

STUDY ON ROADS DESIGNING OF AUTOMOBILE VIRTUAL EXPERIMENT FIELD BASED ON MULTIGEN CREATOR

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ABSTRACT. *In the process of researching and production process of the vehicle, the vehicle test results should reflect the actual situations, so that the vehicle needs to be exposed to the actual use of the environment, and automobile experiment field is needed. During the process of driving, the vehicle will encounter a variety of road conditions, so that the vehicle test field should include many kinds of roads. Using virtual reality technology to generate a virtual environment is a timesaving and effective method, and the roads of automobile virtual experiment field can be designed using the computer technology. First, this paper analyzes the roads' characteristics of the automobile test field, and makes a comprehensive analysis on the function, scale and facilities of the roads in the vehicle test field. Secondly, based on the Multigen Creator, a 3D model of the roads and the auxiliary facilities are established.*

Keywords: Road designing, Multigen Creator, Vehicle, Virtual experiment field

1. **Introduction.** Through using the virtual reality simulation technology, the digital information in the simulation is changed into an intuitive 2D or 3D simulation animation. The designing and producing of a new vehicle should be tested seriously before using. Using virtual reality technology to generate an automobile virtual experiment field is a timesaving and effective method for vehicle testing [1]. 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 roads, the dynamic simulator is used to predict and evaluate the dynamic characteristics of a new type of vehicle [2]. In the research of the reliability of the virtual experiment, Isuzu Motor Ltd. is in the forefront of the field of truck body strength test in the field of virtual experiment, which has been successfully used in the virtual test of some key parts of the fatigue strength test [3]. North Carolina University researched vehicle driver's virtual environment, and researched in virtual environment to drive a virtual vehicle, to seek a reduction of traffic accidents driving scheme [4]. The automobile experiment field can be divided into comprehensive test site and the professional test field according to the function of the experiment field [4]. This paper aims to study on the virtual roads designing of comprehensive test site.

The vehicle test field should include many kinds of the roads, so that this paper researches the roads of the automobile virtual experiment field. Firstly, this paper analyzes the roads' characteristics of the automobile test field, and makes a comprehensive analysis on the function, scale and facilities of the vehicle test field. Secondly, this paper establishes 3D model of the roads and the auxiliary facilities using Multigen Creator.

2. Overview of Automotive Testing Roads. In the process of researching and producing process of the vehicle, a rigorous road test is needed. In order to make the vehicle test results reflect the actual situation, the vehicle needs to be exposed to the actual use of the environment. In the process of driving, the vehicle will encounter a variety of road conditions, so that the vehicle test field should include many kinds of the roads. Automobile manufacturers in the world hope to improve the efficiency of the vehicle test, and shorten the cycle of testing, and the vehicle test field comes into being.

2.1. Classification of experimental fields. If the 10 km² facility covers an area, the automobile test field can be called large field test. For example, Europe's largest vehicle test field Ehra-Lessien test site, located in the German Wolf fort, is the German Volkswagen vehicle test site. The overall layout is quite distinctive, straight 9 km long, the phone shape of high-speed ring road 20.5 km long week.

Although the area is limited, small and medium-sized comprehensive experimental field includes all kinds of the test road and the pilot project, and most of Asian experimental field belong to this kind. There are some small and medium scale test fields which are used for meeting the product development in the construction of automobile parts company. For example, Germany WABCO Company near Hannover built special testing ground for meeting the needs of the company development and evaluation of braking antilock braking system ABS, ASR, etc. In general, the virtual experiment field should include many kinds of roads for vehicle testing, such as high speed ring road, comprehensive performance road, rotation characteristic test field.

2.2. Typical test roads and infrastructure for the test. The functions and scales of the vehicle test fields are different. And the test field of the test roads and the types of facilities, geometry are also different. Therefore, the analysis of the typical test roads and facilities will be researched [5,6].

High-speed ring test road in the vehicle test field is in the outer ring of high-speed circular runway. Its cost and difficulty of construction are maximum in the test field, and the length also marks the size and level of test field, which is an important part of all facilities.

