Research on the Driving Risk Evaluation in Highway Work Zone Section based on Cloud Model

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ABSTRACT: In order to evaluate the driving risk of the highway construction and maintenance work zone, identify the dangerous sections and improve the level of road traffic safety, considering the traffic conditions, speed and deceleration were used to evaluate the driving risk by cloud transformation and cloud reasoning technology. Based on the traffic flow theory, the traffic volume, speed and deceleration were chosen as the three evaluation indexes, and determine the certainty degree of evaluation index in the concept of cloud model, and the rule base of driving risk evaluation in highway was established and the risk could be evaluated by this method. The research results quantify the impact of traffic volume, speed and acceleration on the driving risk at the highway construction and maintenance work zone, which provides a good reference value for the future road safety design.

KEYWORDS: road engineering; driving risk evaluation; cloud model; highway work zone

INTRODUCTION

In recent years, road engineering has been rapidly developed. As showed in the website of Ministry of Transport of China (MOT), as of the end of 2015, the total mileage of the national highway in China has reached 4463900 kilometers with an increase of 107700 kilometers over the previous year from. The growth of new road engineering is stable, while the road extension shows the trend of increasing year by year. Highway work zone is a special traffic management area which is set up for highway maintenance and repair engineering. The traffic isn’t expected to interrupt by the road construction, so the work zone area will be affected by the construction work, and the road work zone area present a high risk for road traffic accidents, not only the driver, but also the construction workers on the road are threatened by the traffic accidents. Therefore, it is necessary to evaluate the driving risk state in the expressway work zone, so as to improve the safety level and ensure the highway reconstruction and extension engineering.

Some scholars identified the dangerous area by the traffic accident to
complete the evaluation. In 2004, Steenberghen identified the dangerous recognition area of the urban road network based on the traffic accident statistics and the GIS technology. In 2009, Liu Saihua considered the characteristics of mountainous expressway linearity and its accident, and proposed the non-fixed length segmentation method, which is based on the characteristics of road alignment. In 2010, Meng Xianghai used traffic accident data to study the mountain highways, and proposed a traffic safety evaluation method based on road geometric alignment. And some others identified dangerous area by analysis road alignment factors. In 2012, Effati considered five road alignment factors and three environmental factors, and put forward the corresponding evaluation criteria, used the method of GIS and fuzzy reasoning method to recognize the dangerous area. In 2013, Agarwal divided potentially dangerous sections into linear segments, curve segments, and intersections and identified the factors that affected each section’s safety. Drawing on the proportion of each factor through an analytic hierarchy process, which can determine the danger coefficient of factors, they used the danger coefficient to sort the dangerous roads.

Some others use the new theory to establish traffic accident prediction model. Wu Bing, Yang Peikun established traffic accident prediction model of the highway work zone based on the gray system theory; Wu Bing, Liu Kaiping used Bayesian theory to analyze the road maintenance construction safety and security issues, extrapolated the accident probability of highway maintenance construction, proposed risk assessment indicators and risk control strategies.

Wu Biao, Xu Hongguo, put forward the traffic safety factors of expressway construction section from the viewpoint of human-vehicle-road and environment system. Then they established identification model of traffic safety influencing factors based on DEMATEL, ISM and integrated DEMATEL-ISM.

In China, the research on the identification and sorting of the driving risk is mainly about transforming the uncertainty into the deterministic. However, driving conditions and traffic influenced factors of the work zone are complex, using certainty methods to analyze the risk not only exists errors, but also cannot well reflect the uncertainty feature of the driving risk state. Many scholars have made some valuable research by using the cloud model method.

Academician Li De-Yi introduced the concept of cloud, the characteristics of the cloud and the implementation process of cloud generator, and builds up and analyzes the mathematical model of cloud generator in his book. With the development of cloud theory, the application scope of the cloud model has been extended by many scholars. In recent years, the cloud model has been successfully applied in areas including intelligent control and forecasting, data mining and system assessment. But in the driving risk evaluation of highway work zone has not been involved.

