Research on the Influence of Lane Width on Drivers' Dangerous Lane Change Behavior on Urban Roads

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Abstract: Dangerous lane change behavior by drivers (DLCB) is defined as the behavior of the driver manipulating the vehicle to produce excessive lane change behavior, which causes a certain degree of danger to the surrounding vehicles or pedestrians. This paper investigates whether lane width and other factors have an impact on DLCB, and explores the correlation between them. Multiple linear regression was used to analyze the relationship between the number of dangerous lane changes and lane width, traffic flow, climate, light intensity and time. Based on the results of the fitting, it can be found that lane width and traffic volume can explain more than 73% of the changes in DLCB. In addition, the reason for the analysis error may be that the bus stop does not have a bus lane, which causes the bus behind to be forced to change lanes when the bus stops at the stop. At present, there is no specific relationship between lane width and DLCB, but it is only pointed out that there may be a correlation between the two. Therefore, the research in this paper can provide ideas for future road design and planning to a certain extent.

1 INTRODUCTION

Lane width generally refers to the width of the lane drawn on the road surface by markings, and the width is determined according to the vehicle type, vehicle speed, vehicle operation characteristics, etc. For a long time, it was widely believed that the wider the road, the safer it was (Zhu, 2023). The current road engineering design code in China uses the vehicle as the basic reference to determine the allocation of road space, resulting in a clear preference for motor vehicles in the right of way (Jiang 2022). Therefore, the lanes are generally designed to be wider. Theoretically, as the width of the lane decreases, the road capacity decreases. However, in practice, there is a high probability of uncivilized driving behaviors (arbitrary lane changes, speeding, irregular overtaking, etc.) in wide lanes, so a reasonable reduction and adjustment of lane widths can limit driving behavior and increase road capacity (Su 2022).

Lane change behavior is a driving behavior that occurs more often in road traffic. According to statistics, traffic accidents caused by inappropriate lane changes account for about 10% of the total number of accidents (Ning 2023). In addition, frequent lane changes in congested road sections will affect the overall traffic efficiency of traffic flow to a certain extent, causing traffic congestion (China Journal of Highway and Transport 2017). At present, the most widely used types of lane change are divided into mandatory lane change and arbitrary lane change (Qi 2020). Lane change behavior is related to the driver's hazard perception. Of all the skills related to driving, only hazard perception is closely related to traffic accidents (Wang 2019). Due to the driver's incomplete observation of the traffic environment, the distance between the vehicles that can be inserted in the target lane is small, which may cause the vehicle in the lane change to collide with the vehicle in front or behind the target lane (Xia 2022). Dangerous lane change can be defined as the behavior of the driver manipulating the vehicle to change lanes excessively, causing a certain degree of danger to surrounding vehicles or pedestrians. If the lane change time is defined by the lane change time, a lane change time of less than 3 s is considered a dangerous lane change (Qi 2020). Dangerous lane changes can be subdivided into frequent lane changes, S-shaped lane changes, continuous lane changes, and too fast lane changes.

This paper focuses on arbitrary lane change behavior and the influence of lane width on the

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number of dangerous lane changes of drivers is studied, and the factors such as traffic flow, climate, and light intensity are comprehensively considered.

2 METHOD

2.1 Data Sources and Descriptions

Combined with the street type and specific construction conditions, the minimum width of a motor lane in the road section can be narrowed to 2.85~3.25m according to different design speeds (Jiang 2022). In this paper, three urban roads with a width of 3.1 meters, 3.32 meters, and 3.45 meters were selected as the research objects, and a total of 25 minutes of traffic flow videos were taken in the morning (8 a.m. to 10 a.m.), noon (12 p.m. to 2p.m,), and evening (18 a.m. to 8:00 p.m.) during the week and on weekends, respectively, according to the ideas shown in Fig. 1. At the same time, the climate of the day is recorded.

2.2 Indicator Selection and Description

In this paper, the relationship between the number of dangerous lane changes and lane width, light intensity, traffic volume, and climatic conditions was studied every 5 minutes. Traffic volume is defined in this article as the total number of vehicles passing through during that period. In addition, considering that the number of lanes is different, it is difficult to compare the number of lane changes, so the three roads selected are all three lanes. Because the impact of buses, cars and motorcycles on the road is different, according to the vehicle conversion factor, a bus can be converted into two cars, and a car can be converted into two motorcycles, to convert the number of vehicles and the number of times of the driver's dangerous lane change behavior. Table 1 shows a portion of the DLCB of climate, temperature, light intensity, and traffic volume recorded at the time of data collection, as well as the measured lane width.

2.3 Method

Fig. 2 and Fig. 3 plot the relationship between the lane width and the traffic volume of the DLCB, respectively, and it can be seen that there is a linear relationship between the lane width and the traffic volume and the DLCB. Therefore, this paper is more suitable for multiple linear regression analysis to analyze the numbers.

