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# Research on the conflict between right-turn motor vehicles and straight non-motor vehicles

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## Abstract

**In most Chinese cities, non-motorized vehicles and motor vehicles are mixed on the road. Such scenes can be seen in many places, among which non-motorized vehicles are mainly composed of tricycles, bicycles, and electric vehicles. At plane signal intersections, there is competition between non-motor vehicles and motor vehicles for space-time resources. This mode of transportation not only increases the hidden danger of traffic accidents at the intersection, but also reduces the traffic capacity of the intersection. This paper analyzes the conflict and interference behavior between right-turning vehicles and non-motor vehicles going straight in the same direction through a typical signal intersection. On the basis of the actual measured data and the analysis of the vehicle running trajectory data, the method is analyzed by mathematical statistics. The reasons and related factors affecting the conflict between the two are analyzed, and the conflict model between the two is established by using the regression model.**

## Keywords

**Traffic conflict; right-turn traffic; straight traffic; Logistic.**

## 1. Introduction

### 1.1. Research background

Due to the rapid growth of my country's economy, the urban area is also rapidly increasing, and people's usual travel distance and time are also increasing accordingly. In the past, my country, which was a bicycle kingdom, is now unable to meet people's travel needs with ordinary bicycles. Therefore, the number of non-motorized vehicles and family cars began to increase rapidly.

Non-motor vehicles and motor vehicles have gradually become part of my country's urban transportation system, especially in small and medium-sized cities, where the phenomenon of mixed driving between the two is particularly serious. Especially at intersections, the combination of aircraft and non-aircraft not only increases the hidden danger of intersection accidents, but also greatly reduces the traffic capacity of the intersection. Therefore, this paper conducts in-depth research on the conflict between straight non-motor vehicles and right-turn motor vehicles at typical signal intersections, explores and analyzes the causes of the problem, so as to reduce some hidden dangers of the intersection to a certain extent, and can provide a good solution for the intersection. Setting the form and management of right-turn traffic provides a certain basis.

### 1.2. Research status at home and abroad

Qian Dalin and Niu Zhiqiang conducted research on the most common two-phase signalized intersections and found that right-turn traffic is most affected by mixed traffic. And through the gap acceptance theory and the traffic fluctuation theory, it is found that when the number of bicycles reaches 500-1500 per hour, the impact on the right-turning vehicles at the intersection is the greatest [1]. Guo Yanyong and Liu Pan et al. established a traffic conflict model by

extracting the traffic conflict data and traffic flow data of 20 intersections in Kunming, and studied the goodness of fit of the model and the factors affecting the conflict. Finally, through the calibration of the traffic conflict model, the selection process of the intersection channelization island is given, and the relationship between the intersection factors and the channelization is expressed [2]. Bao Yiting et al. established a new human-vehicle conflict simulation model by studying and analyzing the decision-making process of right-turning vehicles and the mechanism of human-vehicle conflict [3]. Werner Briton, Thorsten Miltner and others investigated the vehicle delays at two-way parking control intersections in consideration of the impact of conflicts between non-motor vehicles, pedestrians and motor vehicles, and based on this, they studied the basic traffic conditions of the traffic flow within the conflict range [4]. MohamedEssa, TarekSayed and others compared the traffic conflict data collected at two signalized intersections in Australia with the simulated data, obtained the correlation between the two, and compared with the actual data in China, and found that the left-hand traffic is significantly different from the right-hand traffic. There are still some differences between the traffic [5]. Peng Chen and Weiliang Zeng et al. verified the severity and number of intersection conflicts by placing each calibrated model on a simulation platform by collecting data from two intersections in Beijing. And through the analysis of sensitivity, it is shown that the size of the intersection and the intersection angle of the road are important factors affecting the safety of the intersection [6].

At present, the research on right-turn traffic and straight traffic at intersections in my country mainly focuses on the relationship between the capacity of right-turn vehicles and slow-moving traffic, and the traffic conflict between right-turn vehicles and straight-through vehicles. On the premise of soft channelization of signalized intersections, this paper explores the conflict between right-turning motor vehicles and non-motor vehicles going straight in the same direction.

## 2. Data investigation and extraction

This paper studies the relationship between right-turning motor vehicles and non-motor vehicles going straight in the same direction under the soft canalization of cross signal intersections, explores the microscopic activities of the two when they conflict at the intersection, and finally establishes the number of conflicts between the two. Model. Therefore, the main data collected in this paper are traffic conflict data, and the data collected next are within the intersection range.

