Design of visual simulation model based on virtual display system

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Abstract—this paper proposed a virtual reality display system, through the three-dimensional simulation of real products modeling, design a visual simulation model software building method. The product characteristics and algorithm principles are displayed in a three-dimensional and full-size interactive display under the virtual environment, and real-time simulation dynamic demonstration can be performed, so that technical personnel can more effectively and reasonably evaluate the product design.

Keywords—*model, virtual reality display system, simulation*

- Introduction

Virtual reality display system is an immersive virtual reality display system based on projection, which is characterized by high resolution, strong sense of immersion and good interactivity. Its principle is more complex, is based on computer image processing, it fuses on the high resolution stereo projection display technology, multi-channel visual synchronization technology, audio technology, sensor technology and other in together, to create a 3d projection screen for the use of people surrounded by fully immersive virtual environment. In virtual reality display system, the object mode is lneed to be input.In the process of the overall design, CAD model in general is very huge, on a single workstation graphics rendering is not feasible, so big operation model and analysis is not possible.Multi-functional three-dimensional visualization software uses the graphical cluster architecture will work assigned multiple image node by the great model rendering graphics , in order to improve the ability of graphics rendering. Therefore, this paper proposes a software design method, a simulation model will be visualized model input into the system.

- Model software analysis

(1) Capable of modeling and developing a full range of products;

(2) Able to convert 2d drawings of products into 3d models by specified software, as an important input for visual display;

(3) With a variety of simulation model base and relative management software, mainly including structure model, component structure model, mechanism model;

(4) The simulator provides real-time simulation of carrier flight. The dynamics and control model runs in the simulator. The simulator needs to support multi-core parallel simulation based on real-time operating system.

(5) The performance parameters of simulation modeling computer shall be no less than Intel Xeon e5-2667v4 3.2 2400, 64GB memory, NVIDIA® Quadro® P6000, NVIDIA Quadro Sync II graphics synchronization card, Microsoft Windows 7 Pro 64-bit simplified Chinese version, with a 24-inch display.

- Development of 2d drawings into 3d models

Generally, the file exchange between different engineering software is usually in STP or igs format. However, since 3dsmax does not support STP files, there will be many broken faces and breakpoints when importing entity igs files into 3dsmax, which cannot be operated. Therefore, proe files can be directly imported into 3dsmax. We usually save proe as an STL file, which is a triangular grid file that is generally supported by 3d software on the market. The STL file format is not smooth enough for surfaces. We'll enter 0 in the chord height column in the proe software export panel.
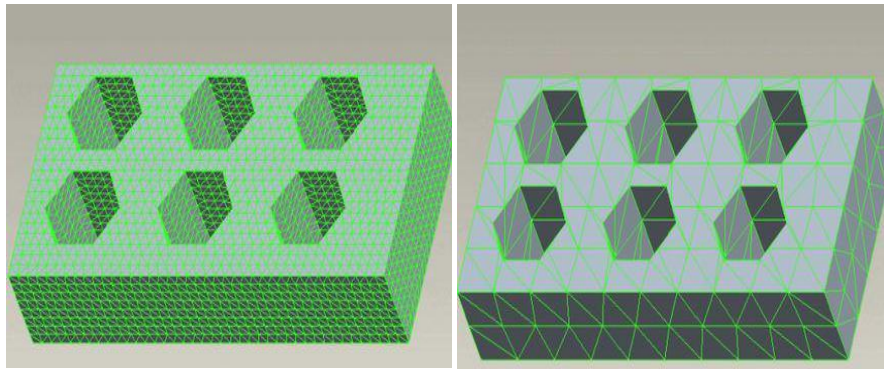

Figuer 1 Export the set smoothness diagram

The system will give the minimum parameter of the triangular surface according to the minimum accuracy, and then input any number greater than 1 in the AngelControl column, and the system will set it to 1 automatically. In this way, we can get as many triangular surfaces as possible, and the surface will be as smooth as possible. Other parameters are set by default. After saving the STL file, we selected to import the STL file with 3dsmax software. Select the quick weld and auto smooth feature in the parameters window so that the file we import has a smooth property.

- Real-time simulation system

In the visualization capability system, a VxWorks6.8 based multi-parallel simulation system is equipped, including a simulator and a carrier dynamics and control model.