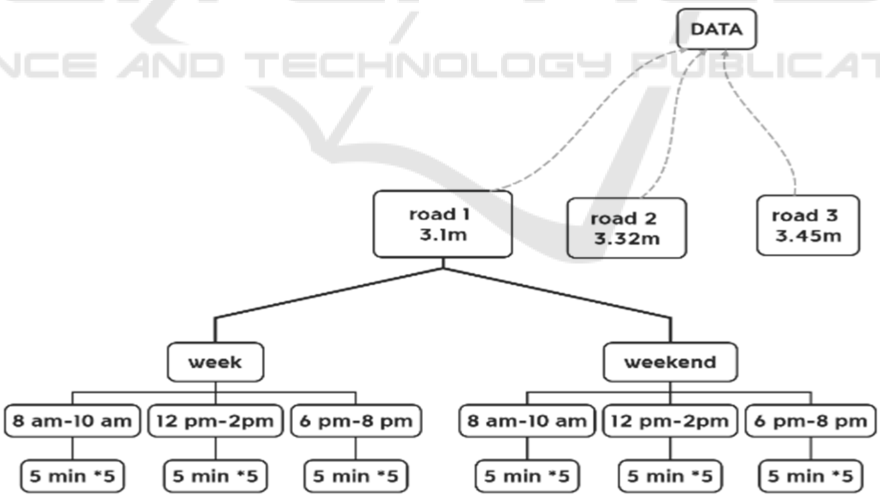

Figure 1: Data collection ideas (Original).

Table 1: Some data are displayed.

Numbering	Lane width/m	Time	Weather	Temp.	Light	Num. of vehicles	DLCB
1	3.1	12:35	cloudy	20	strong	113	3
2	3.32	9:50	Sun.	7	Weaker	164.5	6.5
3	3.45	12:40	cloudy	20	strong	216	7

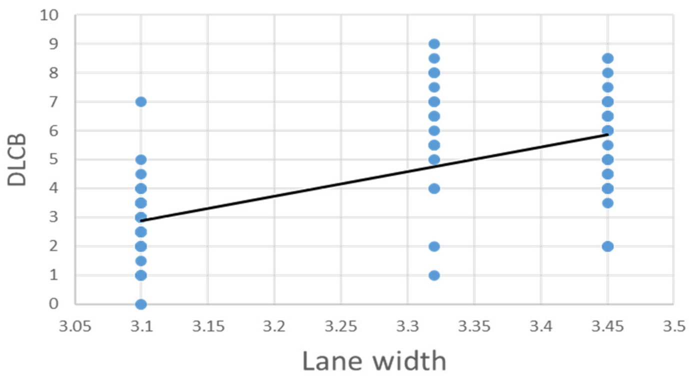

Figure 2: Scatterplot of the lane width and DLCB (Original).

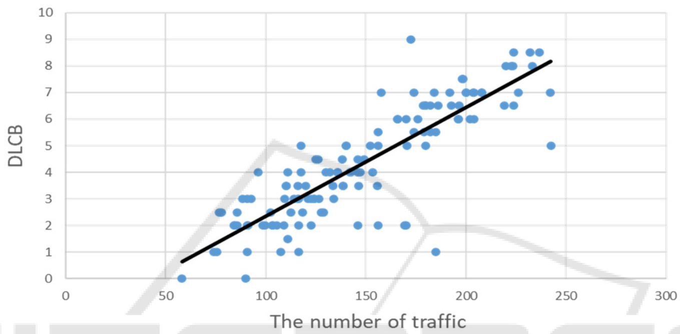

Figure 3: Scatterplot of the number of traffic and DLCB (Original).

Linear regression is a simple method of regression analysis that explores the linear relationship between two variables. Multiple linear regression is an extension of linear regression that explores the linear relationship between multiple independent variables and one dependent variable (Zhang 2022). The principle is to estimate the regression coefficient by minimizing the sum of squares of the residuals, so that the residuals between the predicted and observed values are minimized. It can help to understand the relationship between variables and can help us determine the effect of different independent variables on the dependent variable, and in turn, determine the most relevant independent variables (Jiang 2022). At the same time, it provides a hypothesis test on whether the regression coefficient is significant to help evaluate the statistical significance of the model. Therefore, it is appropriate to choose multiple linear regression in this paper.

This paper examines whether the number of dangerous lane changes is related to lane width. Therefore, linear regression can be used to study whether there is a correlation between the two, that is, the number of dangerous lane changes of drivers is the dependent variable Y, and the lane width is the independent variable X. At the same time, it is also necessary to consider the time (there may be differences in the state of the driver in the morning, noon and evening), climate environment, light intensity and other factors, so the data processing method can be used by multiple linear regression. In addition, in order to test the rationality of the model, 20% of the data were randomly selected for the test of the final regression equation, and the remaining 80% was used for regression training.

