Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2022, 9(8):44-50**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Research on the Application of Electric Police Data at Intersections

Benxing Liu, Xiaoqing Wang, Yingcui Du, Yuan Fu, Shulong Dong, Pengsheng Zhao

Shandong University of Technology, School of transportation and vehicle engineering, Zibo 255000, China

Abstract With the large-scale construction and use of electronic police in cities, the electric police data becomes one of the important ways to sense traffic parameters. In this paper, we propose a pre-processing method for the system's electric police data in terms of data integration and data cleaning, and evaluate the quality of the pre-processed data to verify the accuracy and validity of the data, taking the electric police data of a certain place as an example, and fuse the video recording and electric police data. Finally, the extraction methods of parameters such as saturation flow rate, trip speed, average delay and queue length of traffic flow are proposed based on the relevant principles of traffic signal control and traffic state evaluation, respectively.

Keywords E-police data; Data pre-processing; Data quality assessment; Traffic parameter

1. Introduction/ Background

In the context of big data, traffic information data collection and application are becoming more and more widespread in the field of intelligent transportation. based on electronic police data, Zhan X et al. [1] combined traffic wave theory and OD model to establish an intersection queue length estimation model to make up for missing downstream electric police data by upstream electric police data. Li et al. [2] proposed a method based on exponentially weighted averaging and Bayesian conjugate prior to calculate and estimate the average travel time of road sections using the crossing data collected from the electric police chokepoints at road intersections; Hao Wu et al. [3] conducted a study on signal-controlled intersections with left-turn-only lanes and left-turn-spread lanes, and proposed a signal-controlled intersection short-lane queue overflow based on the chokepoint electric police data Li Dacheng [4] relied on big data and cloud computing technology to establish an intelligent traffic cloud computing platform to process and analyze the collected massive bayonet data, obtain the average speed of each section of the interval, and finally determine the signal control scheme; Hao et al. [5] proposed a traffic state identification method based on license plate recognition data, and ensured the travel time by dividing the sample size and traffic periods calculation is reasonable; Cho et al. [6] used dual-section monitoring data to calculate the traffic wave speed and vehicle arrival rate, and combined with traffic wave theory for intersection traffic parameter extraction.

The above studies mainly focus on road state identification and single traffic flow operation parameter extraction, while the research on the error analysis and accuracy check of electric police data is not perfect. To this end, this paper comprehensively compares the electric police data with video recordings, deeply analyzes the defects of the electric police data, and then designs pre-processing techniques such as integration and cleaning in a targeted manner, so as to obtain improved accuracy and effectiveness of the electric police data, and performs error analysis and traffic operation parameter extraction on the processed data set.

2 Methods

In the actual road data collection, the data acquired by the electronic police is usually incomplete. Data abnormalities can be caused by bad weather and speeding vehicles during the data collection stage, and abnormal data can be generated during data transmission and storage due to system instability, equipment damage, and algorithm accuracy. Pre-processing of electric police data can obtain high quality and easy to analyze and process electric police data, which can improve traffic signal control benefits and traffic evaluation authenticity.

2.1 Data integration

Data integration is to remove redundant data, classify data according to specific rules, and store all data in a database or file to form a complete set of data.

The electric police data include vehicle color, vehicle brand, vehicle label, driver's illegal violation and other information, which is less valuable for the study of traffic control, so only important data are extracted and integrated during the analysis and processing. The integrated data are shown in Table 1.

Table 1: Key data details

Main information of data	Data form	Description
License plate number	Lu C ****4	License plate identification number, the existence of no license plate data
Vehicle type	Small car	Vehicle type is divided into small, medium and large categories
Direction of travel	From south to north	Mainly divided into 4 categories, namely the intersection of each import
Lane number	3	Each import from left to right lane number increment
Passing time	2022-07-24 08:07:15	The moment the vehicle passes the parking line

2.2 Data cleaning

Data cleaning means that based on the existence form and causes of noisy data, the noisy data are removed according to specific methods and techniques, and the data that meet the conditions are analyzed for accuracy and data transformation to improve the quality of the underlying data [7].

(1) Special character cleaning

There are more separators and special characters (such as ", etc.) in the electric police data files, and these special symbols not only do not help our research, but also produce certain negative effects, which requires us to clean off this part of special symbols.

(2) No license plate data cleaning

There are some data without license plate in the data sheet of electric police, which are usually analyzed by video recording, such as the vehicle itself without license plate or obscured by other vehicles.

(3) Duplicate data cleaning

There are more duplicate license plate data in the electric police data, after comparing and analyzing with the video footage, it is found that the reason for duplicate data is mainly that the same vehicle is identified twice when it passes the stop line of the same import lane.

