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# Innovative Application of Highway Traffic Safety Hazard Investigation and Accident Prevention Technology

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**Abstract:** With the continuous improvement of China's economic level, China has increased its efforts in the construction of transportation infrastructure. The number and mileage of highways in China are constantly increasing, which requires us to strengthen the investigation of road safety hazards on highways. Once road safety hazards are found, they must be dealt with in a timely manner to effectively ensure the road safety of highways and provide guarantees for the driving safety of the people.

**Keywords:** Expressway;Hidden danger investigation; BP neural network; Risk prediction

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## Introduction

The construction of the highway network plays an important role in the development of China's economic level and the improvement of people's living standards. The investigation and management of road safety hazards are of great significance in reducing and preventing highway safety accidents. Therefore, how to do a good job in the investigation and management of highway road safety hazards has become the most important part of current highway management work.

## 1. Risk prediction theory

### 1.1 BP neural network

The BP neural network can learn and store the mapping relationship between input and output vectors. Based on the principles of gradient method and steepest descent method, it continuously adjusts the internal node connection weights and node output thresholds of the network to minimize the total error of the network. The expected vehicle speed prediction adopts a BP neural network, with rainfall, visibility, flow rate, and truck mixing rate as input layer parameters and speed as output layer parameters, to construct a double-layer hidden layer with 9 nodes.

### 1.2 Wavelet neural network

The wavelet neural network is based on the topology of the BP neural network and uses the wavelet basis function as the hidden layer node transfer function. The flow is a non-stationary sequence with strong time-varying characteristics, which is related to the flow of the first few periods of the same road section and has a periodicity within 24 hours, making it suitable for wavelet neural network prediction.

## 2. Data preprocessing

There are varying degrees of deficiencies and anomalies in the original traffic operation and meteorological data. In order to make the prediction results more accurate, data cleaning was carried out during the data fusion process:

(1) The lane detector has intermittent invalid collection. If two or more lane detectors on the same section fail to collect data at the

same time, the section data at that time will be removed;

(2) The lane detector has been continuously collecting invalid data for a long time, and the section data has been removed.

(3) If there are abnormal monitoring indicators such as rainfall and visibility at the meteorological station, the corresponding time section data will be removed.

$$TSR = V_E - V_S(\frac{km}{h}) \quad (1)$$

The ‘recommended speed expected speed’ model is a product of comprehensive consideration of multiple factors, reflecting the safety risks caused by the mismatch between the driver’s subjective cognition and the objective road environment.

# 3. Input parameter prediction

This article uses existing data and does not make predictions. The data of the previous week’s flow rate and the mixing rate of large vehicles were used as input parameters, and a 7-15-1 structure wavelet neural network was used for prediction. The learning rate was set to 0.01, the error accuracy was 0.001, and the number of iterations was 1000. The minimum prediction error of 5 times was taken as the final prediction result, where the flow rate was the cumulative flow of all lanes passing through the section within 5 minutes (see Table 1).

Table 1 Evaluation of Input Parameter Prediction Effect

| Section number | Flow rate (vehicles/5min) | | | Large vehicle mixing rate | | |
|---|---|---|---|---|---|---|
| | Predictive value | Actual value | Mean absolute error | Predictive value | Actual value | Mean absolute error of small car flow rate (vehicle/5 min) |
| 1 | 388 | 389 | 27 | 0.363 | 0.406 | 28 |
| 2 | 164 | 174 | 25 | 0.250 | 0.270 | 40 |
| 3 | 224 | 257 | 23 | 0.290 | 0.241 | 28 |
| 4 | 221 | 257 | 34 | 0.333 | 0.354 | 16 |
| 5 | 186 | 203 | 40 | 0.306 | 0.305 | 46 |
| 6 | 129 | 107 | 12 | 0.202 | 0.112 | 30 |

# 4. Traffic Safety Risk Prediction

## 4.1 Expected vehicle speed prediction

The basic principle of sample selection is to maximize the coverage range of input parameter values. The first hidden layer of the network is set to use the tansig transfer function, the second hidden layer is set to use the logsig transfer function, and the output layer is set to use the purelin transfer function. The learning rate is set to 0.01, the error accuracy is 0.001, the training is 5000 times, and the repeated operation is 5 times. The minimum mean square error is taken as the final prediction result.

