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# Risk assessment model of traffic safety operation of urban road based on integration of vehicle-road-cloud

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**Abstract**

Accurate operational risk assessment model of urban road traffic safety is an important basis to reduce the probability of accidents. This paper constructs a risk assessment model of urban road traffic safety operation based on vehicle road aggregation. First, the braking response time of vehicles on urban roads is obtained, and the braking acceleration speed of vehicles is perceived, and the minimum safety threshold of vehicles is set, and the safe distance of roads is extracted. Then, cloud computing was used to fuse vehicle end perception data and road end perception data, and the clustering center of operation data was automatically determined by linear regression model and residual analysis, and the dimensions of different attribute data were determined by binary method. Finally, the risk index system of urban road traffic safety operation is constructed, and the risk evaluation model is designed by using fuzzy comprehensive evaluation method. The results show that the model can improve the accuracy of safe operation risk assessment.

*Keywords* **-** *vehicle end data perception, road data perception, cloud computing, cloud perception, regression model, vehicle road cloud integration*

## 1. Introduction

With the development of social economy, road construction has become an important medium for economic interaction among different cities. The infrastructure construction of social roads is becoming more and more perfect and traffic is more and more accessible. But the road traffic safety problem is becoming more and more serious [9]. With the continuous improvement of the road, the increasing of vehicles, frequent road traffic accidents, seriously endangering people's lives and property [14]. People's life rhythm is accelerating. In order to shorten the time required in the work road, most urban workers choose to drive and travel, which undoubtedly increases the traffic pressure on urban road and increases the risk of urban road traffic safety [1]. Therefore, how to reduce the risk of traffic safety and marketing safety traffic has become a hot issue in this field. Therefore, some researchers have put forward some effective methods to reduce the risk of safe operation.

Hu et al. [4] designed a vehicle operation risk assessment model based on fuzzy wavelet neural network. The road traffic safety is evaluated by the vehicle operation state. Firstly, the risk factors in vehicle driving are identified. Combined with the data of regional accidents, the main risks of accidents are determined by Bernoulli equation, and the probability of the occurrence risk is determined. On this basis, the evaluation index system is designed, and the risk assessment model is constructed by using the fuzzy wavelet neural network to complete the risk identification and evaluation. The model can effectively improve the prediction accuracy of accident probability, but there are few old donkeys in urban pavement, and further improvement is still needed. Qiu et al. [11] designed a risk assessment model of highway traffic based on influence coefficient. Firstly, the main risk indicators are aggregated, and the weight risk in the evaluation model is determined by the influence coefficient. The probability of collision in the free driving state of vehicles under different scenarios is designed. The wind risk increment is determined by setting the safety conditions and the same proportion of index gain, and the risk status evaluation is completed. The method divides the risk into levels, which improves the accuracy of the evaluation, but the operation process is complex and has great limitations. Deng et al. [2] proposed a new method of highway risk management based on critical fuzzy comprehensive analysis. This method sets traffic safety risk level for different urban pavement conditions, designs a risk identification method, uses the critical method to determine the weight of risk data, and constructs a road risk assessment model. Through the study of traffic safety status in a place, the paper analyzes the assessment of traffic safety by different influencing factors. The calculation accuracy of the method for the weight of risk factors is high, But the error of traffic safety risk assessment is higher in different situations, so it needs to be improved continuously.

In view of the problems existing in the above methods, this paper proposes to build a risk assessment model of urban road traffic safety operation based on vehicle road cloud integration. The technical route of this paper is as follows

(1) The reaction time of vehicle braking in urban road driving is obtained, and the friction coefficient of braking road surface is determined. According to the braking time threshold, the acceleration speed of vehicle braking is sensed, and the vehicle end data perception is completed.

(2) Set the minimum safety threshold of vehicle road, extract the safe distance of road when the vehicle is running, and realize the road operation data perception.

(3) In cloud perception, urban road data is fused with cloud computing, the clustering center of operation data is automatically determined by linear regression model and residual analysis, and the dimensions of different attribute data are determined by using binary method to realize the perception of urban road vehicle operation data.

