Traffic Congestion Identification Method Based on GPS Equipped Floating Car

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***Abstract*—According to the fact that the application conditions needed for traditional link average speed estimation models based on GPS equipped floating cars are too harsh to meet data demands with high precision and low cost for users, which leads to the poor effects of traffic congestion identification system, a new model for estimating link average speed is designed considering the shortcomings of traditional models, and a method for identifying traffic congestion is put forward with link average speed obtained above. Then, the method is verified using measured GPS and GIS data based on a part road network of a large urban. The results show that the precision of traffic congestion identification by the method in this paper is much higher.**

Keywords-traffic congestion; floating car, global position system; average speed

I. INTRODUCTION

GPS equipped floating car have become increasingly attractive as a cost-effective alternative to traditional loop-detector and other fixed detection technologies. In order to enhance traffic operations control room monitoring capabilities, however, GPS equipped floating car must be capable of providing reliable link average speed information during short-term non-free flow conditions such as traffic incidents and severe weather events.

The link average speed collection technology based on GPS equipped floating car refers to set GPS receivers on vehicles which collect GPS data (coordinates etc.) with some time intervals, and data transmitted through wireless communication to the information center for map matching, then the link travel-times are obtained through analysis and treatment [1].

Currently, the models for estimating link average speed are divided into two main groups called site-time interpolating model and velocity-time integrals model respectively. Link average speed is estimated using GPS coordinates of individual floating car by the former [2, 3], and link average speed is estimated using GPS instantaneous velocity of individual floating car by the latter [4, 5]. However, the existed researches show that small enough sampling time interval of GPS is the prerequisites for two main models above, or else the precision of link average speed will be much lower [6].

This paper describes a new model for estimating link average speed with large sampling time interval of GPS, and provides a more accurate traffic congestion identification method.

II. LINK AVERAGE SPEED ESTIMATING

Generally, GPS points left by individual floating car on a link are inadequate for estimating accurate link average speed using site-time interpolating model or velocity-time integrals mode, when sampling time interval is too large. In this paper, a model adapting large sampling time interval of GPS is designed considering the fact that sampling time interval is always large in practice.

In Figure 1, let the GPS points along link AB associated with the first floating car be X_1 to X_3. In Figure 2, let the GPS points along link AB associated with the second floating car be Y_1 to Y_3. In Figure 3, let the GPS points along link AB associated with the first floating car be Z_1 to Z_3. Obviously, the area covered by GPS points associated with any floating car is very limited.

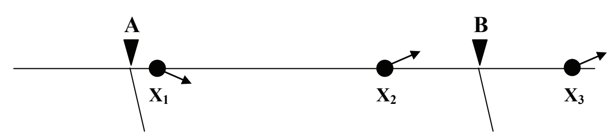

Figure 1. GPS points on link AB associated with the first floating car

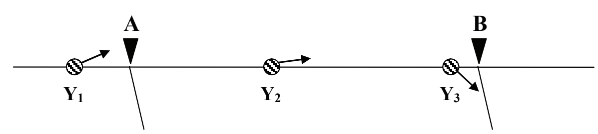

Figure 2. GPS points on link AB associated with the second floating car

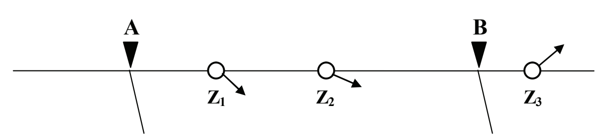

Figure 3. GPS points on link AB associated with the third floating car

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In Figure 1, however, the area covered by GPS points will be much larger as all the GPS points considered be associated with the same floating car, and based on this, a new model is designed for estimating link average speed.

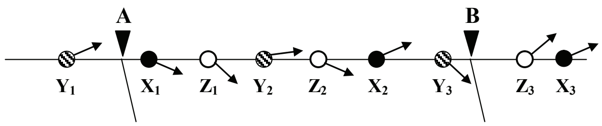

Figure 4. GPS points on link AB associated with three floating cars

In practice, GPS instantaneous velocity is exported as 0 sometimes, but corresponding real velocity of the floating car is much greater. GPS instantaneous velocity like this is called “abnormal GPS instantaneous velocity 0”. In order to reduce the negative influence of abnormal GPS instantaneous velocity 0 to the precision of link average speed, the GPS instantaneous velocity 0 must be differential treated.

Consequently, link average speed $\bar{u}$ is estimated as followed:

$$\bar{u} = \frac{m+n}{\frac{m\alpha}{m\alpha+n\beta}\cdot\sum_{i=1}^{m}\frac{1}{0+0.01}+\frac{n\beta}{m\alpha+n\beta}\cdot\sum_{j=1}^{n}\frac{1}{v_j}} \quad (1)$$

Where m is the amount of GPS instantaneous velocity 0, n is the amount of other GPS instantaneous velocity, α is the weight coefficient of GPS instantaneous velocity 0, β is the weight coefficient of other GPS instantaneous velocity, and $\alpha < \beta$.

III. CRITERION OF CONGESTION DETERMINING

The criterion of traffic congestion is the foundation for identifying traffic congestion. Because the criterions of traffic congestion about only trunk road are provided in “Evaluation index system of urban road management of China”, the criterions of traffic congestion about other urban road classes are determined in this paper.

a) Determining the lower limit and upper limit of speed about all classes of urban road according as “Design specification of urban road of China”;

b) Using lower limit of speed about the second traffic state as the criterion of traffic congestion of trunk road according as “Evaluation index system of urban road management of China”;

c) Calculating the ratios of the criterion of traffic congestion of trunk road to the corresponding results in a), and then multiplying the results of other road classes in a).

Table 1 shows the criterion of traffic congestion about all classes of urban road.

