The Method to Add Sky Background in 3D Virtual Engine

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Abstract. In GTENG engine, scene manager is used to establish the corresponding mesh nodes of skybox or sky hemisphere, and sky texture files are set up in the order of the built-in texture name. These sky texture files are placed in the directory that can be searched by state manager, and they can be called when using to generate sky background. This paper gives the general process of creating skybox and sky hemisphere. By classifying and defining the outer, inner and cloud layer of skybox, the composition of their texture files is explained. Further, the general procedure of making skybox texture by using Terragen software is discussed. The methods of making outer and inner sky texture are illustrated, including setting and adjusting atmosphere, light, water, camera, coordinate, rendering and texture block. The application shows that it is a very effective and convenient method to add sky background in GTENG engine cooperating with Terragen software to create skybox texture, and the effect of sky background in the application of 3D visual simulation is realistic.

1. Introduction

Sky Background is indispensable in large-scale virtual training simulation system of engineering equipment and game. Sky is a built-in Class in virtual GTENG engine, which is the predefined node. All nodes of self-developed GTENG engine inherit from CbaseSceneNode, sharing own member variable and member function. GTENG engine has both predefined and external nodes. Sky nodes are not added to scene manager when being not used, but they will be created and be in position by built-in function in SceneManager. The code based on VC++ to creat sky nodes by scene manager of GTENG engine is shown below:

```cpp
pSceneManager - > CreateSkySceneNode (0);
```

When the parameter is zero, GTENG engine creates the default skybox. If the parameter is not zero, it creates the sky hemisphere. Whether it’s skybox or sky hemisphere, it is just generated code. They are actually grid nodes that need to be supported by external data. GTENG engine builds in vertex buffer data of skybox and sky hemispheres for users, so it need create the sky texture file in order by the predefined texture name and place it in a directory that can be searched by CStateManager.

It needs use SearchFileInPath function to search files by CStateManager. The first parameter of the function is file name, which can provide the full path name or only the name of the file and extension. The second parameter is the full path file name returned, which contains both the file name and the full path name. If the function returns false, it means that the file is not found in the set path. The examples are as follows:

```cpp
if( !CStateManager::GetInstance() - > SearchFileInPath( m_name, strPath ) )
{
    MessageBox( NULL, filename, "File not found!", MB_OK );
    return false;
}
```

The flow chart of adding sky background is shown in figure 1.
2. Build Skybox

The skybox in GTENG engine is divided into three layers. The default skybox created by the scene manager requires a texture file in a directory that CStateManager can search for.

2.1. Outer Skybox

Outer skybox contains a cube with six faces, as shown in figure 2. This is the outermost background of the scene, mainly used to represent the sky, the sun and other immovable scene background. The corresponding texture files are "Front.bmp", "Back.bmp", "Left.bmp", "Right.bmp", "Top.bmp" and "Bottom.bmp".

![Figure 2. Outer skybox](image1)

2.2. Inner Skybox

Inner skybox contains a cube with six faces. It is mainly used to represent the distant mountain, forest and other background of the scene, as shown in figure 3. The black part is alpha transparent so that the outer skybox clouds behind the inner skybox can be shown. The corresponding texture files are "front2.bmp", "back2.bmp", "left2.bmp", "right2.bmp", "top2.bmp" and "bottom2.bmp".

![Figure 3. Inner skybox](image2)
2.3. Cloud Layers
Cloud layers is between the outer and inner skyboxes that can be created movement animations. The image is alpha transparent except for cloud layers, as shown in figure 4. The texture file is called "alphacloud.bmp".

![Figure 4. Alpha transparent clouds](image)

3. Make Sky Hemisphere
When "pSceneManager->CreateSkySceneNode(0)" function is called, if the parameter is 1, the engine creates a sky sphere. The sky sphere is a hemisphere model with textured clouds image named "clouds.jpg", to simulate the sky background. The texture projected onto the sphere aggregates in the center of the sphere and looks false probably, so it needs to be dealt with carefully.

4. Make Skybox Textures
The main job of making skyboxes is to make textures, and there are many methods and tools available. We use Terragen software to make skybox textures. Terragen can quickly generate natural landscape and its animation, mainly including terrain, water, atmosphere, cloud and light.

4.1. Creation Outer Skybox
Outer skybox does not terrain, but Terragen has terrain by default. Therefore, we can turn off “Enable” option of terrain so that not the terrain but the sky will be rendered. Turn this option on when we need to render the terrain. However, the ground is dark when the terrain is not added, it is better to add a blue ocean.

