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Driving Behavior Theory and Computer Simulation System of Driver's Risk Perception Based on 3D

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Abstract

Drivers take up the leading role in road traffic system, in all road traffic accidents, the ones initiated by driver factor account for over 90%. The main reason is that such drivers have not formed the "internal pattern" of correctly driving a vehicle in their brain, so that drivers cannot strongly experience the potential danger. When danger comes, drivers still have unawareness, or although they take measures, it is too late to avoid the happening of an accident. This paper has carried out further investigation on the drivers' danger sense based on a profound analysis of driving behavior. 3DS MAX is used to implement dangerous scene cartoons, which can form one continuous driving time and space, so that drivers trained can observe at some points, which can provide understanding of sense organ for drivers. Furthermore, the method of hall type discussion is adopted to improve drivers' psychological ability to bear and potential risk cognitive level. Such we have made is to make the psychology experiences for drivers under the precarious position in person experienced, to offer experience for storing the correct "interior mode", finally reduce the traffic conflict and the probability of traffic accidents.

Keywords: Traffic safety; Risk perception; Interior mode; 3D MAX; Hall-style discussion

1. Introduction

Road traffic accidents have been "the biggest public nuisance of the world ", and the mortality of road traffic accidents in our country has been the first one. Lots of research results show that drivers have a large part of the responsibility in the traffic accidents. It is because, human-vehicle-road constitutes a dynamic complex system, the "car" is the only controllable variable, "road" and "environment" are not controllable and objective parameters, "person" (especially the driver) is the only autonomy variable in the system, compared with other variables, only the diver is active and conscious, who is able to accept the information from the road, the environment, and the current state of the traffic flow, through the judgments and making decision-making, to
control and operate the vehicles. It is the most important and active factor, so the driver factor plays a lead role in the road traffic system.

In order to ensure safe driving vastly, the driver who drives his (or her) car in all kinds of traffic environment, should have the area of "in time of peace preparing for war", have the strong ability of danger sense, especially on spacious road. Appropriate alertness can help drivers keep the mind clear, of course not too much, while too much alertness will cause drivers be nervous for a long time, which will cause fatigue driving, not good at driving safety. The ability of danger sense is relevant to the ability of predicting the potential danger in traffic environment, when drivers have strong ability of danger sense, who can also predict the potential danger in traffic environment strongly.

In general, the cognitive ability to the potential danger is better; the earlier drivers can take effective measures, which can avoid traffic accidents vastly. If the driver is able to predict the potential danger 1s earlier, this can help reduce front collision 30%. And a lot of traffic accidents are due to the driver itself, who doesn't realize the existence of the potential danger or has low estimate to the danger, which causes him (or her) not to take effective measures. In traffic system, the potential danger is an objective existence, but need drivers percept subjectively. For example, at the bus stop where a bus is stopping, at the same time one pedestrian is coming, circumambulating the bus from right to left. While the car driver who drives his car close to the bus, will lead to crash with the pedestrian in all probability, if he (or she) hasn't predicted this case and been continuing maintaining the original driving. Conversely, if the car driver has cognitive ability to the potential danger, he (or she) is able to take effective measures before the potential danger turns into real danger, and this will help avoid unnecessary accidents finally.

2010 traffic accidents statistical result according to the driving experience (as shown in figure 1) showed that the drivers had high accident rate who had driven cars less than one year, the main reason lay on unskilled driving technique and lack of driving experience. Then they couldn't make the right judgment about the traffic condition, also couldn't predict the potential danger subjectively existing in the traffic environment. Of course, they couldn't take effective measures to avoid danger. From the chart, we also found that the drivers had high accident rate who had driven cars for 6 ~ 10 and 11 to 15 years. The drivers' driving technique had been quite skilled, also had been rich in driving experience. However, because of these advantages precisely, which made them be self-assured for driving; easy to careless and blind confidence, think themselves can make accurate judgment to any road traffic conditions. Even when the danger had appeared, they treated it lightly which leading them not to take measures timely and effectively, finally resulting in traffic conflicts, even traffic accidents. The high accident rate of this group is in the final analysis because of that they are lack of correct prediction and identification about the potential danger existing in the traffic environment.

