Research on Fuzzy Recognition Method of Regional Traffic Congestion Based on GPS

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Abstract. When using traditional traffic congestion recognition method to judge traffic congestion, there is a lack of accuracy. In view of the above problems, a fuzzy identification method of regional traffic congestion based on GPS is proposed. First, the GPS floating vehicle traffic information collection technology is used to collect the traffic information of the road network, and it is pretreated at the same time. Then the effective data and the electronic map are matched to determine the accurate position of the floating car on the road. Finally, a fuzzy comprehensive discriminant model based on the GPS data is set up, and the road traffic status is entered. The line is accurate. The results show that the accuracy of the method is 44% higher than that of the traditional traffic congestion recognition method, which basically achieves the purpose of this study. Experimental results are better, this article can bring guidance meaning to the future research.

Keywords: Big data · Cable tunnel · Leakage signal · Positioning method

1 Introduction

With the rapid development of social economy, traffic jams have become one of the major social problems that restrict the development of cities. Traffic jams affect people's daily life and work. Fast, accurate and real-time access to road traffic information, and then identify traffic congestion in the road network, is of great significance to the formulation of reasonable and effective traffic congestion and guidance measures [1]. At present, relevant experts have a very good research results on traffic congestion identification technology. Reference [2] Proposes a weighted traffic condition research method for FCM expressway. It can detect traffic congestion and evacuate congested streets. It can smooth traffic very well, but the feedback information is not timely. Reference [3] A weighted index method for expressway traffic state estimation based on fuzzy C-means is proposed. This method can effectively complete the real-time detection of expressway traffic state, but this method does not consider the problem of traffic evacuation. It is a new technology in the field of traffic state detection to use GPS floating car data to evaluate regional traffic condition. In this paper, based on the GPS

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floating car acquisition technology, the road traffic information is collected in real time, the data is analyzed and processed, and the effective traffic parameters are obtained by map matching. Based on the fuzzy comprehensive evaluation method, the road traffic status of the floating car is judged, which is the decision of the traffic management department and the out of the traveler. The line provides the basis and auxiliary information [4]. First, the GPS floating vehicle traffic information collection technology is used to collect the traffic information of the road network, and it is pretreated at the same time. Then the effective data and the electronic map are matched to determine the accurate position of the floating car on the road. Finally, a fuzzy comprehensive discriminant model based on the GPS data is set up, and the road traffic status is entered. The line is accurate. In order to solve the problems of low recognition accuracy and long recognition time, a method of regional traffic congestion recognition based on fuzzy recognition is designed. In order to verify the accuracy of the method, a comparative experiment was carried out. The experimental results show that the system can effectively improve the speed and accuracy of traffic congestion detection.

2 GPS Floating Vehicle Traffic Information Collection

The GPS floating car acquisition technology receives the GPS satellite signal through the GPS receiving module installed on the vehicle, thus obtaining the real-time information of the vehicle, and then the vehicle positioning, tracking and other functions. If GPS receiver module is installed on multiple vehicles, the traffic flow information collection of road network can be realized through the feedback of GPS information from these vehicles. These vehicles are called floating cars and are usually used by taxis [5]. Through the acquisition and processing of the GPS data of a large number of floating vehicles, the estimation of the average travel time of the section and the discrimination of traffic state can be realized, and the prediction of traffic jam can be realized. So as to formulate reasonable traffic guidance measures to facilitate public travel [6].

GPS floating car collection technology is used to collect traffic conditions, and the acquisition process is shown in Fig. 1.

In the traffic information acquisition technology based on GPS floating vehicles, some parameter configurations have an important impact on the real-time and reliability of traffic state discrimination, such as the time interval of data sampling, and the determination of the sample size of the floating car.

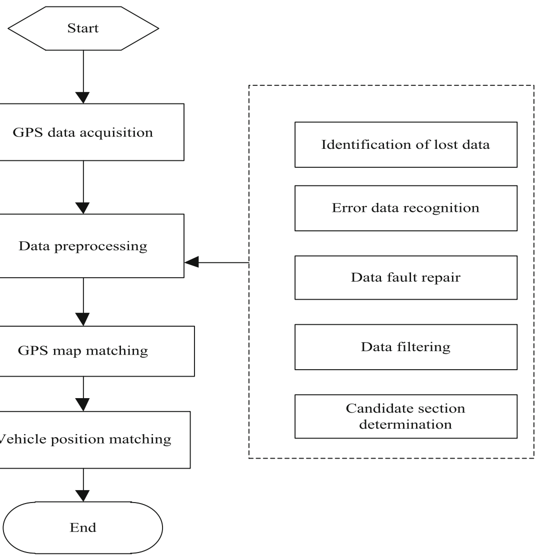

Fig. 1. GPS floating car traffic information collection process

3 GPS Data Preprocessing

In the actual acquisition, due to the objective conditions of equipment, technology and methods, the original data of the GPS floating car inevitably has errors. Therefore, this section is mainly based on the reliability of data and preprocessing the data.