The carrier simulation system needs to meet the real-time requirements, and Matlab/Simulink can be used for simulation modeling. Simulink is one of Matalab's most important components, providing an inheritance environment for dynamic system of modeling simulation, and

comprehensive analysis. It is able to describe linear systems, nonlinear systems, support single-rate or multi-rate tasks, and can model and simulate for continuous systems, discrete systems, or hybrid systems. Simulink takes modules as functional units and connects them through signal lines. The user adjusts the parameters of each module through the GUI, and the simulation results are presented in numerical and image visualization.

- *carrier dynamics and control model*

Taking the missile as an example, the dynamic and control model is divided into seeker module, guidance law module, stability control module, carrier motion module and projectile relative motion module. Each module can be implemented in a Matlab/Simulink environment.

(1) Seeker algorithm

Seeker algorithm implementation principle is: according to the els provided by the relative motion module in the three-dimensional space, the relative position of carrier and target motion relations, imbalance Angle calculation, according to judge whether to intercept the target echo energy, then through tracking servo control system, and the output line of sight angular velocity, the formation of control instruction, output guidance information.

The first step is to calculate the misalignment Angle, which is the Angle between the line of sight of the missile and the axis of the seeker. During the calculation, the coordinates of the target should be converted. Then, the pitching component δy and yaw component δz of the target should be calculated.

$$\delta y = \arcsin\left(\frac{y}{R}\right)$$

$$\delta z = \arcsin\left(\frac{z}{R\cos\delta y}\right)$$

Where, R is the projectile distance, $R = \sqrt{x^2 + y^2 + z^2}$, x, y and z are the target coordinates. The required guidance information is extracted and sent to the next guidance law model to complete the carrier instruction overload calculation.

(2) Guidance law algorithm

The guidance law model uses the measurement information of the seeker and the information provided by the relative motion module to the acceleration command, which is output to the stability control module.

The guidance law adopts the method of proportional guidance. The formula of proportional guidance method can be expressed as:

$$\dot{\theta} = K\dot{q}$$

K—proportional coefficient;

$\dot{\theta}$—the rotational angular velocity of the missile velocity vector V;

$\dot{q}$—the angular velocity of the target line of sight.

(3) Control algorithm

According to the carrier by three autopilot loop stability control, and through the guidance law guidance instruction decoding module calculation of projectile response parameters, mainly including the system acceleration and angular velocity information, etc.

Pitch channel control law

$$\delta y = K_{ny}(n_{yc} - n_y) + K_{\omega_z}\omega_z + K_{iy}\int (n_{yc} - n_y)dt$$

Yaw channel control law

$$\delta z = K_{nz}(n_{zc} - n_z) + K_{\omega_y}\omega_y + K_{iz}\int (n_{zc} - n_z)dt$$

Roll channel control law

$$\delta x = K_\gamma(\gamma_c - \gamma) + K_{\omega_x}\omega_x + K_{i\gamma}\int (\gamma_c - \gamma)dt$$

(4) The relative motion of the projectile

According to the motion parameters of the launching platform, the missile and the target, the relative distance and relative velocity of the launching platform, the target and the missile were calculated.

The relative motion model of launch platform and target

$$X_{PT} = \begin{bmatrix} x_{PT} \\ y_{PT} \\ z_{PT} \end{bmatrix} = \begin{bmatrix} x_p(t) - x_T(t) \\ y_p(t) - y_T(t) \\ z_p(t) - z_T(t) \end{bmatrix}$$

Model of relative motion of missile and target

$$X_{MT} = \begin{bmatrix} x_{MT} \\ y_{MT} \\ z_{MT} \end{bmatrix} = \begin{bmatrix} x_M(t) - x_T(t) \\ y_M(t) - y_T(t) \\ z_M(t) - z_T(t) \end{bmatrix}$$

Angular velocity model of missile and target line of sight

$$\dot{q} = \frac{V\sin\sigma - V\sin\sigma_M}{R}$$

Where R is the projectile distance, $R = \sqrt{(x_T - x_M)^2 + (y_T - y_M)^2 + (z_T - z_M)^2}$

x_p, y_p, z_p is the three-dimensional coordinates of the launch platform in the geodetic coordinate system;

x_M, y_M, z_M is the three-dimensional coordinates of the missile in the geodetic coordinate system;

x_T, y_T, z_T is the three-dimensional coordinates of the target in the geodetic coordinate system;

σ, σ_M are the leading angles of the missile and the target respectively.