(4) According to the integrated risk data of vehicle road cloud integration, the risk index system of urban road traffic safety operation is constructed. With the help of fuzzy comprehensive evaluation method, the factor set of urban road traffic safety operation risk index evaluation is set and mapped, Complete the design of urban road traffic safety operation risk assessment model under vehicle road cloud integration.

## 2. Urban road traffic operation data perception based on vehicle road cloud integration

In view of the rapid growth of urban traffic motorization trend, it is of great significance to improve vehicle operation safety, improve travel safety and avoid accidents that damage lives. Therefore, this paper first analyzes the research of vehicle road cloud integration. Through vehicle perception, road perception and cloud perception, the risk assessment model of urban road traffic safety operation is designed.

### *2.1. Car-side perception*

In the research of urban road traffic safety, vehicle end perception mainly refers to the perception of vehicle braking state data. When urban road vehicles are running, they are affected by vehicles from different directions, and the growth or deceleration of vehicles in operation is easy to lead to accidents. Due to the relatively slow driving speed of vehicles on urban roads, the frequency of scuffing and rear end collision is higher, and the steering angle of vehicles is smaller when there are more vehicles [10]. Therefore, in the vehicle perception, it is necessary to sense the vehicle starting and braking on the road. Firstly, the braking reaction time is analyzed in the vehicle end perception to get the vehicle end state after braking.

Assuming that the vehicle braking reaction time in urban road driving is $S_a$, brabrake time is $S_b$ , the difference of vehicle braking mode is also the key factor to reflect the market. Generally, the hydraulic braking time is less than 0.4s, and the pneumatic braking time is less than 0.6s. At this time, the response results of urban road vehicle braking are as follows:

$$S = \frac{C}{0.4\ V \times U} - \frac{S_b}{2} \tag{1}$$

where C represents the operating speed, V represents the gravitational acceleration, U represents the roughness of the pavement.

When vehicles are running on urban roads, the roughness of the road affects the effect of perception data [7], and has a direct impact on its braking response. Therefore, the friction coefficient of pavement should be considered

$$U = \sum_{i=1}^{n} C \times Y \times t \tag{2}$$

where Y represents a coefficient of friction, t represents the response time length.

In vehicle end perception, different states of vehicle driving reflect different risk states. When an accident occurs, it is necessary to sense the accident risk signal and the length of the accident

$$G_x = S_a + S_b + \frac{C}{0.4\ V \times U\mu} \varepsilon \tag{3}$$

where $G_x$ represents the accident signal, μ represents the final reflected time length, and ε represents the time threshold.

In road driving, when the adjacent vehicles decelerate, keeping the safe distance is an important part of perception. Safe vehicle distance refers to the distance between the head and tail of two vehicles. In case of an accident, the safe distance between two vehicles shall be maintained after emergency braking

$$F = f_s + f_e - f_f \tag{4}$$

where $f_s$ represents the current vehicle distance, $f_e$ represents the exercise error distance, and$f_f$ represents the distance of adjacent vehicles.

During vehicle braking, the perception of its force increase data is also an important content to improve safety [3]. This force increase process is a short time, deceleration shows a straight rise trend, in order to perceive the force increase speed of the vehicle when braking, to obtain:

$$f_v = hS_a + \frac{1}{2} d_{max} + S_b \tag{5}$$

where $h$ represents deceleration and $d_{max}$ represents maximum response length of braking.

In the end perception, the vehicle braking response time is obtained and the friction coefficient of the braking road is determined. According to the time threshold of braking, the speed of force increase is perceived during the braking process, and the data perception of the vehicle end in the model design is completed.

### *2.2. End of road perception*

On the basis of the above vehicle sensing data, the road sensing data is obtained. In this perception stage, we mainly obtain the accident risk data of urban road data. Rear end collision is the most frequent accident in traffic accidents. Therefore, in the road end perception, data similar to rear end collision is obtained. The fixed safety distance model can be expressed as follows:

$$K = l \tag{6}$$

where $K$ represents a safe distance, $l$ represents the distance constant, The value is a fixed value. And this value is an alarm threshold. When the spacing between the vehicles is $K < 1$, represents the probability of risk.

