Research on 3D virtual high performance multimodal mesh simplification and display system

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Keywords: mesh simplification; error measurement; 3D display

Abstract: In order to achieve a smooth three-dimensional display effect, this paper studies the triangle mesh simplification algorithm, mesh simplification of the three-dimensional model. Based on the typical virtual reality HMD HTC VIVE, a three-dimensional display system of automobile model is designed. Users can experience the realistic 3D effect on the client side and perform basic interactive operation.

1. Introduction

With the rapid development of Internet technology and the rapid rise of e-commerce, online shopping has become a way of consumption, more and more merchants will publish their commodity information on the Internet, so that more consumers know about their products and choose their own products at the same time.

Car - the online ordering system, in addition to placing orders, can also preview preview models online. Sometimes when you go to a dealer to order a car, you don't have to see all the color of the accessories, and you're not sure what the look of the car will look like when you add them. But in a web-based customization system, buyers can mix in front of the computer and enjoy the car in advance.

Virtual reality is the excellent crystallization of the information age. It simulates the real environment, generates real feelings through human-computer interaction, and adds virtual technology to the customization system. It can greatly enhance the visual impact and interactivity of the website on the users, and enhance the satisfaction and pleasure of the users in the process of purchasing cars, so as to promote product sales. And the purpose of fame.

2. Triangular mesh simplification

In the process of dynamic interaction of 3D scene, it is often encountered that the rendering speed is too slow because of the large number of meshes in 3D model. In order to achieve a smooth and realistic 3D effect, it is usually necessary to simplify the mesh of the 3D model in the scene to achieve the best balance between rendering speed and scene display effect.

In the process of model simplification, we must consider two core issues [1,2], one is the principle of simplification, the other is the method of error measurement, also called error measurement. Among them, the principle of simplification is the guiding ideology of the simplification algorithm, which should be followed from beginning to end. Generally, the principle of minimum vertices or minimum errors is adopted; the error measure restricts the implementation of the simplification algorithm, and the principle of minimum error measure is used in every step of the algorithm.

This paper mainly studies several commonly used model simplification algorithms and error measurement criteria. Firstly, the mesh simplification methods are summarized and studied, then the error measurement methods are studied. Finally, the vertex-to-vertex shrinkage algorithm is used to simplify the vehicle model combined with QEM algorithm.

2.1 Mesh simplification method

- Edge collapse algorithm

Hoppe[3] first proposed the use of edge collapse algorithm to simplify the three-dimensional mesh. The idea of this method is to delete the vertices, also known as collapse edges. Folding an edge into a vertex simplifies the edge and all triangles it connects. Edge folding method has been widely used since it was put forward. It can be divided into two types: half-folding and full-folding. The half edge collapse method is to select the new vertex position on the two vertices of the edge. The folded vertices in the full folding method can be computed by recalculation of new positions.

- Vertex contractive algorithm

The main idea of the vertex-pair contraction method [4-6] is to fold two vertices without edge connections into one, also known as the virtual edge collapse method (Fig. 1). Through this method, unconnected parts can be connected to stitch holes in the mesh.

Fig. 1. Virtual edge folding method

In order to reduce the time complexity, the distance threshold of two vertices can be set. Two vertices whose distance is less than two are valid vertices, and only the valid vertices can be contracted.

- Triangle collapse algorithm

The principle of triangle folding is to collapse a triangle into a vertex. The vertex can be either the original vertex of a triangle or a new vertex position obtained by calculation. The advantage of the triangle folding method is that only the triangle is stored in the simplification process, so the storage space can be saved. However, in the practical application process, due to the larger processing granularity, the resulting mesh is rough.

- Vertex deletion algorithm

The vertex deletion method is divided into two steps, first deleting the vertex and its connected edges and triangles, and then triangulating the resulting holes (as in Figure 2) [7,8].

