

Research on Application of Virtual Reality Technology Based on Data Visualization in Visualization of Engineering Design

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Abstract: spatial data visualization is one of the research hotspots in the field of 3dgis. The interactive visualization of engineering analysis data is realized on avs platform by using the simulation result data of engineering analysis software and visualization development package avs/express, combining data glove and position tracker. Engineering analysis data and realistic models are combined, and virtual reality technology is used to provide interactive visual environment for users. On this basis, with the help of virtual reality technology and opengl, a 3dgis prototype system is implemented, which has the functions of realistic visual expression of spatial data, real-time roaming of 3d scenes, interactive query, etc. The 3d model is downloaded to the client for display. Complex operations and simulations are performed on the server, thus realizing the separation of the server-side assembly model and the client-side display model. Thus, the quality of engineering design is greatly improved, and a new visual realization mode of engineering analysis data is provided.

1. Introduction

Virtual reality, or vr for short, is a high-tech emerging in recent years. Vr is a comprehensive and integrated technology that generates realistic three-dimensional senses of sight, hearing and smell, enabling people to experience and interact with the virtual world through appropriate devices as participants [1]. It uses computer-generated simulation environment, which is an interactive three-dimensional dynamic scene and entity behavior simulation system with multi-source information fusion, making users immersed in the environment. In particular, virtual reality technology has the characteristics of immersion and interaction, which can make people feel immersive and help people to conduct qualitative and quantitative research on spatial information [2]. Therefore, people gradually introduce virtual reality technology into spatial data visualization. Visualization of cae and other engineering analysis data is an effective way for designers to control the performance indexes of designed products [3]. At present, the visualization function of commercial cae software has some limitations in interactive mode, so designers feel powerless in obtaining hidden details in large and complex components, thus restricting the observation of more physical phenomena of products [4]. Under virtual conditions, the product is conceived, designed, manufactured, tested and analyzed. Although virtual product design has only appeared for a few years, it has had a huge impact on the industry, and its scope of influence continues to expand. Virtual product development technology has become the focus of global manufacturing industry.

2. Introduction to virtual reality technology

Virtual reality technology is an important direction of simulation technology. It is a collection of simulation technology and computer graphics man-machine interface technology, multimedia technology, sensing technology, network technology and other technologies. It is a challenging cross-cutting technology frontier discipline and research field [5]. The technology has three characteristics: immersion, which means that users get immersive feeling in the virtual environment created by developers; interaction means that users can interact with various sensors and multi-dimensional information environment. "simulated environment" is a computer-generated three-

dimensional realistic image with double viewpoints and real-time dynamics. Realistic is to achieve three-dimensional vision, even including three-dimensional hearing, touch and smell. The simulation environment can be a real realization of a specific world or a world of virtual ideas. It is helpful for designers to understand the data more intuitively and accurately, find out the problems in the design more quickly and easily, thus speeding up the process of product design and development. In addition to the visual perception generated by computer graphics technology, there are other senses such as hearing, touch, force perception and motion. The computer processes the data suitable for the participants' actions and makes real-time response to the user's input. Sensing equipment refers to three-dimensional interactive equipment.

3. Visual Development Environment

AVS (Advanced Visual Systems) Company is famous in the world among visual software suppliers. Its core product is AVS /Express Development Edition. AVS Development Edition includes 5 software packages including graphic display, data visualization, image processing, database management and user interface. Different kinds of data have different properties and expressions in structure, storage and visual expression, and the differences between them are often very large. The application layer provides HTTP services, simulation operations and database operations. The database in the resource layer stores part models and related information. The three-dimensional display in the customer layer is separated from the simulation operations in the application layer. AVS /Ex-press has 3 methods that can be used to create visual applications. The main interface, AVS /Express V programming language and V command processor can be used, or AVS /Express application source interface (APIs) can be used. The object set includes all entities in the scene (such as static entities such as terrain objects, river objects, building objects, and moving entities such as airplanes, cars, and tanks). The environment set describes the environmental parameters of the current scene (such as lighting effects, fog effect, sky effect, etc.).