However, according to the above set safety distance, the situation of road perception is less [8]. Therefore, it is necessary to consider the influence of various factors, and the set safety distance obtained is as follows:

$$p = [p_1 + p_2 + p_3 + p_4]r \tag{7}$$

wherep $p$ represents different risk data on road surface and $r$ represents interference coefficient.

In road operation data perception, the minimum safety threshold of vehicle road is designed, and the safe distance of road is extracted to realize road operation data perception.

### *2.3. Cloud awareness*

Cloud sensing refers to the method of processing and saving the above-mentioned vehicle and road operation data with the help of cloud computing technology. Because there are many similar data in the above data. Therefore, in cloud perception, cloud computing [5] is used to process urban road data, and the cloud computing architecture is shown in Figure 1.

Firstly, the characteristics of road vehicle operation data are analyzed, and the data are divided into three categories: numerical dominant, classified dominant and balanced data. Then, the characteristics of operation data in different situations are clarified, and the corresponding distance measurement method is selected to determine the density and distance of each point in the road vehicle operation data set [15], The cluster center of running data is automatically determined by linear regression model [6] and residual analysis.

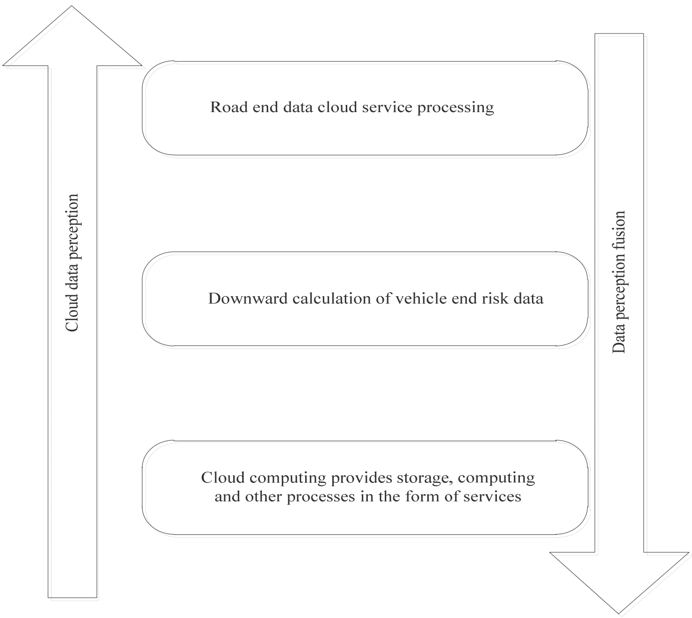


Fig. 1 - Cloud computing architecture

The road operation data set is set as follows:

$$Q = \{q_1, q_2, \dots q_i . . q_n .\} \tag{8}$$

Each kind of running data has a certain dimension, and its dimension attributes are represented as:

$$Q' = \{q_1', q_{2''}, \dots q_i' . . q_n' . q_i^d\} \tag{9}$$

where d represents the run data property, and i represents the classification attribute.

Introduction of the predominant factor α, Then the attribute ratio results of running data are taken as the optimal standard of cloud computing data processing. If present:

$$\frac{r}{d} > \alpha \tag{10}$$

It indicates that the running data set is valid data, if present,

$$\frac{q}{d} > \alpha \tag{11}$$

It indicates that the dataset data is invalid data.

In the cloud perception preprocessing stage, some known data with class labels are randomly selected from the training data set, and the training data object is obtained dimension attributes [12]. After processing, we need to solve the distance between different attributes of road running data to get the final preprocessed data.

SuPPose the numerical property distance of any two pavement running data $x_i, x_j$ is:

$$d(x_i, x_j) = \sqrt{\sum_{q=1}^{n} (x_i, x_j)^2} \tag{12}$$

If each dimensional distance in the classification attribute of any two running data state $x_i, x_j$ uses a binary method, the distance is:

$$d(x_i, x_j) = \begin{cases} 0, x_i^p = x_j^p \\ 1, x_i^p \neq x_j^p \end{cases} \tag{13}$$

For any two numeric objects, $x_i, x_j$, their attribute distance can be represented as:

$$d(x_i, x_j)_n = \sum_{p=1}^{r} (d \ x_i^p) - x_j^p \tag{14}$$

In cloud perception, urban road data is processed by cloud computing, the clustering center of operation data is automatically determined by linear regression model and residual analysis, and the dimensions of different attribute data are determined by using binary method to realize the perception of urban road vehicle operation data.

