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REAL TIME PREDICTION OF CAMPUS RISK BASED ON ANALYTIC HIERARCHY PROCESS

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ABSTRACT
Traffic safety has always been a hot topic in society, and this problem also exists in the campus of colleges and universities. With the increasing number of motor vehicles and non motor vehicles in campus, traffic safety is more prominent. This paper takes Shandong University of technology as an example, excavates the risk sources of campus traffic safety, classifies the factors influencing traffic safety by AHP, forecasts them in real time, and prevents the occurrence of various campus traffic accidents.

KEYWORDS: Campus risk sources; Traffic safty; AHP; Rrisk evaluation

1. INTRODUCTION
Safety is the first criterion for students to study and live in school, and traffic safety is the primary consideration. However, in the university campus, there are many serious phenomena, such as people and vehicles passing in disorder, vehicles parking at will, complex roads, no clear signs and markings, students and staff's weak awareness of driving according to traffic rules, students in groups, crazy on the road, and playing with mobile phones. These factors lead to frequent campus accidents. In order to effectively prevent traffic accidents on campus, many scholars have investigated all kinds of traffic accidents on campus and put forward improvement measures. For example, Suthanaya P A [1] analyzed the type and quantity of vehicles on campus, and put forward management schemes for scooters, bicycles, electric vehicles and cars on campus, which solved the problems of chaotic traffic flow and disorderly parking and placing; V. V. Kholshchevnikov[2] recorded the risk sources in the school through field observation, established the fault tree model, analyzed the main causes of the accident, and concluded that human risk psychological factors were the most important risk factors; Shah J[3] analyzed the characteristics of road traffic in Colleges and universities, and put forward the view of introducing campus traffic safety laws and regulations and strengthening the study and safety education of road traffic safety law.

In the existing campus road management measures and proposed reform programs, most of them solve the campus traffic problems by means of safety education or vehicle management. Few of them put forward the program of early warning the risk sources by perceiving and identifying the campus risks. In this paper, through the establishment of risk level evaluation system, the use of analytic hierarchy process, questionnaire assisted method to analyze the risk sources existing in the campus, and through mathematical methods for grading, this method can effectively prevent the occurrence of traffic accidents, but also for future campus construction to play a reference.

2. MATERIALS AND METHODS

2.1 Risk sources of campus traffic environment
This paper mainly from the traffic flow, artificial environment and natural environment three angles to consider the factors affecting traffic safety. Through the field investigation of the traffic environment of university campus, it is found that the main risk sources are as follows:

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(1) Traffic flow

a. China's University Park covers a large area, so large campus makes students on campus can not walk alone, most students have their own bicycles or electric vehicles, in addition, there are a large number of shared bicycles for students to use, the school also provides students with school bus, staff usually drive to and from work. In addition to ordinary means of transportation, there are also student scooters and balance cars. It can be seen that the structure of traffic flow in campus is relatively complex.

b. The students' trip in university campus presents tidal traffic phenomenon. During the period of classes, the flow of people and cars is very large, while other times are relatively sparse. There is a sudden change in the flow. The change of flow has different impact on the traffic.

c. According to the regulations, the speed of motor vehicles in the campus can not exceed 30km / h, but from the actual observation, many vehicles do not drive according to the regulations, sometimes even at the speed of 50km / h. Speeding in campus is also one of the important causes of traffic accidents.

(2) Artificial environment

a. Most of the school roads are not isolated from the road, and the motor vehicle and non motor vehicle roads are not separated. During the peak hours, there is a chaotic traffic flow [4].

b. There are conflict points at some intersections, which have a certain impact on the traffic order.

c. In addition, whether the setting of crosswalk is reasonable is also one of the risk factors.

(3) Natural environment

In rainy, snowy and foggy weather conditions, the visibility will be reduced, the road will be wet and slippery [5], the pedestrians will walk slowly, the vehicles will slip, and the road traffic efficiency will be reduced, so the bad weather is also one of the risk sources affecting the campus traffic safety.

Traffic flow, artificial environment and natural environment are not isolated parts, so they should be considered together when analyzing their impact on traffic safety.

2.2 Risk level evaluation system

The risk level evaluation system is mainly composed of two parts: the first part is to determine the risk level of each factor. This part refers to the risk level division rules of "highway traffic safety situation assessment specification" and divides the campus risk according to the actual situation of the campus; The second part is to determine the weight coefficient of risk factors, which is also the key content of this chapter. Finally, the risk level can be obtained from the risk series and weight coefficient[6]. In this paper, analytic hierarchy process is used to calculate the weight coefficient of each risk factor to the decision-making goal, which needs to be assisted by questionnaire.