The high-speed ring road is dedicated to automobile for continuous high speed test of circular runway. According to maximum speed of automobile, the high-speed ring road is designed into a certain super high spatial 3D surface, which is shown as Figure 1.

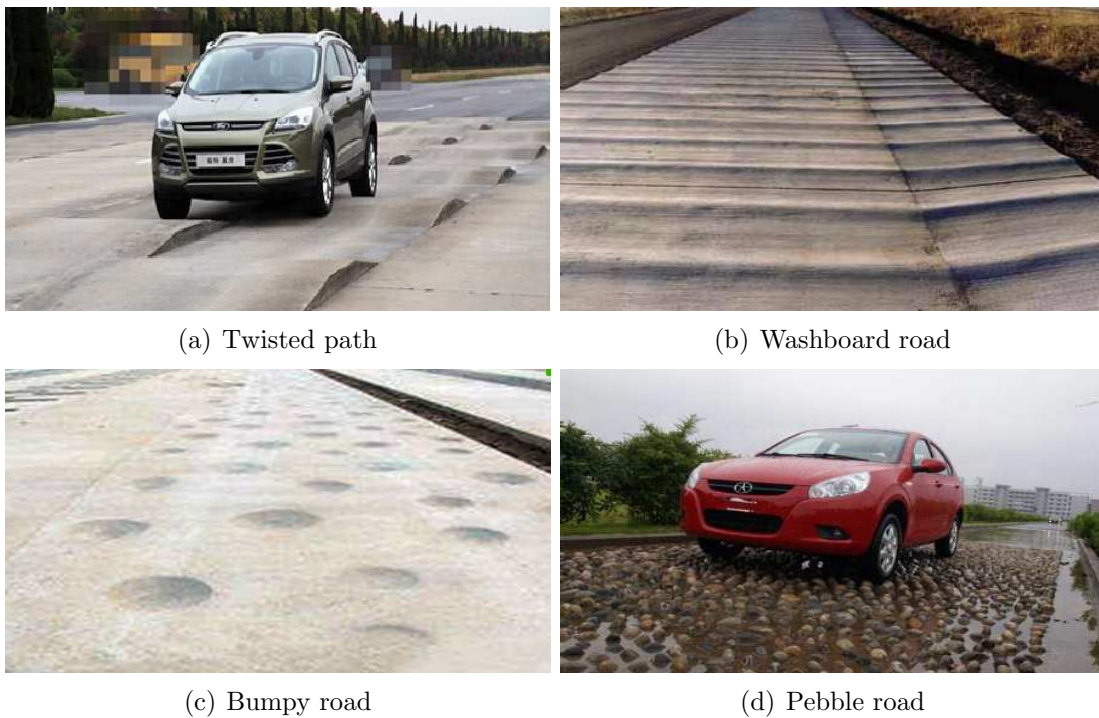
The comprehensive performance of road is generally as the telephone line shape. At both ends of the turn, the main functions are starting and accelerating for vehicle, the corner of turning should set a certain super high. The test sections should be flat and uniform. The cross slope should be as small as possible under the premise of guaranteeing the drainage, and the longitudinal slope should not be greater than 2 per thousand. The



FIGURE 1. High speed loop test



FIGURE 2. Steering test field



(a) Twisted path

(b) Washboard road

(c) Bumpy road

(d) Pebble road

FIGURE 3. Reinforced pavement roads

test road can be carried out with the braking performance and ABS research, identification test, tire performance and antislid evaluation test, and so on.

Rotary characteristics test field should have flat surface and stable friction coefficient. The introverted slope or decumbent slope must be less than 0.5%. The rotation characteristic test field can be used for automobile steering, driving around the shape of “8” and the driving stability of the snake around the pile test, such as Figure 1 and Figure 2.

