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Real-Time Simulation of Large Scale Terrain in Helicopter Simulator

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Abstract: The real-time simulation of large scale terrain has been broadly applied to GIS, VR, military simulation, etc. In order to meet the requirements of visual system of helicopter simulator, this paper researched on modeling and the real-time rendering technology of large scale terrain. The terrain data was obtained from Google Earth, the 3D terrain model was created in ArcScene and LOD of terrain model was created in Creator to improve the real-time performance of simulation. The texture data matched with terrain was obtained from GetScreen. Finally, real-time rendering was realized by using OSG. The experimental results prove that the method presented in the paper can meet the requirements of helicopter simulator.

Key words: Large scale terrain, real-time simulation, LOD, rendering

INTRODUCTION

As the fast development of computer graphics and the constantly improvement of the computer processing ability, it has been possible to use computer to show 3D terrain scene in real time. But for large scale terrain, whose terrain data quantity and texture data quantity are enormous, currently the computer processing ability still cannot meet the demand of real-time simulation. Therefore, it has become a problem demanding prompt solution in the field of GIS and VR that how to achieve the real-time simulation of large scale terrain.

Key Laboratory of Marine Dynamic Simulation and Control for Ministry of Communications, which the authors work in, has been devoted to develop the simulation system like simulator, etc, for many years. In 2009, helicopter simulator was primarily built, which was equipped with CAVE 3D visual system, as shown in Fig. 1, can simulate the helicopter to provide salvage for ships and people in distress. While the viewpoint of the helicopter is usually located in the air, a wide range of land, ports and urban constructions can be seen. Therefore it is necessary to conduct further research on modeling and rendering technology of large scale scene especially large scale terrain.

Fig. 1: Helicopter simulator

RESEARCH STATUS

To simplify the complexity of the whole scene and reduce data quantity in rendering and resolve the contradiction between quantity and speed in displaying, some scholars at home and broad have researches on the simulation of large scale terrain in recent years and put forward the relevant algorithm, which mainly involves three aspects: the terrain data processing, texture data processing and data scheduling.

Terrain data processing: In the field of terrain data processing, Clark (1976) put forward the basic concept of level model, whose automatic building process was called the model simplification. Lindstrom *et al.* (1996) proposed Continuous Level of Detail (CLOD) which was based on the Regular Square Grid, This algorithm used quad tree to

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manage the terrain scene, applied screen error determination condition to build up nodal elevation function and achieved simplification through down-top iterating merge of triangle. Duchaineau *et al.* (1997) proposed the algorithm of Real-time Optimal Adaptive Mesh (ROAM) which conducted top-down recursive dichotomy on the surface topography to build up the triangle binary tree; T fracture wouldn't appear in each step of operation because of forced subdivision.

Texture data processing: In the field of texture data processing, based on continuous LOD terrain model, Wei *et al.* (2004) used the texture compression quad tree method to solve the problem of frequent switch of texture and improve the efficiency of the texture mapping. You (2006) put forward a scene rendering model which combined terrain general mechanism and texture tile pyramid. On the premise combining high efficient load and rendering of data, the model set buffer queue for texture, used hash table to load texture and realized the mapping of high resolution texture image, obtained highly realistic mapping effects and high frame rates. Pi (2006) proposed a large scale dynamic texture synthesis method which based on the small sample texture. Under the framework of Patch-LOD terrain algorithm, the method made full use of the access predicting mechanism and LOD control mechanism of the geometrical data, considered comprehensively the geographical information and geometry information of the terrain data and realized the real-time dynamic texture synthesis on the basic of several small-sample textures.

Data scheduling: In data scheduling, Losasso and Hoppe (2004) used image to store terrain elevation data which transformed the scheduling problem of terrain to image. This method made full use of the CPU operation ability and improved rendering efficiency. Schneider and Westermann (2006) proposed that when rendering large scale terrain texture, a LOD rendering techniques which was suitable for CPU could be adopt. Ulrich (2002) and Victor (2002) advanced a theory to put the terrain data into several pieces to organize. Each piece of data was generated different levels of meshes and was stored in external storage medium. When operating, the currently visible appropriate level of terrain block was imported into internal storage and then set down to rendering.