![Fig. 1. traffic accidents statistical result according to the driving experience in 2010](image)
Some developed countries made an extensive research in the field of driving kernel dangerous prediction, acquiring a more mature theoretical system, developing the education, and developing a risk prediction ability training system for active safety awareness education. There are two kinds more mature safe driving education programs in Europe and the United States. One is the American IPDE method (identification, forecasting, decision-making and action) driver education program, and the second is the safe education series, that the federal republic of Germany road traffic institute developed for driver characteristics. Japan pay more attention to application research, they have made a lot of research on driver dangerous susceptibility. In Britain and western provinces of Australia, the test about the ability to predict the potential danger has become one of the driving tests necessarily. As the driver training and examination in China are also carried out in the coaching field currently, they’re lack of vigilance, motion perception of receiving continuously and processing space-time information from outside, and they have a high risk driving under the emergency operation (brake, steering, start, merge and change lane). It is very likely to have a mistake in judgment, decision making and operation, which will cause traffic accidents. According to the survey of the traffic accidents, new drivers account for 15%. The reasons are that drivers aren’t good at predicting the potential danger, also because these drivers have not formed the "interior mode" in their brain towards to these dangerous scenes. The interior model means the drivers extracted the methods according to objective regulation outside in the long term, through repeated processing of the brain, and then stored these methods as available models in the memory system. When some specific information from outside comes into the thinking system, drivers’ thinking system will compare the information with the stored information and find the best one to match the situation, then process the information according to this model.

In a word, lots of road traffic accidents are due to that drivers haven't judge the potential danger in the traffic environment, and then cannot conduct effective prevention in accordance with "interior mode" in their brain. Once the potential danger turns into the real danger, the occurrence of the accident becomes inevitable. For enhancing drivers’ ability to predict the potential danger and forming "interior mode", if through actual driving, it will take a long time, also actual driving conditions differ in thousands ways. For the same potential danger, drivers could not take exercise again and again, not easy to form "interior mode". So, in the article some dangerous scene cartoons have been set up based on 3D picture model, which can form one continuous driving time and space, and can be observed at some points. These cartoons can also provide understanding of sense organ for driver and improve the drivers' psychological bearing capability and potential risk cognitive level, making drivers have experiences under the precarious position in person, offer experience for storing the correct "interior mode". In the future, our country could train drivers through setting up some dangerous scene to give drivers long-term sensory stimulation, so that drivers can inform the correct internal driver model, which will help develop good driving habits. So when the driver is indeed in actual dangerous situation, the inherent "internal model" can help reduce the traffic accidents in real world. At the same time, through watching these dangerous scene in actual traffic environment, another driving factors can be found existing in road traffic environment which go against safe driving, especially the danger which is difficult to judge in advance. Then many problems possibly led by these driving factors can be solved through perfecting road facilities, increasing active safety equipment of vehicles and other ways. Not only from the driver itself, but also from roads and vehicles of the dynamic system, driving safety can be ensured to reduce the life and property losses.

2. Analysis of Driving Behavior and Drivers’ Risk Perception

In driving homework, because of the vehicle’s high speed, complex and changing traffic environment, it is required that drivers must have some special abilities: flexible, natural, coordinating ability for allocating attention; awareness of the space and distance and position of pedestrians; and can response quickly and accurately.
For the driving operation, the road’s information changes very quickly, which requires the driver make the appropriate response in a very short time. Therefore, the control behavior of shorter reaction time will be more useful. Experiences show that a trained driver is more skillful than the driver who is not trained both in wielding skill and following rules. This is mainly because the driver who has been trained and practiced has stored a lot of image of processing road traffic conditions, as long as a stimulus on the road information or traffic scene which is similar to the image in his brain of the driver, it marks the completion of information processing, who can make the appropriate action to deal with the situation quickly, which means he has strong risk perception.

The concept of risk sensitivity has the narrow and broad point: a narrow sense means the subjective cognition and evaluation of the drivers' to the inherent and potential risk in external environment; in a broad sense, it also contains a preparatory action, including subjective cognition and evaluation of the potential danger in external environment and the corresponding preparation activities. Usually, in the study of risk sensitivity, objective danger and subjective danger are commonly used. Objective risk refers to a variety of different specific traffic barriers in driving, usually expressed by the distance and time of danger exposure or scale of population in danger. Subjective risk is connected with risk perception based on psychological dimension, which is subjected to personal experience, scene immediately and other factors. Subjective risk and objective risk are the two levels of risk perception. Drivers’ driving process is shown in Figure 2. It shows that the driver should feel the traffic information from the outside world in the driving process, and regard these as information to cognize. Then the driver should judge whether to encounter dangerous situations now or 1 to 2s latter or not, and to make judgment about the level of the danger (if there the danger exists). Finally, take behaviors according to such judgments. The drivers who have sufficient prepare for safe driving, they always face towards the risk psychologically, which isn’t saw now, but perhaps will be encountered in 1 to 2s (potential danger). Therefore, the drivers are able to sense the potential danger as the objective existing danger and perceive as soon as possible, so as to provide a longer time for take measures to avoid risk. Therefore, it can help drivers be able to driving continually in safe condition.