## 3. Construction of urban road traffic safety operation risk assessment model

Based on the data of urban road traffic operation extracted from the vehicle road cloud integration, the risk assessment of urban road traffic safety operation is realized and traffic safety is guaranteed. The evaluation model is built with the help of these data. Firstly, the risk index of urban road traffic safety operation is determined. According to the integrated risk data of vehicle road cloud integration, the data leading to risk is determined [13]. The risk index system is shown in Figure 2. Figure 2 divides urban road traffic safety operation risk index into three parts, including vehicle abnormal driving risk data, vehicle abnormal driving sub risk data and vehicle deviation risk data. The risk index system of urban road traffic safety operation is designed.

In the risk index of traffic safety operation of urban road, the abnormal driving risk data of vehicles can be expressed as follows:

$$B = \sum r_i \times P_J \tag{15}$$

where $r_i$ represents the risk data, $P_J$ represents the risk index, and B represents the abnormal driving data.

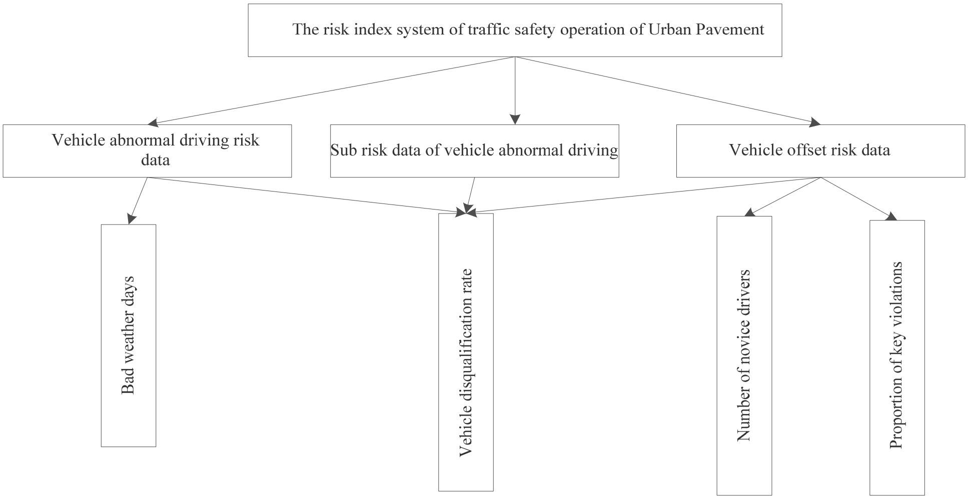


Fig. 2 - Urban road traffic safety operation risk index system

According to the above, the risk index of urban road traffic safety operation is determined, and the risk assessment model of urban road traffic safety operation is constructed. With the help of fuzzy comprehensive evaluation method, this paper constructs the risk assessment model of urban road traffic safety operation.

The set of risk indicators for urban road traffic safety operation is as follows

$$O = \{o_1, o_2 \ldots o_n\} \tag{16}$$

The risk assessment set is constructed

$$M = \{m_1, m_2, \ldots m_m\} \tag{17}$$

The risk factors of urban road traffic safety operation are mapped

$$y: U \rightarrow F(v), \forall u_i \in U \tag{18}$$

According to the mapped risk factors of road traffic safety operation, the risk judgment matrix is determined

$$Z = \begin{bmatrix} z_{11}, z_{12} \ldots z_{1m} \\ z_{21}, z_{22} \ldots z_{2m} \\ \ldots. \\ z_{n1}, z_{n2} \ldots z_{nm} \end{bmatrix} \tag{19}$$

where $z$ represents the weight factors of different road traffic safety operation.

