Key Technologies of Modeling for Equipment Training Environment

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Abstract

For the purpose of equipment training, realistic training environments need to be built and makes operators having an immersed sense. Aiming at present military requirement for equipment operation training, a universal 3D modeling method for equipment training environment was put forward, which integrated with terrain, feature and special effect. The related key technologies such as terrain modeling flow, terrain model optimization, Large Area Database Management (LADBM) and particle system are also detailed. Finally, a simulation example was presented to prove the feasibility of the modeling method. It can provide beneficial reference for building realistic equipment operation training environment quickly.

Keywords*: Training environment, 3D modeling, Terrain model optimization, Large area database management, Particle system*

1. Introduction

Equipment warfare simulation has been defined as a simulation method, which is supported by computer technology and taking accurate equipment models, forces and intelligent force model into more realistic virtual warfare environment [1]. Within the method, simulation experiment technique was adopted to realize warfare simulation and some losing and results will be generated. Equipment warfare simulation usually carries on a realistic virtual battlefield environment basing on the background and objects. As an important subject of equipment warfare simulation, equipment operation training must be carried into execution in living environment in order to get real training experience. So simulation training environment is the base of related training systems and simulators.

For the reason mentioned above, exploring a universal and convenient modeling method for building equipment operation environment, which will has important and practical significance for building training simulation system and improving training validity [2]. Whereas equipment operation training environment contains ocean, land, air, sky and electromagnetism, only those basic composing elements of equipment simulation training system in common use such as terrain, feature and special effect are researched.

2. Terrain modeling

Realistic simulation operation environment is built basing on 3D terrain modeling. So terrain 3D modeling is the keystone of environment modeling. Requirement of equipment operation training can be summarized as follows.

1) The terrain modeling fields should be wide in order to meet equipment maneuvering and deploying demand.

2) Multiform terrain should be included such as mountain, hill, desert, plan and town etc.

3) Abundant physiognomy features should be added such as road, river, building and tree etc [3].

4) Both model granularity and system spending should be considered. Since the equipment training environment modeling is a kind of near-land simulation, so simulation granularity need to be subtle enough necessarily. In view of system normal run will be affected seriously by excessively enormous data and every simulation system has a spending upper limit, they must be taken into account in modeling process at the same time.

2.1. Modeling flow

Basing on the analysis of training environment mentioned above, the terrain modeling flow can be plot clearly out to nine steps involving field selection, elevation data collection, texture data collection, character attributes & rules setting, civilization character drawing, terrain model generation, feature model loading, terrain model optimization, terrain model control & rendering and LADBM [4]. Its modeling flow can be shown in Figure 1.

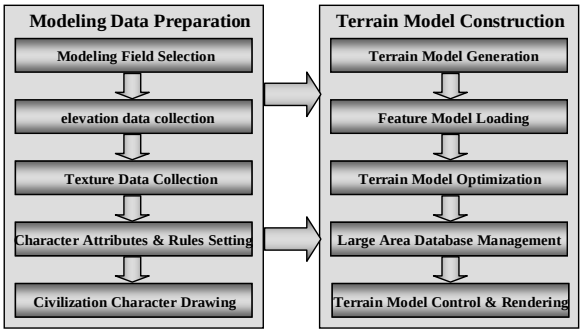


Figure 1. The terrain modeling flow

Elevation data of modeling field can be collected by measuring and map digitizing. Then the data will be converted from vector to raster in software named Global Mapper [5]. Its rendering effect of coloring according with different layers is shown in Figure 2.

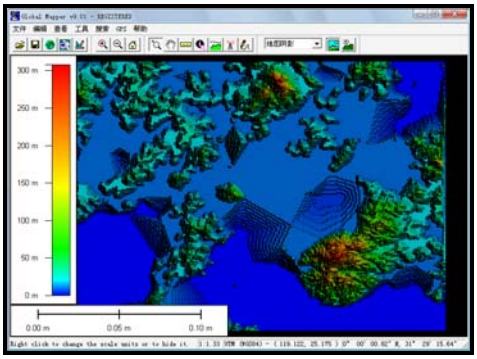


Figure 2. The rendering effect of coloring according with different layers

Limited by measuring precision and computing speed, detailed terrain can't be modeling. But fidelity of terrain model can be increased by mapping texture on the terrain. The economical method is getting photos from Google Earth map platform. Though high resolution photo is more suitable for construction high realistic 3D terrain model, capacity of real-time simulation system must be considered. So satellite photos of level 16 to level 18 are the best selection. The rendering effect of certain area is shown in Figure 3.