3.1 Lost Data Recognition

In practical applications, due to the complex urban conditions, there are signal blind areas in some areas, resulting in abnormal or missing GPS data. One way to identify missing data is to recognize the time period of the GPS receiver based on the set of GPS receivers. If the setup period is one minute, all data received in the 12:30:00–12:31:00 cycle will be identified as 12:30:00 at this time [7]. Checking all the data received, if there is no data in a cycle, or multiple data in a cycle, it can be considered that the data in this cycle is abnormal, missing or wrong, and the data should be repaired.

3.2 Error Data Recognition

When the GPS receiver itself problems or the communication channel problems, the abnormal data will be generated, and the traffic characteristics can not be described directly with these data. In order to identify the data of these anomalies, the collected parameters are usually limited to a normal interval. If the actual data is in this interval, the data can be roughly identified as the valid data [8]. The following are the reasonable intervals of several common traffic parameters for GPS detection system, namely, vehicle instantaneous speed, travel time and road congestion length.

Instantaneous speed of vehicle a_i: $0 \leq a_i \leq f(x) \cdot a_k$

In this formula: a_k indicates the maximum speed limit (Km/h), and $f(x)$ indicates the speed correction coefficient.

Travel time t_e: $\frac{g}{a_k} \leq t_e \leq \frac{g}{a_j + h}$

In this formula: g is the length of the section; a_j indicates the speed of the section at the lower reaches of the section; h represents a small real number of more than 0, which is to avoid the calculation error caused by the a_j taking of 0.

Road congestion length l_m: $0 \leq l_m \leq l + h_1$

In this formula: l represents the length of the road; h_1 indicates the maximum permissible error of the road length.

3.3 Data Fault Repair

After identifying the abnormal data, we need to use the method of weighted estimation Ye(t) to repair it.

The calculation method is as follows:

$$\mathrm{Ye(t)} = \mathrm{a} * \mathrm{y(t-1)} + (1 - \mathrm{a}) * \mathrm{y}^{k-1}(t) \tag{1}$$

a is the weighting coefficient of (t − 1) time data, and the large weighting coefficient indicates that the repaired data is mainly affected by the measured data. This method not only takes into account the connection between traffic data, but also considers the function of historical trend data, which has the characteristics of stability.

3.4 Data Filtering

The actual traffic data will be affected by random factors, which will affect subsequent use. The fault recognition and repair processing of traffic data can only act on fault data and not remove random components [9]. Before using traffic data, data are usually filtered. The Calman filtering algorithm is a data processing method based on linear regression analysis. It can efficiently remove the random components of noise and so on from the measured data. In this algorithm, the optimal estimation of the current time is obtained by using the optimal estimation of the previous moment and the observed values at the present time. Calman filtering algorithm is a recursive algorithm, and the state optimal estimation is carried out through continuous iteration. In the process of iteration, the system state vector is modified according to the linear unbiased estimation to achieve the filtering effect.

3.5 Candidate Section Determination

First, determine the scope of the road and a certain range of positioning error. In the extended attribute data table, supplement the road information, including maximum and minimum longitude and latitude, length, design speed, direction vector value and so on [10]. In the implementation of matching, we only need to select the information of the current running section in the data analysis dialog box, then we can conduct the next GPS data location map matching.

4 GPS Map Matching

According to the actual research needs, we only need to get a map area range with a few roads. The smaller the area that the map can show, the closer its projection coordinates to the coordinates of the rectangular coordinate system, the smaller the local coordinate error. In order to map matching, the first step is to complete the registration of map coordinates. Because the data collection of the floating car includes its latitude and longitude coordinates, it is easy to register the electronic map with the latitude and longitude coordinates. So, the registration of the map can be completed as long as the 3 control points with accurate latitude and longitude coordinates are calibrated in the Google earth. The schematic diagram is shown in Fig. 2, $A(x_a, y_a)$ represents a road detection point.