ABS test road is composed of high and low adhesion coefficient roads. The road surfaces with different adhesion coefficients are combined in butt-joint or stitching together way. The roadside is provided with a spraying and draining water device for different adhesion coefficients. The braking test can be carried out, such as automotive antilock braking system test, test of braking distance, and braking stability.

Reinforced pavement roads aim to the needs of the rapid test of the reliability of the vehicle, which are specially built, so as to strengthen the bad road and that can be referred to the reliability test road such as twisted path, washboard road, bumpy road, and pebble road, which are shown in Figure 3.

3. The Establishment of the Roads of Virtual Experiment Field.

3.1. Multigen Creator profile. Multigen Creator is software designed by the American Multigen-Paradigm company, which is 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 [7].

Creator software mainly consists of the basic modeling tools, the standard road modeling module and the terrain modeling module. In this study, a variety of modeling methods are used to satisfy the virtual scene.

The standard road modeling module is an important module in creator. Using this module, this study can quickly establish a highway model, urban roaming in the viaduct, etc. This study uses standard road module and the basic module of the way, so that the establishment of the scene is more real.

3.2. The establishment of the basic roads of the vehicle virtual test field.

3.2.1. The establishment of high speed ring road. The structure of the virtual high-speed ring road matches the various parameters of the existing test field, such as the transition curve length, turning radius, the outer side of the ring road, and a high degree of difference. Therefore, according to the actual test field parameters, the parameters of the road are designed in the process of modeling the virtual highway using road modeling module in Multigen Creator. For example, the length of easement curve segment in the field is 135 m, curve radius is 120 m, the lateral height of high-speed ring road curve is 3.6 m, high speed circuit is designed using cement concrete pavement, which is oblong, and the width is 9 m. The runway is divided into low-speed, medium speed, high-speed loops. The road includes three kinds of lanes, which includes speed 50 km/h, 100 km/h and 160 km/h respectively, and the maximum safe speed is 210 km/h. Construction of the three lanes of virtual high-speed ring road is shown in Figure 4, which is built using Multigen Creator.

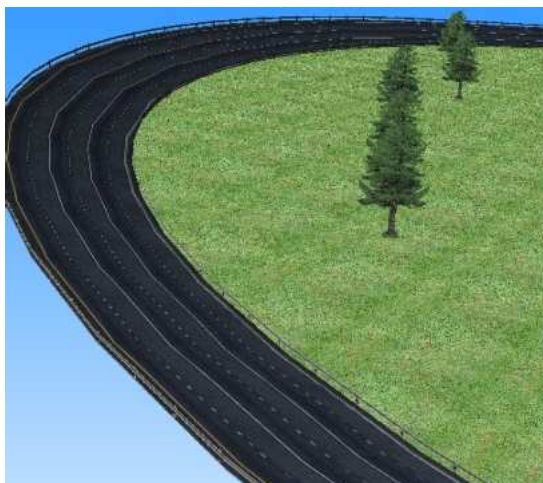


FIGURE 4. Virtual high speed loop

3.2.2. The establishment of integrated road. This paper will combine the conditions of the reliability, strengthening, durability for test road into the integration of the formation of a comprehensive road.

(1) Twisted road. The cross section shapes of the twisted road can be a waveform, a trapezoid or a cone which adapt to different vehicle types. This paper uses waveform distortion which is twisted road. Two adjacent rows of convex blocks of twisted road are mutually staggered arrangement, which ensure that the right and left wheels of the vehicle in the past twisted road are respectively placing in the wave crest of convex block

