Estimation of Normal Traffic and Traffic Impact Based on Float Car Data

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***Abstract*—The paper proposed a novel estimation method of normal traffic trends, and where traffic effect from bad weather and large activities is analyzed meticulously. Using data mining, the micro-traffic status and rules are reflected. Through analyzing the Float Car Data (FCD) and designing the model, the paper adopted some novel ideas to research normal traffic trends. And the traffic impact analysis for bad weather and large social events is given, which reflects the true change in Beijing. The experiments results show that it does not only fit true conditions, and also it is effective, which can give the public highly effective driving guidance.**

***Index Terms*—OD travel time, estimation model, traffic impact, float car**

I. INTRODUCTION

In modem international metropolitan, the transportation become more and more serious due to traffic congestion, accidents and bad weather etc., which makes a great impact on public travel. So it becomes an urgent task to change the current terrible traffic conditions. With the development of technology, the Intelligent Transportation System (ITS) attracts more and more attention, which is used widely to solve various urban traffic problems [1], [2], [3]. And with the advent of ITS, demands for better and more reliable services are increasing. ITS is the best acknowledged method to solve problems in traffic field at present, such as traffic jam, traffic block, traffic accidents, traffic pollution.

Before, the federal highway bureau investigation report "Traffic Congestion and Reliability: Linking Solutions to Problems" pointed out that large activity, traffic accidents, road construction, the non-reasonable intersection time, and severe weather are five main reasons to cause the traffic jam. And along with the increase of people's material and cultural life level, the large number of activities, such as some large culture sports activities, exhibitions, business promotion activities, are held more and more. During large activities, often, a lot of people and traffic are gathered in very short time period and rather limited space [4], [5]. All of this has brought us many new challenges.

Currently, those researches about traffic effect analysis from large activities or weather and so on focused on Tour-based models or analysis of macroscopic perspective. Tour-based systems were first developed in the late 1970s and 1990s in the Netherlands Daly[6], et al., and are being used extensively there and elsewhere. First tour-based model systems have been developed in Italian Transportation System by Cascetta [7] and Biggiero [7], and then there are many researchers adopting this model to develop ITS. Mohamed Omer [8] suggested a way to incorporate the features of new generation models using ordinary PT (person trip) data, to get an optimum model to capture the link among travel decisions of a day as a travel pattern. However, those researches are from the prospect of the public behavior, and reflected the macroscopic traffic rather than microscopic traffic.

In this paper, a novel estimation method of normal traffic trend is developed and traffic effect from bad weather and large activities is analyzed meticulously. The main contributions in this paper can be summarized as follows: through data mining, the micro-traffic status and rules are reflected. Firstly, a novel method is developed and urban traffic effect model for special activities is proposed. Through analyzing the Float Car Data (FCD), during designing the model, the paper adopted some novel ideas. And an impact analysis is given, which reflects the true change in Beijing and gives the public highly effective driving guidance.

The rest of paper is organized as follows: section2 reviews related work, the detail design of the model as well as the whole effect analysis. Section 4 proposes the experiment and assessment result using true Beijing FCD data.

II. ESTIMATION METHOD AND RELATED WORK

A. Travel Time vs. Time Curve Approximation

In this paper, many taxis as probe cars are used to collect GPS information which identifies their location. The collection is real-time, and Floating Car Data includes individual vehicle speeds and positions at each sampling point. Every day more than 1.5G GPS data are collected

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and saved. Afterwards, those GPS data are processed by map-matching algorithm. After the map-matching algorithm, the position information for these GPS points on specific links is obtained. Now, for each GPS point, both position and velocity are known. For every car, its trajectory is obtained. Thus, given a pair of GPS points, the driving distances and travel time can be calculated through start-position and end-position [8].

In order to estimate the real traffic effect efficiently, four roads around are selected. The Fig. 1 shows that OD (Origin: Dongzhimen in Beijing, Destination: Jianguomen in Beijing) travel time on Monday 2011, which are calculated from more than 13000 probe cars collecting GPS location information. Here, the horizontal axis shows time segment every day, and the ordinate axis is travel time.