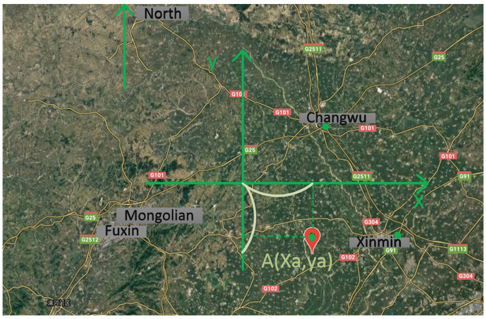

Fig. 2. GPS map matching simulated diagram

5 Fuzzy Comprehensive Discriminant Model Based on GPS Data

Applying fuzzy comprehensive discriminant model to the identification of traffic congestion, we need to establish a model first. The establishment of the model should take full account of the specific factors affecting the traffic state and the extent of the impact. At the same time, from the perspective of GPS data, we should make full use of the advantages of GPS data to input accurate and reasonable traffic parameters for the model. The main steps of the fuzzy synthetic discriminant method are shown in Fig. 3.

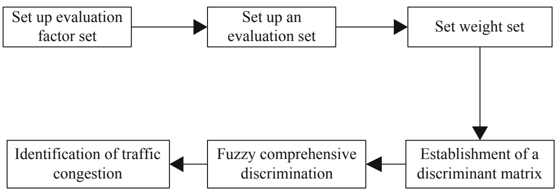

Fig. 3. Fuzzy synthetic discriminant steps

5.1 Membership Function Determination

First, a series of values with dividing points are determined on a continuous interval, and then the actual index values are processed by linear interpolation formula, and the degree of membership corresponding to the index value can be obtained.

Assuming that the evaluation factor of a traffic state is x and the membership function is n(x), $x \in \{0, 1, 2, 3, 4, 5\}$, $n \in (0, 1)$, the membership degree of the factor for the traffic state evaluation at all levels is $n_1(x), n_2(x), n_2(x), \cdots, n_{o+1}(x)$:

$$n_1(x) = \begin{cases} 1 & x \le z_1 \\ \frac{z_2 - x}{z_1 - z_2} & z_1 \le x \le z_2 \\ 0 & x \ge z_2 \end{cases}, \quad n_2(x) = \begin{cases} 1 - n_1(x) & x \le z_2 \\ \frac{z_3 - x}{z_3 - z_2} & z_2 \le x \le z_3 \\ 0 & x \le z_1, x \ge z_3 \end{cases}, \quad n_{o+1}(x) = \begin{cases} 0 & x \le z_o \\ 1 - n_o(x) & z_o \le x \le z_{o+1} \\ 1 & x \ge z_{o+1} \end{cases} \tag{2}$$

In this formula: z_1, z_2, z_{o+1} is the classification value of each state grade evaluation set.

The selection of average speed is referred to “Evaluation of Urban Road Traffic Management” (2008 Edition). The threshold range of average speed is obtained by using the average speed classification table of urban trunk road (as shown in Table 1), which mainly consider the application in large cities.

Table 1. Average speed scale of urban trunk road

Evaluation grade standard	1	2	3	4	5
Large and class A Cities	[25, 30]	[22, 25]	[19, 22]	[16, 19]	[0, 16]
Class B Cities	[28, 33]	[25, 28]	[22, 25]	[19, 22]	[0, 19]
Class C, D Cities	[30, 35]	[27, 30]	[24, 27]	[21, 70]	[0, 21]
Index	[90, 100]	[80, 90]	[70, 80]	[60, 70]	[0, 60]

5.2 The Establishment of Fuzzy Comprehensive Evaluation Model

In fuzzy synthesis evaluation, a fuzzy relation synthesis operation is usually used. When there are many factors of evaluation, if the weight of each factor is small, the evaluation of all single factors is lost easily by taking small calculation, which makes the result lose the meaning of evaluation. In order to ensure the comprehensiveness and reliability of the evaluation effect of the comprehensive evaluation model, it is necessary to take into account the influence of all factors, balance the importance of each factor, avoid overemphasizing the role of a major factor and ignore the effect of other single factors. Therefore, this paper selects the fuzzy synthetic operation of weighted average, takes into account the effect of all factors, considers the information of each single factor, and carries out the comprehensive evaluation of the state.

$$p_r = \sum_{i=1}^{w} (a_i \cdot \alpha_{ij}), j = 1, 2, 3, \cdots, w, \quad \sum_{i=1}^{w} a_i = 1 \tag{3}$$

In the formula, α_{ij} indicates the subordinate degree of the I evaluation factor to the j traffic state evaluation grade; and W is the number of the characteristic components of the evaluation index in each sample.

