Research on Dynamic Simulation System of Dangerous Goods Road Transportation Accident Process

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Abstract. Firstly, the overall scheme of the dynamic simulation system of the dangerous goods road transportation accident process is determined. According to the technical route of the system development, the functional framework of the software and the main input parameters (vehicle mass, speed, etc.) are completed, the three-dimensional model of the vehicle and scene is established, and the function of the simulation system is developed. The typical accidents such as rear end collision, fire explosion and leakage explosion in tunnel are simulated. The real-time display of accident process parameters and the visual display of accident hazard radius are realized.

1. Introduction
In the process of road transportation of dangerous goods, once there is a traffic accident, it is very easy to have accidents such as fire and explosion, which will cause catastrophic damage to the surrounding facilities and people, and then a series of secondary accidents. How to deal with road traffic accidents quickly and scientifically and find out the causes of accidents is a very important topic. With the continuous progress of computer graphics technology, virtual reality technology has been more and more widely used. Using computer simulation to reproduce the accident process and analyze the road traffic accident can provide important reference for revealing the mechanism of accident chain. In this simulation system, by creating a three-dimensional vehicle traffic accident demonstration platform, the virtual 3D scene can be reproduced, and the particle effect system is introduced to vividly present the real-time dynamic process of flame and explosion combustion. It is very helpful to explore the occurrence and development mechanism of the accident and determine the reasonable consequence evaluation method. It can provide reference for enterprises and governments in the prevention, prediction and evaluation of road transport accidents of dangerous goods and the formulation of emergency plans.

2. Simulation system scheme

2.1 System architecture
Based on the demand analysis of the simulation of dangerous goods road transportation accident process, the functional framework of the system is determined, as shown in Figure 1.
2.2 System development process

Vehicle collision is the main form of road transportation accidents, in fact, two vehicle collision is the most common traffic accident. Therefore, this system is mainly developed for the three-dimensional simulation system of the collision, leakage, combustion and explosion between the dangerous goods transport tanker and the truck. The flow of system function design is shown in Figure 2.

The establishment of scene mainly includes the establishment of transport vehicle model, road traffic environment model, collision deformation model, combustion and explosion flame particle model, leakage effect, etc. In the generation of the physical convex body collision mesh, there is a certain limit to the number of faces of the model data, so it is necessary to optimize the 3D car model used to provide the object data. The suburban and tunnel environment established in this system is used to simulate the rear end leakage, combustion and explosion accidents of dangerous goods transport tanker. With the help of the natural rendering module, the road environment is optimized to achieve efficient rendering operation. In the main
elements of the physical operation engine, the scene provides a place for the physical simulation of the object. Each object participating in the physical movement is defined as a role, and the shape is used to describe and express the external form of a role. For the buildings and traffic facilities in the environment, the independent physical role is reestablished and designed as a static rigid body model.

### 3. Simulation model establishment

#### 3.1. Vehicle model
Using the 3D modeling software, according to the actual parameters of the vehicle, the tractor and tank semi-trailer (head and tail) of the dangerous goods transport vehicle are respectively 3D modeled, as shown in Figure 3. On this basis, the overall appearance of the vehicle is optimized. In order to restore the scene effect more realistically, transparent materials and metal materials are designed for various parts of the vehicle, such as glass, metal shell, oil tank, chassis, tires, etc.

![Figure 3. Vehicle model](image)

#### 3.2. Terrain model
The scene of dangerous goods transport vehicles mainly includes country road and city road. At present, in order to better show the process of accidents, a field road model with less shelter is established, as shown in Figure 4.

![Figure 4. Road model](image)

#### 3.3. Flame and explosion particle model
Because the goods transported by dangerous goods transport vehicles are usually inflammable and explosive materials, such as gasoline, diesel, methanol, natural gas, etc., the system mainly simulates and demonstrates the fire and explosion accidents caused by accidents. The simulation of flame needs to be realized by establishing particle simulation system. Combined with the pictures and videos of real accidents, the system has established a more realistic effect of oil fire, as shown in Figure 5.

Explosion is one of the most serious consequences in the accident of dangerous goods transportation vehicles. It has strong destructive power, great harm and wide range of casualties. Therefore, the simulation of explosion process is one of the key contents of the system. When explosion, the most intuitive effect is the huge flame and smoke caused by explosion. In order to present this effect better, we need to create an example model of explosion separately. This system establishes the explosion effect model through the particle simulation method and optimizes it, as shown in Figure 6.