3. Results

Real-time and accurate traffic operation parameters extraction is the basis of urban road operation status evaluation and traffic control design, and the pre-processed electric police data can be used as the basic data to extract index parameters such as saturation flow rate, travel time, delay and queue length in real time for intersection and road section operation status evaluation and intersection and arterial signal control scheme design [8].

3.1 Saturation flow rate extraction

Saturated headway time distance is not only a key parameter to determine the saturation flow rate, but also an important basis to reflect the road capacity and management level, which is of great significance to road drainage design, intersection signal timing, etc. Some of the headways extracted in this paper are shown in Figure 2 and Figure 3.

(1) The headway time distance in the morning and evening peak hours are shown in the figure, the traffic flow is large during this time, and the vehicle release is in saturation release state. The headway distribution is similar in the morning and evening peak hours, and the headway is mostly concentrated between 1s to 5s, and the average headway is 3.5s, which indicates that the vehicles are concentrated when passing through the intersection. The headway distribution in the morning and evening peaks is shown in Figure 2.

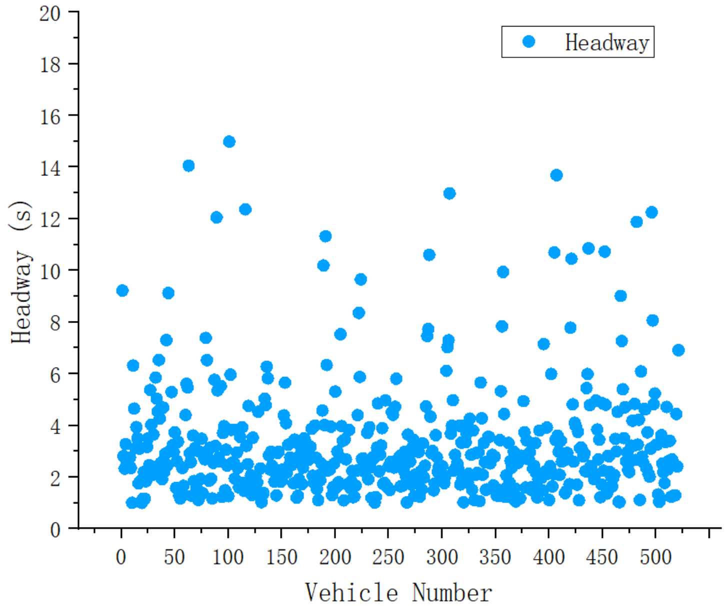

Figure 1: Distribution of headway in morning

(2) The distribution of headway time distance during the peak hours is shown in the figure. The traffic flow during this time is small, and the vehicle release belongs to the coordinated release state because of the green wave coordination control on the arterials, so the headway time distance is relatively large, mostly concentrated between 1-8s, and its average headway time distance is 4.7s, indicating that the vehicles are more discrete when passing through the intersection. The average headway time distance is 4.7s, indicating that the vehicles are more discrete when passing through the intersection.

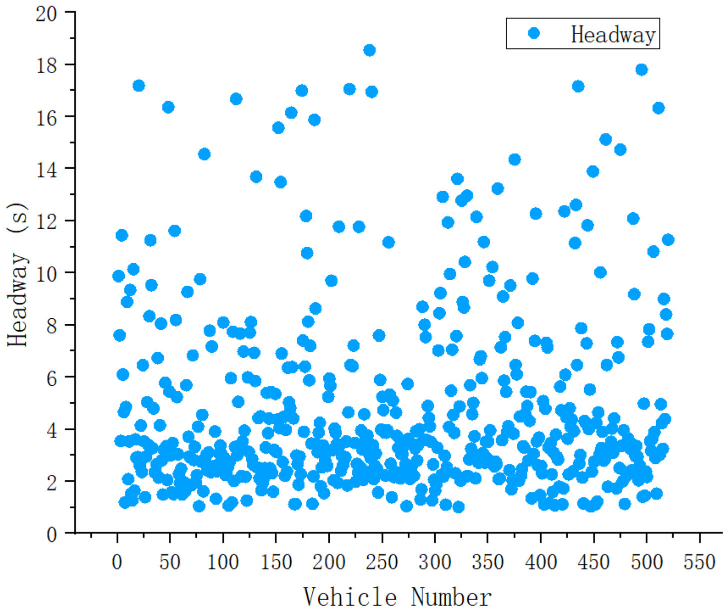

Figure 2: Time interval distribution of flat peak locomotive

3.2 Trip Speed Extraction

The travel time is the time interval between vehicles passing through adjacent intersections. The average travel time is the average of the travel time of all vehicles passing through two adjacent intersections in a certain time interval.