Table I. Criterions of traffic congestion about all classes of urban road

Road classes	Expressway	Trunk road	Sub-arterial road	Branch road
Class-A urban	20km/h	16km/h	13km/h	10km/h
Class-B urban	--	19km/h	15km/h	11km/h
Class-C, D urban	--	21km/h	17km/h	12km/h

IV. TRAFFIC CONGESTION IDENTIFYING

In order to offer the location, time, duration time and type (accidental traffic congestion or regular traffic congestion) of traffic congestion occurring to traffic management department, an algorithm is designed for identifying traffic congestion.

If the inequality (2) is tenable for two successive periods, it can be considered that traffic congestion has occurred. For some while, if the inequality (3) is tenable for two successive periods, it can be considered that traffic congestion has passed.

$$\bar{u}(t) \geq K_1 \quad (2)$$

$$\bar{u}(t) < K_1 \quad (3)$$

Where $\bar{u}(t)$ is the actual link average speed of current periods, K_1 is the criterion of traffic congestion.

If the inequality (4) is tenable when traffic congestion occurring, it can be considered that the traffic congestion is accidental; otherwise the traffic congestion is regular.

$$\left|\frac{\hat{u}(t)-\bar{u}(t)}{\hat{u}(t)}\right| \geq K_2 \quad (4)$$

Where $\hat{u}(t)$ is the forecasting link average speed of current periods, K_2 is the criterion of traffic congestion type, and $K_2 = 0.5$ is recommended.

V. DATA VALIDATION

GPS measured data are acquired from taxi dispatching system of a big city, China. Figure 5 shows the line of GPS data surveying.

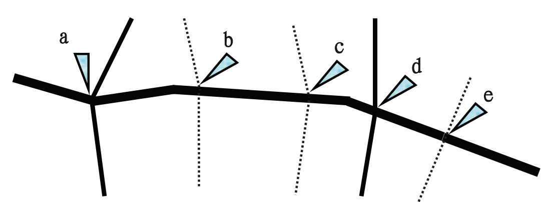

Figure 5. Line of GPS data surveying

In this paper, GPS measured data on link ab of trunk road on Jul. 16, 2009 are selected as an example to illuminate the result of link average speed estimation model and traffic congestion identification method. The sampling time interval of GPS is about 20s-60s, and the GPS positioning precision is about 20m.

In addition, license plate measured data on link ab on Jul. 16, 2009 are acquired for estimating the true value of link average speed.

Figure 6 shows the comparison results between the estimated value and the true value of link average speed calculated per 5min. After calculation, the average relative error of estimated value of link average speed is 23.8%. It is obvious that the link average speed estimation model is efficient for identifying traffic congestion.

The mean value of historical data is used as the forecasting link average speed for traffic congestion identification method. Table 2 shows the result of traffic congestion identification.

VI. CONCLUSIONS

Here we may draw the following conclusions from experiments above.

The link average speed estimation model can provided input data with high precision for traffic congestion identification algorithm, and the traffic congestion identification algorithm can obtained the location, time, duration time and type of traffic congestion accurately.

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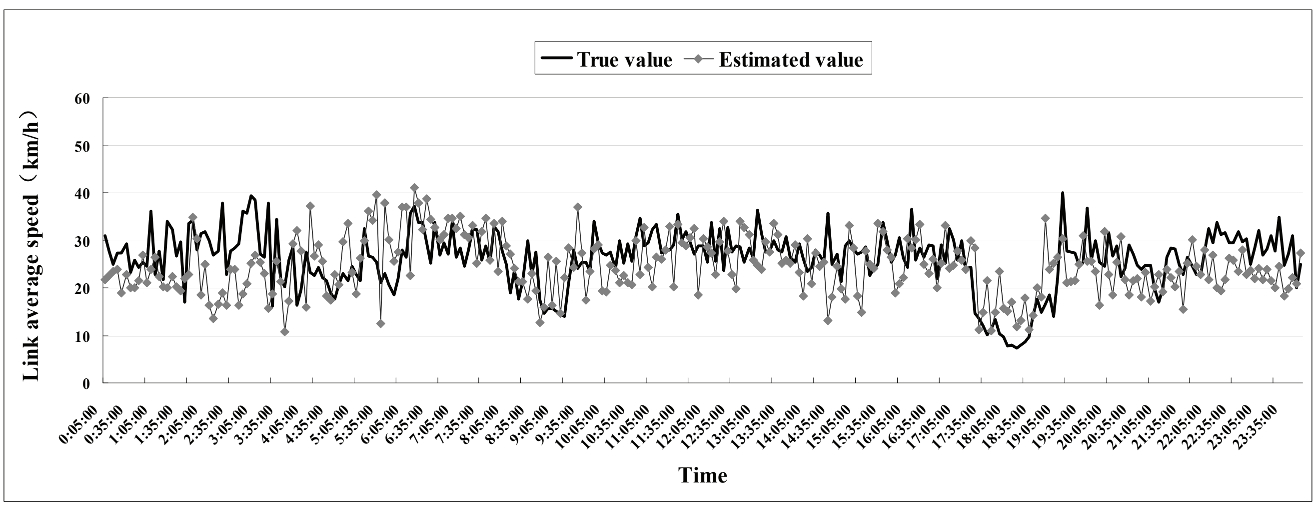

Figure 6. Comparison results between the estimated value and the true value of link average speed

Table II. Result of traffic congestion identification

True starting time	True end time	True duration time (min)	True congestion type	Estimated starting time	Estimated end time	Estimated duration time (min)	Estimated congestion type
8:50:00	9:20:00	30	Regular congestion	8:45:00	9:15:00	30	Regular congestion
17:25:00	18:50:00	85	Regular congestion	17:30:00	18:40:00	70	Regular congestion