Research on Virtual Visualization Technology of Flight Simulation

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Abstract. This paper describes various common modeling techniques and optimization methods in visual flight simulation. A large area of terrain, airplane and instrument are modeled visually using modeling tools Creator. The models are optimized using the LOD (Levels of Detail), DOF (Degree of Freedom), Fst and bounding volume techniques. In the design of the visual virtual environment, the environmental sounds are joined in order to enhance the realism of virtual environment. Through visual programming LynX and code writing, the real-time dynamic interactive driving of the instrument in the cockpit has been realized, and the prototype of the flight simulation visualization system has been realized.

1. Introduction

In recent years, due to the development of science and technology, it is possible to use computer systems to simulate flight rehearsal, and to use the combination of digital and reality to complete the flight rehearsal in the digital world. Moreover, with the further development of computer and other technologies, the application of this simulation technology will be more extensive, and the effect and fidelity of the simulation will also be higher and higher.

VR (Virtual reality) technology, also known as the spiritual environment technology, was born in the rapid development of information science [1]. It is based on many subjects such as computer science, mathematics, dynamics, acoustics, optics, mechanics, biology, and even aesthetics and social science. It has developed rapidly on the basis of the rapid development of computer graphics, image processing and pattern recognition, intelligent interface technology, artificial intelligence technology, sensor technology, phonetics and acoustics, network technology, and parallel processing technology and high-performance computer system [2].

The so-called simulation visualization is to turn the digital information in the simulation into an intuitive, graphical simulation process in front of the researchers, which changes with time and space, so that researchers can know the relationship between variables, variables and parameters, variables and the external environment, and directly obtain the static and dynamic characteristics of the system [3].

The use of flight simulation system for simulation training is a means to improve the combat effectiveness widely used by all the air force powers in the world. It can simulate many difficult

technical and tactical actions, which not only ensures the quality of pilot's training, but also avoids the danger and unnecessary loss in training. It also saves expenses and has great economic benefits [4].

In this paper, the aircraft in the flight simulation system based on high-level architecture (HLA) is taken as the research object, and the realization technology of flight simulation virtual visualization is studied. Multigen Creator Pro /Vega are used to develop three-dimensional real-time models and configuration and driving of visual running scenarios. Microsoft Visual C++ is used as a development platform to realize the development of visual models and user running interfaces.

2. Flight simulation visualization modeling techniques

Through the requirement analysis in the virtual visualization system of flight simulation, the visual model that needs to be modeled in the system is determined. In this paper, the aircraft and its instruments and large area terrain are visually modeled using the 3D modeling tool Creator. LOD technology is applied to large area terrain modeling, and the dynamic interaction of instrument pointer is realized by using DOF technology. The real-time response speed of model control is improved by using bounding box and FST format of database. With the above technology, the visualization of aircraft, instrument and terrain simulation is realized.

2.1. LOD Technology

Using LOD technology can make the same model object show different degree of detail. In this paper, LOD technology is used in large area terrain design to make the terrain accuracy of the plane displayed at different ground height different, reducing system memory occupancy [5]. As shown in Figure 1, the terrain model is obtained under two different LOD
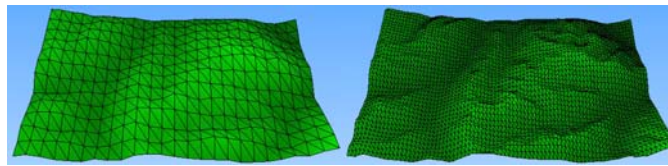

Fig.1 Terrain model under two different LOD

2.2. DOF Technology

DOF (Degrees Of Freedom) technology is also called the degree of freedom setting technology, that is to set the local coordinate system and the degree of freedom on the DOF node of the model object, and using DOF technology can make the model object have the ability to move [6]. The DOF node can control all its child nodes to move or rotate according to the set range of degree of freedom. In this paper, the dynamic interaction of instrument pointer is realized by using DOF technology.

2.3. Bounding Volumes Technology

Bounding volumes refers to an invisible geometry shapes surrounding a model object, such as cuboids, spheres, cylinders and so on. The bounding volume is a conservative estimate of the model object, which can be used to approximate the model for some rough calculations [7]. Bounding volume technology is mainly used for collision detection between different models in the interactive process of real-time systems. The real-time system only needs to judge whether the bounding boxes of the models are intersecting or not, so it is very effective. If you don't use bounding volumes technology, you need to traverse all the polygons to judge whether it is crossed with the rest polygons, and the real-time speed will drop a lot. The bounding Volumes technology is used in collision detection in this paper.

2.4. Fst

Fst is a special file format used to save the 3D model constructed [8]. Fst format files are converted from files in Flt format, which can contain all the models and textures in the Flt file, and the file size is

only about 1/10 of the Flt file. If the Flt file is very large, converting Flt format into Fst format will significantly improve the speed of the real-time system, And since the Fst file is read-only, you can't open the edit with Creator, but you can only use Vega to load the render, so it also has the role of protecting the intellectual property of the creator [9].