Atmosphere and cloud layers in Terragen is controlled by the tool box of “Atmosphere”, as shown in figure 5.

![Figure 5. Atmospheric tool box in Terragen 4](image)
Atmosphere is mainly the upper part of the rendering above the horizon, and the lower part is generally obscured by the actual objects in the scene.

“Atmosphere” tool consists of 6 setting page label, the first of which is “Main” page label, as shown in figure 4. “Main” page label mainly includes two setting of “Haze” and “Bluesky”. If “Haze density” is the higher, the sky will be whiter and the fog will be thicker. The sky is clearest when density is zero, and you can’t see the horizon when it is 100. The lower “Bluesky density” density is, the bluer the sky is. And the higher it is, the whiter the sky is. Its algorithm should be a gradient between blue and white.

“Height control” is the second page label. It is used to adjust the affect height of “Haze” and “Bluesky” respectively.

After the atmosphere being set up, we can render 6 textures for the outer skybox from six different directions.

4.2. Lighting Set

“Lighting” tool can adjust position, intensity, color and other information of sunlight and environment light, as shown in figure 6.

4.3. Water Set

Whether creating the sky or the clouds behind it, water is not needed.

4.4. Camera Set

The option on the right is to position the camera. To render 6 consecutive images without seams, you need to set this carefully. The following table shows the camera Settings for each texture.

Click the Camera Setting button to open the Camera tool box, as shown in figure 7.

![Figure 6. Sunlight set](image)

![Figure 7. Camera tool box](image)

To choose “Perspective” not “Orthographic” or “Spherical” in the Camera tool box gives a sense of perspective for skybox textures.
Figure 8. The coordinate of camera

The position coordinates and rotation angles can be changed directly to adjust the direction of the camera. Its coordinate is shown in figure 7, the coordinate origin is in the middle of the terrain. For example, if the terrain is 256 by 256, the camera is in the middle of the terrain. The camera’s origin position is set as (0,10,0) which will always keep a Height of 10 meters above water. To get 6 textures, the setting of “Position” and “Rotation” is as shown in table 1.

Table 1. Camera coordinate settings for rendering skybox texture

| View       | Position(X,Y,Z) | Rotation(X,Y,Z) | Filename   |
|------------|-----------------|-----------------|------------|
| Front view | 0.10,-128       | 0,0,0           | Front.bmp  |
| Right view | -128,10,0       | 0,90,0          | Right.bmp  |
| Back view  | 0,10,128        | 0,180,0         | Back.bmp   |
| Left view  | 128,10,0        | 0,-90,0         | Left.bmp   |
| Top view   | 0,-128,0        | 90,0,0          | Top.bmp    |
| Bottom view| 0.128,0         | -90,0,0         | Bottom.bmp |

4.5. Rendering Set
The rendering control interface in Terragen is the tool box of “Renderers”, as shown in figure 9. We can adjust rendering image size, quality and so on in the tool box of “Renderers”.

Figure 9. “Renderers” tool box
4.6. Create Inner Skybox

The inner skybox represents the background of the mountains and the trees can be made expediently in Terragen. Certainly, other softwares can make the inner skybox, such as 3DS max and its Dreamscape plugin. I found Dreamscape was also much faster than Terragen in making the sky and much easier to control.

The names of the six sides of a skybox created with Dreamscape and 3DS max are different from those in GTENG. It needs to adjust the front and back that the ground rotation 270 degrees, as shown in the figure 10.

![GTENG engine](image1.png) ![3DS MAX](image2.png)

(a) GTENG engine

(b) 3DS MAX

Figure 10. Textures differences between 3DS MAX and GTENG engine

Regardless of the software used to create the texture, the alpha channel should be made in Photoshop so that the texture can be transparent to the clouds.

5. Conclusion

Making textures of sky background is a basic and careful job, and it will directly affect the visual effect of simulation system and game production just like other scenes. GTENG engine can support twelve layers texture mixed in the preprocessing stage through alpha channel, and support shadow casting algorithm. Through the scaling technology, it can support infinite scenes in theory. The mesh rendering process is optimized to achieve high FPS realtime rendering. We can quickly create sky backgrounds for virtual simulation and game production using the method of this paper which having more realistic effect. An application scene of semi-physical simulation maintenance training system of engineering equipment based on GTENG engine is shown in figure 10. The method to add sky background has high application value in 3D virtual system.

![Scene effect based on GTENG engine](image3.png)

Figure 11. Scene effect based on GTENG engine
6. References

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