Based on the license plate recognition technology of the electric police chokepoint, the vehicle crossing time point information collected from the upstream and downstream chokepoints is matched to the license plate data to get the time of the vehicle passing through the adjacent two intersections and eliminate the abnormal data. Due to the fixed spacing of adjacent intersections, the average travel speed of the road section can thus be obtained.

$$T_i = t_{i2} - t_{i1} \qquad (1)$$

Where t_{i1} is the moment when the ith vehicle passes the upstream intersection choke, t_{i2} is the moment when the ith vehicle passes the downstream intersection choke, and T_i is the travel time of vehicle i at the upstream and downstream choke, s.

$$v_i = \frac{T_i}{l_i} = \frac{t_{i2} - t_{i1}}{l_i} \qquad (2)$$

Where, l_i is the spacing of adjacent intersections, m.

Fast Fourier Transform (FFT) is computationally small, which can reduce the interference of noisy data when filtering, and also can effectively retain the periodicity of the data. Taking the electric police passing data of adjacent intersections A and B as an example, the average travel speed of the vehicle section is extracted and subjected to FFT low-pass filtering to approximate the variation of the actual running fleet speed, and the processing results (partial data) are shown in Figure 3.

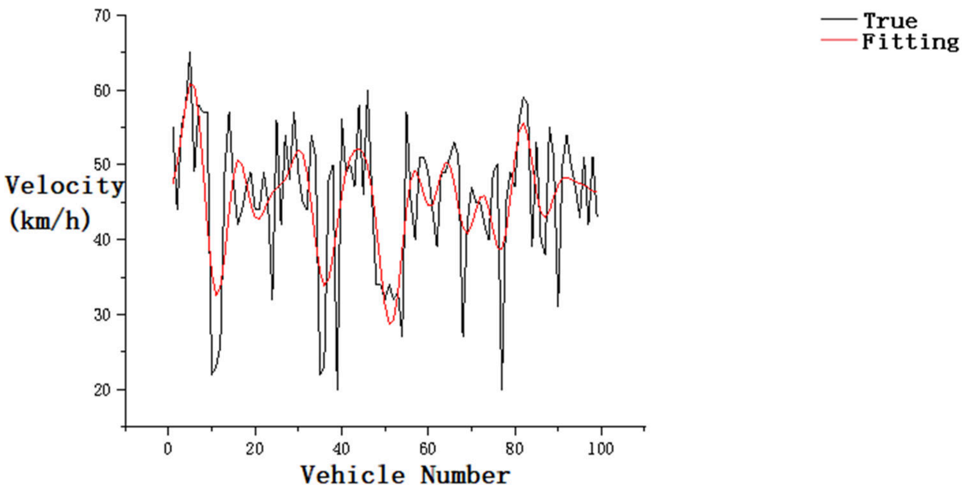

Figure 3: Travel speed map

From the above figure, it can be seen that the vehicle speed after filtered fitting can more effectively show the distribution characteristics and periodicity of the formed vehicle speed. The trip speed is mainly distributed between 40km/h and 50km/h. The trip speed of each cycle first increases gradually from a low peak to about 45km/h, and then tends to stabilize.

3.3 Average delay extraction

The delay is the difference between the actual travel time and the ideal travel time, which is determined by the design speed and intersection spacing, as shown in the following equation.

$$t_0 = \frac{l_{(i,i+1)}}{v} \tag{3}$$

Where, t_0 is the ideal travel time at the design speed, s; $l_{(i,i+1)}$ is the distance between intersection i and intersection i+1, m; v is the design speed, m/s.

On the basis of the trip speed extraction, the actual travel time is calculated by equation (4).

$$t_{i,i+1} = \frac{l_{(i,i+1)}}{v_{i,i+1}} \tag{4}$$

where $t_{i,i+1}$ is the actual travel time at the travel speed, s; $v_{i,i+1}$ is the travel speed between intersection i and intersection i+1, m/s.

Therefore, the average delay is calculated as in (5).

$$t = \frac{\sum_{n=1}^{n}(t_0 - t_{i,i+1})}{n} \tag{5}$$

where t is the average delay, s; t_0 is the ideal travel time at design speed, s; $t_{i,i+1}$ is the actual travel time at trip speed, s; and n is the number of vehicles passed, pcu.

The average delay handling results for the evening peak hours are shown in Figure 4. As can be seen from the figure, the delays reach their peak at 17:18, indicating that the road traffic demand reaches its peak during this period.