The large area terrain models and aircraft models in this paper are converted into Fst format for calling, which improves the real-time response speed of model control. With the above technology, visualization of aircraft, instrument and terrain simulation is realized.

2.5. Aircraft visual modeling

In order to be able to establish a realistic aircraft model, the movable part and the part that does not move in all the actions of the aircraft must be considered firstly. The movable part refers to the specific part of the aircraft required to make a specific action in advance when the aircraft need to complete an action. Such as the landing gear, the wing and the tail.
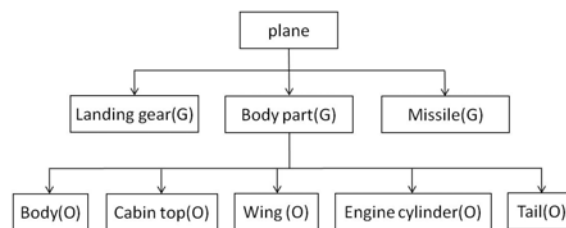

Fig. 2 the organization tree of the aircraft model

Figure 2 is the organization tree of the aircraft model, where (G) represents the object group and (O) represents the object. The aircraft model is organized in the form of a tree. The advantage of the model is that it is easy to organize and manage. It needs to be maintained and improved only when the target node is modified, while the other parts remain unchanged.

3. Visual virtual environment of flight simulation

In this paper, the Vega software platform is used to develop the corresponding virtual environment, and the ADF files in the Vega are called through the application interface API of the C language. The ADF file contains and configures the models of aircraft, missile, instrument, terrain and so on. The position and posture of these models can be driven or set up through code writing, and thus the implementation of these models can be realized. The interactive effects of aircraft manipulation, dynamic driving of instruments, roaming of scenes, collision detection between aircraft and ground make the virtual environment of flight simulation more realistic and more immersive [10].

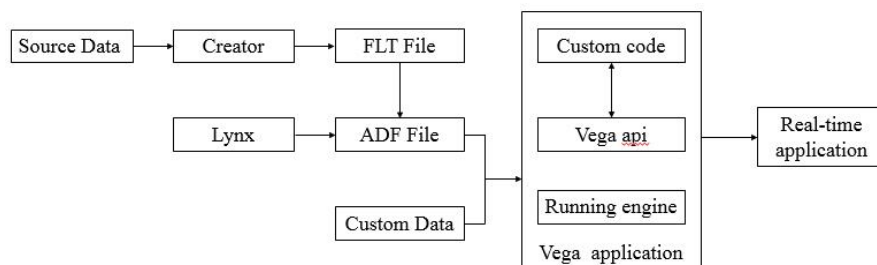The process of virtual visualization using Vega is shown in Figure 3.

Fig.3 Vega virtual visualization process

Because of the large area of the flight simulation, the fast movement of the aircraft and the fixed viewpoint at any location, it is impossible to observe all the contents of the flight simulation at any

angle. In order to solve this problem, multi-view, multi-angle and flexible viewpoint change schemes must be designed. In this paper, the problem is solved by means of fast switching of viewpoints. In this way, the operator can observe the flight state and three-dimensional model of any aircraft at any time. The following code illustrates the way to achieve the interface control viewpoint and the fast switching of viewpoints.

(1) Interface control view: the user can switch the view to the front view, the rear view, and the cockpit of the aircraft through the menu operation, and the following code is to switch the view point to the rear view of the aircraft.

```
Void CFlightEmluView::backView()        // Rear view of aircraft
{
vgPosition *posFlight = vgNewPos();
PlyerA10 = vgFindPlyr("a10");// Obtain aircraft motion body
float ox ,oy ,oz;
vgProp(m_obs,VGOBS_MAXTLIST,0.1);// Setting the parameters of the view point
vgProp(m_obs,VGOBS_TLAG,0.1);
vgProp(m_obs,VGOBS_PLYRCLOAK,VG_OFF);
vgObservPlyr(m_obs,PlyerA10);// Attach the point of view to the aircraft's motion body
vgProp(m_obs,VGOBS_LOOKAT_TARGET,VGOBS_L_PLYR ); // The point of view is always
facing the aircraft
vgProp(m_obs,VGOBS_TETHERSTATE,VGOBS_FOLLOW);// The point of view follows the plane
movement
ox = 4.15f,oy = -100.0f; oz= 0.7f;// Repositioning of the point of view
vgObservTetherOffset(m_obs,ox,oy,oz);// Set the position of the view point to deviate from the
plane
vgUpdate(m_obs);// Update view
}
```

(2) Fast switch of view point, the code is as follows:

```
void::OnPlane20()
{
vgPosition * postPosition= vgNewPos();
vgGetPos(PlyerA10, postPosition);// Get the position of the plane
  vgPos(obs, postPosition);          // Switch the point of view to the position of the aircraft
vgDelete(postPosition);
}
```

Through the above two control mode of viewpoints and the aircraft, the operator can roam freely in the virtual scene, control the orientation of the view point, control the flight state (flight speed and direction of flight) of the aircraft.

