

## DESIGN OF SIMULATION-BASED VIRTUAL AUTOMOBILE EXPERIMENT FIELD

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Received May 2016; accepted August 2016

**ABSTRACT.** *Virtual reality is a multidisciplinary development of computer technology, which uses computer graphics technology, human-computer interaction technology, simulation technology and other technologies. Using computer technology to generate a virtual environment, the user can make use of certain devices with the object in the virtual environment to interact and generate a sense of the real environment. The automobile virtual experiment can be used for automobile tests, such as performance test, braking test, and handling stability test. The emergence of virtual reality technology makes the emergence of the virtual automobile experiment field become possible and brings the automobile industry into another new era. In this paper, based on the Multigen Creator, the three-dimensional models of the roads, the auxiliary facilities and the automobile are established for automobile virtual experiment field, and the optimization techniques and modeling methods of 3D virtual scene are introduced. Finally, this paper loads the virtual experiment field and the virtual automobile model, and realizes the real-time roaming of the virtual experiment field using Vega Prime.*

**Keywords:** Virtual reality, Multigen Creator, Vega Prime, Virtual experiment field, Real-time roaming

**1. Introduction.** Virtual reality technology is based on system science, computer science, probability theory and numerical calculation method [1]. In the virtual reality simulation technology, the digital information in the simulation is changed into an intuitive 2D or 3D simulation animation. Through making full use of the characteristics of immersion, interactivity and imagination of virtual reality, it can improve the fidelity and readability of the simulation process and result [2]. The road tests in automobile experiment field include a series of road conditions in the process of automobile driving, which can speed up the development period of automobile and reduce the cost of development. Using virtual reality technology to generate an automobile virtual experiment field is a timesaving and effective method for automobile testing.

The virtual test technology is used in the product development of the Mercedes Benz automobile company. By giving the design scheme and parameters of the new model, the dynamic simulator is used to predict and evaluate the dynamic characteristics of a new type of automobile [2]. In the research of the reliability of the virtual experiment, TOYOTA and Isuzu Motors Ltd. are attaching great importance to the study of the reliability and durability of the automobile in the virtual test. Isuzu Motors Ltd. is in the forefront of the field of truck body strength test in the field of virtual experiment, and

has been successfully used in the virtual test of some key parts of the fatigue strength test [3]. North Carolina University researches automobile driver's virtual environment, researching in virtual environment to drive a virtual automobile, to seek a reduction of traffic accidents driving scheme. The United States has made a lot of achievements in the field of automobile virtual experiment, which has contributed to the industrialization of virtual reality technology.

Therefore, the combination of the analysis of the performance of the automobile and the interactive roaming of the virtual scene has become an important aspect of the study. Firstly based on the Multigen Creator, the three-dimensional models of the roads, the auxiliary facilities and the automobile are established for automobile virtual experiment field. And then, the optimization techniques and modeling methods of 3D virtual scene are introduced. Finally, this paper loads the virtual experiment field and the virtual automobile model, and realizes the real-time roaming of the virtual experiment field using Vega Prime.

## 2. The Establishment of the Scene of the Virtual Test Field of Automobile.

**2.1. Introduction of Multigen Creator and Vega Prime (VP).** Multigen Creator is a software designed by the American Multigen-Paradigm company, which is a powerful and interactive 3D modeling software for real-time visual simulation. This software can quickly realize the real-time scene rendering, and it can effectively solve the problem of real-time rendering. Vega Prime software is also developed by the Paradigm Multigen Company for scene driven software. The most basic functions are driving, controlling, managing the virtual scene and can easily achieve a large number of special visual and sound effects.