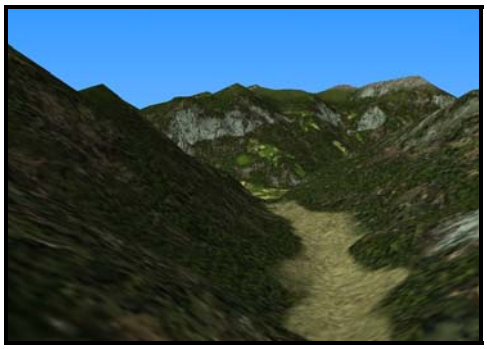


Figure 3. The rendering effect of certain area

2.2. Terrain model optimization

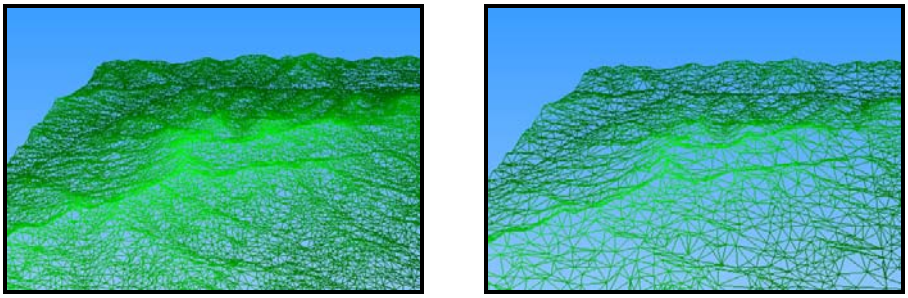
In view of system rendering efficiency is affected by the degree of model optimization, optimization work must be carried throughout the whole modeling flow. All works can be summarized as follows.

1) Optimization in initial phase. For those character data of unreached and farside fields, 3D details will be replaced by photo textures in most situations.

2) Optimization in model constructing. The setting of max polygons number will determine the upper limit of terrain model polygons. So a rational polygon number setting range can ensure rendering efficiency and reality.

3) Optimization in later phase. By adopting manual method and professional model simplification toolkits, redundancy polygons can be taken out and surface of model keeps unchanged.

By the means mentioned above, the constructed terrain model will be optimized in maximum and real-time system will run in more fluent way. The effect of model optimization is shown in Figure 4.



a. The model before optimizing b. The model after optimizing

Figure 4. The effect of model optimization

2.3. Large Area Database Management

Mass terrain data management is a difficulty of simulation and its efficiency affects directly to the fluency and reality of rending. For most simulation training environment, the terrain data can't be loaded in one-time [6]. So LADBM technology is adopted to solve the problem mentioned above. Terrain model data is described and organized with MetaFlight format based on XML, which is the main ideal of LADBM. The data in model database will be loaded to memory in pagination manner when simulation system is running.

Applying LADBM, the circle interesting area with special radius is constructed at first, which takes the current eye point as the center. The terrain sub-blocks intersecting with interesting area will be loaded dynamically by system and the other sub-blocks will not be loaded accordingly. The basic principle of LADBM can be shown in Figure 5.

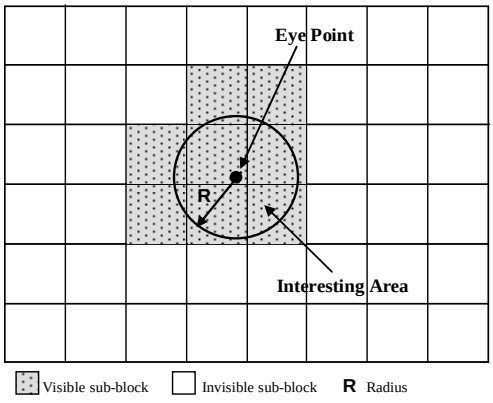


Figure 5. The basic principle of LADBM

3. Feature modeling

Features are an important component of equipment operation training environment and it is can be static and dynamic objects such as buildings, vehicles, characters, trees and so on. The reality of virtual 3D environment is incarnated by features in detail. So modeling for tree, building and road are researched.

3.1. Tree

For lots of trees being found everywhere, model data and vision reality are two difficulties firstly. Two modeling methods applied broadly are adopted, which are named as billboard and cross faces.

Billboard is a polygon fixing on a point and rotating around an axes or point. It can change its orientation basing on observer's sight and keeps texture face looking on observer. The 2D texture photo is used to substitute for the 3D entity model, which is the essence of this method and rendering speed will be increased by reducing face number greatly. Thousands of faces are needs for constructing a 3D tree model when 3D entity models are used. But one texture face is enough adopting billboard method and mass resources can be saved [7]. High rendering speed and better flat vision effect are its two outstanding merits. But obvious rotation will be seen from high altitude though trees are always static no matter how eye point transform. It can be shown in Figure 6.