The control system is equivalent to the controller that controls aircraft flight and is a very important part of the flight interaction simulation [11]. This system realizes aircraft's advance, backward, turn, pitch and so on by keyboard control, so as to control aircraft's flight in an interactive way. The aircraft control code is as follows:

```
vgGetPos(PlyerA10, postPosition);// Get the position of the plane
vgGetPosMat(postPosition,mat);// Conversion of a position structure into a matrix structure
vgLoadMat(stack,mat);// Press mat into the stack
vgRotMat(stack,-DELTA*frame_time*7,'y');          // Spin the head matrix in the stack around
the Y axis
vgGetMat(stack,mat);// Out of the stack
vgPosMat(postPosition,mat); Conversion of matrix structure into position structure
vgPos(PlyerA10,postPosition);// Put the new position to the plane
vgGetPos(PlyerA11, postPosition);
vgGetPosMat(postPosition,mat);
```

```
vgLoadMat(stack,mat);
vgRotMat(stack,-DELTA*frame_time*7,'y');          // The point of view rotates around the Y
axis
vgGetMat(stack,mat);
vgPosMat(postPosition,mat);
vgPos(PlyerA11,postPosition);
```

4. Solution to the problem of visual jitter

With the development of computer technology, communication technology and other related technologies, flight simulation technology is also developing continuously. It has developed from single flight simulation to multi computer network flight simulation. However, in the flight training simulation, the problem of visual jitter often occurs, especially in the training of joint flight simulation. The observed aircraft appeared to be more dithering in the visual system, which seriously affects the immersion and simulation credibility of the virtual environment [12].

In this paper, the graphics processing capability and load status of the system are considered comprehensively when selecting the frame period, so that it can smoothly complete each frame update in the case of heavy load. The system is set in Frame Management, and the frame period is 40 milliseconds, that is, 25 frames per second, which not only satisfies the requirements of human visual consistency, but also does not cause obvious image jitter, and the effect is better.

Because both the viewpoint and the observer are in high-speed motion, the final jitter problem is still manifested in the coordinate transformation of the adjacent entity viewpoint. If the state data entering the scene solution can be smoothed in real time, the jitter problem of the neighboring entity can be solved.

According to the data analysis, it is found that since the viewpoint coordinates and the observed coordinates are high-frequency variations, the relative coordinates may have a data sequence of high-frequency jitter [13]. Since the driving data is generated by real-time solution, and the fitting algorithm must ensure the real-time requirement, otherwise the visual solution will generate delay, so the straight-line fitting method is considered to smooth the relative coordinates [14].

5. System running case

In order to verify the feasibility of the instrument control system, visual jitter solution and other technical methods established in this paper, a practical flight simulation visualization system is selected as a running example. The flight simulation virtual visualization system is built on the basis of Creator/Vega. After entering the simulation system, the aircraft appears in the air in a certain situation. At this time, the viewpoint can be switched through the menu, and the simulation process can be switched to the desired viewpoint state. By defining the function keys on the keyboard, the upper, lower, left and right flight control of the aircraft can be completed.
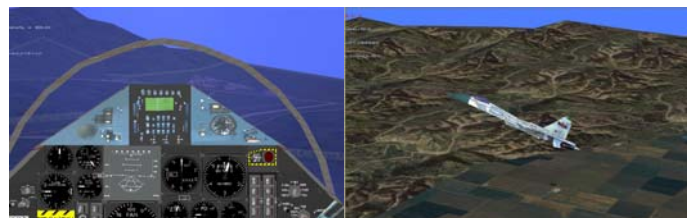

Fig.4 Screenshot of the aircraft cockpit instrumentation and state of the aircraft ascending during flight simulation

In this paper, the visual point switching, dynamic display of instrument and collision detection of aircraft in the process of flight simulation are realized and satisfactory results have been achieved.

6. Conclusion

In this paper, the realization technology of virtual visualization of flight simulation is studied. The theory of virtual visualization of flight simulation and the concrete realization process and the key technology used are discussed based on Creator/Vega. The physical model and dynamic model in the flight simulation system are constructed, and the virtual scene with real time and interactive drive is realized. By adding the effects of dynamic instrument interaction, collision detection, view roaming and audio in visual virtual environment, the fidelity of the system and the immersion of the user are enhanced.

The modeling techniques and processes of aircraft, missiles, instruments and large-area three-dimensional terrain in flight simulation virtual visualization system are studied in detail. The key technologies such as DOF and Fst in geometric modeling and the original data conversion and terrain in terrain modeling and key steps in generating algorithms, applying terrain textures, and features are analyzed. The principle and implementation method of batch terrain transformation are introduced.

The physical modeling in the flight simulation virtual visualization system and the dynamic modeling and optimization of aircraft cockpit instrumentation are realized. The design principle and development process of the flight simulation visual virtual environment are analyzed. The specific contents include real-time dynamic interaction of the leveling instrument and the altimeter in the aircraft cockpit, roaming of scenes in virtual environments, manipulation of aircraft, and addition of ambient sounds.

Aiming at the serious problem of close-range view jitter, the reasons for possible jitter are analyzed from the aspects of network, coordinate transformation and computer hardware processing capability, and the specific solutions to the corresponding problems are proposed.

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