![Figure 5. Flame particle model](image)  
![Figure 6. Explosion particle model](image)

### 4. Interactive control
For a practical software system, its interface is a very important part. In this software, the status monitoring module, visual angle control board, simulation process control button and parameter setting interface are set for the user, as shown in Figure 7.
4.1. Status monitoring function

In order to present the simulation effect in real time, the state information monitoring board is added in the simulation process of specific scene. It is used to reflect vehicle operation information and collision information, mainly including vehicle status, loading quality, driving speed, driving direction, driving distance, braking distance, collision speed, collision deformation and injury radius. In addition, in order not to affect the embodiment of the simulation process, the state parameter monitoring panel is semitransparent on the left and right sides of the scene.

4.2. Observation function control

The observation function mainly includes observation angle control, vehicle model display and scene capture. In order to facilitate the observation of the accident process, visually observe the rendered picture, experience the collision, observe the car shape after the collision, etc. By adding different cameras to the system and calling through the channel conversion module, it is convenient for users to switch multiple perspectives at any time, including the main perspective, follow perspective, global perspective, rear perspective and front perspective, which can realize all-round observation and interactive experience. In addition, in order to facilitate the user to observe the simulation process, a hidden pop-up button is set for the perspective control panel.

4.3. Parameter setting function

For parameter setting, the user can complete it through the parameter setting interface. Click the wrench button at the upper left corner of the interface to enter the parameter setting interface, as shown in Figure 8. In order to facilitate the user to set the parameters, three panels are designed: the head parameter setting panel, the tail setting panel and the impacted vehicle setting panel. The panel can be switched through the left and right arrows below.

After setting the parameters, users can click the Apply button to apply the set parameters to the scene. In addition, you can save the current parameter information through the Save button. The next time you open the software, the parameters will be automatically updated to the saved configuration. At the same time, the parameter setting interface can view the detailed technical parameters of the vehicle.

4.4. Simulation control

In order to facilitate the control of the simulation process, the control buttons are set, including start / pause button, reset button and repeat button.
5. Typical accident simulation

5.1. Main scene simulation

5.1.1. Simulation of collision process. As most of the material of the vehicle is metal, once there is a collision accident, the vehicle will have different degrees of deformation. The size of the shape variable is determined by the relative running speed of the vehicle before collision, the friction coefficient of the ground, the hardness of the impacted part of the vehicle and the mass of the vehicle. Therefore, it is necessary to build a collision effect that can be simulated dynamically according to the parameters. Through the establishment of code script, this effect is achieved, the effect is as follows.

5.1.2. Fire process simulation. When the vehicle collides, it is necessary to judge the energy conversion process according to the collision situation. Once a high temperature is generated at the oil, it is easy to produce a fire. Therefore, in view of this situation, the effect of fire after vehicle collision is completed, and the time of fire, the size of fire can be set and correlated through parameters.

5.1.3. Hazard impact radius. After the explosion of dangerous goods, the influence radius of blast wave is displayed intuitively.

5.2. Simulation effect.
The system can visually display the process of combustion and explosion accidents caused by vehicle collision leakage, and can output real-time data such as braking distance, collision speed, collision deformation, vehicle mass, loading mass and injury radius.
The simulation results of rear end, combustion and explosion accidents in suburban environment are shown in Figure 9.

![Figure 9. Rear end combustion and explosion effect of tank car](image)

The rear end, leakage and explosion effects of tank cars in the tunnel are shown in Figure 10.

![Figure 10. Explosion effect of rear end leakage of tank car in tunnel](image)

6. Conclusion
The research of this system is based on the 3D development platform, and the 3D modeling method and C# programming technology are deeply studied. Based on the analysis and calculation of dynamics and thermodynamics in the accident of dangerous goods transport vehicle, a three-dimensional demonstration platform of vehicle accident is established by integrating the law of energy conversion. The platform can be used for 3D reconstruction of road traffic accidents. Through this platform, we can fully and truly feel the movement of vehicles in the accident, so as to intuitively reveal the behavior and potential danger of vehicles in the traffic accident. By analyzing these behaviors and risks, we can make contributions to the prevention of traffic accidents.
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