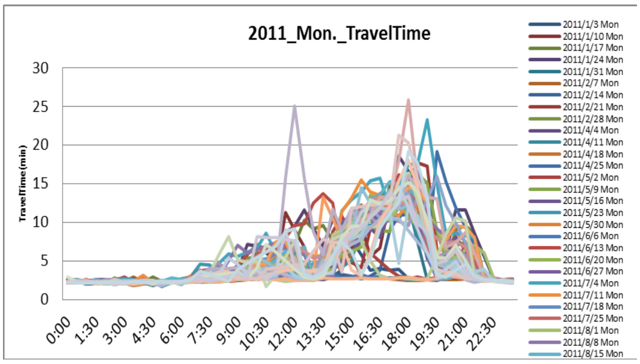


Figure 1. OD travel time vs. time curve

In figure above, there is OD travel time vs. time curves for 52 Mondays in 2011. It is obvious that the majority exhibit the same traffic trend, which is called normal traffic trends. Most importantly, normal transportation trends extraction is the most key step to analyze the traffic effect from bad weather or some large activities.

B. Normal Transportation Trends Curve Extraction

Normal transportation trends extraction is the most key step for the estimation model. Firstly, it reflects what the real commute traffic flow is, especially during day and night rush hours. Moreover, it is very important to analyze the traffic effect from bad weather or some large activities.

For normal transportation trends extraction, the paper proposed an effective model, with regard to the true data distribution and traffic characteristics. Take the OD from Dongzhimen to Jianguomen as an example, the confidence ∂ is set 70%. The confidence set turns out to be all the possible values between a lower and an upper limit. And the confidence set is also normal transportation trends data set. So an upper and a lower limit are what we are in need of firstly. For the first, the 52 Monday data are selected and for every time segment, data are individually processed.

Secondly, the frequency distribution from DongZhiMen to JianGuoMen for every time segment is needed, as shown Fig. 2-5.Here, the horizontal axis shows OD travel time for one time, and the ordinate axis is corresponding frequency.

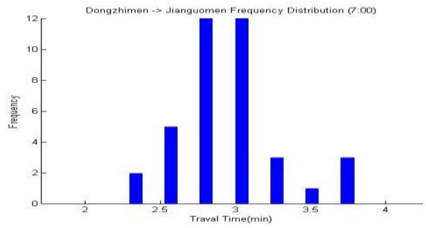
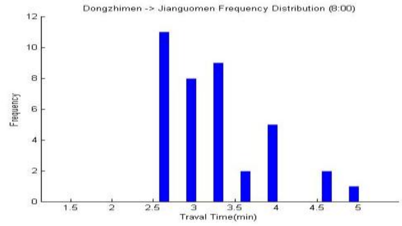


Figure 2. Mon. 7:00



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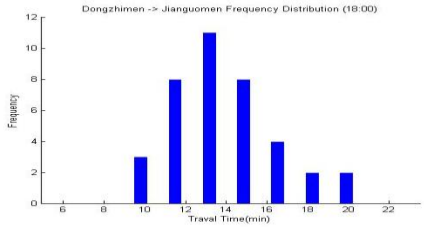

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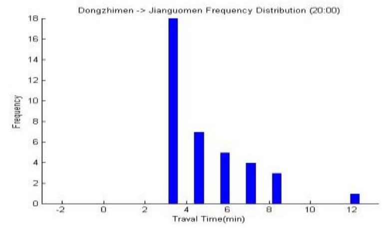

Figure 5. Mon.20:00

Regarding to four figures about four frequency distributions， It is evident that in some time segment, its distributions are correspondent with normal distribution approximately, but also there are some distributions for some time segments which don't fit normal distribution. Based on this analysis, we propose different algorithms to get the upper and lower limits.