2.2.1 Risk index element risk grade

The structural composition of traffic flow is divided into three levels according to the risk levels of traffic flow, passenger flow and interference to driving; The sudden change of traffic flow can be divided into three levels according to the increase of traffic flow in 15 minutes compared with that in the last 15 minutes; Overspeed is divided into three levels according to the speed exceeding the school regulations, and the specific division is shown in Table 1.

Table 1. Classification of traffic flow risk series

	Risk level	Condition description
Structure composition	Level 1	People are not mixed, the traffic flow and people flow are small, and the driving order is good.
	Level 2	The mixture of motor and non motor vehicles and the large flow of non motor vehicles interfere with the driving.
	Level 3	The traffic flow of non motor vehicles and people is very large, and the driving order is chaotic.
Flow mutation	Level 1	15%<The traffic volume in 15 minutes of the road section is higher than that in the previous 15 minutes ≤ 30%

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	Level 2	30%<The traffic volume in 15 minutes of the road section is higher than that in the previous 15 minutes≤45%
	Level 3	45%<The traffic volume in 15 minutes of the road section is higher than that in the previous 15 minutes≤60%
Speeding	Level 1	10%<Prescribed speed on campus≤20%
	Level 2	20%<Prescribed speed on campus≤30%
	Level 3	30%<Prescribed speed on campus≤40%

The intersection is divided into two levels according to the number of conflict points and whether it has an impact on the traffic order; The road isolation is divided into two levels according to whether there is isolation and whether it has impact on the driving; Pedestrian crossing is divided into two levels according to whether the setting is reasonable, and the specific division is shown in Table 2.

Table 2. Risk grade division of artificial environment index

	Risk level	Condition description
Intersections	Level 1	There are fewer conflict points and better traffic order at intersections.
	Level 2	There are conflict points at intersections and the traffic order is poor.
Road isolation	Level 1	There is no isolation in the road, which has a slight impact on the traffic.
	Level 2	There is no isolation in the road, which affects the driving.
Pedestrian crossing	Level 1	There are crosswalks, which are reasonable.
	Level 2	The setting of pedestrian crossing is unreasonable.

According to the amount of rainfall, the index of rainy day is divided into three grades; According to the amount of snowfall, the risk level of snow index is divided into three levels; According to the visibility, the risk level of fog index is divided into three levels. The specific division is shown in Table 3.

Table 3 Classification of natural environment index risk series

	Risk level	Condition description
Rain	Level 1	Light rain, Precipitation<25mm/d
	Level 2	Heavy rain, 25mm/d≤Precipitation≤49.9mm/d
	Level 3	Rainstorm, 50mm/d≤Precipitation≤100mm/d
Snow	Level 1	Light snow, 0.1mm/d≤Snowfall≤2.4mm/d
	Level 2	Moderate snow, 2.5mm/d≤Snowfall≤4.9mm/d
	Level 3	Heavy snow, 5.0mm/d≤Snowfall≤9.9mm/d
Fog	Level 1	Mist, 200m<Visibility≤500m
	Level 2	Large fog, 100m<Visibility≤200m
	Level 3	Dense fog, 50m<Visibility≤100m

2.2.2 Determine the weight coefficient

To determine the weight coefficient, this paper uses analytic hierarchy process to determine the weight coefficient. Analytic hierarchy process (AHP) decomposes the indexes related to the conclusion into the levels of objective, criterion and scheme, which is a hierarchical weight decision-making method[7]. It is divided into five steps: find the evaluation index, establish the hierarchical structure model, construct the comparative judgment matrix, get the weight coefficient, and carry out the consistency test.

Establish evaluation index

The establishment of evaluation index is the first step and the key of the whole system evaluation. This paper starts from the actual traffic environment of university campus, excavates the factors that affect traffic safety, and determines the evaluation index according to the principles of representativeness, objectivity, measurability and comparability. The hierarchical structure is mainly divided into three layers. The first layer is the target layer, which is the problem to be solved; The second layer is the criterion layer, which is the first level index that affects the target layer[8]. Here, the traffic flow, natural environment and artificial environment are taken as the criterion layer,; The third layer is the index layer, which is the secondary index with subordinate relationship with the criterion layer, and nine elements with subordinate relationship with the criterion layer, such as structure composition, flow change, speed, intersection, road isolation, crosswalk, rain, snow and fog, are used as the index layer. Thus, the hierarchical structure model of campus traffic risk is established, as shown in Figure 1.

