The Micro Individual Characteristics in Non-motorized Traffic Mixed of Bicycles and Mopeds

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Abstract—In order to understand the overtaking behavior of, overtaking physical separation events between bicycles and mopeds was taken out. According to the analytical model of road bicycle passing events vehicle spatial features, the bicycle passing events into free events overtaking, adjacent events and blocked events, and based on the bicycle traffic flow velocity distribution characteristics and bicycle space distribution probability, an analytic model of 3 kinds of passing events was taken out. According to the passing events’ survey results on the physically separated non-motorized lanes of Shanghai, the model is calibrated and verified and the passing events’ overtaking number calculation results was according with the real situation. The model stream the results show that the parameters for the bicycle traffic, road bicycle, bicycle traffic flow in the running speed, traffic flow speed standard deviation and lane number significantly influence of 3 kinds of overtaking event number. This paper aims to present the micro individual characteristics in non-motorized traffic mixed of bicycles and mopeds.

Index Terms—Micro Individual Characteristics; Non-motorized Traffic Mixed; Bicycles and Mopeds

I. INTRODUCTION

In China, where the motorization has developed rapidly in decades, non-motorized traffic is still one of the main trip modes for many households. However, as an inexpensive and convenient form of private mobility, mopeds have increased rapidly which changed the traditional bicycle flow to traffic flow mixed of bicycles and mopeds [1]. According to the comprehensive traffic survey of Shanghai, the trip mode share of mopeds is increasing from 3.0% in 1995 to 15.2% in 2009. The number of ownership and the utilization of mopeds are increasing faster and faster in China, while those of bicycles are decreasing [2].

The characteristics of city traffic flow in China are significantly different from those in foreign countries, and the mixed traffic flow consisting of motor vehicles, non-motorized vehicles, and pedestrians is an important characteristic of the current urban traffic of China. This phenomenon makes the behavior of traffic flow more complicated. From the point of view of the urban economy and development trend of non-motorized vehicle traffic in China, the mixed traffic will certainly exist for a long time.

The micro individual characteristics of bicycles were widely concerned and lots of work has been done in recent years in the studies on characteristics of passing, meeting and following maneuvers of bicyclists, which are required to measure LOS and develop a simulation model for bicycle traffic [3].

Khan and Raksuntorn [4] collected bicycle location data every 0.5s from video images of bicycle traffic scenes recorded on an exclusive bicycles path. The passing and passed bicycles are found that do not maintain constant speeds during the entire passing maneuver. But they maintain a constant speed difference. The lateral spacing during passing, average passing lengths,and the shape of passing were also reported, which provide information that can be used to develop a comprehensive bicycle simulation model.

Raksuntorn and Khan [5] collected data on off-street and on-street facilities to study the characteristics of passing maneuvers. Based on the location, speed and lateral position of both passing and passed bicycles, the aspects including decision of bicyclists to pass, distance headway before passing, bicycle speed during passing, maximum lateral spacing, and lateral spacing and speed maintained during passing were studied. The relationships between the critical distance headway before passing and the difference in speed were developed.

Li and Wang [6, 7] analyzed bicycle passing events on physically separated bicycle roadway in China. The passing events were classified into free passing events, adjacent passing events and delayed passing events. The sensitivity analyses were conducted to explore the relationships between bicycle passing events and bicycle traffic flow parameters. The results show that bicycle traffic flow rates, bicycle speed, standard deviation of bicycle speed, and number of bicycle lanes significantly impact the number of three types of bicycle passing events.

However, researches for non-motorized traffic flow mixed of bicycles and mopeds lag far behind. Few studies to data have collected micro-level data or non-motorized vehicle trajectory data of mixed non-motorized vehicles is not clear [8]. The changes of the non-motorized traffic in turn challenge the adaptability of traditional non-motorized traffic facilities planned and designed based on
traditional bicycle flow, as well as the dated method of measuring LOS.

In this paper, according to the China bicycle road traffic situation has carried on the classification to the passing events, and puts forward the analytical model to calculate the number of passing events, overcomes the lack of theoretical basis, the general model of bad, and quantitative analysis of the bicycle traffic flow parameters and road width for passing events [9]. The establishment of foreign events overtaking model mainly for road infrastructure two-way traffic bicycle smaller width, flow rate is low, the model does not conform to our country road traffic conditions, cannot be directly used for China's overtaking event modeling; domestic studies using statistical regression analysis is the relationship between events and the number of bicycle traffic flow parameters, complex rules bicycle overtaking behavior does not reveal the universal model, leading to smaller [10, 11].

