel time of unit length on the road.

$$s_{ij}(t_k, t_{k+1}) = r_{ij}(t_k, t_{k+1}) = \frac{T_{ij}(t_k, t_{k+1})}{d_{ij}} = \frac{1}{v_{ij}(t_k, t_{k+1})}$$

Road traffic status index took two sections of physical quantities into account: the travel time and the length, and the travel time can be calculated into the average road speed, at the actual traffic state identification and forecasting has important practical significance.

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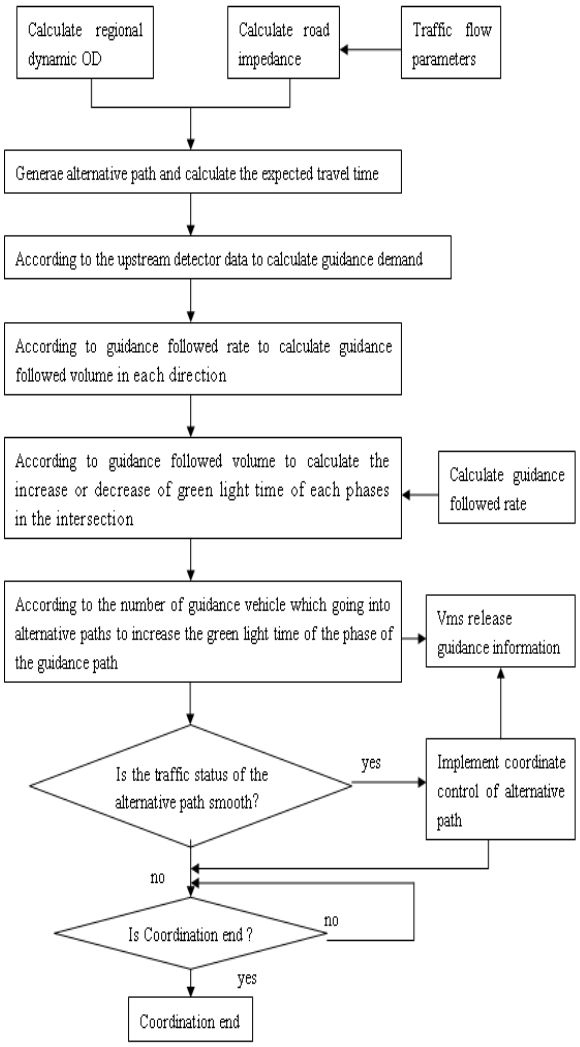

Figure 2. Coordination module process flow chart

B. *Road impedance*

Traffic manager's information guidance and drivers' path choose are influenced by variety of interrelated and mutually constraining factors, is a complex system problems. Impedance on the section contains a number of content or quality of service: travel time, safety, and comfort and other travel expenses, in order to ensure the important sections of the region's traffic efficiency, this paper mainly consider the travel time and travel safety issues in order to achieve rapid and safe enter or through the local area [3].

At any time t, the definition section of the flow impedance of the vehicle at time t is the time required to pass the sections, it was related to the status of traffic on the sections[4]. In paper, the instantaneous impedance of this road set as $c_a[x_a(t),u_a(t),v_a(t)]$, can be abbreviated as $c_a(t)$. Among them, $x_a(t)$ represent the traffic volume on road a at time t; $u_a(t)$ represent the enter flow rate on road a at time t; $v_a(t)$ represent the outflow rate on road a at time t.

For a set of path {..., p, ...} between the decision node l to the end s, at any time t, the path instantaneous impedance on path p is defined as the instantaneous impedance change at time t on all sections of the path instantaneous impedance, so the instantaneous impedance of path p is:

$$\psi_p^{ls}(t) = \sum_{a \in p^{ls}} c_a[x_a(t),u_a(t),v_a(t)] \qquad \forall l,s,p$$

Among them, p^{ls} is a path that from the decision node l to the end s.

C. *Guidance followed rate*

Real-time dynamic traffic assignment is based on traffic information detection in traffic flow to rearrange the traffic flow. It need consider the influence of traffic participants - the driver under the influence of traffic information in the driving behavior to achieve the goal of traffic flow rearrangement. Guidance followed rate is subject to the network that can be guided by the proportion of vehicles followed the guidance, it is a critical factor for the traffic guidance systems and traffic signal control systems connection [5] .

The VMS influence factor on the road represented as:

$$Q_{ij}^{\ k}(D) = \sum_{m=1}^{k} \sqrt[3]{(\frac{1}{1+D_i})^2}$$

Among them: $Q_{ij}^{k}(D)$ —is the VMS factor of road ij, I and j represent the number of intersection of the two ends of said section;

k —— if have k times VMS within the region, its impact factor overlay.

The guidance followed rate $F_{ij}(t)$ on the road can be subject to the following formula:

$$F_{ij}^{k}(t)=(1-f_d)\times S_{ij}\times Q_{ij}^{k}(D)\times f_a\times f_b\times f_c=(1-f_d)S_{ij}f_af_bf_c\sum_{m=1}^{k}\sqrt[3]{(\frac{1}{1+D_i})^2}$$

Among them : $F_{ij}(t)$ — during the time of t the guidance followed rate on road ij, t use the same time period with regional traffic signal control system .

f_a — Influence factor of the guidance area location ;

f_b —Influence factor of the guidance information release time;

f_c — Influence factor of the natural of the released guidance information;

f_d — The rate of not follow the guidance.

In practice, the above formula f_a, f_b, f_c, f_d and other parameters need to be in accordance with the findings of field observations and calibration.

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D. Phase time of the signal adjust method

When the traffic status trigger the coordination conditions, the system according to the traffic status decide coordination strategy, automatically generated guidance information, and the phase of the signal of the guidance path be adjusted accordingly.

Assume that at time t the guided enter volume of the path is the amount of q, and these vehicles need to turn left, the fleet average speed is v, length of this section is l, that is, at the time of $t + l / v$ the increased number of vehicles need to turn left is the amount of q, at this time, the phase time of turn left need to be adjusted, adjust method as follows:

Keep the original signal change time, compress the green light time of the phases which have conflict with this one and increase the green light time of the phase of the guidance path. The specific time change is:

$$\Delta t = \frac{t_0}{s_0} \cdot q$$

Among them, t_0 is the original phase time; s_0 is the saturation throughput of this direction at the time of t_0.

IV. CONCLUSION

With increasing urban traffic congestion and increased traffic complexity, isolated traffic control and traffic guidance is difficult to deal with urban transport problems. This paper presents a systematic approach to ensure interoperability in a variety of state regional road traffic running smoothly and orderly, reduce the incidence of congestion, to avoid further deterioration of the congestion, improving the efficiency of the vehicle access to and pass through the region.

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