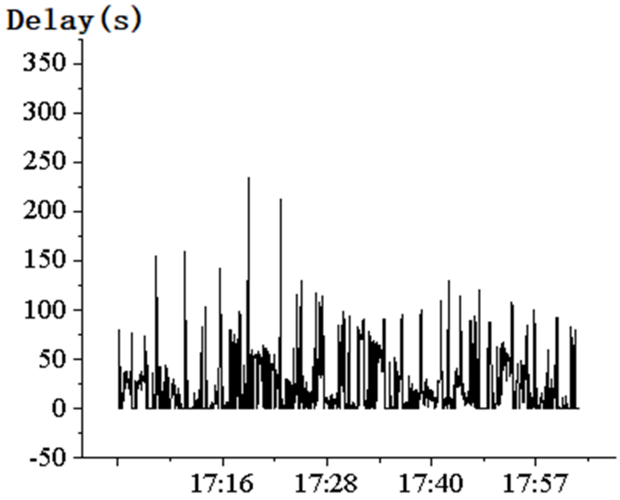

Figure 4: vehicle delay P.M. Peak

Select the morning peak hour, divide the cycle by time series to determine the number of passing cars in the cycle, then extract the headway time distance h_i for each cycle, and calculate the average headway time distance formula as follows.

$$\bar{h} = \frac{1}{n}\sum_{i=1}^{n} h_i \tag{6}$$

The queue length variation of an intersection during the morning peak hours obtained from the electric police data is shown in Figure 5.

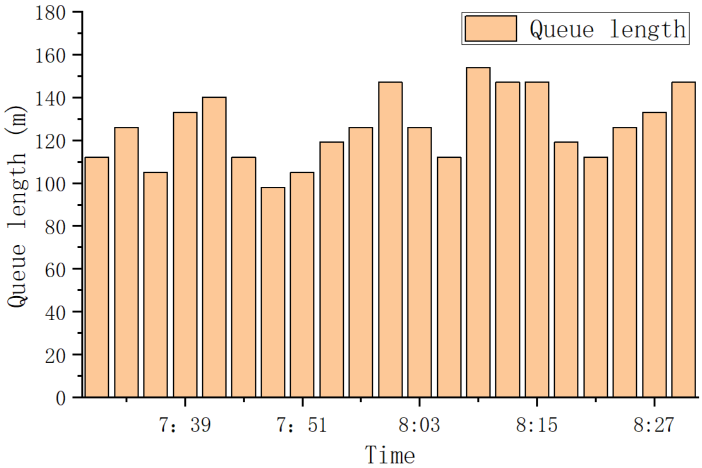

Figure 5: Queue length map

4. Conclusion

In this paper, a complete pre-processing process and method for electric police data is proposed in terms of data integration and data cleaning. The data quality is evaluated by comparing the electric police video with the pre-processed data, and the results show that the errors of the pre-processed electric police data are small compared with the actual situation. Finally, the extraction and optimization methods of parameters such as saturation flow rate, trip speed, average delay and queue length of traffic flow are proposed, which can provide data support for traffic state evaluation and dynamic optimization of signal timing. How to improve the adaptability of the electric police data pre-processing method to different formats of electric police data, and how to further improve the accuracy and timeliness of parameter extraction to provide data support for inductive signal control and adaptive signal control are to be further studied.

References

[1]. Zhan X, Li R, Ukkusuri S V. Lane-based real-time queue length estimation using licenseplate recognition data [J]. Transportation Research Part C: Emerging Technologies, 2015,57:85-102.
[2]. Li X. Travel time calculation method based on electric police chokepoint [C]. China Intelligent Transportation Association. Proceedings of the Ninth Annual Conference on Intelligent Transportation in China. 2014: 155-160.
[3]. Wu H. Identification of short lane queue overflow at intersections based on electric police data [C]. China Intelligent Transportation Association. Proceedings of the 13th Annual Conference on Intelligent Transportation in China. 2018: 550-560.
[4]. Li D X. Coordinated traffic signal optimization control system based on vehicle big data [C]. China Intelligent Transportation Association. The 10th Annual China Intelligent Transportation Conference Excellent Paper Collection. 2015:168-178.
[5]. Hao P, Ban X. Long queue estimation for signalized intersections using mobile data [J]. Transportation Research Part B: Methodological, 2015, 82:54-73.
[6]. Cho H J, Tseng M T, Hwang M C. Using detection of vehicular presence to estimate shockwave speed and upstream traffics for a signalized intersection [J]. Applied Mathematics and Computation, 2014, 232:1151-1165.
[7]. Turochy R E, Smith B L. Altermative Approaches to Condition Monitoring in Freeway. Management Systems [R]. VTRC02-R8, January 2002.
[8]. Zhu Y. Research on the theory and method of urban traffic signal control [D]. Beijing Jiaotong University, 2003.