Therefore, it is significant to identify and sort the driving risks of highway work zone based on the cloud model, which can avoid the interference of deterministic analysis. Based on the measured data and the method of Gaussian cloud transformation, this paper analyzes the data and obtains a comprehensive conclusion.
1 EVALUATION MODEL OF DRIVING RISK STATE BASED ON CLOUD MODEL

1.1 Theory of Driving Risk

Driving risk refers to the probability and possible severity of the accident on a certain road, a certain period of time. If this section has a greater possibility to occur accidents, this section will have a high driving risk. The risk factor can reflect the possibility that the current state of the driver, the vehicle and the traffic environment will lead to the accident, and quantify the driving risk under different road traffic conditions of this special section of expressway.

The work zone area has a complex driving condition, and the vehicle is faced with risk of changing lanes and car-following. At the same time, traffic flow in the work zone has a great influence on the driving, and the driving condition is also changed with the change of the traffic flow. Therefore, it is necessary to evaluate the driving risk state from three aspects, such as vehicle lane changing, vehicle following, and traffic flow.

1.2 Cloud Model Theory

The cloud model is an uncertainty transformation model that deals with qualitative concepts and quantitative descriptions.

Take $U_1$ as an exact numerical value to represent a quantitative domain, and $C$ is a qualitative concept on $U_1$. If quantitative value $X \in U_1$, $X$ is stochastic realization of qualitative concept $C$, and determination $\mu(x) \in [0,1]$ of $X$ to $C$ is a stabilize random number, distribution of $X$ in the domain $U_1$ is called cloud, each $X$ is called a cloud droplet.

$$\mu : U_1 \rightarrow [0,1] \quad \forall x \in U \quad x \rightarrow \mu(x)$$

(1)

Cloud is characterized by the expectation $Ex$, entropy $En$, hyper entropy $He$. $Ex$ is the expectation of cloud droplets that distribute in the domain; $En$ is the uncertainty measure of qualitative concept, which depends on the randomness and fuzziness of the qualitative concept; $He$ is uncertainty measure of entropy. Normal cloud generator is a process that the qualitative concept transforms to their quantitative expressions, that is a process the digital characteristics of cloud generated cloud droplets; background cloud generator is a process that the qualitative value transform to qualitative concept, that is a process that the digital characteristics of cloud was obtained from cloud droplets.

1.3 Driving Risk Evaluation of Highway Work Zone Based on Cloud Model

Driving risk in the complex section is also one of the uncertainties data. Considering the traffic volume, the cloud transformation and cloud reasoning technology are used to evaluate the driving risk state in complex work zone sections by processing the speed data and deceleration data. And it can show the randomness and ambiguity of driving risk state.
The specific process of using cloud model to evaluate driving risk state is as follows:

1. The traffic volume, speed coefficient of variation and mean deceleration of the measured data are processed by the reverse cloud generator, and the cloud model eigenvalues $\{Ex, En, He\}$ of the traffic volume, speed coefficient of variation and average deceleration are calculated, and the initial concept data of the three types of data are obtained, and then use the adaptive Gaussian cloud transform to conceptually jump the concept of the three types of data to achieve the concept of cognitive level, and the concept of all kinds of evaluation indexes is extracted to classify cloud eigenvalues. Finally, driving risk level cloud model is established through the number of traffic conflicts, and converted into percentile system for the latter part of the quantitative score.

2. According to expert knowledge and experience, the number of traffic conflicts, the traffic volume, and speed coefficient of variation and deceleration data are used as reasoning conditions, and the risk level is taken as reasoning result. And the weighting value of the three evaluation indexes was determined by expert scoring method.

3. Calculate the activation intensity of the three specific values of traffic volume, speed coefficient of variation and the mean deceleration. Find the maximum value of the activation intensity, the degree of conceptual level of the evaluation index. According to the concept level of each evaluation index, the established rule base is accessed to get the degree of driving risk, and the qualitative evaluation of the driving risk state of the complex work zone is finished.