The evaluation matrix can be obtained by combining the principle of the comprehensive evaluation model with the membership functions defined by the above indexes.

$$\beta = \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} = \begin{bmatrix} n_A(\bar{V}) & n_B(\bar{V}) & n_c(\bar{V}) \\ n_A(\bar{T}) & n_B(\bar{T}) & n_c(\bar{T}) \end{bmatrix} \tag{4}$$

The three evaluation factors of the average travel speed of the section, the average road delay and the average travel time of the intersection correspond to the Weight A and the membership function of the three road traffic states, which can enter the fuzzy comprehensive model evaluation stage, and make fuzzy transformation, and get the fuzzy comprehensive evaluation result Vector B.

$$B = A \cdot \beta = [a_1, a_2, a_3] = [b_1, b_2, b_3] \tag{5}$$

The comprehensive evaluation set B has only three traffic conditions in which road traffic is unimpeded, mild congestion and heavy congestion. Therefore, in the result Vector $B = [b_1, b_2, b_3]$ of fuzzy comprehensive evaluation, B1 represents the importance of evaluation factors to the unimpeded state of road traffic, and the evaluation factor of B2 is corresponding to the light congestion of road traffic. The importance of B3 is that the evaluation factors correspond to the importance of road traffic congestion.

For the comprehensive evaluation set B, the maximum membership degree method can be used to determine the final result of the fuzzy comprehensive evaluation. The maximum subordinate degree principle can be obtained. If $B_T = \max[b_1, b_2, b_3]$, the corresponding subscript T is the final judgement level of the fuzzy comprehensive evaluation object. That is to say, the state grade corresponding to the maximum value in B1, B2 and B3 is taken as the final result of fuzzy comprehensive evaluation of road traffic condition.

In the road traffic state evaluation, β is essentially the fuzzy mapping relationship between the evaluation factor set and the evaluation set, so the relationship between the evaluation index parameters and the road traffic state is also the same. The relationship between them can be represented by Fuzzy Mapping β, as shown in Fig. 4.

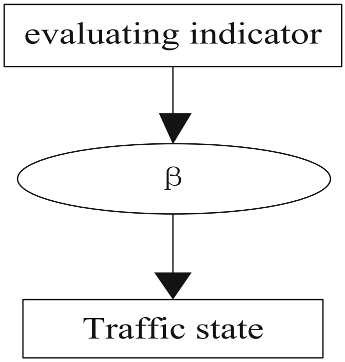

Fig. 4. The relationship between evaluation index and traffic state

6 Contrastive Experiment

In order to verify the effectiveness of the fuzzy recognition method for regional traffic congestion based on GPS, the method and the traditional traffic congestion status identification method are used to discriminate traffic congestion in the 6 analysis period of 8: 00–9: 30 in the morning of a road.

According to the steps and principles of establishing the model, the fuzzy comprehensive evaluation algorithm model is set up, and the model algorithm program is compiled with Matlab computer programming language. The parameter values of each period evaluation index are input into the program, and the corresponding membership importance will be calculated automatically. Finally, the final fuzzy synthesis is obtained according to the maximum membership degree principle. Judge the result and display the real-time traffic state in graphic form. The results of the evaluation are shown in Table 2.

Table 2. Two methods of evaluation of traffic conditions

Time interval	8:00–8:10	8:10–8:20	8:20–8:30	8:30–8:40	8:40–8:50	8:50–9:00	9:00–9:10	9:10–9:20	9:20–9:30
Real traffic condition	0	0	1	1	2	0	0	2	1
This paper method	0	0	1	1	2	0	0	2	1
traditional method	0	1	1	1	2	0	1	1	1

Note: 0 represents smooth state; 1 represents mild crowding; 2 represents severe congestion.

From Table 2, it can be seen that the traffic congestion situation based on the fuzzy recognition method based on GPS is exactly the same as the actual traffic congestion. The accuracy of traffic status recognition is 100%, and the traffic congestion and actual traffic conditions are found by the traditional traffic congestion status recognition method. The error is wrong in the judgement of 2 time periods, the accuracy is only

56%. Compared with the two, the accuracy of the former was increased by 44%. The validity of the method is proved by this method.

7 Conclusion

To sum up, a simple and practical map matching method to deal with the GPS data of a large cab floating car is adopted, and the method for determining the candidate sections is given. Finally, the map matching results are displayed on the map in the form of track segment diagram, so that the matching effect is visualized and the accuracy of matching is guaranteed from a certain level. The fuzzy comprehensive evaluation model is established. Based on the original data characteristics of the floating car and the result of map matching, the average travel speed and the average driving time delay of all vehicles in the specified analysis time are taken as the evaluation index of the road state, and the road traffic state is judged and the road traffic is completed in the evaluation period. The state discrimination is more reasonable, avoiding the deviation caused by single index discrimination. At the same time, the method also needs to be improved, because of the rate of not taking the test to the traffic congestion identification follow-up intelligent processing, and then will further optimize the intelligent processing function.

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