![Fig. 2. Dangerous driving in the role of feelings](image-url)
However, the driver whose potential danger sensitivity is low, only when the potential danger turns into traffic obstacles, is trying to avoid accidents hurriedly. At this time, less avoidance maybe lead to accidents. Even if avoidance is in a timely manner, a traffic conflict will be formed, which makes the driver undergo a frightening experience. The essential differences of risk perception between safe drivers and dangerous ones mainly lie in: (1) the former recognize the hazards rationally, while the latter recognize the hazards perceptually. (2) the former prevent the danger, but the latter cause dangerous. (3) the former defuse danger positively, and the latter avoid danger blindly. (4) the former arrange time systematically through, the latter waste effective time unconsciously. When the practical obstacles appear really in the real traffic environment, drivers are helpless. Even drivers are aware of this situation; it is very difficult for them to put forward corresponding countermeasure at that moment. In view of this, when drivers are training in danger sensitivity, the scene which the danger has appeared in front is not used, but the scene before the conflicts which isn’t saw now should be used as training scene.

Thus, danger sensitivity can change driving behavior of a driver; also can say it has the same effect of Driving behavior differs as the position of switch is different. When dangerous sensitivity is "open", the driver could forecast and perceive the potential danger in the traffic environment of earlier, and the driver could take measures timely and effectively before the danger happens to ensure the safe driving. However, when dangerous sensitivity is "off", it is harmful to driving safety. In this state, the driver doesn’t notice the coming risk, much less how to prevent. When the danger is drawing near, the driver still drives according to the original driving style. The driver hasn't realized to take measures, until the danger appears. At this time, if the driver can be unflappable, and take measures decisively, maybe accident would be avoided. Conversely, otherwise.

3. Method of Improving Drivers’ Risk Sensitivity

3.1 Computer simulation method of improving drivers’ risk susceptibility

In the aspect of improving risk sensitivity of drivers, because of the leading position of drivers in the transport system, it is a good way in which let drivers master the correct driving way to improve risk sensitivity through the psychological training of drivers. This paper explores a method, using hall-style discussion and a further individual interview to hold safety psychological training for drivers.

Hall type discussion is an education method that can stimulate students thinking about themselves, in which drivers are divided into groups and classes for training them to judge and think independently. Through this method, drivers’ cognitive ability can be trained, who can master the driving style towards dangerous scenes, through high level of thinking process, no longer rely too much mechanical memory.

This method has been used to test drivers in Japan; it showed that the method has indeed played a very good effect on drivers’ feelings, coordination, attention and security awareness. But when drivers were being trained, they also used the traditional static images. After absorbing the hall-style method of Japan critically, in accordance with the actual situation of our country we use dynamic simulation method to replace the traditional static images. Dynamic simulation is a method in which the real risk scenes are structured through computer simulation, then to study driving behavior in this scene. In the view of the development of computer technology, image processing technology now is evolving from 2D planar imaging to 3D feeling simulation, which provides the possibility of using the computer technology to simulate the actual risk scenes.

This method has many advantages: ① It need not the participation of the real system, which is economical and convenient; ② The time scale of dynamic simulation could be different from the real time scale, so we can practice real-time simulation, can also practice time-shortened simulation and time lengthened simulation; ③ The same scene can be played again and again; ④ The process and reason of the unexpected accidents can be presented by 3D computer animation, which the situation can not be contacted directly or the accidents may happen when drivers’ are trained on train equipments, So it can make the transmission and trainers’ feeling of dangerous information more authentic, the trainers can obtain profound training experience. In addition, 3D
computer animated simulation can be used to take the place of some statement difficult to express, and is superior to traditional live-action shooting in showing the risk scenes.

3.2 The method of computer simulation training to improve drivers’ risk perception

The conduct of training as follows:

(1) Implement training: The training uses the animation scenes that we have developed, consisting of the traffic scenes saw from different viewpoints and questionnaires. The questionnaires should include the following aspects: the perception and forecast of traffic conditions, and the preparation, attitude and speed we use. For one scene, you can use the 0 frame static picture firstly, and then use another frame, which are seen by participants, next let participants see the change of the situation and predict what will happen.

(2) After implementing training, carry out hall-style discussion immediately using the animation scenes used in training. In the process, drivers in the training are divided into some groups; each group contains about 10 persons, and gives each group a coach as the moderator. Generally, in one test five scenarios are used to test and discuss for drivers. The time needed for discussion generally as following: the implementation is about 30 minutes, together with 10 to 15 minutes’ discussion for each scene, the whole discussion needs 60 to 90 minutes. The overall training time is about 90 to 120 minutes. However, in the time-bound case, the number of traffic scenarios could be reduced properly, thereby reducing the whole time required. Because the dangerous scenes outside show a variety of features, it is impossible to simulate each scene. The main objective is to teach drivers the method of observing the scene and dealing with problems. If scenes are not enough, it is difficult to establish internal models with regard to the real traffic scenes. The effect will be much worse than the training with more different types of traffic scenes. However, judging from each scene, the characteristics of drivers will show clearly in each scene. At this point, there is no problem even to reduce the number of scenes. Finally, play the animation and perspective animation to produce the sensory experience for drivers.