This paper aims to present the micro individual characteristics in non-motorized traffic mixed of bicycles and mopeds. Modeling and simulation based on road bike, on the basis of the analysis of non-motorized traffic flow characteristics. The establishment of a model about non-motorized traffic between bicycles and mopeds used Matlab software. The experimental results show that, the model of speed, range and the measured data density and maximum capacity fitting is better. The vehicles in mixed model and simulation based on the proposed model, non friction disturbance and non block interference model based on the cellular automata, and has carried on the simulation analysis and the measured data.

II. CHARACTERISTIC ANALYSIS OF MIXED TRAFFIC FLOW

A. Non Interference in Mixed Traffic Flow Characteristic Analysis

The method of regression analysis is a mathematical tool to examine the relationships between the variables [12]. A lot of observations on traffic flow data, used to find the hidden in those who looked uncertain phenomenon of statistical laws of mathematical statistics method. Using the regression analysis technology, can find out the relationship between variables and the influence factors, model building experience. But the experience model of the lack of theoretical basis, do not have general applicability [13, 14].

The vehicle time space displacement diagram (Figure 1) due to the interference of bicycles total delay was basically section.

B. The Degree of Interference

To describe the degree of interference quantitatively, the definition of traffic flow interference degree based on traffic control mode in a certain process, in the interference region, time loss due to non- mutual crossing behavior of the ratio of the time required for the normal traffic [15, 16].

\[
x_i = \frac{a_1 + a_2 x_i + a_3 y_i}{a_4 x_i + a_5 y_i + 1} \\
y_i = \frac{a_6 + a_7 x_i + a_8 y_i}{a_9 x_i + a_10 y_i + 1}
\]

\[
x, y — Target points x and y coordinate on the field \\
x, y — Corresponding points x and y coordinate on the image \\
d_1 - d_n — factor
\]

\[
L = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}
\]

Null hypothesis \( H_0 \):

\[
F(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} e^{-(x - \mu)^2/2\sigma^2} dx, -\infty < x < +\infty
\]

C. Bicycle Through the Right Turn Vehicle Gap Defined

In the mutual crossing behavior of bicycles and mopeds, from the analysis of non signal intersection can pass through the gap theory, the definition of a traffic individual in the face of a traffic flow duration, duration is defined through the gap is selected when the traffic flow is through the gap, the gap is not selected for denial of clearance, the minimum clearance allows for individual cross traffic critical gap.

\[
HL = \sum_{i=1}^{n} \frac{(y_i - n_i \hat{p}_i)^2}{n_i \hat{p}_i (1 - \hat{p}_i)}
\]

\[
f(x, \sigma, \epsilon) = \mu(x) e^{-\frac{(x - \mu)^2}{\sigma^2}}
\]

So the output of the first floor is:

\[
o_j^{(1)} = gauss2mf((x, \sigma, \epsilon)) = \mu(x)
\]

\[
= \epsilon ((\lambda_1 < c_2), e^{-\frac{(x - \mu)^2}{\sigma^2}} (else))
\]

\[
o_j^{(2)} = o_j^{(2)} \sum_{j=1}^{m} \alpha_j^{(2)}, (j = 1, 2, 3, 4...m)
\]

\[
o_k^{(3)} = \sum_{j=1}^{m} \gamma_k \alpha_j^{(3)} \quad k = (1, 2, 3, 4...m)
\]

\[
o_j^{(4)} = \sum_{k=1}^{r} \beta_k \alpha_j^{(4)} \quad k = (1, 2, 3, 4...m)
\]

\[
o_j^{(5)} = \sum_{k=1}^{r} \beta_k \alpha_j^{(5)} \quad k = (1, 2, 3, 4...m)
\]
III. MIXED TRAFFIC FLOW DATA COLLECTION METHOD

A. Definition and Classification of Passing Events

The physically separated non-motorized lane is the most common in our country, this kind of road cycling process without interference from the motor vehicle and pedestrian, bicycle traffic environment provides a more pure. Therefore, this paper focuses on the micro individual characteristics in non-motorized traffic mixed of bicycles and mopeds in our city.