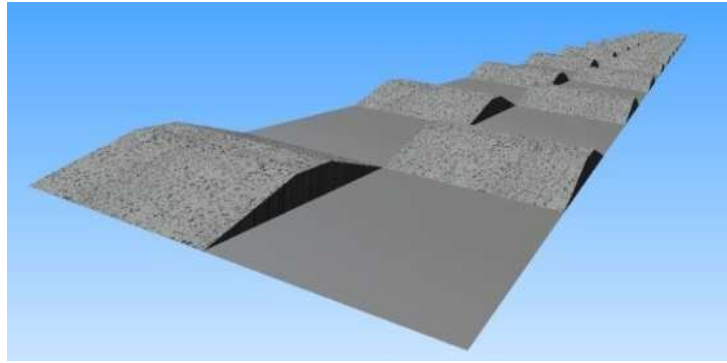


FIGURE 5. Twisted road

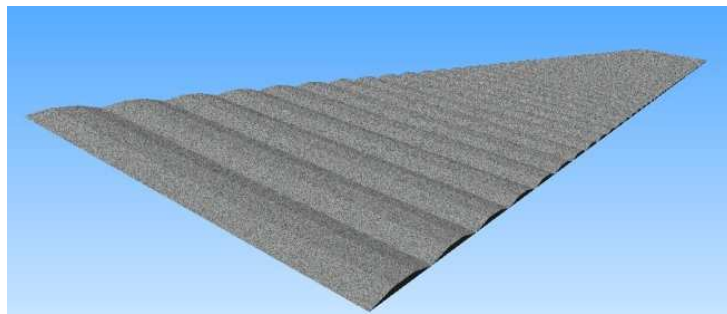


FIGURE 6. Washboard road

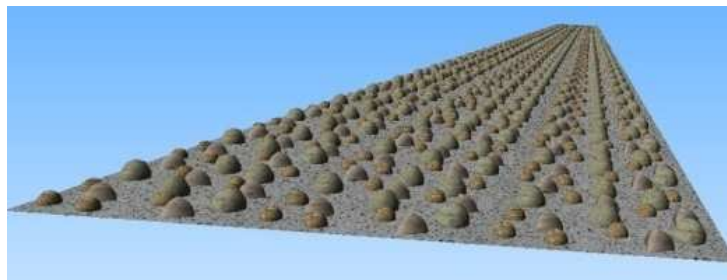


FIGURE 7. Pebble road

and trough position, and the distortion degree is relatively large. In this paper, we design two types of twisted roads, which are heavy and medium-sized twisted roads, total length is 50 m, and total width is 6 m. The heavy and medium-sized twisted road wave heights are 200 mm and 100 mm. The length of the road is 2 m, and the pavement is made of concrete. The model of twisted road is shown in Figure 5.

(2) Washboard road. The shape of washboard road is similar to the sine wave, whose wave height is about 30 mm, wave distance is from 500 mm to 900 mm, wave speed is about 1000 mm. The left and right sides of the inclined washboard road often arrange at an angle, and the left and right wheels caused by certain phase difference. The length of wave is 600 mm, and height is 20 mm. Figure 6 shows the length of 50 m and standard washboard road, which is inclined 140 degrees.

(3) Pebble road. There are three different sizes of heavy-sized pebbles whose diameters are 180 mm, 150 mm and 100 mm. The diameters of medium-sized pebbles are 90 mm, 120 mm and 150 mm. After road modeling, the pebbles along the road direction are randomly arranged, which is shown in Figure 7.

3.2.3. *Comprehensive performance road.* The comprehensive performance of road is designed as turn loop shape, which is concrete structure. The two ends of the straight line