Firstly, all data for the same time segment is tested and verified whether it is normal distribution. If yes, the upper and lower limits are obtained by the normality test formula, otherwise, all the data set for the same time segment is classified into two classes by K-means cluster algorithm. Afterwards the class, where the mean of the whole data set is in, is normal traffic class. On the contrary, the other class is non-normal traffic class. Meanwhile, its proportion to whole data set is calculated. If the proportion rightly equals to the confidence, the upper and lower limits are the maximum and minimum of normal traffic class data set. If the proportion is bigger than the confidence, the mean of the normal traffic class is calculated and by Euclidian Distance the data at the greatest distance is deleted. The normal traffic class is iteratively processed like this until the proportion approximately equals to the confidence. If the proportion is smaller than the confidence, the mean of the normal traffic class is calculated and by Euclidian Distance the data at the nearest distance from the non-normal class is added. The normal traffic class is iteratively processed like this until the proportion approximately equals to the confidence. The upper and lower limits are the maximum and minimum of the latest normal traffic class data set. From what has been discussed above, the normal range for every segment is accessible.

The Fig. 6 shows the normal range of OD from Dongzhimen to Jianguomen on Monday in 2011. It describes how commute traffic flow changes with time, especially during night rush hours, as the OD travel time becomes bigger than usual, the traffic passes in wide jam condition. The trend provides the public objective true understanding of OD traffic flow and gives them a better travel reference.

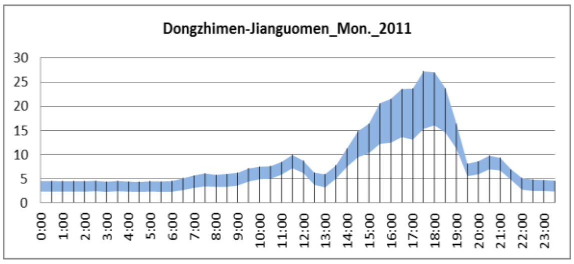

Figure 6. The normal range of OD (Dongzhimen-Jianguomen_Mon._2011)

C. Estimation of Traffic Impact from Bad Weather and Large Activities

Based on the extracted normal traffic range, the effect on traffic flow some special bad weathers make is analysed in this part. As reported on News, a catastrophic rainstorm happened on 23th Jun., 2011 in Beijing city. Start time is about 15:30 o'clock, and that day is Thursday.

The Fig. 7 compares normal traffic conditions with the traffic on 23th Jun., 2011 in Beijing. It can be seen from the graph that on that day the traffic flow deviated from its corresponding normal trends at about 16:00 o'clock. That is, the effect on traffic flow the rainstorm made began after the rain remained half an hour. At about 18:30 o'clock the traffic became rather heavier and the OD travel time changed to nearly twice than normal travel time.

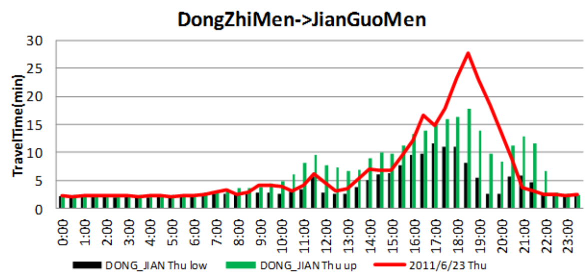

Figure 7. Contrast for catastrophic rainstorm

Take a concert as an illustration the paper introduces how the large activities influence on normal traffic flow. The whole live concert for Cai Yilin started at 19:30 on 28th May, 2011 and lasted about 2 hours. Its host place is Works Stadium of Beijing. The size of the concert was large and there were many participants in it.

After the comparison and analysis of normal traffic trend in 2011 and traffic flow for the day, it is obvious to find that the traffic near became heavier than commute at two hours before concert's beginning, and during the concert its traffic got back to normal. Then at the end, about 21:00, some audiences spun away from stadium, so the traffic deviated from normal level, and the state lasted about 1.5 hour. Based on analysis above, what we can see from the simple figure is consistent with truth, thus fully illustrating that the model provided in this paper is very efficient and effective.

III. EXPERIMENTAL RESULTS

Using the method proposed in this paper, normal traffic trends parameters and range are calculated and compared to some special days. In the method above, about 70% of FCD data is used to extract the normal traffic curve, so in order to estimate the method above, the left 30% data is used to estimate the performances and some related parameters are proposed.