### 2.1. Data investigation plan

In this survey, in order to make the obtained data representative and universal, a typical cross signal intersection is selected as the survey object. Since this paper mainly studies the right-turn traffic under the soft canalization setting, the selected intersection is the soft canalized intersection. Select an entryway to film. The intersection should meet the following requirements:

(1) The type of intersection is signal cross soft channelized intersection;

(2) The selected intersection should be conducive to shooting, requiring a good line of sight, without the obstruction of billboards, trees, etc.;

(3) The flow volume of the two types of traffic studied at the selected intersection is relatively large, so as to obtain more required conflict data;

(4) Since the research content of this paper is the right-turn traffic in the soft channel mode, the right-turn motor vehicle should not be controlled by the signal.

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## 2.2. Data extraction

Based on the above-mentioned original video, the required data is extracted through video playback software and video processing software. Since the article studies the conflict between two types of traffic, the required data types are roughly divided into 6 categories according to the needs of the article, namely feature class, flow class, time class, acceleration class, speed class and density class.

# 3. Analysis of traffic operation characteristics

## 3.1. Analysis of non-motor vehicle traffic characteristics

3.1.1 Analysis of non-motor vehicle types

According to the survey, electric vehicles account for a large proportion at intersections, accounting for 82% of all non-motor vehicles, and tricycles account for the smallest proportion, about 1%. In line with the transportation mode of urban residents, most residents use non-motorized vehicles for work needs. Compared with bicycles and tricycles, electric vehicles are not only faster but also labor-saving, so choosing electric vehicles is in line with the actual situation of urban residents' travel.

3.1.2 Analysis of spatiotemporal characteristics of non-motor vehicles

According to relevant data, non-motorized vehicles have the following characteristics in travel time:

(1) The traffic of non-motor vehicles gathers in the morning and evening peaks

The number of non-motorized trips in the morning and evening peaks accounts for a high proportion of all-day trips, and is concentrated in a short period of time.

(2) The peak occurrence time of non-motor vehicles and motor vehicles is staggered

Peak times for non-motor vehicles are often different from peak times for motor vehicles because non-motor vehicles travel at lower speeds than motor vehicles. And as the city gets bigger, this time also increases.

Spatial distribution of non-motorized traffic: The size of urban population density and the service level of public transportation will affect the spatial distribution of electric vehicles. Usually in the community and at the intersection of the branch road and the secondary road between the communities, the traffic volume of electric vehicles in one hour during peak hours will not reach 5,000 vehicles, but on the main roads in large and medium-sized cities, the hourly traffic volume during peak hours can be As many as 10,000 to 24,000 vehicles, and such intersections are basically located in urban areas and important industrial sites [7].

3.1.3 Agglomeration and dissipation characteristics

Due to the red light, non-motor vehicles sometimes need to wait at intersections. Unlike motor vehicles, non-motor vehicles show irregular waiting because there is no specific waiting lane. When the opposite green light is on, non-motor vehicles pass through the intersection. Because the route of non-motor vehicles is not fixed, when crossing the intersection, it has a certain lateral expansion, and because non-motor vehicles are very flexible, sometimes it will encroach on a large part of the intersection.

## 3.2. Analysis of traffic characteristics of right-turn motor vehicles

3.2.1 Types of right-turn motor vehicles

By sorting out the obtained data, it is found that during the morning peak period, the proportion of cars is very high, accounting for 95% of the total traffic, while the large vehicles only account for 5%, which is in line with the law of urban traffic. During the morning rush hour, more people use cars to go to work, and some cities have policies prohibiting the passage of some large

vehicles during the morning rush hour, so the proportion of cars in the morning rush hour is very high.

3.2.2 Arrival characteristics

Calculate the flow of right-turn motor vehicles arriving at the intersection every five minutes and convert them into standard vehicles. The results are shown in figure 1.