Figure 6. The tree models applying billboard method

Cross faces constructs tree model with two or more cross faces plumbing each other and all faces will be drawn in double faces with same texture photo [8]. Better vision effect can be gotten when observer is far away from the tree. The fidelity will be reduced due to fork phenomena, which appears when observer is near the tree. Its rendering effect is shown in Figure 7.

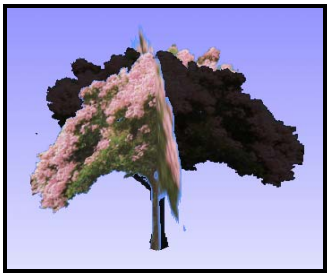


Figure 7. The tree models applying cross faces method

Though cross faces method can reduced programming complexity comparing with billboard method, burden will be increased to drawing of graphic system. Integrated their different merits and disadvantages with requirement of equipment operation training environment, two different level degrees were set as the tree's LOD. Billboard can be adopted to modeling for near trees and cross faces can be adopted for the trees far away.

3.2. Building

Building model is the basic character feature of city training environment and model is constructed in trim size may as well. Its inside can be ignored and modeling precision will be regulated according to importance of building. For those buildings far away from observer, they could be constructed adopting billboard method. At the same time, the buildings near the observer must be constructed in detail.

Some simple building can be seen as a box and constructed with software named Multigen Creator. Firstly, the bottom outline will be drawn box, which can be pulled by the 'wall' tool [9]. Then different textures photos would be mapped to different character faces and child faces could be constructed to give importance to detail faces. The rendering effect of building is shown in Fig. 8.

3.3. Road

Roads are indispensability for training environment. It is hard to construct road model by manual without modeling tools. Road modeling module of Creator can provide 'external reference' and 'strip faces' tools, which can generated road model automatically by defining horizontal, vertical slope and round radius. The rendering effect of building and road is shown in Figure 8.

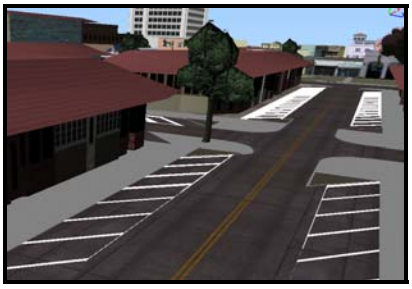


Figure 8. The rendering effect of building and road

3.4. Models loading

Equipment operation environment is still boring for lacking of various features in actual scene such as rooms, trees, flowers, grasses and so on. It will not meet the simulation demand if it only has terrain model. The fidelity of environment will be improved by loading feature models. The models are the independent on the terrain polygon beside geography civilization characters such as road, river and so on.

In consideration of features spread over the terrain and have great numbers, how to load them in an efficient and precise way is the most important question. So the technology named post-project was introduced and it is opposite to projection in advance. Within this technology, feature models will be projected on the generated terrain model ground in later modeling phase and civilization features will be replaced by existing feature models. It can locate and load the feature models in batch model and its poses will adjust itself automatically with the wave of the earth's surface. The terrain rendering effect applying post-projection technology is shown in Figure 9.

Figure 9. The terrain rendering effect applying post-projection technology

4. Special effect modeling

4.1. Particle system

Realistic equipment operation calls for special effect such as rain, snow and so on. All these effects can be realized with particle system, which is brought forward by William T. Reeves [10]. Lots of tiny particles owing various attributes are adopted to forming dynamic system, which can be used to describe ruleless dynamic objects. The realization process of particle system can be shown as Figure 10.

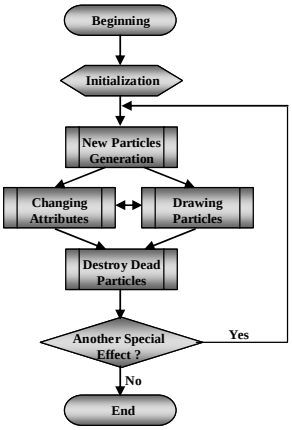


Figure 10. The realization process of particle system

Special effect is realized by controlling a set of attributes of particle system. The attributes includes lifecycle, shape, color, clarity degree, movement direction, movement speed and so on. Most of them are time function and changes with time moving on. At the same time, particle system needs building based on some given mechanics model such as wind field, gravity field and so on. So particles will take simple mechanism movement influenced by outside forces.

4.2. Rain

The movement characters of rain can be concluded as follows.

1) Descent speed of rain is faster and its particle lifecycle should be shorter.
2) Great density of raindrop leads great number of particles.
3) Rain speed takes on rectangle distribution.
4) Gravity vector of particle should be greater because gravity of raindrop is greater than air resistance.
5) Raindrop falls to the ground almost vertically.
6) Raindrop will change its shape due to affection of pulling force.