FIGURE 8. Comprehensive performance road

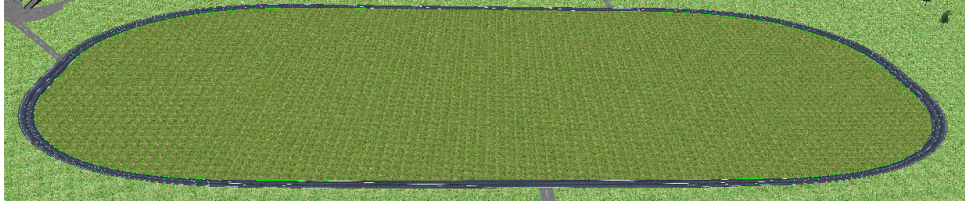


FIGURE 9. Two ring road

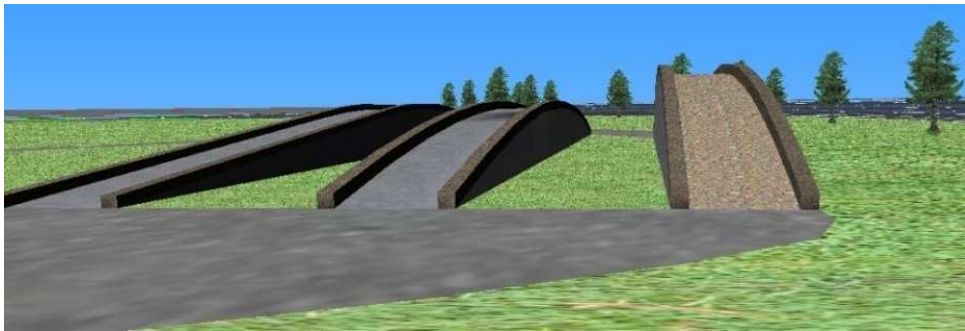


FIGURE 10. Standard ramp

segment are provided with a braking road surface, and the braking route is composed of two kinds road surface of high and low adhesion coefficient [8]. High adhesion coefficient of road surface is concrete structure, and the low adhesion coefficient of road surface is about 0.25. The design of the straight line segment length is up to 300 m, width is 8 m, and no longitudinal slope. Through modeling of straight road, curved road and different adhesion coefficient roads, the model of comprehensive performance road is shown in Figure 8.

3.2.4. *The other road.* Two ring roads are composed of asphalt pavement, total length is 1000 m, and the width is 6m. The model of two ring roads is shown in Figure 9. Standard ramp roads include slopes of 10%, 20%, 40%. The width of the lane is 4 m. The first and second types are concrete pavement, and 40% slope of the ramp road is a stones partial pavement. The protective devices of the ramp road are on the road side. Figure 10 shows the model of three different slopes of the ramp using Multigen Creator.

3.3. **Establishment of auxiliary facilities in the virtual test field.** In auxiliary facilities modeling of virtual roads, the geometric modeling tools of Multigen Creator can easily build fence, signs and lighting facilities, when the establishment of the road models achieves a good visual effect. The length of protective fence model is about 4 m using the modeling tool, which is placed on both sides of the road using the external reference technology or examples.

4. **Road Combination and Application of Virtual Test Field.** After the road models are established, the set and the model are set up to match the requirements of the scene by a certain form. Through combining the current actual vehicle test scene with the established various kinds of road models and auxiliary facilities models, virtual