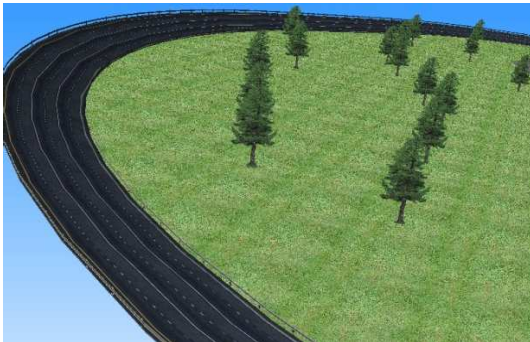


FIGURE 1. High speed ring road

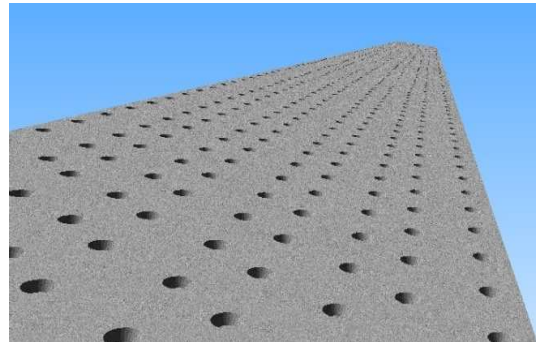


FIGURE 2. Pothole road

**2.2. Example of modeling the basic roads of automobile virtual test field.** The modeling of high speed ring road needs to meet the various parameters of the existing test field, such as the transition curve length, turning radius, and the height difference between the inner and outer sides of the ring road. In the modeling process of high speed road, this study makes full use of the roads models for the design of parameters based on the parameters of the actual test field [4]. Figure 1 is a high speed ring road.

Comprehensive road contains twisted road, washboard road, pothole road, and so on [5]. These models can be built by using geometric modeling tools in Multigen Creator. Figure 2 is a pothole road model. Using the wall tool in the geometric construction tool box of Multigen Creator, the horizontal surface of the circular or rectangular plane of the road is pressed. The effect appeared potholes.

**2.3. The establishment of auxiliary facilities in the virtual test field of automobile.** The virtual scene modeling of the auxiliary facilities, with geometric modeling tools in Multigen Creator, can be easily constructed, such as the fence, signs and lighting facilities. After the models are established, a good visual effect is achieved by mapping the texture. Figure 3 is 4m long protective fence model using modeling tools. On both sides of the road, they are placed on both sides by an external reference or an instance of the road.



FIGURE 3. Protective fence



FIGURE 4. Truck model

**2.4. The establishment of a virtual automobile model.** According to the dimension parameters given by the design drawings of the automobile, the 3D model of the specific automobile should be built using the modeling tool provided by Multigen Creator. However, under normal circumstances it is difficult to obtain the automobile design drawings and detailed design parameters. Therefore, the usual practice is by a two-dimensional image as a background image to create a 3D model of an automobile, the 2D image is used to provide modeling reference point, and obtain the front, back, left and right views of automobile in the picture. The basic parameters of the automobile size can be a proportion of automobile model.

Figure 4 shows the model of the truck. In Multigen Creator, according to the data hierarchy of Multigen Creator, the parts of the automobile model are divided. In the construction of truck, the automobile body and tires are divided into two parts. For automobile steering wheel, there is a steering movement, except its motion forming around the rotation of the axis. In addition, this paper adds degrees of freedom to the wheels, which can contribute to building a good model for the follow-up simulation.

**2.5. The integration of the scene.** After the models are established, the sets and the models are set up to match with the requirements of the scene by a certain form. Combined with the actual automobile test scenarios, the various road models, auxiliary facilities and landscape models are combined and optimized. The model of automobile virtual test field can be carried out for basic automobile test. Containing a large number of polygons, the model can be used for external reference technology in order to save memory space. The terrain construction of small units can be directly modeled. The general layout and local scene of the virtual experiment field are shown in Figure 5.

### 3. Key Technologies and Optimization of Multigen Creator Modeling.

**3.1. Texture mapping technology.** In Multigen Creator modeling process, the polygon of the model can increase the real sense of the object, but in the drive, a large number of polygons will make the graphics display speed is slow, and the simulation results are affected. Texture mapping maps 2D images onto a geometric shape, and a technique for the representation of the true degree of the model through the true sense of the image.