On this basis, the risk assessment model of urban road traffic safety operation is built. Set different weights for each risk factor factor obtained above and represent it as a fuzzy subset, namely:

$$L = (l_1, l_2 \ldots l_n) \tag{20}$$

And it exists:

$$\sum_{i=1}^{n} b_i = 1 \tag{21}$$

On this basis, the risk assessment model of urban road traffic safety operation is built. Set different weights for each risk factor factor obtained above and represent it as a fuzzy subset, namely:

$$k_A = \frac{\sum_{i=1}^{n} v_i \times h_i}{\sum_{i=1}^{n} v_i'} \tag{22}$$

where $k_A$ represents the risk value of road traffic safety operation, $v_i$ represents the driving risk index, and $v_i'$ represents the risk evaluation index.

According to the integrated risk data of vehicle road cloud integration, the risk index system of urban road traffic safety operation is constructed. With the help of fuzzy comprehensive evaluation method, the risk evaluation model of urban road traffic safety operation is constructed, and the factor set of urban road traffic safety operation risk index evaluation is set and mapped, Complete the design of urban road traffic safety operation risk assessment model under vehicle road cloud integration.

## 4. Experimental analysis

### *4.1. Experimental scheme design*

In order to improve the traffic safety of urban road, the experimental analysis is designed. In the experiment, a central road in a city is selected as the research object, and 1000 meters of the road section is selected as the road section to study the traffic safety operation risk of the urban road. The road section is the core and core of the center location, and the risk probability of the road section in 5 working days is monitored.

The experimental research scenarios are set up in this section. The specific scene parameters are shown in Table 1.

### *4.2. Experimental index setting*

According to the setting of the above experimental scheme, this paper compares the model, the risk assessment model of fuzzy wavelet neural network and the risk assessment model based on the influence coefficient in the experiment, and takes the accuracy and time cost of the assessment as indicators. In order to ensure the effectiveness of the experiment, the experiment is carried out for more than 100 iterations, and the generated experimental data is processed by SPSS software.

### *4.3. Result analysis*

In the experiment, the model, the risk assessment model based on fuzzy wavelet neural network and the risk assessment model based on influence coefficient are compared for the accuracy of urban road traffic safety operation risk assessment of sample roads. The results are shown in Figure 3.

The results of the experiment in Figure 3 show that with the continuous changes of iterations, there are some differences in the accuracy of the risk assessment of urban road traffic safety in this paper, the fuzzy wavelet neural network and the risk assessment model based on the influence coefficient.

Tab. 1- Urban road traffic safety operation scenario parameters

| Scene Number | Risk category | Road conditions | Accident |
|---|---|---|---|
| 1 | Crowd | Straight section | Violation of traffic regulations |
| 2 | Automobile | Poor section without signal | Too fast in speed |
| 3 | Automobile | Poor signal section | Running a red light |
| 4 | Non-Motor Vehicle | Straight section | Across |

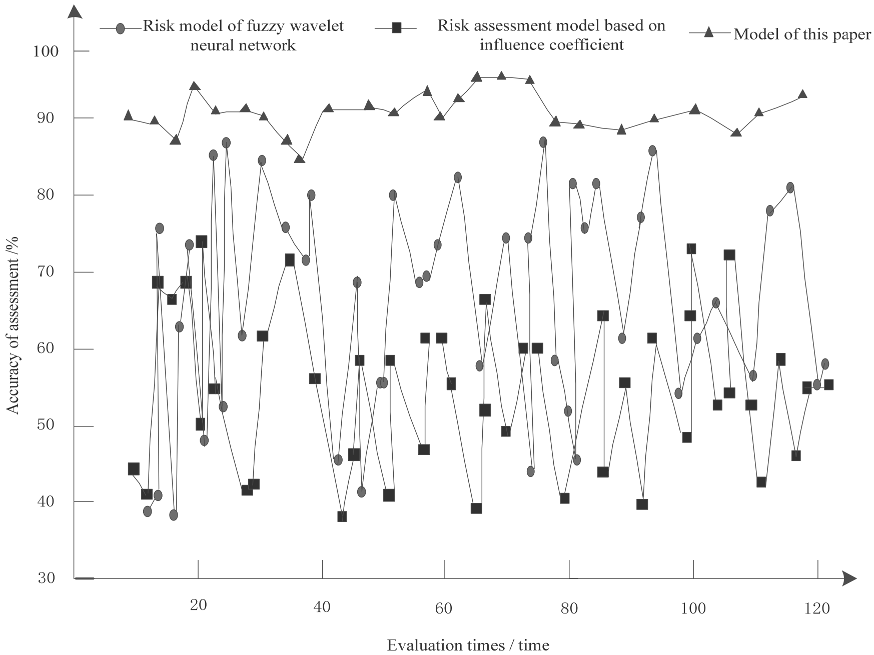


Fig. 3 - Accuracy analysis of urban road traffic safety operation risk assessment of sample roads