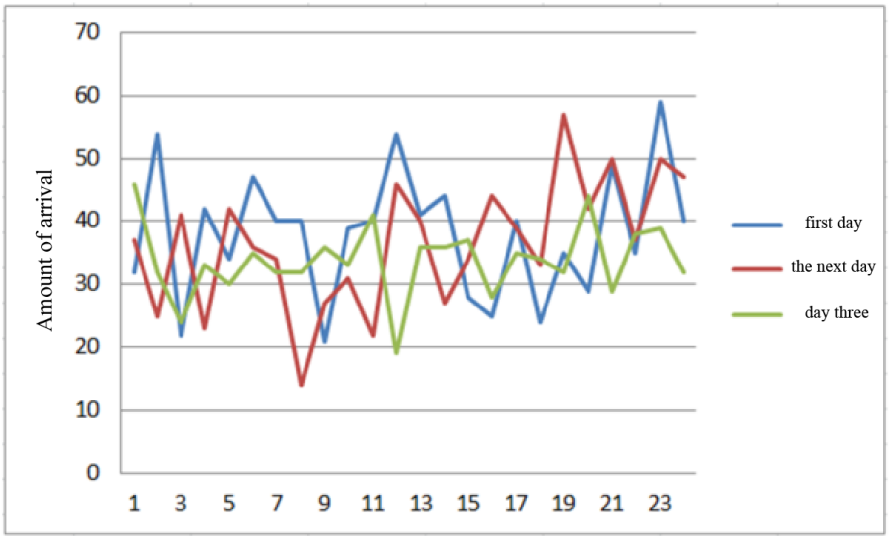


Fig.1 Flow every five minutes

As can be seen from the above figure, in the five-minute statistics during the morning peak period of these three days, the maximum arrival volume is about 60 vehicles, and the minimum arrival volume is about 15 vehicles. It can be seen that the number of right-turn motor vehicles per five minutes is between 30 and 40 vehicles, indicating that the arrival volume of right-turn vehicles every five minutes at this intersection is relatively stable during the morning rush hour without much fluctuation.

## 4. Traffic conflict analysis between right-turn motor vehicles and straight non-motor vehicles

Through the previous data investigation and arrangement, this chapter analyzes the traffic conflict between these two types of traffic through the data obtained from the investigation. First, the concept of conflict and the conflict area are clarified, and the conflict indicators are selected. Through analysis, since flow, speed and density are the three elements of traffic, through the data analysis of the two types of traffic in the conflict area, the conflict behavior of the two types of traffic is analyzed and studied, and a traffic conflict model is established on this basis.

### 4.1. Conflict area determination

4.1.1 Basic Concepts of Traffic Conflict

Although there are many explanations for traffic conflicts, so far, there is no uniform standard. In general, it is divided into two aspects. On the one hand, traffic conflicts are generated by motor vehicles, non-motor vehicles and pedestrians, and each person's psychology will change with the road, environment and other factors, so it cannot be measured by a unified standard. On the other hand, each traffic system has its own characteristics and differences, and the traffic conflict technology needs to be effective according to the characteristics of each traffic system.

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Therefore, due to the different characteristics of the transportation systems in different countries in the world, there are certain differences in definitions.

There are many definitions of traffic conflict today. As Hyden put forward the standardized definition: "traffic conflict is an observable situation in which two or more road users are close to each other in space and time, and if they keep their running trajectories unchanged, it may lead to a collision [8]. According to the actual traffic situation in my country, some domestic scholars have defined traffic conflicts. For example, Zhang Fangfang proposed that “traffic conflicts refer to the speed or speed of motor vehicles approaching each other in a certain space and time in order to avoid collisions. Traffic phenomenon with a significant change in direction [9].

This paper considers the traffic conflict behavior between two types of traffic, so the definition of traffic conflict is: under measurable conditions, when the two are close to each other in a certain time and space, in order to prevent the two from colliding, the two When at least one of the parties takes certain measures, such as changing the running trajectory, suddenly accelerating or decelerating, and stopping to move forward, it is a conflict between a right-turning motor vehicle and a non-motor vehicle running straight in the same direction.

4.1.2 Soft canalization conflict area

Qian Dalin et al. concluded that mixed traffic has the greatest impact on right-turning vehicles through the flow of different lanes at the intersection and the relationship between motor vehicles and non-motor vehicles. Taking the south entrance as an example, a motor vehicle turning right will be disturbed by non-motor vehicles going straight at the west entrance when the straight direction is red; when the straight direction is green, it will be disturbed by non-motor vehicles going straight at the south entrance. Therefore, the conflict area between right-turning motor vehicles and straight non-motor vehicles is determined as:

1). Taking the south entrance as an example, when the green light is in the straight direction, as shown in Figure 2 below, the conflicting area is the red area in the following figure. It is bounded by both sides of the north-south sidewalk and the extension of the right-turn motor vehicle exit lane.

2). Taking the south entrance road as an example, when the straight direction is a red light, the conflicting area is surrounded by the two sides of the east-west pedestrian crossing and the extension lines on both sides of the right-turning motor vehicle entrance road.

Since this paper is a research on the crossing between a right-turning vehicle and a non-motor vehicle traveling straight in the same direction, the type of conflict considered is shown in Figure 2.