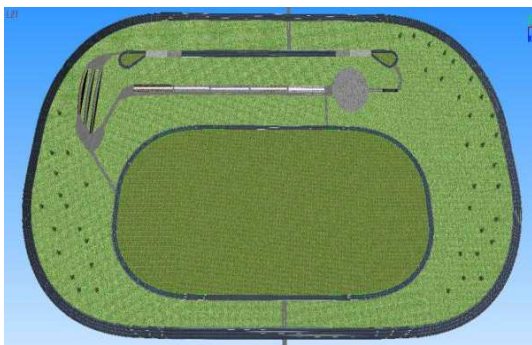


FIGURE 5. General layout

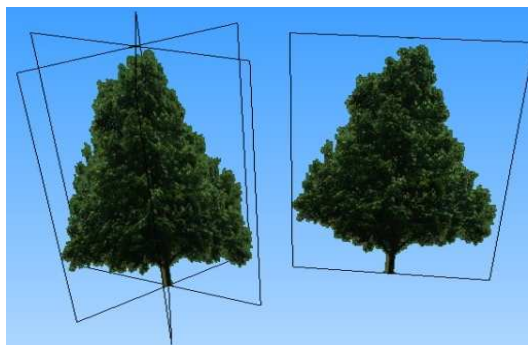
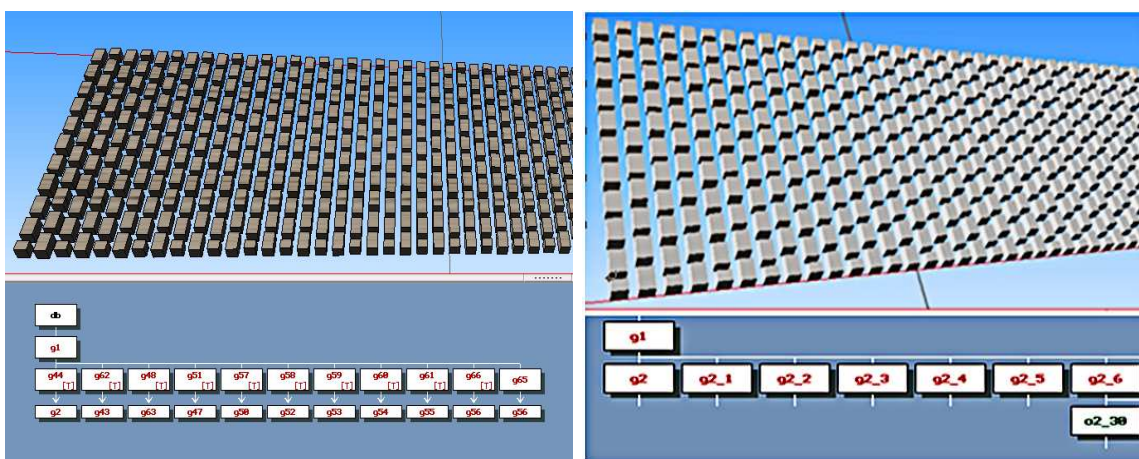