MODELING OF LARGE SCALE TERRAIN

Terrain data mainly includes geometrical data and texture data. Along with the rapid development of remote sensing technology, we can easily approach high-definition satellite remote sensing images. So the topography geometry and texture data can also be gained through satellite remote sensing images. In this paper, we use high-definition remote sensing images provided by Google Earth and then process them by Civil 3D, ArcScene, Photoshop, etc. to build large scale terrain. The procedure of terrain model is as follows:

- Acquisition of terrain geometry data. Find the terrain region to be modeled in Google Earth (Fig. 2 is the terrain area of Zhoushan Island). Extract elevation

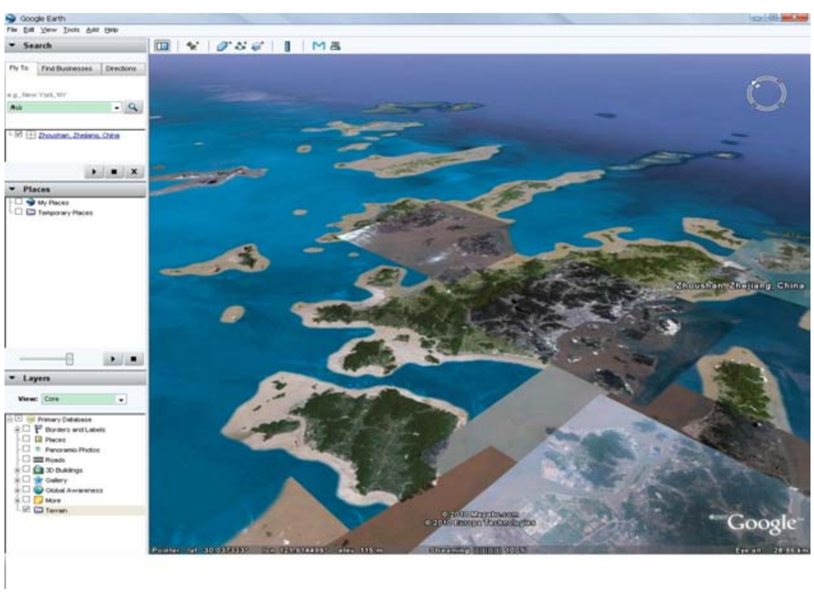

Fig. 2: Zhoushan Island in google earth

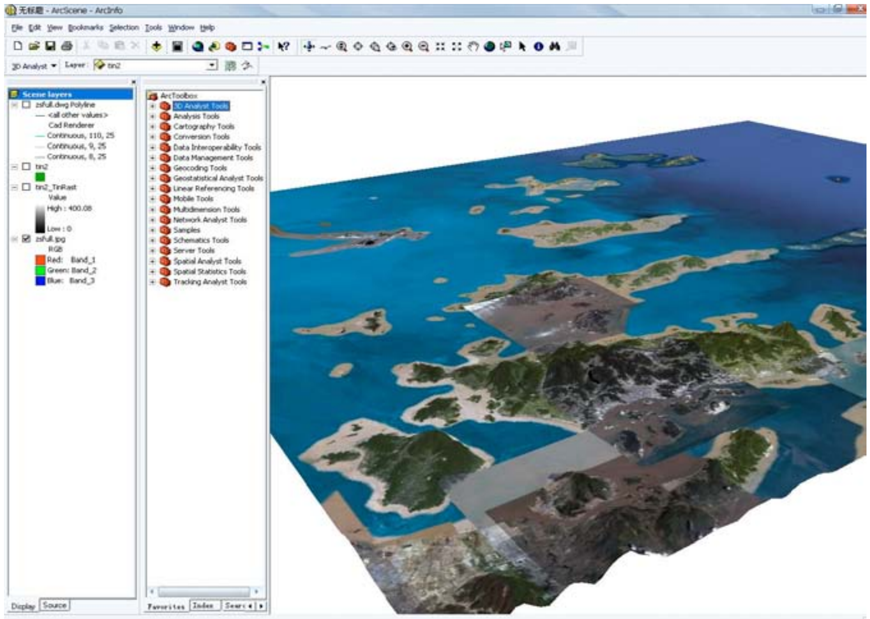

Fig. 3: Model of Zhoushan Island after texture mapping

data of that area from Google Earth by Autodesk Civil 3D software

- Acquisition of terrain texture data. Obtain texture data corresponded that terrain area from Google Earth by GetScreen. Process properly the texture data by Photoshop
- Construction of topographic geometric model. Add the geographic information into the obtained elevation data. Then import it into ArcScene to generate terrain geometric model
- Texture mapping. Import texture data into ArcMap for registration. Then add it to ArcScene to map onto the generated terrain geometric model (As shown in Fig. 3)
- LOD setting. Introduce the terrain in ArcScene to Creator software and set LOD

LOD is the division of the same object according to details and then construct models ranging from simple to complex. During displaying we can choose model of corresponding level by judging the distance from object to viewpoint. Normally the farther the object is, the simpler the model we choose. Using LOD technology properly, we can guarantee that the scene not only with enough details, but also at a relatively high and steady speed. Taking Zhou Shan Island terrain model as example, there are three levels of LOD: the first level is a simplified model, including 27191 triangles. It is visible when the viewpoint is very far (6-10 km) away from the terrain surface; the second level is a relatively complex model, including 93696 triangles. It is visible when the viewpoint is not very far (3-6 km) away from the terrain surface; the third level is the most complex one including 146962 triangles. It is visible when the viewpoint is near (0-3 km) from the terrain surface.