Based on the visualization research of engineering analysis data, the visualization module of engineering analysis data is developed on AVS/Express platform, and the interactive visualization of engineering analysis data is realized by means of data glove, position tracker and stereo display system, which can accurately and intuitively display the distribution of stress and strain of product structure. The model has very accurate description, including dimension description and material data for manufacturing or operation. Its surface is often defined by NURBS or Spline, but when it is used for real-time interaction, it will bring about considerable rendering operation. The visual simulation seeks to obtain exquisite immersive effects and the highest possible output efficiency, but there is a contradiction between quality and efficiency. Exquisite immersive effects are at the cost of consuming a lot of rendering time and data calculations, The effect of rapid output is often difficult to meet the requirements of reality, and it is impossible to guarantee that the simulated effect is highly consistent with the actual built effect [6]. All entities in the scene are organized and managed in units of objects, and are divided into different categories according to their characteristics, such as terrain object CTerrain, river object CRiver, lake object CLake, road object CRoad, tree object CTree, building object CBuilding, vehicle object CVehicle, etc. Combining virtual reality technology with visualization of scientific computation, natural and intuitive visualization helps people to understand the internal characteristics of things more clearly [7].

4. Visualization Module

4.1 Architecture

In engineering design, as the complexity of the physical model for numerical simulation increases, the application of a single engineering software often cannot meet the needs of analysis and simulation. Therefore, according to the characteristics of different engineering software, several engineering software are usually used to analyze and calculate the physical model. Each entity object is managed by the corresponding management class instance, and the latter is responsible for

initializing the former, adding it to the scene, rendering, extracting attributes during query, deleting it from the scene, etc. Before the scene model is established, the geometric spatial position of each entity element in the field and the structural relationship of the model should be sorted out and confirmed, so as to determine the hierarchical structure of the building space environment, and adopt a data structure combining hierarchical structure and object-oriented. In addition, AVS provides a rich library of visual functions. The interactive development environment enables the development of this visual module to get twice the result with half the effort. The whole module uses mixed language programming and data file interaction to communicate between the calculation program and the visualization module (Figure 1). A scene and an observer form a Channel. To the observer, the channel represents a 3D drawing surface. Channels contain information such as fill color, viewport coordinates, and the frame buffer to which they belong.

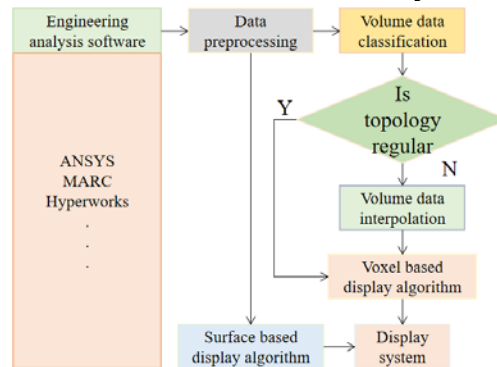


Fig.1 Architecture

4.2 Visualize Specific Process

The specific flow of visualization program includes three parts: reading data module, data reorganization module and display data module. An instance of a Frame Buffer object will establish a connection between software and graphics hardware. An instance of a frame cache object can contain multiple channel instances. When the CAD model is converted to VRML model, the accuracy and specific assembly features will be lost, which is not conducive to accurate control of assembly. In order to enhance the control and simulation functions in VRML environment. This module packs and processes the original data files to form a relevant data structure convenient for AVS /Express software processing. The purpose of reading the data module is to read the analysis result file and generate the domain data structure required for AVS display. The simulation principle of traditional 3D animation renderer is to summarize the surface properties of each material into the main properties such as intrinsic color, highlight, diffuse reflection, environmental color, reflection, refraction, etc. The bottom layer of the pyramid is the original data with the highest resolution. As the number of layers increases, the resolution of the data decreases layer by layer, and each layer is organized in blocks. When spatial analysis is needed, the data at the bottom of the pyramid is selected. The data recombination module uses three-dimensional texture mapping to synthesize fault planes in volume data so as to be displayed by a geometric display.