FIGURE 6. Texture mapping



(a) Instance

(b) Copy

FIGURE 7. (a) Instance and (b) copy

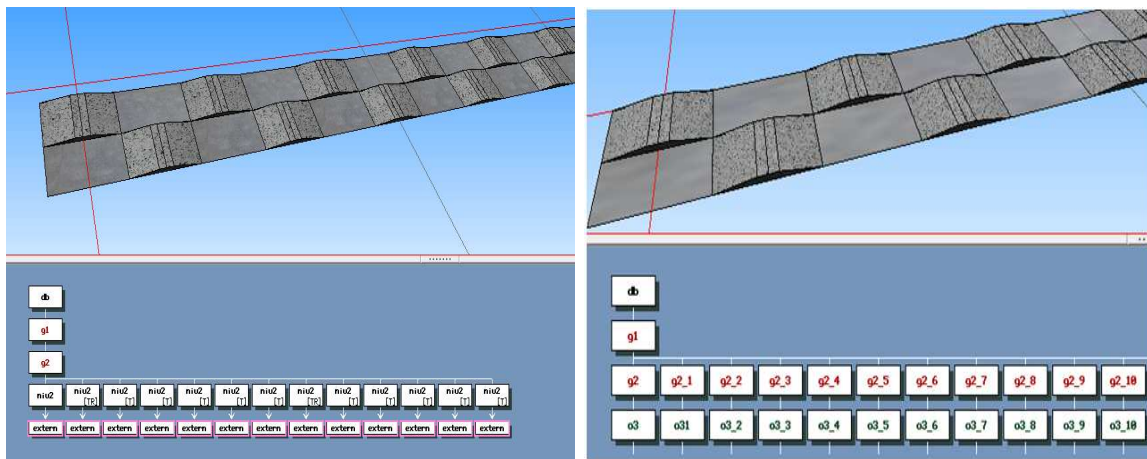
In order to ensure the texture of the normal display, the size of the texture included the length and width of the two directions should be  $2^N$  [6]. If in the visual simulation software is not reached, and then transferred to the texture picture, there will be the phenomenon of distortion. Figure 6 is texture mapping of the tree on the road.

**3.2. Optimization of the instance.** An instance is a reference copy of a model object in the model database, which can be used to represent multiple objects, which are the same geometry but different locations. For example trees, street lamps, railings, and so on between instances of an object model and a copy model of the object, there is a substantial difference. Copy is the full copy of the model object geometry, and the instance is only a pointer to the model database in the objects model. Instances are installed in memory only once, similar to the file of dynamic database [7].

Figure 7 is a comparison between an object using instance technique and the model's replication for the long 50m Belgian Road. Figure 7(a) is the model using instance technology, and the memory size of file is 61.6KB. Figure 7(b) is the model which replicates the object, and the memory size of file is 226KB. The difference between the two models shows that the views are not large, but the memory sizes have a big difference.

**3.3. External reference technology.** The technology of external reference is similar to the instance technology, and it is only a pointer to model which is external reference, and not to directly copy and paste the model.

Figure 8(a) is the use of an external reference of twisted road, whose memory size is 29KB. Figure 8(b) is a simple copy of the twisted road, whose memory size is 71KB. Therefore, in the constructing process of scene model, external references can refer directly



(a) External reference

(b) Simple copy

FIGURE 8. (a) External reference and (b) simple copy

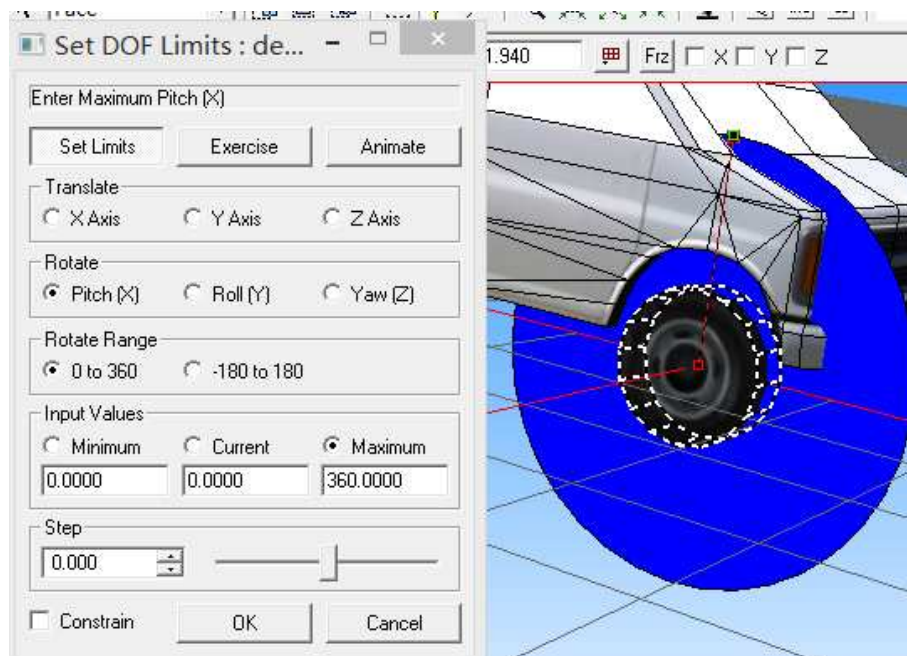


FIGURE 9. The right front wheel degree of freedom

to other database models into the current database model to optimize the hierarchical layout of the entire scene, and improve the real-time performance.