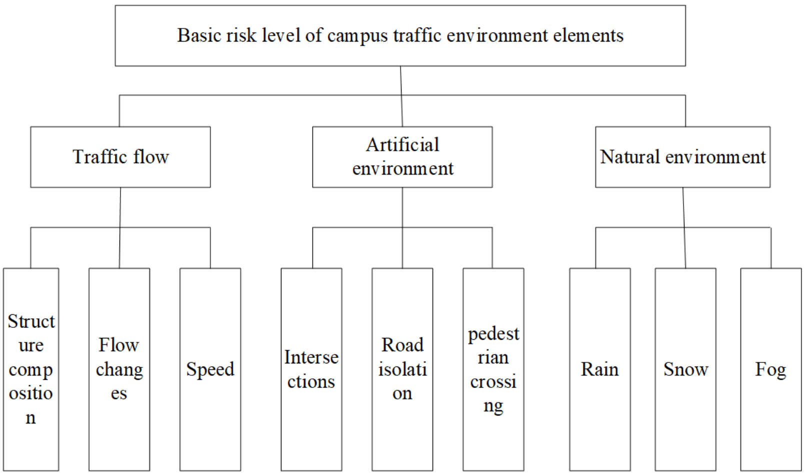

Figure 1. Hierarchical structure model

Weight coefficient of risk index elements

In order to obtain the weight coefficient of risk index elements, it is necessary to build a comparative judgment matrix, obtain the eigenvector and the maximum eigenvalue, and pass the consistency test. The number table of comparative judgment matrix is composed of the evaluation importance of each risk factor.

(1) Evaluate the importance

The importance of evaluation is mainly completed in the form of questionnaire. The respondents were mainly experts in the field of road traffic, senior drivers, school electric vehicles, cyclists and pedestrians. The importance of evaluation can be divided into nine grades: 1-9. The participants of the questionnaire rated each factor at the same level by comparing each other. In order to evaluate the accuracy of the results, the mean value is taken as the final evaluation result.

(2) Construction of comparative judgment matrix

The comparison judgment matrix AI of criterion layer B to target layer a and the comparison judgment matrix Bi of index layer C to criterion layer B are constructed respectively. The number table of the comparison matrix is composed of the following data: AIJ, the importance of this factor to the decision-making goal, and the data is obtained from the questionnaire; A_{ji} is the reciprocal of A_{ij}, a_{ii} is 1. The form of the comparison judgment matrix is as follows. According to the hierarchical structure model established above, the comparative judgment matrix is constructed, which includes the comparative judgment matrix of traffic flow, natural environment and artificial environment conditions on the basic risk level of campus traffic environment elements, the comparative judgment matrix of traffic flow structure composition, traffic flow mutation and vehicle speed on traffic flow, intersection, road isolation and traffic flow The comparison judgment matrix of crosswalk to artificial environment and the comparison judgment matrix of rain, snow and fog to natural environment.

$$A=(a_{ij})_{n\times n}=\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}$$

(3) Consistency test

a. The consistency test of hierarchical single sort

Hierarchical single ranking is to calculate the weight vector through the obtained comparative judgment matrix, and get the ranking weight of each factor in a certain level relative to the elements with subordinate relationship in the previous level. In this paper, the eigenvector and the largest eigenvalue are obtained by using the eigenvalue method, and the weight coefficient is obtained by normalization[9]. When the random consistency ratio CR < 0.1, pass the test, when CR > 0.1, need to revise the comparison matrix.

The random consistency ratio is obtained from the formula (i).

$$CR = \frac{CI}{RI} \quad \text{(i)}$$

RI is the randomness index, which can be obtained by looking up the table according to the order of the matrix. CI is the consistency test index, which can be obtained by the formula (ii).

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad \text{(ii)}$$

b. The consistency test of hierarchical total ranking

Tomographic total ranking is to get the relative importance of all elements in a certain layer to the highest layer, that is, the target layer, according to the order from top to bottom. The upper layer contains n elements A_1, A_2... A_n, and the total sorting weights are A_1, A_2... A_n respectively; The next layer contains n elements B_1, B_2... B_N. For the upper layer, the single sorting weights are b_{1j}, b_{2j}... B_{nj} respectively, then the total sorting weights of the next layer are calculated by formula (iii).

$$\sum_i^n a_i b_{ij} \quad \text{(iii)}$$

The formula for checking the consistency of hierarchical total ranking is as follows.

$$CR = \frac{a_1 CI_1 + \cdots a_n CI_n}{a_1 RI_1 + \cdots a_n RI_n}$$

2.2.3 Risk classification

The risk level is divided into five levels, namely low risk, low risk, general risk, high risk and high risk, as shown in Table 4.