REAL-TIME RENDERING OF LARGE SCALE TERRAIN

At present, scene management software are mainly OpenGVS, Vtree, Vega, OSG, in which OSG is high-performance, it has powerful features and advantages in many ways. Therefore, real-time rendering of large scale terrain is realized by OSG in this study.

OSG scene management software

OSG Scene Graph: OSG has an effective mechanism of rendering because of its reasonable scene structure. It manages the scene through scene graphic. OSG uses bounding sphere and bounding box together to manage the scene, which improves the organizing and accessing ability of the scene.

As shown in Fig. 4, the scene graphic tree organizes space data sets by using a top-down, layered tree data structure in order to improve the efficiency of the rendering. At the top of the scene graphic tree there is a root node. Extending from it each group node includes geometry information and information for the control of

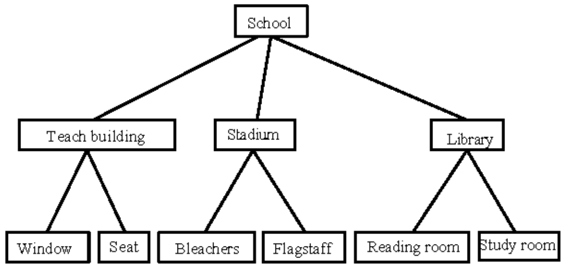

Fig. 4: Scene graph tree

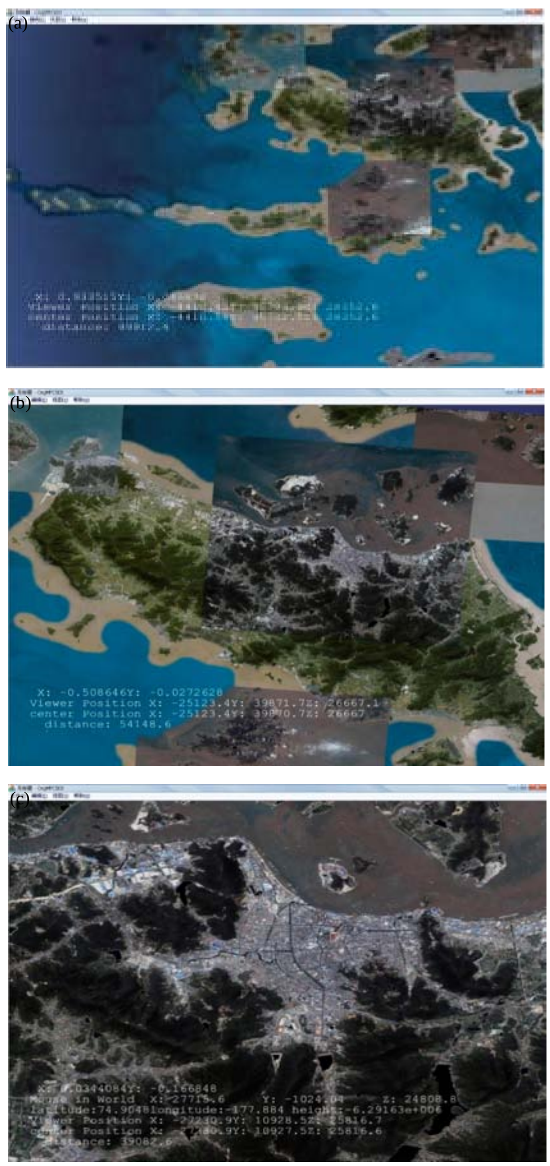

Fig. 5: Terrain scene of Zhoushan Island. (a) LOD of the first level, (b) LOD of the second level and (c) LOD of the third level

the appearance and rendering state. The root node and each group root may have zero or several subdivisions. At the bottom of the scene graphic tree, each leaf node contains actual geometric information for the composition of the objects in the scene.

OSG rendering mechanism: There are three traversals in OSG rendering: update, culling and rendering.