**3.4. DOF (Degree of Freedom) technology.** Using DOF technology can make the model have the ability to exercise. DOF nodes can rotate or move the sub nodes according to the DOF which is set.

In the dynamic model, the automobile wheels need to be set up with the degree of freedom, and be driven in Vega Prime which is a visual driving software, through using Lynx Prime (LP) interface of the drive software and writing C++ program codes. Figure 9 is the automobile right front wheel, which is set by 0 ~ 360 degrees of freedom around the axis of the wheel.

#### 4. Virtual Scene Real-Time Drive Roaming.

4.1. **Design flow of Vega Prime.** The development process of simulation system is divided into three parts, which are model creation, settings of Lynx prime graphical interface and designing of visual simulation program.

Model creation mainly has the establishment of the static three-dimensional model library and the generation of large scene terrain.

Settings of Lynx Prime graphical interface include settings of basic environment, settings of the initial location of model, settings of special effects, etc. ACF files generated by settings of Lynx Prime can be achieved to control visual model database and drive entire scene. The main contents include the implementation of real-time driving algorithm, processing of real-time simulation data, collision detection and response, scheduling and management of scene, viewpoint controlling, and so on.

Designing of visual simulation program is mainly to complete the process of whole simulation, and provide real-time and smooth simulation scene for users. When designing visual simulation program, the static properties of the configuration can be achieved by the graphical interface of configuration tool Prime Lynx. And then, the desired scene rendering is generated using the API function of Vega Prime.

#### 4.2. Realization of visual simulation.

4.2.1. *Scene observation.* Visual effects of visual simulation is performed through the screen, and a virtual reality system can generally have more screens. The screens are displayed in the window through the channels.

Two channels are set in this paper. Through adding the first channel, the coordinate of dynamic system is the starting point for an observer which will be set at the back of the automobile as the first point of view of the simulation point. And this model adds the second channel as the channel for looking down.

The position of the channel in the main window is set in the LP of draw area. Figure 10 shows the settings of the channels. If left-right is set to 0 ~ 0.5, from left to right accounted for half of the main window. If up-down is set to 1 ~ 0.5, it means that half of the main window is from top to bottom. That is the second window which covers the main window position in the upper left corner of the location, whose size is 1/4 of the main window.

4.2.2. *Collision detection.* Collision detection is used to detect whether there is a collision between different objects in the field of computer graphics, system simulation and other research fields.

In Figure 11, the terrain is as the target of tripod detection. Isectortripod will use the terrain to find contact. And the information is transmitted to all relevant movement

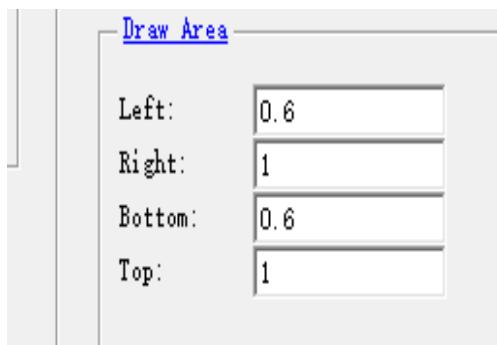


FIGURE 10. Channel setting

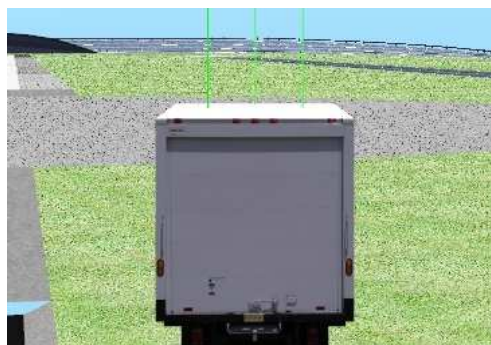


FIGURE 11. Collision detection

patterns. The terrain target is found using isector. The lines are displayed as green and terrain targets can be viewed through the active preview.