4. According to the certainty degree of the evaluation index in the concept level, combining with its weight, the uncertainty degree of the cloud model is calculated, and then the uncertainty degree is input into the driving risk cloud model. Then a series of cloud droplets with specified degrees of certainty will be output. The geometric center of the generated cloud droplet is calculated, which is the specific score of driving dangerous state, and the quantitative evaluation of driving dangerous state is completed.
2. EVALUATION INDEXES AND ESTABLISHMENT OF RULE BASE OF WORK ZONE

2.1 Evaluation indexes

It is found that the traffic accident in the work zone is mainly caused by the change lane suddenly or the acceleration and deceleration of the vehicle in the work zone area of the expressway. Many scholars have researched on micro-traffic safety, analyzed the relationship between road geometry design, vehicle operating characteristics, driver's psychological and physiological responses, environmental factors and traffic safety, and considered vehicle driving risk caused by various reasons. Therefore, this paper extracts the influencing factors from the lane changing model, car-following model and traffic state.

2.1.1 Traffic conflicts

In the evaluation of driving risk in the work zone, the driving state of the vehicle in the work zone area is an important factor to evaluate the traffic condition. Traffic conflict is a direct response to the dangerous state of the work zone in the road, so take the traffic conflict as an evaluation factor of driving risk evaluation in the work zone. Traffic conflict can be divided into two types: forced confluence conflict and rear-end collision. The forced confluence is the traffic conflict in the behavior of the vehicle lane changing. The rear-end collision is the traffic conflict in vehicle following action. Conflict statistics principle is as follows: ① when the vehicle forced to merge, the vehicle was forced to slow down and even park to wait is a conflict; ② emergency brake ensures sufficient safety distance is a conflict.

2.1.2 Speed coefficient of variation

The speed of vehicles in the work zone is an important factor to reflect the driving state of the vehicle. In this paper, the speed coefficient of variation is taken as another evaluation factor for the driving dangerous risk evaluation in the work zone. Coefficient of variation is the ratio of the standard deviation of the sample velocity to its mean, and it can reflect the magnitude of the discrete value of the velocity data in the sample. Therefore, it can be considered that the coefficient of variation reflect the degree of dispersion of the data, as well as the range, standard deviation and variance. The coefficient variation is not only affected by the discrete degree of the velocity variable value, but also affected by the average level of the velocity variable value. Therefore, the speed coefficient of variation can objectively reflect the speed distribution of the vehicle in the work zone, and the formula for calculating the speed coefficient of variation is shown below.

\[ CV = \frac{S}{\bar{x}} \]  \hspace{1cm} (2)

Where \( CV \) is the speed coefficient of variation, \( S \) is the standard deviation of the sample (km/h), and \( \bar{x} \) (km/h) is the mean of the sample.

2.1.3 Deceleration

When the vehicles traveling in the work zone area, when they find that there is danger in the front of the road, they will decelerate to avoid an obstacle or stop. At this time, the driving risk degree of the work zone can be judged
according to the change of deceleration. The deceleration is larger, and then it will be more dangerous when the vehicles travel in the work zone. So the deceleration of the vehicle can reflect the driving risk in the work zone, so the deceleration when driving in the work zone is also taken as an evaluation factors.

2.1.4 Traffic volume

In the high-density traffic flow, the degree of freedom of the vehicle will drop. Mutual influence is gradually increased, mainly in car-following and lane change. Accident statistics show that high-density traffic flow is one of the main causes of traffic accidents. So the vehicle speed data and deceleration data cannot fully reflect the driving risk state in the work zone, and need to consider the traffic flow status of the work zone. In this paper, the influence of the traffic volume on the driving risk in the work zone is considered.

2.2 Establishment of expert knowledge rule base

2.2.1 Establishment of the rule base

<table>
<thead>
<tr>
<th>Table 1. Concept partition of evaluation indexes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept partition of Traffic Flow Q(pcu/h)</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
<tr>
<td>IV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concept partition of speed coefficient of variation CV</th>
<th>$Ex$</th>
<th>$En$</th>
<th>$He$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.15</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>II</td>
<td>0.35</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>III</td>
<td>0.60</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>IV</td>
<td>0.85</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concept partition of deceleration $a$ (m/s$^2$)</th>
<th>$Ex$</th>
<th>$En$</th>
<th>$He$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1.0</td>
<td>0.65</td>
<td>0.08</td>
</tr>
<tr>
<td>II</td>
<td>2.5</td>
<td>0.35</td>
<td>0.04</td>
</tr>
<tr>
<td>III</td>
<td>4.5</td>
<td>0.50</td>
<td>0.06</td>
</tr>
<tr>
<td>IV</td>
<td>7.0</td>
<td>0.65</td>
<td>0.08</td>
</tr>
</tbody>
</table>

First of all, finish the Concept partition to complete the classification of the evaluation index according to the experience. The evaluation indexes are speed variation coefficient, vehicle deceleration rate and traffic flow, and each index is divided into 4 levels as showed in the table 1.