- **Update:** Updating traversal allows program to modify scene graphic to realize the dynamic scene scheduling. It is operated by program or callback functions corresponding to the nodes
- **Culling:** When culling traversal, the scene graphic library will check the bounding volume. If the leaf node is in sight, there will be a reference of the leaf node added to the rendering list, which ranging according to whether they are apparent or not. As for the apparent, they need to be re-sorted according to the degree of depth
- **Rendering:** When rendering traversal, the scene graphs will traverse the rendering list and then call underlying API to render the geometry

Real-time rendering of large scale terrain

Real-time rendering: This study uses OSG as management software and adapts LOD technology during terrain modeling, so real-time rendering is guaranteed. The author tested in the intermediate configuration of PC (CPU is Core 2 2.8 GHz, the graphics card is NVIDIA GeForce G100, memory is 2G). As it is shown in Fig. 5a-c are respectively the terrain in sight when the viewpoints are about 9 km, 5 km, 2 km away from the area. Figure 5a shows LOD model of the first level, the whole Zhou Shan Island can be seen, but there aren't many details of the surface. The average rendering frame speed is 42 fps. Figure 5b shows LOD model of the second level. The main city of Zhou Shan Island can be seen with more details. The average rendering frame speed is 38 fps. Figure 5c shows the third level; a part of the main city of Zhou Shan Island can be seen. The average rendering frame speed is 36 fps.

Photorealistic: By this method, the photorealistic is improved. Take Shidao port in Shandong as example, Fig. 6a is the terrain modeled by traditional method of repeated mapping, there is obvious repeatability of the textures of hills and lands. Fig. 6b shows the terrain modeled by the method of texture mapping. It is obvious that the photorealistic of the surface is definitely improved.

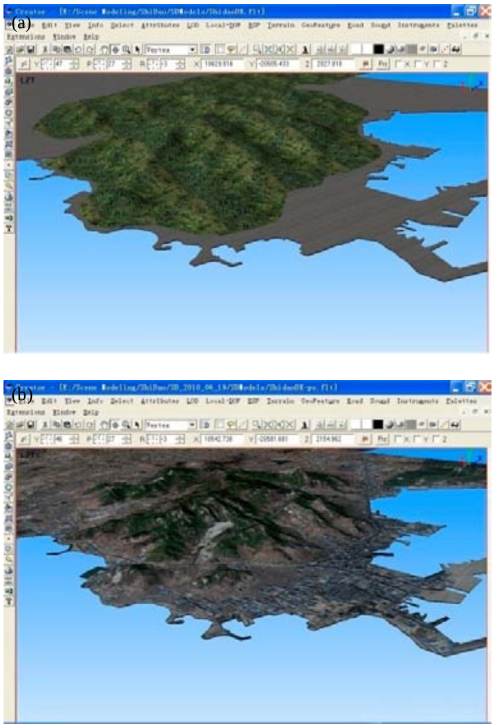

Fig. 6: Shidao port terrain in Creator. (a) The traditional method and (b) The method in this study

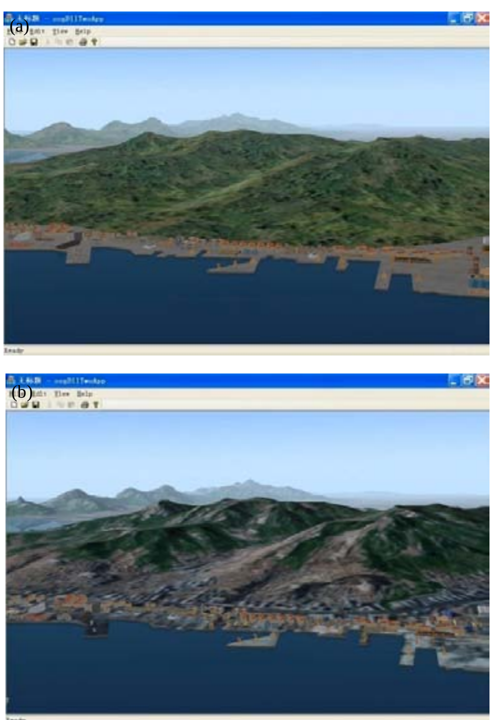

Fig. 7: Rendering effect of Shidao port. (a) The traditional method and (b) The method in this study

Figure 7 is the rendering effects by OSG of the two terrain models above. It can be seen clearly that in the scene processed by this method, the ups and downs of mountains are obvious and the details of the surface are more vivid. The visual effect is distinct.

CONCLUSIONS

In this study, the terrain data is obtained from Google Earth, meanwhile, the texture data which match with terrain also can be obtained with GetScreen. The 3D terrain is created by ArcScene, which improves the modeling efficiency helicopter simulator and create LOD in creator for the real-time rendering. Finally, real-time rendering is realized by using OSG. The experiments show it is possible to realize the real-time rendering of large scale terrain if the methods in this paper are applied.

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