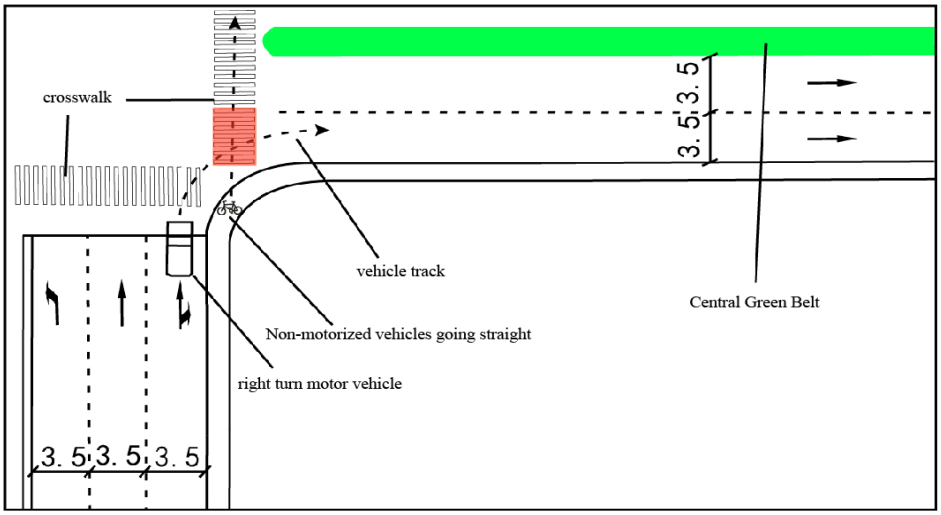


Fig.2 Conflict zone

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## 4.2. Selection of conflict indicators

The extraction of conflict data mainly lies in the identification and judgment of conflicts. Combined with the method used in the data survey in this paper, the time can be accurately measured. Therefore, this paper selects time as an indicator to divide serious conflicts and non-serious conflicts. Finally, this paper uses the time distance method to judge the severity of the traffic conflict. Among them, the PET index calculation is relatively simple, and only need to pay attention to two points: (1) the moment when the first vehicle leaves the conflict area; (2) the second vehicle arrives in the conflict area. moment. Another judgment index, TTC, needs to extract the instantaneous speed of the vehicle when avoiding danger, and then calculate the time from the current moment to the occurrence of the conflict, which is more difficult to measure than PET. The article will use PET in the time-distance discriminant method to determine the severity of traffic conflicts. When collecting the conflict data, because the traffic conflicts with PET less than 3.0s are serious conflicts [10], this paper only collects traffic conflicts with PET less than 3.0s.

## 4.3. Correlation analysis of influencing factors based on regression model

4.3.1 Conflict data survey

This paper uses the multiple regression analysis method of SPSS to analyze the influencing factors of traffic conflicts between the two types of traffic. Flow, speed and density are the three basic parameters of traffic flow. When traffic occurs, flow, speed and density are bound to occur. When non-motorized vehicles cross an intersection, due to the flexibility of their use and the uncertainty of their trajectory, their density will affect the traffic flow to a certain extent. As for the motor vehicle, its running trajectory is relatively stable, so the impact of its density on the traffic flow is negligible, so this paper does not study the density of right-turn motor vehicles.

4.3.2 SPSS regression analysis

Using SPSS multiple linear regression analysis, the analysis results are obtained as shown in Tables 1-3.

Table 1 Model summary

| Model | R | $R_f$ | Adjusted R-square | Error in Standard Estimation | change statistics | | | | | Durbin Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R-squared Variation | F Variation | DOF 1 | DOF 2 | Significant F change | |
| 1 | .965a | 0.932 | 0.875 | 2.752 | 0.932 | 16.400 | 5 | 6 | 0.002 | 1.529 |
| a. Predictors: (Constant), Non-Motorized Vehicle Density, Non-Motorized Vehicle Speed, Motor Vehicle Speed, Motor Vehicle Flow, Non-Motorized Traffic | | | | | | | | | | |
| b. Dependent Variable: Number of Conflicts | | | | | | | | | | |

Table 2 ANOVA

| Model | | sum of square | degrees of freedom | mean square | F | salience |
|---|---|---|---|---|---|---|
| 1 | return | 621.211 | 5 | 124.242 | 16.400 | .002b |
| | residual | 45.456 | 6 | 7.576 | | |
| | total | 666.667 | 11 | | | |
| a. Dependent Variable: Number of Conflicts | | | | | | |
| b. Predictors: (Constant), Non-Motorized Vehicle Density, Non-Motorized Vehicle Speed, Motor Vehicle Speed, Motor Vehicle Flow, Non-Motorized Traffic | | | | | | |