5. Key Technology

5.1 Data Interface

Due to the diversity of data sources in the visualization system, the basic idea of data processing is to solve the continuous spatial solution of the discrete computing model as grid points. If the spatial topological relation of the solution is structural rules, volume visualization can be directly performed. Firstly, several parametric 3D modeling templates are designed for each vector feature. Each modeling template can be regarded as a 3D symbol representing the corresponding feature. The process of defining templates is equivalent to the process of symbol design. Then Java Applet controls the movement of VRML model through EAI to reflect the simulation results. At the same

time, this implementation method can reduce the requirements on the client's software and hardware environment without installing additional customized software. The engineering analysis data in this paper is calculated and generated by the engineering software ANSYS, which includes spatial topological relations. The task of data conversion is to extract spatial topological relation arrays and data values from the calculation results. Google Earth can also be used to intuitively recognize the landform status of the determined design area. After preliminary design, Auto CAD is used to draw the general plan of the project and the elevation of the building. These drawings are the important basis for subsequent modeling work. This is equivalent to the process of symbol collocation. Users can also design their own templates and match them to certain feature vectors, which is equivalent to introducing user-defined 3D symbols.

5.2 Vr Peripheral Enable Design

In order for the visualization system to effectively analyze, judge and respond to VR peripheral signals, the mapping relationship between VR peripheral and AVS program must be established. In actual drawing, different 3D model generators Creator respectively draw parametric 3D models of different vector objects. Some approximate vector feature types can share the same generator (such as railways and highways, pipelines and wires, etc.). In this case, we use VRML technology to build a virtual reality model of staggered truss. Construction personnel can learn how to build staggered truss by using this virtual model. It can establish the mapping relationship between physical semaphores collected by VR peripherals and parameters in virtual scenes. Various VR peripheral signals are transmitted to the peripheral manager through serial sensors. One of the important conditions for VR immersion experience is the existence of collision volume. Only by properly setting up model collision can designers experience roaming models based on the ground and not walk through walls. It can be easily imported into VRML assembly environment. However, due to the inability to understand the conversion details, it is difficult to control the conversion accuracy and establish the corresponding mirror image model, which limits the expansion of functions.

5.3 Stereo Display

Stereoscopic display is based on the principle of stereoscopic image generation. Single channel passive stereoscopic display technology is adopted. The left and right eye views corresponding to stereoscopic pixels are generated by computer calculation and then put into a frame buffer to be combined and projected on a large screen, as shown in Figure 2. When an event occurs in the event source, the corresponding node can be changed through the event path to achieve a dynamic effect. The color map is the basic style of the material. The color material added in Google Sketch Up can be imported into UE4 together with the model, while the color map of the material can be replaced in UE4 Material Editor, which also determines the overall tone and texture characteristics of the material [8].

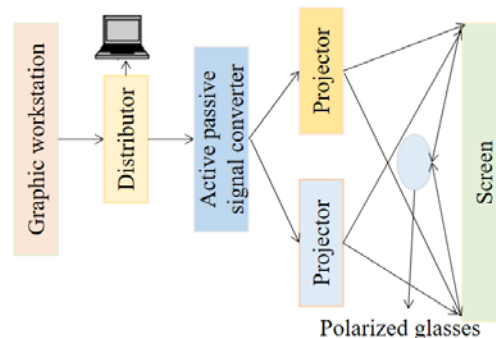


Fig.2 Schematic Diagram of Single Channel Passive Stereo Display

In order to expand VRML's interactive ability and processing ability, it needs the intervention of programming language. VRML standard itself does not specify a programming language, but Java is the most attractive language in the network environment, and its combination with VRML is quite natural. One active signal source input by the graphics workstation is converted into two

passive signals, which are output to two projectors, and one viewpoint is automatically adjusted to two viewpoints of left and right eyes, so that the image is mapped on the silver powder screen. Through the three-dimensional and intuitive model form, the staggered truss can be observed and studied from different angles, and convenient and efficient application learning can be realized.