4.2.3. *Selection of roaming mode.* The roaming modes include automatic roaming and manual roaming. Automatic roaming path can be set up on the LP using navigation tools in the scene with appointing certain roaming speed to each path. Through interactively using the VP of API function, this mode controls these paths and the automatic navigation paths can be switched with each other.

The users and computers in manual roaming mode control the roaming system interactively through a variety of inputting devices, and operate using the mouse or keyboard. In this paper, the MotionDrive mode is used to control the speed of movement mode and controlling action.

4.2.4. *Lynx Prime setting and driver of Vega Prime.* The file of Lynx Prime is established in the ACF file of application configuration mentioned in this paper. ACF includes all the information required for VP application initialization and some of the data required to run. To establish a virtual scene which is real-time and interactive, many parameters are needed to be defined. For example, there are a series of parameters, such as putting the terrain and the various objects into the scene, the observer's position, the movement of the object and the location of the object. In the LP visual interface graphics of VP, we can easily manage these parameters setting for complex scene. We can also set the basic parameters in the LP, export \*.cpp files, and write more complex and real-time applications using VC++. In addition, VP provides a rich function database. We can call it and can achieve the function of automobile driving simulation.

In the LP, this paper sets up the virtual scene in the various parameters to create an ACF file, starts the VP system, and calls the ACF file, so that real-time simulations of virtual scene and roaming are achieved such as Figure 12 and Figure 13.

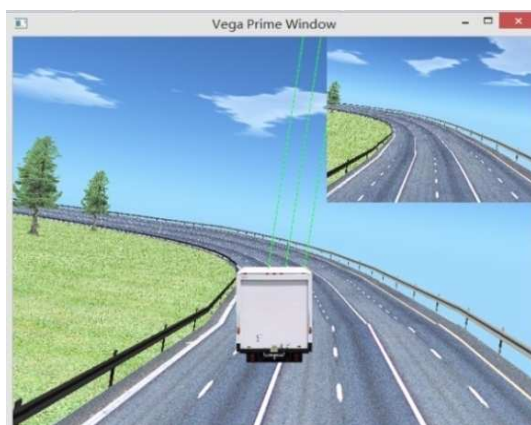


FIGURE 12. The scene in the ring road

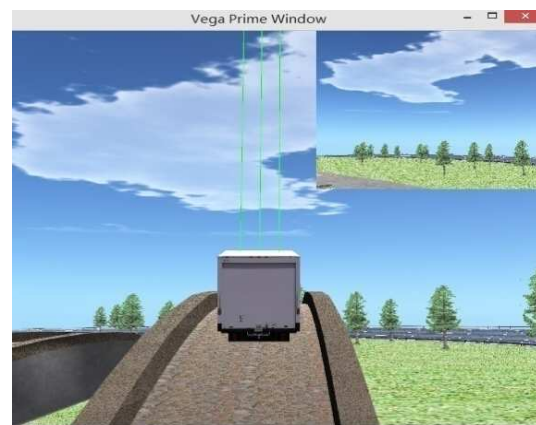


FIGURE 13. The scene in the ramp road

5. **Conclusion.** The automobile virtual experiment can be used for automobile tests, such as performance test, braking test, and handling stability test. This paper used virtual reality technology to design the virtual automobile experiment field. In this paper, based on the Multigen Creator, the models of the roads, the auxiliary facilities and the automobile are established for automobile virtual experiment field, and the optimization techniques and modeling methods are researched. Finally, this paper loaded the virtual experiment field and the virtual automobile model, and realized the real-time roaming using Vega Prime. In the future research, the results of the paper will be used for the vehicle test.

**Acknowledgment.** The project was supported by the Special Fund for Basic Scientific Research of Central Colleges, Chang'an University (ID: CHD2012JC006). The authors also gratefully acknowledge the helpful comments and suggestions of the reviewers.

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