(3) Making an evaluation form from the training, managements make personal interview according to the evaluation form.

The training process is to improve drivers’ awareness and prediction of the potential danger through the educational activities of training, the hall-style discussion and evaluation (personal interview), finally make the drivers' awareness develop towards more safe.

4. Design of Computer Simulation System of Improving Drivers’ Risk Perception

3D MAX software is easy to use, has more available plug-ins, has strong function with three-dimensional animation, and has the functions with huge material library. Therefore, this paper uses 3D MAX software to build the simulation system (simulation system design flow chart showed in Figure 3), and uses Auto CAD to offset the problem of inaccurate location of 3D MAX, to combine the accuracy of Auto CAD and the authenticity of 3D MAX fully.
The characteristics of pedestrians and bicycles are very similar as the vulnerable groups, so we mainly draw two types, one is pedestrian and the other is vehicle. The two models mainly adopt the polygon modeling method with strips modeling and NURBS modeling. Based on the traffic accident statistics of every year, it is found that three kinds of accidents such as frontal impacts, sideway impacts and rear-end impacts accounts for high cumulative frequency, about 3/4 of the total accidents numbers (Figure 4). So the three forms should be the main types in the animation.

Fig. 4. Type of road traffic accidents scale drawing in 2010

When choose the scenes, considering the high accident ratios on the straight road, detour, sloping road, these are researched mainly (Table 1).
Table 1. This is the number of accidents in a city.

<table>
<thead>
<tr>
<th>Road conditions</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight road</td>
<td>213</td>
</tr>
<tr>
<td>Tortuous path</td>
<td>34</td>
</tr>
<tr>
<td>Sloping road</td>
<td>16</td>
</tr>
<tr>
<td>Crossing road</td>
<td>3</td>
</tr>
<tr>
<td>T character road</td>
<td>5</td>
</tr>
<tr>
<td>Narrow road</td>
<td>8</td>
</tr>
<tr>
<td>Rotary road</td>
<td>2</td>
</tr>
<tr>
<td>Bridge</td>
<td>1</td>
</tr>
</tbody>
</table>

When designing the scenes, in order to make the scenes more visual and lifelike, certain background should be designed. Based on a large number of references, the background is designed as an entity covering the models, and giving stickers, which produces a very good effect. In order to simulate the driving characteristics under the bad climate conditions, particle systems are used to simulate the visual characteristics under the rain and snow. Rendering is a crucial process when making the scenes, 3D MAX as the default is used. The objective of this paper is to provide the simulative scenes for traffic participants and analysis of the risk prediction, so no more need in the quality, finally AVI widely used is adopted, which can make the software practical and wide in use.

In order to use the dangerous scenes conveniently and simply, and be able to add and maintain subsequently, Visual Basic 6.0 is adopt to invoke and exploit scenes. Basic interfaces are shown in figure 5 and figure 6.

5. Case Analysis

A driver is driving his car in a street, for some reasons, a van parks in the opposite driveway, forming the blind spots in front of the truck for the driver; while there is some fallout scattering on the other side of the street (a tire set in the figure), behind the fallout, a pedestrian and the car are traveling towards the same direction, which is likely to form conflict with the driving car (Figure 7).

Main scenes as following:
For such scene, you can use the 0 frame static picture firstly, and then use another frame, which are seen by participants, next let participants see the change of the situation and predict what will happen. The training process is to help drivers inform the correct internal driver model, then help drivers develop good driving habits through the educational activities of training, the hall-style discussion and evaluation (personal interview), finally improve drivers’ awareness and prediction of the potential danger in such scene(same or similar).

CONCLUSION

Based on the analysis of driving behavior and pattern in theory, the effect of drivers' risk perception during driving and the formation of the internal model are analyzed. The method combining hall-style discussion with personal interview is put forward to make drivers judge and think independently to enhance perception to the potential danger. 3D MAX software is used to develop some potential dangerous scene which drivers often encounter. The perspective of each scene and drivers' driving action animation in the scene are made through using the wireframe of the software. To form the observation with multi-perspective and multi-dimension, the camera is set in different locations to shoot scenes. These simulation scenes are provided for training drivers, which can improve the drivers' risk perception and help form the correct internal mode to reduce the accident rate. The system has a great significance for the development of some simulation software on drivers’ ability of risk perception for future.

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