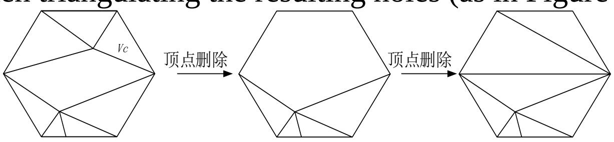

Fig. 2. Vertices delete holes for triangulation

2.2 Error metric

In order to delete the meshes with inconspicuous visual features in the model, it is necessary to select the appropriate error measurement criteria in the process of simplification, so as to guide the simplification algorithm and speed up the model processing. Error measurement is actually to quantify the difference between the original model and the simplified model and constrain the mesh simplification process.

Geometric error measurement is generally used to simplify the error measurement. Geometric error measurement is mainly to keep the simplified model as consistent as the original model in geometric characteristics as far as possible, to ensure that the geometric shape of the simplified model does not change greatly. Geometric error measurement has the following common categories:

1) The distance from vertex to vertex.

By setting the maximum distance between the new vertex and the deleted vertex not to exceed a certain threshold, the new generated vertex is represented, and the deleted vertex is represented (Figure 3):

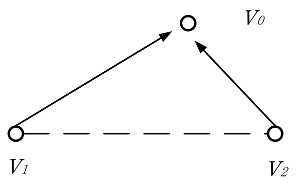

Fig. 3. Vertex distance

The distance between vertices is taken as the error measure, only the coordinate information of the points is considered, and the topology of the mesh is not concerned. Therefore, the simplified result obtained by this method is usually larger than the original model.

2) Distance from vertex to plane

The distance from the vertex to the plane represents the flatness of the mesh surface, and the smaller the distance, the closer the newly generated vertex to the surrounding vertex is to the same plane. Removing this vertex has little effect on the model. This method is simple, effective and most commonly used.

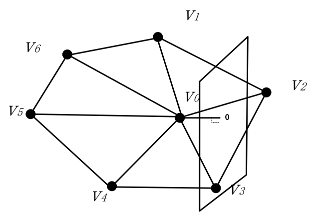

Fig. 4. Distance as a measure of error

In this method, the distance from the vertex of the mesh to its corresponding plane is used as the error measure (Fig. 4). The quadratic error measure (QEM) proposed by Garland [9] is the most classical one. The method takes the square of the distance from the point to the plane as the error measure.

3) Curvature metric

Curvature is the most commonly used model description parameter in model processing. Curvature represents the sharpness of the mesh model at this point, which is a sensitive area in visual features. There are many mature methods for calculating the Vertex Curvature [10,11].

4) Volume measurement

Before and after the simplification of the model, the volume changes can directly reflect the effect of simplification. This method usually presupposes a threshold as the error. The larger the threshold, the rougher the simplified model and the fewer the remaining patches. Zhou Yuanfeng [12] and others put forward the method of using the square of volume as the error measure. The experimental results verify the effectiveness of this method.

2.3 Triangular mesh simplification results

In the dynamic interaction of three-dimensional scene, the real-time requirement is very high. In order to achieve the fastest simplification efficiency, improve the rendering speed of the scene, and get the most realistic display effect, the vertex-to-vertex contraction method and QEM evaluation algorithm are used to simplify the triangle mesh of the vehicle model.

QEM algorithm requires less storage space, and can quickly simplify the mesh, while maintaining the realistic appearance of the three-dimensional mesh model. It is a method to achieve the best balance between the implementation speed of the algorithm, the fidelity of the output mesh and the robustness of the algorithm.

3. Prepare Your Paper Before Styling3D display system for vehicle models

3.1 Development tools for 3D display system of vehicle models

VR technology refers to the use of computer simulation to create a three-dimensional virtual world, so that users feel as if they are in the scene, can observe real-time three-dimensional models in space. As the user moves, the computer immediately performs complex computations and sends back accurate three-dimensional world videos to create a sense of presence. The basic principle of stereopsis is to rely on depth perception and binocular parallax. (Fig. 5)

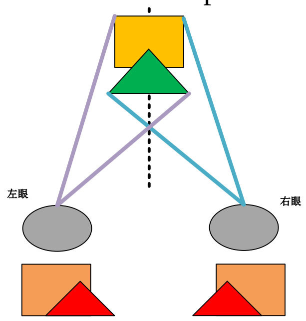

Fig. 5. The principle of stereopsis in human eyes

Many VR experiences are presented as applications, which means you have to search and download before experiencing VR. Web VR has changed this form. It brings the VR experience into the browser. This system uses the WebVR experience of three. js. Three.js encapsulates the underlying graphical interface, which is a 3D JavaScript library.