Among them, the risk assessment model of fuzzy wavelet neural network and the risk assessment model based on influence coefficient have a high accuracy volatility and low value for the risk assessment of urban road traffic safety operation. Although there is a certain fluctuation in the evaluation process, the model is always superior to the other two models, and it is always higher than 85%. The reason that the accuracy of the fuzzy wavelet neural network risk assessment model and the risk assessment model based on the influence coefficient fluctuates constantly is that the data of the risk caused by urban pavement changes rapidly and much, which can not be processed in time. This paper analyzes the change of road risk factors accurately by integrating vehicle, Road and cloud data, Therefore, the effectiveness of this method is improved.

The experiment further analyzes the time cost of this model, the risk assessment model of fuzzy wavelet neural network and the risk assessment model based on the influence coefficient for the urban road traffic safety operation risk assessment of the sample road.

The data in Figure 4 show that the time cost of the risk assessment of sample road operation is different by using three models under the same experimental environment. Among them, the time cost of the risk assessment of urban road traffic safety in this model is always lower than 2S, while the time cost of other two models for the risk assessment of urban road traffic safety operation is always higher than that of this model. This is because according to the integrated risk data of vehicle road cloud integration, the paper constructs the risk index system of urban road traffic safety operation, sets up the factor set and maps the risk index evaluation of urban road traffic safety operation by means of fuzzy comprehensive evaluation method, and completes the design of risk assessment model for urban road traffic safety operation under the integration of vehicle road and cloud, The risk of assessment can be shortened by the designed model.

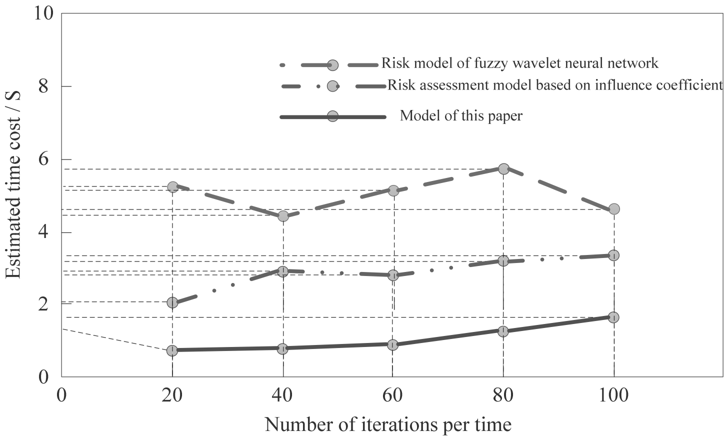


Fig. 4 - Time cost of urban road traffic safety operation risk assessment of sample roads

## 5. Conclusion

In view of the problems of low accuracy and long time cost in the existing urban road traffic safety operation risk assessment, this paper proposes an urban road traffic safety operation risk assessment model based on vehicle road cloud integration. The reaction time of vehicle braking on urban road is obtained, and the friction coefficient of braking road is determined. According to the time threshold of braking, the speed of force increase during vehicle braking is sensed, and the data perception of vehicle end is completed, set the minimum safety threshold of vehicle road, extract the safe distance of the road when the vehicle is running, and realize the road end data perception. The vehicle end perception and road end perception data are fused through cloud computing, and the clustering center of operation data is automatically determined through linear regression model and residual analysis, and the dimensions of different attribute data are determined by binary method to complete the cloud perception of urban road vehicle operation data. On this basis, the risk index of urban road traffic safety operation is determined. According to the integrated risk data of vehicle road cloud integration, the risk index system of urban road traffic safety operation is constructed, and the risk assessment model design of urban road traffic safety operation under vehicle road cloud integration is completed. The model designed in this paper has the following advantages:

(1) The proposed model can improve the accuracy of urban road traffic safety operation risk assessment, which is higher than 85% of the traditional method,

(2) Using the proposed model can improve the safety of urban road traffic operation, and the time cost of risk assessment is shorter, which is always less than 2 s.