Therefore, 64 inference rules are established according to expert knowledge and evaluation factor concept, among which the evaluation indicators are connected by "And" statement, for example:

If traffic volume is "I" And speed coefficient of variation is "I" And deceleration is "I".
Then risk degree is "I";
If traffic volume is "Ⅰ" And speed coefficient of variation is "Ⅰ" And deceleration is "Ⅲ",
Then risk degree is "Ⅲ";
...
If traffic volume is "Ⅲ" And speed coefficient of variation is "Ⅲ" And deceleration is "Ⅲ",
Then risk degree is "Ⅲ";
If traffic volume is "Ⅳ" And speed coefficient of variation is "Ⅳ" And deceleration is "Ⅳ",
Then risk degree is "Ⅳ".

2.2.2 Weight determination

According to the expert scoring method, the weight of each evaluation index is determined. Analytic hierarchy process is used to determine the weight of the evaluation factors.

(1) Determine the evaluation system of the judgment matrix $P$. First of all, the weight set is defined as $A = \{a_1, a_2, a_3\}$, where: $a_1$ is traffic volume; $a_2$ is the weight factor of CV; $a_3$ is the weight factor of a. We made a questionnaire survey for ten experts and scholars who study the driving risk for a long time. After paired comparing the importance of these three performance factors, the performance factors of the three driving risk were obtained. The judgment matrix and the judgment matrix are shown as follows.

Table 2. Importance judgments.

<table>
<thead>
<tr>
<th>Importance</th>
<th>Same</th>
<th>Slightly important</th>
<th>Important</th>
<th>More important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_{ij}$</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Note: when $a_{ij}$ is even number, its importance lies between two odd numbers.

Calculate the average of the importance judgment value, the results is shown in table 3.

Table 3. Performance factors judgment matrix.

<table>
<thead>
<tr>
<th>$T$</th>
<th>$a_1$</th>
<th>$a_2$</th>
<th>$a_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_1$</td>
<td>1</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>$a_2$</td>
<td>0.625</td>
<td>1</td>
<td>0.875</td>
</tr>
<tr>
<td>$a_3$</td>
<td>0.701</td>
<td>1.14</td>
<td>1</td>
</tr>
</tbody>
</table>

(2)The specific form of the judgment matrix is as follows:

$$P = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} = \begin{bmatrix} 1 & 1.6 & 1.4 \\ 0.625 & 1 & 0.875 \\ 0.701 & 1.14 & 1 \end{bmatrix}$$

Taking normalization or regularization for the weight vector $W$, $W= (0.25, 0.40, 0.35)$.

(3) Consistency checking. Whether the feature vector above is a reasonable weight distribution, it also needs to check the consistency of the judgment
matrix. After calculation, CR=0.0036<0.1, which shows that the matrix \( P \) has good consistency. So \( W \) can be used as the weight coefficient, and the weight coefficient \( W = (0.25, 0.40, 0.35) \).

3. EXAMPLE VALIDATION

3.1 Data Acquisition and Processing

In this paper, we select the front and back end of the upstream transition zone of the three construction zones of Xuwei expressway in Henan Province as the data acquisition section. The total length of this section is 10.1km. The road section contains three construction areas. The satellite images of this section are shown in the following figure.