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Table 3 Coefficient

| Model | | Unstandardized coefficients | | standardized coefficient | t | significant | 95.0% confidence in B interval | |
|---|---|---|---|---|---|---|---|---|
| | | B | standard error | Beta | | | lower limit | upper limit |
| 1 | (constant) | -103.131 | 28.917 | | -3.566 | 0.012 | -173.888 | -32.374 |
| | motor vehicle traffic | 0.205 | 0.071 | 0.743 | 2.904 | 0.027 | 0.032 | 0.378 |
| | non-motorized traffic | 0.196 | 0.074 | 0.694 | 2.665 | 0.037 | 0.016 | 0.376 |
| | motor vehicle speed | 2.967 | 0.787 | 0.643 | 3.770 | 0.009 | 1.041 | 4.893 |
| | non-motorized speed | -1.079 | 1.325 | -0.191 | -0.815 | 0.446 | -4.321 | 2.163 |
| | Non-motorized vehicle density | 132.718 | 252.669 | 0.138 | 0.525 | 0.618 | -485.541 | 750.977 |

As shown in Table 1 above, the linear fitting equation can reflect 87.5% of the original data. R-squared stands for goodness of fit, which is a measure of how well the estimated model fits the observations. When the R square is greater than or equal to 0.6, it means that the linear equation fits well. Durbin-Watson is an effective method to test whether the model has autocorrelation. When the D-W statistic is between 1.5 and 2.5, it means that there is no significant autocorrelation. Table 1 above shows that the DW value is 1.529, so its autocorrelation is not considered. Sig represents the significance level. When Sig is less than 0.05, it indicates that the null hypothesis does not hold, indicating that at least one independent variable can have a significant impact on the dependent variable. As shown in Table 2 above, the value of the significance level Sig is 0.002, indicating that among all the independent variables (the flow, speed, and density of non-motor vehicles, and the flow and speed of right-turning motor vehicles), there is at least one independent variable pair. The dependent variable (number of conflicts) has a significant effect. As can be seen in Table 3, the flow and speed of motor vehicles and the flow of non-motor vehicles, the significance level is less than 0.05, so these three factors will have a significant impact on the number of conflicts, while the speed and density of non-motor vehicles have a significant impact on the number of conflicts The effect of numbers is not significant.

4.3.3 Construction of Traffic Conflict Model

After the SPSS linear regression analysis in the previous section, the relationship between the dependent variable (the number of conflicts) and the independent variables (the right-turn motor vehicle flow, speed, straight non-motor vehicle flow, speed, density) is obtained, namely:

$$N = -103.131 + 0.205X_1 + 0.196X_2 + 2.967X_3 - 1.079X_4 + 132.718X_5$$

Among them, N: the number of conflicts between the two; X1: right-turn motor vehicle flow; X2: straight non-motor vehicle flow; X3: right-turn motor vehicle speed; X4: straight non-motor vehicle speed; X5: straight non-motor vehicle density.

Combining the survey data and SPSS analysis results, it can be concluded that the impact of motor vehicle flow, speed, and non-motor vehicle flow on the number of conflicts is significant. At a plane intersection, with the increase of the two types of traffic flow, the possibility of conflict between the two will increase, and the number of conflicts will increase, while at the intersection, as the speed of the right-turn motor vehicle increases, The degree of conflict between the two types of traffic will also increase, which to a certain extent aggravates the generation of traffic conflicts at intersections. Straight non-motor vehicles have the characteristics of flexibility and instability in the driving process, and their speed when passing through the intersection has a negative impact on the number of conflicts. Because, in the actual environment, when the motor vehicle observes that the speed of the non-motor vehicle is very high, it will decelerate and give way in advance to prevent accidents, so this will have a negative impact to a certain extent.

The impact of non-motor vehicle density on traffic conflict is greater, but the significance is not very high. Reflected in practice, non-motor vehicles cross the street in groups, but right-turning motor vehicles turn right in an orderly manner. Usually, when the green light is on, a right-turning motor vehicle avoids multiple or even groups of non-motor vehicles and waits. A group of non-motor vehicles left and then continued to leave the intersection. Therefore, the number of collisions between the two types of traffic will continue to increase with the increase in the density of straight non-motorized vehicles.

## 5. Conclusion

Through this study, it is concluded that the flow and speed of right-turning motor vehicles and the flow of non-motor vehicles going straight have a significant impact on the number of conflicts between the two. The greater the flow of the two types of traffic at the intersection, the more likely the two traffic conflicts will occur, and the safety of the intersection will be greatly reduced at this time. And because the non-motor vehicle has lateral expansion when driving, it does not have a certain running trajectory like a motor vehicle, so that the motor vehicle needs to reduce the speed when turning right or even stop and wait for the non-motor vehicle to leave before driving away. To a certain extent, the traffic efficiency of right-turn vehicles at the intersection is reduced.

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