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## References

1. Alsobky, A., Mousa, R. (2020). Estimating free flow speed using Google Maps API: accuracy, limitations, and applications. *Advances in Transportation Studies*, 50, PP. 49-64
2. Den, W., Wei. Z., LIU, T. Z., PU, W. P. (2019). Risk Management of Mountain Highway Based on CIRITIC-Fuzzy Comprehensive Analysis Method. *Science Technology and Engineering*, 19(29), PP. 339-343 .
3. Deng, Z., Huang, D., Liu, J., Mi, B., Liu, Y. (2020). An Assessment Method for Traffic State Vulnerability Based on a Cloud Model for Urban Road Network Traffic Systems. *IEEE Transactions on Intelligent Transportation Systems*, 15(19), PP. 1-14.
4. Hao, X. L., Shu, L. B. (2021). A Distributed Hydrodynamic Model for Urban Storm Flood Risk Assessment. *Journal of Hydrology*, (1–2), PP. 126513.
5. Huang, J., Wu, Y., Sun, J. (2021). Health risk assessment of heavy metal(loid)s in park soils of the largest megacity in China by using Monte Carlo simulation coupled with Positive matrix factorization model. *Journal of Hazardous Materials*, 415(14), PP. 125629-125635.
6. Hu, L.W., Ling, H.H., Yang, J.Q., Zhao, X.T., Yin, Y., Tian, H. L. (2020). On the risk assessment model for commercial vehicles in business operation based on the fuzzy wavelet neural network. *Journal of Safety and Environment*, 20(3), PP. 862-870.
7. Li, X., Erpicum, S., Mignot, E., Rivière, N., Pirotton, M. Dewals, B. (2020). Numerical Insights in to the Effects of Model Geometric Distortion in Laboratory Experiments of Urban Flooding. *Water Resources Research*, 56(7), PP. 1029-1034.
8. Meng, X., Chang, J., Wang, X., Wang, Y., Wang, Z. (2019). Flood control operation coupled with risk assessment for cascade reservoirs. *Journal of Hydrology*, 572(02), PP. 543-555.
9. Pamula, T. (2019). Impact of Data Loss for Prediction of Traffic Flow on an Urban Road Using Neural Networks. *IEEE Transactions on Intelligent Transportation Systems*, 15(02), PP. 1142-1146.
10. Qiu, L., Cheng, D., Deng, Z.G., Liu, J.B., MA, X. L. (2020). An Expressway Driving Risk Assessment Model Based on Influence Coefficient. *Journal of Highway and Transportation Research and Development* , 37(3), PP. 123-129.
11. Ujjwal, J., Bandyopadhyaya,V., Bandyopadhyaya,R. (2021). Identifying key determinants for parking management to reduce road traffic congestion for congested cities – A Structural Equation Modelling approach. *Advances in Transportation Studies*, 54, PP. 143-158.
12. Xue, H., Ding, D., Zhang, Z. (2021). A fuzzy system of operation safety assessment using multi-model linkage and multi-stage collaboration for in-wheel motor. *IEEE Transactions on Fuzzy Systems*, 16(99), PP.1-1.
13. Xue, Y. L., Hao, Y. Z. (2021). Main Road Signal light Pass Reliable Measurement Evaluation Simulation. *Computer Simulation*, 38(3), PP. 73-77 .
14. Zhang, Z., Wang, Y., Tan, F., Bao, M. , Chen, J. (2019). Characteristics and risk assessment of organophosphorus flame retardants in urban road dust of Dalian, Northeast China. *Science of The Total Environment*, 705(12), PP. 135995-135998.
15. Zheng, F., Liu, X., Zuylen, H. V. (2019). A methodological framework of travel time distribution estimation for urban signalized arterial roads. *Operations Research*, 59(1-2), PP. 115-117.