Take the front and rear section in the transition area of the work zone as the data acquisition section, the vehicle speed data and deceleration data are acquired, and the traffic volume and the number of traffic conflicts could be extracted from the video. The measured data are shown in Table 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>Traffic Volume(pcu/h)</th>
<th>Speed coefficient of variation</th>
<th>Deceleration (m/s²)</th>
<th>Traffic conflicts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>638</td>
<td>0.21</td>
<td>1.9</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>1511</td>
<td>0.57</td>
<td>4.7</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td>897</td>
<td>0.39</td>
<td>3.9</td>
<td>56</td>
</tr>
</tbody>
</table>

Then calculate the Gaussian cloud concept ambiguity of traffic volume, speed coefficient of variation and deceleration rate, the formula is as follows

\[
CD = \frac{3He}{En} \tag{3}
\]
Figure 2. Evaluation of risk degree.

The data are sorted according to the data types, and each type data is judged as the ambiguity of each Gaussian cloud. If $CD > \beta$ ($\beta = 0.5$ is the atomization boundary conditions of the concepts), the number of concepts $m_j = m_j - 1$ ($j = 1, 2, 3$). Otherwise, input the $M_j$ Gaussian cloud which ambiguity is less than 0.5. Through this step, we get the concepts cloud of traffic volume (pcu/h) $C_\alpha(Ex_k, En_k, He_k), k = 4$, the concepts cloud of speed coefficient of variation $C_{cv}(Ex_k, En_k, He_k), k = 4$, the concept cloud of deceleration $C_a(Ex_k, En_k, He_k), k = 4$, and the cloud model image is plotted in Fig. 2.

Input measured traffic volume and get the activation intensity of each cloud that is the certainty degree $\mu_\alpha$. The highest activation intensity is selected as the corresponding evaluation index of the input traffic volume. For the speed coefficient of variation and the deceleration rate, take the same method as described above to obtain the concept level which it belongs. Through access to the rule base, the corresponding risk degree grade can be obtained, and the evaluation result of the work zone dangerous grade can be given qualitatively.

To further quantify the specific grades obtained under the same level of the dangerous grade, according to the certainty degree, calculate the activation level of the degree of driving risk, the certainty degree of driving risk is calculated by the weight and certainty degree of the each grade, the certainty degree formula as follows.
\[ \mu = \frac{\omega_q \mu_q + \omega_{cv} \mu_{cv} + \omega_a \mu_a}{\mu_q + \mu_{cv} + \mu_a} \]  

(4)

According to the 2.2.2 weight determination, \( \omega_q = 0.25, \, \omega_{cv} = 0.4, \, \omega_a = 0.25 \), and the cloud characteristic value and the certainty degree of the risk degree has been calculated, the single conditional cloud generator could be used to obtain the cloud droplets with certainty degree \( \mu \), and according to the gravity center of cloud droplets, the risk state fraction could be obtained, cloud droplet calculation formula is as follows

\[ D = \frac{D_1 + D_2 + \ldots + D_n}{n} \]  

(5)

To verify the effectiveness of the method, select the following three sets of data, as showed in Table 2. Input the three evaluation factors of the data into the concept, the certainty degree of three indicators in the cloud model could be gotten, as showed in Table 3. From the degree of certainty:

Group 1, the traffic volume is "I", the speed coefficient of variation is "I" and the deceleration rate is "I".

Group 2, the traffic volume is "III", the speed coefficient of variation is "III" and the deceleration rate is "III".

Group 3, the traffic volume is "II", the speed coefficient of variation is "II" and the deceleration rate is "III".

The result of the concept level extraction is consistent with the result of direct judgment based on the concept eigenvalue, which proves that rule prerequisite activation is correct. Through access to the rule base, we can get the qualitative evaluation results of the construction road risk degree:

Group 1 risk degree of grade is "I", that is "secure";

Group 2 risk degree of grade is "III", that is "more dangerous";

Group 3 risk degree of grade is "III", that is "more dangerous".

The group 1 and group 2 is obviously correct, and the results of group 3 need some explanations, the traffic volume and speed coefficient of variation is II, and the deceleration is III, but the speed coefficient of variation is in the combination of and III of the cloud which means is a dangerous II, and the deceleration is in the III of the cloud. The speed coefficient of variation and the deceleration have a higher weight, so although the traffic volume and speed coefficient of variation, the risk degree of grade is "III".