3 RESULT AND DISCUSSION

3.1 Data Analysis

The results of linear regression fitting are shown in Table 2 with lane width, traffic flow, weather, temperature and light intensity as the independent variables, and X_1, X_2, X_3, X_4, X_5 the number of dangerous lane changes of drivers as the dependent variables Y.

Table 2: Fitting results of traffic volume, lane width, climate, etc., to the number of DLCB.

	B	standard error	Beta	t	p	VIF	Tolerance
constant	-7.638	2.476	-	-3.085	0.003	-	-
Lane width	1.990	0.837	0.149	2.376	0.019	1.836	0.545
Traffic Num.	0.036	0.003	0.750	11.846	0.000	1.872	0.534
Weather	-0.116	0.202	-0.027	-0.576	0.566	1.050	0.952
temperature	0.003	0.015	0.011	0.231	0.818	1.091	0.917
Light intensity	0.122	0.098	0.059	1.245	0.216	1.061	0.943
R^2	0.743						
Adjust R^2	0.732						
F	F (5,120) =69.408, p=0.000						
D-W values	1.687						

Dependent variable: Number of dangerous lane change behavior
* p<0.05 ** p<0.01

Table 3: Linear regression analysis results.

	B	standard error	Beta	t	p	VIF	Tolerance
constant	-7.173	2.413	-	-2.973	0.004	-	-
Lane width	1.870	0.818	0.140	2.287	0.024	1.766	0.566
Traffic	0.036	0.003	0.761	12.427	0.000	1.766	0.566
R^2	0.739						
Adjust R^2	0.735						
F	F (2,123) =174.002, p=0.000						
D-W values	1.657						

Dependent variable: Number of dangerous lane change behavior
* p<0.05 ** p<0.01

As can be seen from the above table 2, the model formula is as follows:

$$Y = -10.660 + 2.893X_1 + 0.036X_2 - 0.077X_3 \quad (1)$$

The R 2 value of the model is 0.743, which means that lane width, traffic flow, weather, temperature, light intensity, and time can explain 74.3% of the change in the Number of dangerous lane change behavior. When the model was tested F, it was found that the model passed the F test, which means that at least one of the lane width, traffic flow, weather, temperature, light intensity, and time would affect the number of dangerous lane change behaviors. In addition, the multicollinearity of the model is tested, and it is found that all the VIF values in the model are less than 5, which means that there is no collinearity problem, and the D-W value is around the number 2, which indicates that there is no autocorrelation between the model and the sample data. According to the summary analysis of the t-test and the p-test, it can be found that the number of traffic, the lane width has a significant positive effect on the number of dangerous lane change behavior. However, weather, temperature, light intensity, and time of day do not affect the number of dangerous lane change behaviors.

Excluding the factors of weather, temperature, light intensity, and time, the results of linear regression fitting are shown in Table 3.

As can be seen from the table 3 above, the model formula is:

$$Y = -7.173 + 1.870X_1 + 0.036X_2 \quad (2)$$

The model R 2 value is 0.893, which means the lane width, and the traffic volume can explain 89.3% of the change in the number of dangerous lane change behaviors.

3.2 Discussion

According to the results of multiple linear regression fitting, it can be seen that there is a linear regression relationship between the number of dangerous lane change behaviors and lane width and traffic flow, but the fitting results can only explain 89.3% of the change reasons. This may be because there are bus stops on the selected section, but there are no bus lanes, so when the bus stops, the cars behind can only change lanes. However, the frequency, stop time, and number of stops on the three roads are not the same, so the influence of bus stops on the number of dangerous lane changes cannot be ruled out. Although it is not possible to rule out the influence of bus stops on the number of dangerous lane changes, it is clear that the number of dangerous lane changes of drivers is indeed related to lane width.

4 CONCLUSION

Dangerous lane change refers to a driver's behavior of excessively changing lanes, posing a certain degree of danger to surrounding vehicles or pedestrians. In this paper, three urban roads with different lane widths in Yan'an, Shaanxi Province, were selected to collect data on traffic flow, climate, and the number of dangerous switching behaviors in 5 minutes. Linear regression analysis was carried out with lane width, traffic flow, weather, temperature, light intensity, and time as independent variables, and the number of dangerous lane change behaviors of drivers as dependent variables. According to the final results, it can be found that the traffic flow of lane width significantly affects the number of dangerous lane change behaviors, and can explain 89.3% of the change of dangerous lane change behaviors. However, the bus stop does not set up a bus lane, which will have a significant impact on the driver to change lanes, so it will lead to a large part of the data test.

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