6. Engineering Application

In the engineering design of a certain type of radar, aiming at the numerous advantages of interactive visualization under virtual reality, the interactive visualization technology under virtual reality environment is adopted to assist the structural design in the structural design of parabolic reflector antenna of this type of radar, and good results have been achieved. All kinds of information (including natural, geographical, socio-economic, military and other aspects) on both sides of the battlefield will be located and integrated by three-dimensional geographic coordinates, and can be directly expressed in real time, so as to provide a brand-new means for commanders at all levels to rehearse before the war, conduct battlefield command and evaluate after the war. The antenna structure is designed in blocks. The technology requires that the radar antenna can effectively resist external force without deformation, especially must meet the design index of stable operation in specified wind speed to meet the telecommunication requirements. Therefore, the structural rigidity design accuracy of the radar antenna is relatively strict. For this reason, we consider to realize the collision detection function on the server side, that is, Applet obtains the position of VRML object and sends it to the operation object on the server side as a parameter, and then it calls the collision detection function library to operate the server side and its corresponding assembly model. Photoshop is used to make normal map and highlight map, which are respectively placed on the normal map channel and highlight map channel of the material to increase the concave-convex texture and stereoscopic impression of the material.

The visualization analysis of radar antenna is based on the above visualization system. Firstly, the full-scale digital parameter model of radar parabolic reflector antenna is established by Pro /E 3D design software, and then the digital model with actual parameters is input to ANSYS software for processing. VRML models are directly output from CAD files, and assembly models are similar polygon surface descriptions supplemented by assembly relationship constraints. Users can drag parts to appropriate assembly positions in sequence according to assembly sequence at the client, and adjust the angle and posture during the process. Switch to the terrain mode, you can choose to draw the terrain or import the external terrain map. In addition, parameters such as terrain material and area control the generation of terrain. The brush tool after setting the parameters can be used to raise or lower the terrain area. The processed working condition data forms a three-dimensional three-dimensional graph in a virtual reality environment, so that an observer can feel personally present when watching through wearing polarized glasses, and deformation conditions at any position can be conveniently observed through data gloves. The processed working condition data forms a three-dimensional three-dimensional graph in a virtual reality environment, so that an observer can feel personally present when watching through wearing polarized glasses, and deformation conditions at any position can be conveniently observed through data gloves. It reflects the weather conditions, terrain, ground vegetation, roads, buildings and other surface features of a battlefield at a certain moment, as well as the deployment of tank clusters.

According to the visualization results of engineering analysis data, the radar antenna structure is optimally designed, which not only reduces the analysis test time in the design stage, but also improves the engineering design accuracy. At the same time, the key points of the assembly are recorded and saved to the server, which can be played back by animation after the assembly is completed. Whether interference occurs during the assembly is calculated by the collision detection module in real time. When packaging the output, you can select a variety of execution platforms, including VR device side-plug-in menu, check htc option, and set enable hdmi in the blueprint to package the model and output it to VR device platform. It greatly improves the efficiency and quality of engineering design, reduces the cost of manpower and material resources in the design process, significantly speeds up the development process, shortens the development cycle, and

brings considerable economic benefits.

7. Conclusion

Visualization of 3D spatial data is the core and development frontier of 3D spatial information technology, and is the breakthrough point and important research content of 3D GIS research. Using AVS to develop a more general visualization module applied to engineering software integration will greatly speed up the development of visualization functions, improve reusability and portability, and play a role of getting twice the result with half the effort. Visualization of three-dimensional spatial data serves as a technical bridge, which connects traditional modeling software commonly used by architectural designers with VR equipment with high efficiency. On the basis of not increasing learning cost as much as possible, the three-dimensional model is transformed into a form of immersive experience using VR equipment, and the fidelity of interaction is enhanced. In this paper, an object-oriented spatial data visualization model is proposed, which uses object-oriented method to express and manage spatial data in 3D scene, organizes and schedules terrain data based on grid pyramid, and realizes visual expression of vector ground object data based on parameterized 3D modeling method. Visualization of engineering analysis data is a beneficial exploration of virtual reality technology in engineering application. With the development of application research field, its application prospect will be more and more extensive.

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