Head mounted display (HMD) is the most common way of experiencing VR at present. Its principle is to magnify the image produced by a small two-dimensional display through an optical system. Specifically, the light emitted by a small display passes through a convex lens so that the image is refracted to produce a similar remote effect. This effect is used to magnify near objects to distant viewing, thus achieving the so-called Hologram. In addition, the display is divided into two parts, showing the image of the left and right eyes respectively. The brain then converts the images (two parallax) seen in the left and right eyes to produce 3D effect. At the same time, HMD will synchronize the view based on head movement. Combined with these features, users experience VR through HMD just as they see it in real life, and this experience is also called immersive experience.

HTC VIVE is a typical helmet-mounted display that provides an immersive experience for users in three areas: a head-mounted display, two single-handed controllers, and a positioning system that tracks both the display and the controller in space.

3.2 Construction of 3D display system for vehicle models

First, the 3D scene is constructed. The basic structural module of the 3D scene is shown in Figure 6.

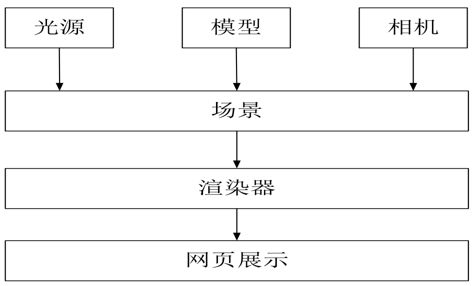

Fig. 6. Basic structure module

In this system, the simplified triangular mesh model is imported, the point light source and hemispherical light source are added, the scene is constructed by the perspective camera, and the rendering is performed by the renderer to complete the basic scene construction.

The surface quality of scene models directly affects the fidelity of scene visual effects. The editing and processing methods of materials include color mapping, normal map and highlight mapping. Color mapping determines the overall tone and texture features of the model. Normal map and highlight map will affect the vertical level and highlight effect of the model. In this system, PNG or JPG format images are used for color mapping, and normal mapping is added to the wheel model to enhance the bump and concavity (Figure 7).

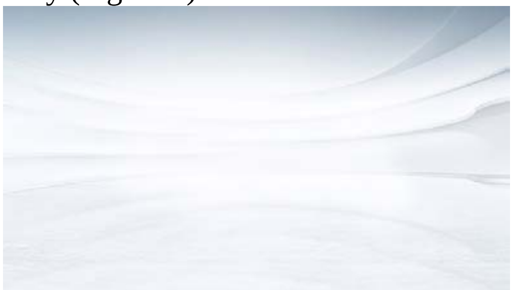

Fig. 7. Scene Diagram renderings

Handle 3D scenes with simple interaction. Use the handle button to control the front and back of the left and right movement, for scene roaming, in order to view the car around. Use the trigger of the handle to click on the operation, through the ray intersection algorithm, calculate the intersection, determine whether the accurate click. The door model is rotated and the door animation is opened. (Fig. 8)

Fig. 8. Interaction effect diagram

4. Summary

From the results of triangle simplification, we can see that the QEM algorithm maintains the topology of the original mesh and simplifies the three-dimensional mesh greatly. However, the QEM algorithm only considers geometric errors to simplify the mesh. Although it maintains the overall visual effect of the original model, it can not maintain the sharp and detailed parts of the mesh. The next step will be to improve the QEM algorithm, expand the range of error measurement, and further refine the simplified mesh. The system completes the preliminary scene display and interaction, gives users immersive experience, and needs to be further optimized in the display effect, and the interactive operation needs to continue to improve.

Acknowledgments

In this paper, the research was sponsored by the Science and Technology Project of State Grid Electronic Commence Company Limited. (Project name: The Research and Application of 3D Technology. No.5268021500000).

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