There was primary research carried out on the interference characteristics of the mixed traffic. Klop J R [17]. set out of the factors influencing the driving of motor vehicles and the characteristics of the traffic flow on the mixed roads. Long X Q and Zhang X D [18,19] designed the relevant theoretical model in connection with the interference of non-motorized vehicles with motor vehicles that lack collection and quantitative analysis of the actual data. Qan D L. [20] analyzed the impact of signalized intersection interference on the velocity of mixed traffic flow. Qu Z W [21] studied the law of arrivals of bicycles and pedestrians in the signalized intersections. Wang D H [22] analyzed the mechanism of the conflicts between motor vehicles and non-motor vehicles. Jing T R [23] studied the issue on the isolation of bicycles from motor vehicles in the intersections of the urban areas of China. Daniels S[24] analyzed the interrelations between motor vehicles and non-motor vehicles under the condition of ring roads. Walker I [25] studied the behavior in which motor vehicles overtake non-motor vehicles and the factors that affect such behavior.

Roadway in the non physical separation of bicycle road width is larger, bicycle flow is higher, the overtaking events showing a variety of forms, and the influence of all kinds of overtaking form to the rider comfort has significant differences. The three classes were shown in Figure 2.

Active overtaking bicycle has at least 2 lanes can choose to complete the overtaking behavior, do not have to drive carefully to avoid transverse scratch, such event of the rider overtaking is comfortable, see Figure 2 (a).

2) Adjacent overtaking events

Adjacent overtaking event only has a lane for overtaking the bike. Adjacent active overtaking was forced to overtake the bicycle rider to complete the overtaking behavior, focus on careful drivers avoid horizontal scratch; such overtaking events on rider comfort have a negative effect, see Figure 2 (b).

3) Blocked overtaking events

Blocked events without adequate space for passing in front of the active overtaking to accomplish overtaking, overtaking the rider must slow down and driving the vehicle in front until the following, overtaking space accelerate the completion of overtaking, overtaking on such event rider comfort have a great impact, see Figure 2 (c).

Bicycle passing events refers the running process of the bicycle, needs extra attention to act beyond the rider to achieve, such as beyond the front speed bicycles and pedestrians, bicycles and pedestrians have to. Some scholars will bike overtaking (or meet) is defined as the traffic conflict, traffic incident in this paper to describe the overtaking behavior the unit of time, unit length section, once beyond the behavior defined rider completed as a passing events. Events overtaking cost extra attention and energy. The rider overtaking process more running events, show driving process hampered bigger, comfortable riding is worse.

B. The Specific Method for Extracting Data

1) Acquisition Methods for Traffic Flow

Select transect and count the number of bicycles \( n_1 \) and mopeds \( n_2 \) that get across transect during a certain time interval (in this work, the length of an interval is 5 seconds). Then the flow is:

\[
Q = \left( \frac{n_1 + n_2}{5 \times W_0} \right)
\]

where, \( Q \) — the flow of non-motorized vehicles; \( n_1 \) — the number of bicycles getting across the transect during a certain time interval; \( n_2 \) — the number of mopeds getting across the transect during a certain time interval; \( W_0 \) — effective width of the lane.

2) Acquisition Methods for Vehicles Speed

Set the number of frames for a vehicle traveling \( L = 10m \) is \( n \), and a frame takes 1/25 seconds, then the speed of the vehicle can be determined as follows:

\[
V_r = \frac{L \times 25}{n}
\]

where, \( V_r \) — the speed of the vehicle, m/s; \( L \) — the length of the observation interval (10m); \( n \) — the number of frames for a vehicle traveling 10m.

3) Acquisition Methods for Density
Count the number of bicycles and mopeds in the observation interval every 5 seconds. Taking into account the variation of vehicle density in the interval, in this study the average of the vehicle numbers \( k_i \) at three moments was adopted, and the vehicle density is the number of vehicles per square meter:

\[
k = \frac{1}{3} \sum_{i=1}^{3} \frac{k_i}{LW_i}
\]  

(9)

where, \( k \) —— density of non-motorized traffic flow; \( k_i \) —— number of vehicles in the \( i \) th image; \( L \) —— length of the observation interval (30m); \( W_i \) —— effective width of the lane.

C. Data Analysis Program

Here, typical road sections in Shanghai were selected for data collection. Wuning Road, Yang Gao Zhong Road and Gonghexin Road are important transport corridors for Shanghai city, which is located in the core area of this city. The shooting location was the footbridge. Data are extracted from 1.5 hours (Wu Ning Road) or two hours (Yang Gao zhong road and Gong he xin Road) videos.

The density and flow in every 5s are extracted from the video, and then merge to 30s. The overtaking number and characteristic value in every 30s are also extracted from the video. Road video screenshot below:

Since what we concern is the interaction between bicycles and mopeds, the following rules must be complied in the process of data screening: (a) mopeds and bicycles must be mixed travelling on the same road space, otherwise deleted; (b) distance headway in front of the mopeds must be large enough, otherwise deleted.