Fig. 8 shows that the changing similarity between the true OD travel time series x_α in Beijing and extracted corresponding normal traffic data series x_β . The parameter is coefficient of similarity ($\gamma_{\alpha\beta}$), which is defined as following,

$$\gamma_{\alpha\beta} = \frac{S_{\alpha\beta}}{\sqrt{S_{\alpha\alpha}S_{\beta\beta}}} = \frac{\sum_{i=1}^{n}(x_{i\alpha}-\bar{x}_\alpha)(x_{i\beta}-\bar{x}_\beta)}{\sqrt{\sum_{i=1}^{n}(x_{i\alpha}-\bar{x}_\alpha)^2\sum_{i=1}^{n}(x_{i\beta}-\bar{x}_\beta)^2}} \quad (1)$$

In fact, $\gamma_{\alpha\beta}$ is coefficient of similarity of the observed values x_α and x_β, where x_α is $\left(x_{1\alpha}, x_{2\alpha}, \cdots x_{n\alpha}\right)^T$ and x_β is $\left(x_{1\beta}, x_{2\beta}, \cdots x_{n\beta}\right)^T$.

The more close to 1 coefficient of similarity can be, he more similar true OD travel time series x_α in Beijing and extracted corresponding normal traffic data series x_β are, the smaller the difference of the sample was.

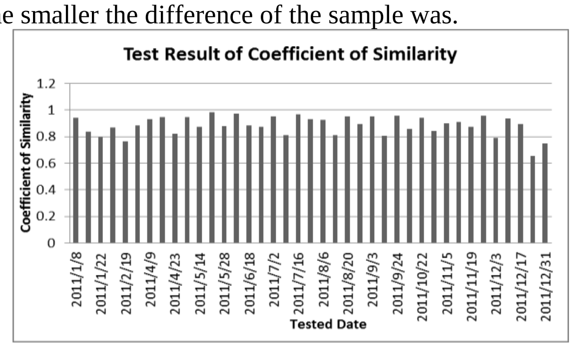

Figure 8. Coefficient of Similarity Result

The test result shows that 85% of all are higher than 0.8 and many 52% of all are higher than 0.9. It proves that true OD travel time and estimated ones are rather similar , moreover , estimated traffic trends can reflect true traffic characteristics and trend.

Table I lists the true OD travel time in Beijing and extracted corresponding mean of normal traffic trend date as well as the deviation parameters(in percent) between the estimated values and the true values.

Most of the estimated travel time (10 out of 38, or about 74%) are within 10% of the true travel time. the worst case is an underestimate of nearly 101.9%, while the best case is an underestimate of only 0 %.

TABLE I. ESTIMATED SIGNAL PARAMETERS-I

Estimated Travel Time (min)	True Travel Time (min)	Deviation (%)	Estimated Travel Time (min)	True Travel Time (min)	Deviation (%)
2.37	2.29	3.49	12.03	12.4	2.98
2.33	2.36	1.27	13.29	11.67	13.88
2.28	2.34	2.56	10.87	10.38	4.72
2.26	2.14	5.61	9.61	10.11	4.95
2.22	2.31	3.90	9.44	10.62	11.11
2.40	2.32	3.45	5.4	6.9	21.74
2.13	2.25	5.33	2.83	3.18	11.01
2.39	2.32	3.02	2.79	2.82	1.06
2.25	2.25	0.00	2.75	3.29	16.41
2.25	2.19	2.74	2.65	3.6	26.39
2.36	2.21	6.79	2.99	3.31	9.67
2.16	2.20	1.82	4.37	2.81	55.52

TABLE II. ESTIMATED SIGNAL PARAMETERS-II

Estimated Travel Time (min)	True Travel Time (min)	Deviation (%)	Estimated Travel Time (min)	True Travel Time (min)	Deviation (%)
2.30	2.11	9.00	5.53	2.75	101.09
2.21	2.39	7.53	2.58	3.29	21.58
2.26	2.40	5.83	2.54	2.37	7.17
2.48	2.42	2.48	2.43	2.34	3.85
2.41	2.48	2.82	2.32	2.37	2.11
2.57	2.66	3.38	3.03	2.81	7.83
2.91	2.83	2.83	6.35	3.92	61.99

IV. CONCLUSION

This paper proposes a novel model to obtain normal traffic condition by Floating Car Data and to estimate the effect from some special weather and large activities. The experimental results imply its efficiency. More traffic estimation methods and conclusions will be discussed in the future research.

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