## 4.2 Suggested speed model construction

The predicted road section will have no rainfall and visibility greater than 1000m. For good weather conditions, combined with the basic properties of the road at each section location, a recommended speed model will be constructed.

## 4.3 Risk prediction

According to equation (3), combined with the expected speed prediction results and the recommended speed model calculation results, indirectly calculate the predicted traffic safety risk value (see Table 2).

Table 2 Evaluation of Traffic Safety Risk Prediction Effect

| Section number | Expected vehicle speed | | | | | Recommended speed/(km/h) | Actual risk/ (km/h) | Predicted risk/ (km/h) |
|---|---|---|---|---|---|---|---|---|
| | Actual value/ (km/h) | Predicted value/(km/h) | Relative error/% | RMSE/(km/h) | R-Square | | | |
| 1 | 86.0 | 78.6 | 8.6 | 3.7 | 0.80 | 101.4 | -15.4 | -22.8 |
| 2 | 86.3 | 84.0 | 2.7 | 4.1 | 0.77 | 101.4 | -15.1 | -17.4 |
| 3 | 70.5 | 69.4 | 1.6 | 5.8 | 0.79 | 83.7 | -13.2 | -14.3 |
| 4 | 74.7 | 74.2 | 0.7 | 8.8 | 0.83 | 101.4 | -26.7 | -27.2 |
| 5 | 80.5 | 76.8 | 4.6 | 6.3 | 0.80 | 80.6 | -0.1 | -3.8 |
| 6 | 60.6 | 71.4 | 17.8 | 11.1 | 0.75 | 101.4 | -40.8 | -30.0 |

At the same time, the relative error between predicted and actual values, root mean square error, and R-Square indicators of goodness of fit are used to evaluate the effectiveness of risk prediction.

## 5. Analysis of Prediction Results

Overall, the risk prediction model and method have a certain degree of reliability. Using the same sample, fine adjustments are made to the hidden layer nodes of the network based solely on changes in the number of input parameters. The node is set to 7, and the expected vehicle speed is predicted without considering the mixing rate of large vehicles. The mean square error of the repeated 5 training results is taken for comparison.

Table 3 Evaluation of Traffic Safety Risk Prediction Effect

| Section number | Considering the mixing rate of large vehicles | | Excluding the mixing rate of large vehicles | |
|---|---|---|---|---|
| | MSE(km/h)² | R-Square | MSE (km/h)² | R-Square |
| 1 | 13.69 | 0.80 | 37.03 | 0.47 |
| 2 | 16.81 | 0.77 | 40.40 | 0.45 |
| 3 | 33.64 | 0.79 | 110.67 | 0.34 |
| 4 | 77.44 | 0.83 | 290.34 | 0.37 |
| 5 | 39.69 | 0.80 | 90.36 | 0.53 |
| 6 | 123.21 | 0.75 | 238.65 | 0.52 |

For the six predicted sections, considering the influence of large vehicle mixing rate, the mean square error (MSE) is significantly smaller and the goodness of fit (R-Square) is significantly higher. Therefore, introducing the large vehicle mixing rate indicator in vehicle speed prediction can improve the accuracy of the prediction to a certain extent.

## Conclusion

The management of dangerous road sections and hidden danger points in traffic accidents is a systematic social engineering project. The quality of highway pavement will have a significant impact on the safety and comfort of vehicles. Therefore, it is necessary to do a good job in road security and road safety investigation in order to solidly prevent major traffic accidents and ensure the safety of people's lives and property.

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