Table 4. risk classification

Section	[0,1.6)	[1.6,3.2)	[3.2,4.8)	[4.8,6.4)	[6.4,8)
Risk level	Lowest risk	Lower risk	Low risk	Higher risk	Highest risk

Finally, the results are obtained by the formula, and the risk level is obtained according to the risk level table.

$$H = \sum_i^n P_i \omega_i$$

3. RESULTS AND DISCUSSION

Taking Shandong University of technology as an example to verify the practicability of the theory, the intersection in front of the third restaurant is selected, and the risk level of this intersection is calculated by the above method. This intersection is a special intersection, that is, Green Island East Road and Green Island West Road are a ring road. Because it is close to the restaurant and is a dormitory intensive area, the flow of people and traffic is very large at noon and in the evening, which leads to the complex road conditions at the intersection; There are many conflict points at roundabouts, and there are often conflicts between people and vehicles in the north-south direction and those in the east-west direction of green island; There are no crosswalks and no road separation; These reasons lead to frequent accidents here.

The following is to calculate the risk level of the intersection during lunch in a foggy day.

According to the risk classification table of index level, the risk level in foggy days with visibility greater than 200m but less than 500m is level 1; The structure of the traffic flow during the class is the mixture of human and non machine, the flow of non motor vehicles and people is very large, and the driving order is chaotic. At this

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time, the risk level is 3; The traffic flow of 11:55-12:10 at noon is the largest, which is 40% higher than that of the previous stage, and the risk level is level 2; There are many conflict points in this intersection, the traffic order is poor, the risk level is 2, there is no middle road isolation and crosswalk, the impact on traffic is small, the risk level is 1 and 2 respectively.

According to the comprehensive questionnaire, the comparison judgment matrix A1 of criterion layer B to target layer a and the comparison judgment matrix B1, B2 and B3 of index layer C to criterion layer B are as follows:

$$A=\begin{bmatrix} 1 & 2 & 4 \\ 1/2 & 1 & 3 \\ 1/4 & 1/3 & 1 \end{bmatrix}$$

$$B_1=\begin{bmatrix} 1 & 3 & 2 \\ 1/3 & 1 & 5 \\ 1/2 & 1/5 & 1 \end{bmatrix}$$

$$B_2=\begin{bmatrix} 1 & 5 & 7 \\ 1/5 & 1 & 4 \\ 1/7 & 1/4 & 1 \end{bmatrix}$$

$$B_3=\begin{bmatrix} 1 & 2 & 3 \\ 1/2 & 1 & 5 \\ 1/3 & 1/5 & 1 \end{bmatrix}$$

The maximum eigenvalues and corresponding eigenvectors of each matrix are obtained by eigenvalue method.

λ_{max} (A)=3.0183, ω_1 = (0.5584, 0.3196, 0.1219)

λ_{max} (B_1)=3.4683, ω_2 = (0.5241, 0.3420, 0.1339)

λ_{max} (B_2)=3.1237, ω_3 = (0.7223, 0.2050, 0.0727)

λ_{max} (B_3)=3.1632, ω_4 = (0.5076, 0.3791, 0.1133)

Take B_1 as an example to test the consistency. According to the table, RI = 0.52, formula $CI=\frac{\lambda_{max}-n}{n-1}$ = 0.00915, random consistency ratio $CR=\frac{CI}{RI}$ = 0.0175 < 0.1, passed the consistency test.

Finally, according to the formula $H=\sum_i^n P_i\omega_i$ = 5.1, the risk level is higher.

4. CONCLUSION

This paper starts with the existing risk sources on campus, finds out the factors influencing traffic safety by analyzing the risk sources, and establishes a comprehensive evaluation system of campus risk sources by using

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AHP and questionnaire. The application of this evaluation system to the campus of Shandong University of technology can effectively grade the risk sources, which proves the practicability of this method. According to this method, the potential risk sources in the campus can be effectively rated. When the campus environmental risk level reaches or exceeds the general risk, the corresponding improvement measures should be made in time according to the weight of each influencing factor and the rating results, which plays a positive role in preventing traffic accidents. The research of this paper is still insufficient. There are many factors involved in the study of traffic environment potential risk. In the selection of evaluation index, this paper only selects the risk factors that have a greater impact on safety as the evaluation index. In the next step of research, we will further improve the evaluation system and the risk level evaluation system.

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