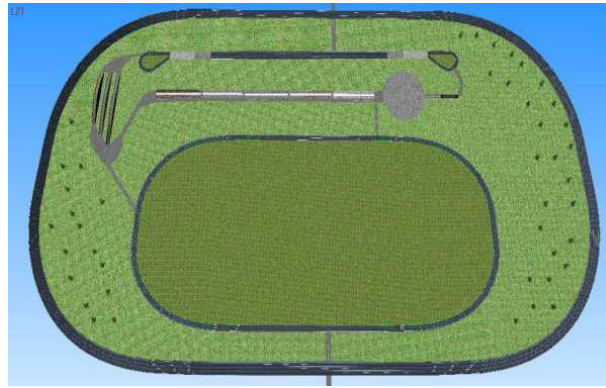


FIGURE 11. Road combination

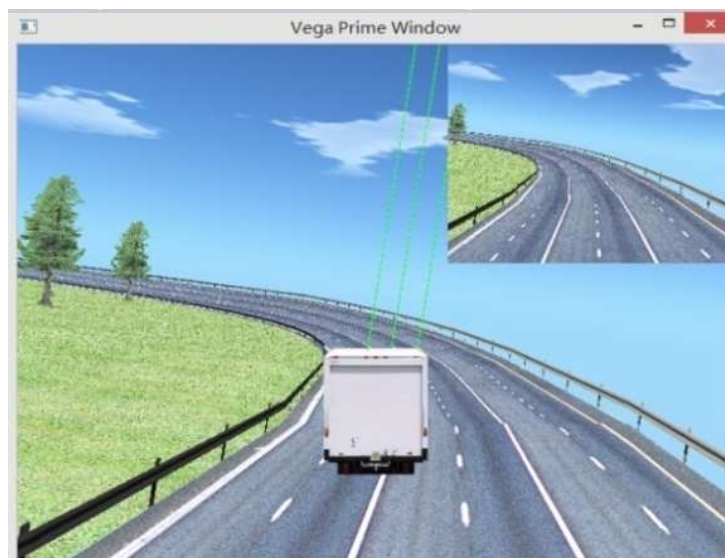


FIGURE 12. Application of virtual test field

experiment field model can be built through recombining and optimizing in Multigen Creator [9]. Figure 11 shows the general layout of virtual test field.

Simulation system development process is divided into three parts: model creation, Lynx prime graphical interface settings and visual simulation program design. Model creation mainly has the establishment of the static three-dimensional model library and the generation of large scene terrain.

Lynx Prime graphical interface settings include the basic environment settings, the model of the initial location settings, commonly used special effects settings, etc. The main contents include real-time driving algorithm implementation, real-time simulation data processing, collision detection and response, scene scheduling and management, and viewpoint control and so on.

Visual simulation program design is mainly to complete the whole simulation process, and provide users with real-time smooth visual simulation scene. Visual simulation program design can be achieved by the graphical interface configuration tool Prime Lynx model of the static properties of the configuration, but also call the visual model to generate the desired scene rendering through the Prime API Vega function. Therefore, this paper achieves real-time simulation of virtual scene and roaming, such as Figure 12. Using the virtual test field, we can do the tests of acceleration performance and handling stability about automobile.

5. **Conclusion.** The vehicle test field should include many kinds of roads, such as high-speed ring test road, ABS test road, and reinforced pavement road. This paper analyzes the roads' characteristics of the automobile test field, and makes a comprehensive analysis on the function, scale and facilities of the roads in the vehicle test field. Based on the Multigen Creator, a 3D model of the roads and the auxiliary facilities are established. And then, the application of virtual test field has been completed. In the future, we will use this virtual test field to do more test about automobile performance and traffic safety, such as braking test, handling stability test, and Driver-Vehicle-Road system.

REFERENCES

- [1] W. Yuan, X. Liang, S. Chien, L. Wei and S. Xue, Design of simulation-based virtual automobile experiment field, *ICIC Express Letters, Part B: Applications*, vol.7, no.12, pp.2655-2662, 2016.
- [2] Q. Q. Yin, Research on construction technology of double-curved concrete pavement of high-speed circular track with small curve radius, *Journal of Shandong Jiaotong University*, vol.22, no.1, pp.53-58, 2013.
- [3] X. Zhang, Brief introduction of domestic automobile test field, *Automotive Electrical Appliances*, vol.12, pp.60-61, 2006.
- [4] R. F. Yang et al., The overview of automobile virtual experiment, *Tire Industry*, vol.12, pp.757-766, 2008.
- [5] C. Yu, T. Li and G. F. Li, The research of making out the proving ground standard based on test correlation technology, *Automobile Applied Technology*, vol.1, no.7, pp.12-14, 2014.
- [6] W. Yuan, Z. Ma, L. Wei and T. Chen, Study on optimization technologies of visual test system for mountainous expressway, *Journal of Wuhan University of Technology*, vol.33, no.10, pp.51-54, 2012.
- [7] MultiGen Paradigm Inc., *Vega Programmer's Guide*, 2001.
- [8] G. Q. Yang, Y. Q. Zhao and P. F. Hao, Method about the road modeling of vehicle virtual proving ground, *System Simulation Technology*, vol.6, no.3, pp.183-186, 2010.
- [9] W. Yuan, L. Wei and T. Chen, GIS terrain generation technique of virtual simulation system for mountainous expressway, *ICIC Express Letters, Part B: Applications*, vol.2, no.3, pp.659-664, 2011.