● *simulation management module*

The main functions of the simulation management module are to receive test control instructions (start, pause, stop, data recording) from the upper computer, fault injection instructions (fault type, fault parameters), and complete the control of the simulation process by the experimenter according to the instruction type. At the same time, the simulation management module provides the internal state of the simulation test software to the upstart computer.
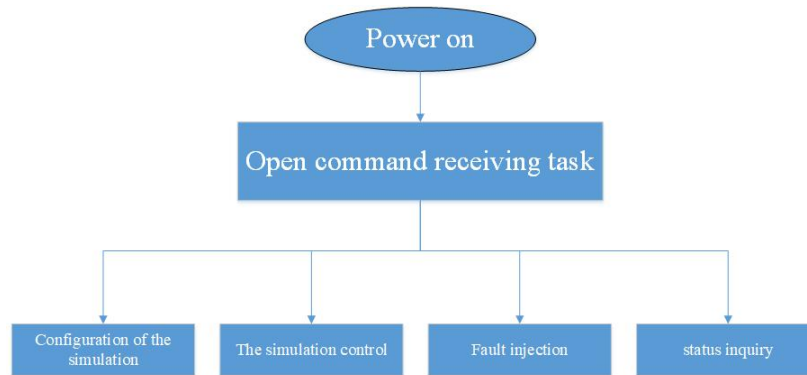
Figuer 2 The simulation of management software modules

● *model calculation module*

The model solution module adopts Simulink automatic code generation technology to automatically generate C code that can be executed under VxWorks by various simulation models developed based on Simulink, thus ensuring the real-time performance of model simulation.

Simulink's RTW toolkit implements automated code generation for simulation. RTW toolbox is an important functional module of MATLAB graphic modeling and simulation environment of SIMULINK, which is simply a simulink-based code generation environment. When we make real-time simulation to model the operation of the environment for the VxWorks real-time operating system, but the standard of the SIMULINK model does not run directly under VxWorks real-time system, so we must pass a certain mechanism converts the SIMULINK model of standard into VxWorks real-time application under the real-time operating system, and RTW (Real - Time Workshop) is a toolbox can achieve this function. The RTW toolkit is an advanced feature of the MATLAB graphical modeling and simulation environment SIMULINK. With the RTW toolkit, we can automatically generate optimized, portable, and personalized code from the SIMULINK model, allowing us to generate programs in a variety of real-time environments based on different target configurations.

● *fault injection module*

The fault injection module will modify the bus and electrical interface of the tested object according to the fault type and fault parameters of the fault injection instructions of the upper computer, so as to realize the fault input of the test system to FSECU input electrical signals.
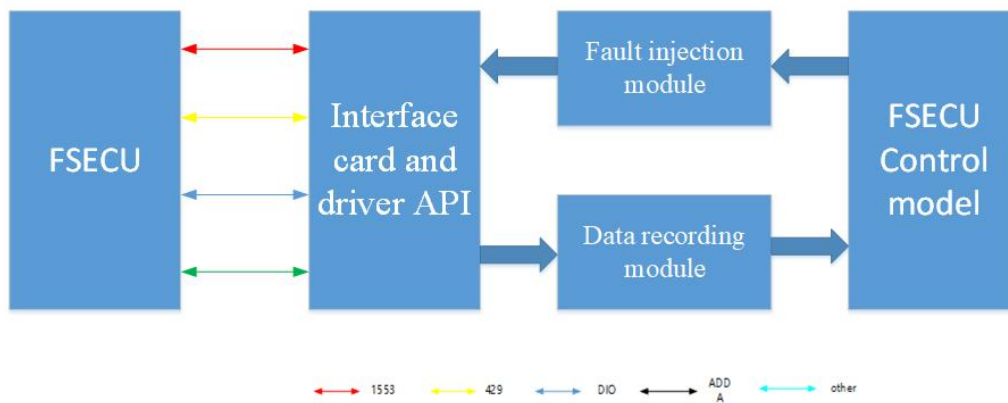
Figuer 3 Fault injection module

- *data recording module*

The functions of the data recording module are as follows: output the electrical sampling data of FSECU, test operation instructions (simulation control instructions, fault injection instructions), connect the data records with time stamps, and send them to the external database.

Due to the large data capacity of some board card sampling, the data recording module will choose whether to compress the transmission according to the data capacity to reduce the data transmission burden.

- *Product modeling effect*

Take an aircraft as an example, use Autodesk 3dsmax software for shape modeling. In Unity3D software, we adjust the physical properties and parameters of the model Shader, and finally we can get the desired 3d model simulation effect.

Figuer 4 Visual modeling effect

The model data is imported into the 3d simulation model, and the model is input into the virtual reality display system, so that we can analyze the product features visually and directly evaluate the performance.

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