IV. EXPERIMENTAL RESULTS

A. Block of Motor Vehicle Traffic Flow on the Delay Model

The background information of 3 roads (Wuning road, Gonghexin road and Yang Gaozhong road) was shown as follows:

<table>
<thead>
<tr>
<th>Road Name</th>
<th>Shooting Time</th>
<th>Lane Width</th>
<th>Lane Valid Width</th>
<th>Observation Interval Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wuning Road</td>
<td>2013.3.14 7:00~8:30</td>
<td>3.5m</td>
<td>3.0m</td>
<td>30m</td>
</tr>
<tr>
<td>Yanggao Middle Road</td>
<td>2013.4.24 7:00~9:00</td>
<td>4m</td>
<td>3.5m</td>
<td>50m</td>
</tr>
<tr>
<td>Gonghexin Road</td>
<td>2013.4.23 7:00~9:00</td>
<td>5m</td>
<td>4.5m</td>
<td>30m</td>
</tr>
</tbody>
</table>

B. Delay Model of Discrete Flow Conditions

Mixed traffic flow data in non disturbance modeling and simulation needs to process data and can be divided into several sections of data. Analysis includes the moped and bicycles with and without interference by the speed of signal averaging and disturbance degree, distribution of static density bicycle parking line, right turning vehicle through the straight going bicycles critical gap and critical delay of right turn moped. In the block delay model, delay of vehicles and vehicle arrival headway, there is a close relationship. When the traffic density is in the road, interaction between vehicles characterized by mutual, the traffic flow is random, discrete flow to analyze the block the vehicle delay model, and the flow in the discrete delay model, for traffic flow to the Poisson distribution the more accurate description.

When the road vehicle flow density is high, the workshop there are constraints, the vehicles are not independent of each other, the traffic flow continuity
characteristics with fluid, using continuous flow analysis of block the vehicle delay model, while in the continuous casting error model, distribution vehicle distance affects the distribution probability model. Open section. As mentioned earlier, the headway distribution can often describe M3 distribution, negative exponential distribution and the displacement of the negative exponential distribution for two special cases of M3 distribution. Here’s to the headway obeys M3 distribution as an example to analyze the headway of the probability distribution of delay in opening.

The collected speed data samples of total of 651 samples were divided into 12 groups, from the frequency histogram speed distribution can be seen, which is close to the normal distribution probability density curve, so first by normal distribution goodness of fit test.

C. Bicycle Arrival Distribution

In order to study the speed behavior of bicycles in road, we choose to run on the bicycle free in 40 meters road upstream speed video shooting, and then collected the extraction of video data and velocity data obtained 688 groups of bicycle on the road.

Mixed traffic flow is the basic characteristic of our country city traffic, and the current domestic and foreign research on this aspect of the application and the data requirements, the critical gap are calculated with the Ruff method of right turn moped across the straight going bicycles are made, gap acceptance and refused clearance of the cumulative frequency curve, the point of two lines: as the critical gap, as shown in Figure 6.

![Figure 6. The point of road with two lines as the critical gap](image)

D. Bicycle Free Running Model

Research shows that: in the bicycle traffic is small; the distribution is applied to describe the bicycle to the distribution of statistics: when the bicycle traffic is very large, negative two distributions are suitable to describe certain conditions of the bicycle to the statistical distribution of the amount of land. The statistics of the bicycle traffic peak during the rush hour, with negative binomial fitting was shown in Figure 7.

![Figure 7. The bicycle 30s to reach the frequency distribution curve](image)

V. CONCLUSIONS

The physical separation of moped and bicycles overtaking was studied in our study. The overtaking and passing adjacent was blocked into three events, the experiments demonstrate the effectiveness of the overtaking model. The results show that the number of 3 kinds of events, overtaking, overtaking road bike with flow velocity and bicycle speed standard deviation increases with increasing trend; the increase in the number of lanes, passing events is mainly free overtaking events and adjacent overtaking events blocked, overtaking events was significantly reduced. According to the Shanghai road traffic situation has carried on the classification to the passing events, and puts forward the analytical model to calculate the number of passing things, overcomes the lack of theoretical basis, the general model of bad, and quantitative analysis of traffic flow parameters and road width for passing events. The model structure establishment is also applicable to non motor vehicles motorcycles in mixed traffic and bicycle. The mopeds and bicycles mixed sections of the overtaking event modeling, the results of the study can be a reference for bicycle road service level and city road based on the optimization overtaking number of events.
REFERENCES