In order to further differentiate the driving risk of the same degree, the driving risk evaluation cloud model of the group 2 and group 3 of is calculated using formula 4:

\[ \mu_2 = \frac{0.25 \times 0.386 + 0.4 \times 0.796 + 0.35 \times 0.836}{0.386 + 0.796 + 0.836} = 0.351 \]

\[ \mu_3 = \frac{0.25 \times 0.674 + 0.4 \times 0.619 + 0.35 \times 0.587}{0.674 + 0.619 + 0.587} = 0.331 \]
Table 5. The Certainty Degree of Evaluation Indexes in the Concept Cloud.

<table>
<thead>
<tr>
<th>Group</th>
<th>Level of concept evaluation indexes</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traffic volume</td>
<td>0.921</td>
<td>0.053</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Speed coefficient of variation</td>
<td>0.602</td>
<td>0.284</td>
<td>0.004</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Deceleration</td>
<td>0.485</td>
<td>0.309</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>Traffic volume</td>
<td>0.000</td>
<td>0.004</td>
<td>0.386</td>
<td>0.105</td>
</tr>
<tr>
<td></td>
<td>Speed coefficient of variation</td>
<td>0.000</td>
<td>0.058</td>
<td>0.796</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Deceleration</td>
<td>0.000</td>
<td>0.000</td>
<td>0.836</td>
<td>0.029</td>
</tr>
<tr>
<td>3</td>
<td>Traffic volume</td>
<td>0.095</td>
<td>0.674</td>
<td>0.003</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Speed coefficient of variation</td>
<td>0.041</td>
<td>0.619</td>
<td>0.121</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Deceleration</td>
<td>0.002</td>
<td>0.015</td>
<td>0.587</td>
<td>0.003</td>
</tr>
</tbody>
</table>

According to the table 3, the traffic volume, speed coefficient of variation and deceleration certainty degree of group 2 is 0.386, 0.796, 0.836. The traffic volume, speed coefficient of variation and deceleration certainty degree of group 3 is 0.674, 0.619, 0.587. Then the $\mu_2$ and $\mu_3$ could be gotten.

Input the above-mentioned certainty degree $\mu_2$ and $\mu_3$ to the third grade of dangerous state cloud model $\{70, 10/3, 0.5\}$, several cloud droplets are generated respectively, and the gravity center of cloud droplets can be calculated. The output risk evaluation fraction of group 2 is 67.5; the output risk evaluation fraction of group 3 is 63.4, thus the construction of road sections dangerous quantitative evaluation is completed. The evaluation results are shown in Fig 3.

Through the qualitative and quantitative analysis of the evaluation results, the final risk degree ranking could be gotten:

**Group2 > Group 3 > Group 1**

The results of the above-mentioned judgment are compared with the number of traffic conflicts observed in each group, and the result of the inference is correct.
4. CONCLUSIONS

(1) Considering the complex traffic conditions and the complicated traffic safety factors, the cloud model is used to consider the degree of traffic conflict from the macroscopic and microcosmic angles, and an evaluation method based on cloud model for driving risk state is built. Based on the traffic flow characters and road conditions in the work zone, the factors that can reflect the dangerous situation in the work zone are extracted, and the evaluation model of driving risk evaluation in the work zone area is established based on the cloud model, and calculate the specific score of the dangerous situation.

(2) Taking the driving status of the work zone as the basis, and the number of traffic conflicts in the traffic was counted. Then the traffic condition of the work zone area, the speed coefficient of variation and deceleration of the work zone area are analyzed by the cloud reasoning technology. The knowledge rule base of the driving risk evaluation in the work zone is constructed based on the expert knowledge, and three evaluation factor clouds are calculated according to the cloud transformation. Then the road sections of dangerous driving analysis were completed.

(3) The evaluation model of driving risk in the work zone can provide the theoretical foundation for the safety warning, traffic organization and traffic safety improvement in the work zone. And it also provides a good reference value for the further study of safety measures in the work zone.

(4) At present, this paper only considers the main factors of the driving risk in the work zone. So the evaluation model is not suitable for the evaluation of...
of driving risk evaluation in all work zone areas. Therefore the driving danger evaluation in work zone needs to be further studied.

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