Basing on the characters mentioned above, attributes of ordinary rain special effect can be setting as Figure 11.

Particle Attributes	Value	Function
Lifecycle	2	Existing time of every rain particle is 2 Second
Particle Numbers	3000	Total number of rain particles is 3000
Particle Shape	Rectangle	Shape of particle source is rectangle
Size of Source	20	Size of particle source is 20×20
Speed Distribution	Rectangle Distribution	Speed of rain particle takes on equality distribution
Fluxion Type	Sequential Type	Rain particles flows out sequentially from source
Boundary Box	(100,100,20), (-100,-100,-80)	Limited movement scope of rain particles
Gravity Vector	(0, 0, -60)	Gravity vector is vertical downwards and its value is 60
Wind Speed Vector	0	Without influence of wind
Particle Size	0.05	Original diameter of rain particle is 0.05
Length of Particle flow	3	The pull length of flowing rain particle is 3

Figure 11. The attributes of ordinary rain special effect

5. Realization

To ensure developing with great efficiency and speed, Multigen Vega Prime was adopted to be the simulation platform [11]. The simulation example of some kind of tactical communication equipment operation training system is realized, which is built on the base of realistic equipment operation training environment. The better training effect has been taken adopting the system and its interface is shown in Figure 12.

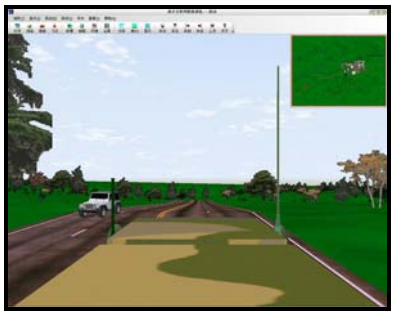


Figure 12. The interface of some tactical communication equipment operation training system

6. Conclusion and future work

The simulation technology mentioned above has been applied successfully in some equipment simulation training platform. The system is developed mainly with Visual C++ 6.0, Multigen Creator, Creator Terrain Studio and Multigen Vega.

The simulation examples have proved that the development method is feasible and valid. As a future possibility, we will work on the bigger and more realistic training environment. An all-purpose simulation environment development platform considering software reusing adequately will be the ultimate target.

7. Acknowledgement

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8. References

[1] Chen Gang, Gan Zhichun, Sheng JianJun, et al, “ Development Technique Project Report for Tactical Internet Simulation Training System”, Communication Commanding Academy, Wuhan, pp. 153-154, 2007.

[2] ZHANG Wang-wei, MENG Chen, CHEN Sheng, PENG Rong-mu, “Research on Architecture of Large Ground to Air Missile Simulation Training System”, Ordnance Industry Automation, Vol. 27, No. 5, pp. 38-39, 2008.

[3] Xi Haijiao, Zhang Xiaolin, “On Real-time Terrain in Viewing System of Flight Simulation and Its Implementation”, Computer Application and Software, Vol. 26, No. 4, pp. 150-151,201, 2009.

[4] REN Hong-xiang, JIN Yi-cheng, YIN Yong, “3D Visualization of Oil Spill in Marine Simulator”, Journal of System Simulation, Vol. 21, No. 1, pp. 161-165, 2009.

[5] LI Wei-gang, LIU Hui-ying, “Controlling Implementation of Dynamic Model Based on Creator/Vega”, Science Technology and Engineering, Vol. 8, No. 4, pp. 1109-1112, 2008,

[6] XIANG Hua, WANG Jiang-yun, “Key Technologies of Synthesis Display System for Flight Simulator”, Journal of System Simulation, Vol. 18, Nol Suppl.2. pp. 483-485,489, 2006.

[7] TANG Jie, GONG Guang-hong, “Modeling and Real-time Rendering Technology of Real Large Area Terrain Database” Journal of System Simulation, Vol. 18, Nol Suppl.2. pp. 453-456, 2006.

[8] XU Zhao-xin, HUA Wen-hua, “Research on 3D Terrain Visualization technology”, Computer Engineering and Applications, Vol. 44, No. 3, pp. 91-93, 2008.
[9] ZHAO Xin, LIN He-ping, “Application of 3D Fractal Tree Modeling in 3D GIS”, Journal of JiLin University (Information Science Edition), Vol. 21, No. 3, pp. 307-311, 2003.
[10] MA Xian-ying, LI Xue-jun, CHEN Xiao-juan, “Design of Simulation Platform in Large Area Virtual Battlefield Environment”, Journal of System Simulation, Vol. 18, No. 1, pp.76-79,, 2006.
[11] TANG Zai-jiang, WANG Jing-ye, “Virtual Reality and Vistualization in the Simulation of Military Equipment Battling”, Computer Simulation, Vol. 21, No. 7, pp. 17-19, 2004.