3D Dynamic Target Simulation Experiments Based on the OpenGL

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***Abstract*—The simulation technology saves the cost of test, improves efficiency and in favor of the image acquisition. This article based on the OpenGL simulates the real-time dynamic 3D target, the physical characteristics of the target and the notion characteristics in the real world. The target images collected by the camera from different angles and azimuth has been demonstrated in this article. The dialog of parameter settings has been added in the platform of VC++ 6.0, which in favor of human-computer interaction. Practice has proved that the virtual target not only has vivid effect and meet the design requirements, but also contribute to the distortion correction of target images. The model is able to locate the center coordinates of the bullet hole accurately.**

Key words: OpenGL; 3D dynamic target Virtual target; Virtual target simulate

I. Introduction

The target is inseparable in the shooting training of civilian, military and police. With the rapid development of modern science and technology, the types of targets are also increasingly diverse. The common type of target are ring target, body target, chest target, head target and chest target. After the shooting completed, we need through image acquisition, image preprocessing, holes identification and the ring value determination to report the value of target. A variety of distortion will be inevitable when we capturing image. The design of target pattern in this article is helpful to distortion correction.

The production of real target needs a large amount of human financial resources and time. Target simulation can not only saving costs, facilitate image acquisition, improve efficiency, but also can verify the accuracy of the real target. It is lay a theoretical foundation for the production of the real target. This Article realized Real-time dynamic 3D targets simulation on Visual C + +6.0 development platform based on OpenGL, and thus more intuitive to show the real effect of the three-dimension targets in the virtual environment.

II. The model of real-time dynamic 3D target simulation

OpenGL simulation of three-dimension target mainly consists of modeling, viewpoint settings, environment settings , rasterization and so on, the concrete steps are as follows:

a) According to the basic graphical elements to establish a three-dimensional target simulation, and to do mathematical description of the established model.

b) Put the target model placed in a suitable location in the three-dimensional space, and set the viewpoint in order to observe the scene of interesting.

c) Calculate the colors of all the target model, determine light conditions, texture mapping methods etc. at the same time.

d) Convent the mathematical description of the target model and its color information into screen pixels.

A geometric model

In this paper, the design of the target pattern is only black and white two colors, improved the target contrast in different backgrounds and different light intensities environment, and conducive to the identification and location of the center of the bullet hole .In addition, the design of target pattern center position with a cursor in this paper, which conducive to the aim and improve the positioning accuracy of the target center. In this paper, the design of the target pattern surrounded by black and white squares, which is equivalent to determine the grid template for the target, play the advantage of checkerboard calibration, and conducive to the precise position of the center of the bullet holes. And facilitate to select the control point of target image correction, the points of obvious feature and grayscale variations. The higher selected position accuracy of the control point, the higher the precision of geometric correction. In this paper, the design of the target pattern is also beneficial to the target image distortion correction.

The pattern of the target is shown in Figure 1. The cross of the target center can be changed its size as required, the black-and-white grids of the targets edge also can be set the size and numbers as required. The size of the simulation of

three-dimensional target and the size of true targets can be converted by the equation (1).

$$\frac{\varphi \cdot N}{L} = \frac{f}{D} \qquad (1)$$

Among them, φ is the pixel size of the camera, N is the number of pixels for object imaging, f is the focal length of the camera, D is the vertical distance of the camera and target center, L is the size of the targets.

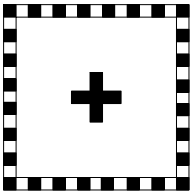


Figure 1 target pattern

Add the parameter settings dialog in Visual C + +6.0, shown in Figure 2, which is conducive to the man-machine interaction. By the setting of the parameters of the target may be fixed to the location of the target in the scene; By the parameter settings of the camera is capable of capturing the target image of a different position, different angle and different distance , which facilitate to image acquisition.

Figure 2 the interface of parameter setting

B motion characteristics

1) the setting of Variable viewpoint

In order to simulate a three-dimensional scene and make the observer to feel immersive,
it utilizes the perspective projection technology of OpenGL in this article:

gluPerspective (fovy, as,Near, Far);

This function defines a perspective view of the visible region as a frustum, Its parameter is the vertical viewing angle, and a height to width aspect ratio, as well as the distance between the proximal and distal clipping plane, as shown in Figure 3.

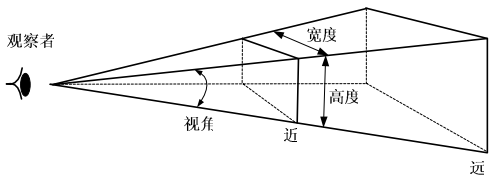


Figure 3 The Principle of Three-dimensional Perspective projection Scene

First of all, the view frustum defines the scope of the field of vision, the space within the scope of the six faces of the schnabelia desk can be seen , The rest of the clipping plane will be cut off.

Secondly, the Three-dimensional target applied perspective projection in the scene, which achieve the visual experience of "the nearer the large, the farer the smaller".

2) coordinate transformation

Since the camera shooting target in space from a different angle and azimuth, target relative to the camera need coordinate transformation in space. The common coordinate transformation has translation, rotation , scaling etc. (X^*, Y^*, Z^*, S^*) is the homogeneous coordinates after transform, $(x, y, z, 1)$ Is Homogeneous coordinates before the transformation. R is a 4 × 4 transform matrix. For different transformation, the transformation matrix R can be determined uniquely converted result. Graphical coordinate origin is translated in the X, Y, Z axis direction X, y, and z, and in the corresponding axis direction respectively amplified Cx, Cy, Cz-fold; As shown in Figure 4, three-dimensional targets around the X-axis rotation of angle α, around the Y-axis rotation of the angle β, around the Z-axis rotation angle γ respectively (the positive direction of The space graphics rotation is a left-handed helix direction).

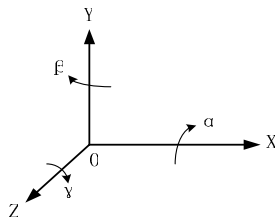


Figure 4 The three-dimensional graphics rotation transformation

C Physical characteristics

1) texture maps

The Texture map is the process of mapping the texture pixels in texture space to the pixels of screen space. First of all, we need to create the texture object (target), and assign it a texture (target pattern); Then determines how to apply this texture to each pixel. Then, enable the texture mapping. Finally, use texture coordinates and geometry coordinates to draw the scene.

Texture mapping can ensure that when the target exchange and rendering, the image Mapped to the surface of the target is also able to demonstrate the correct behavior

2) Illumination

If there is no light, the target looks not like a three-dimensional, the interaction of target and light is very important to create a real-time dynamic 3D target. In the model of OpenGL, one or more light of Illumination can be used to achieve. Only when the surface of target model absorption and reflection of light, the light source will be useful. The lighting model of OpenGL divide light into the ambient light, the scattered light, a mirror light and reflected light, etc., Under the joint action of these four components to form the desired lighting effects.

III. real-time dynamic 3D target distortion simulation

When acquisiting the target image, due to the effect of the relative positional relationship of the target and the camera in the three-dimensional space, lens distortion and camera quality Its acquisition of image exist geometric distortion. The acquisition of target image. when reporting the target, mainly has Hermite transformation, Affine transformation, Projection transformation, Radial distortion

etc. The radial distortion mainly includes barrel distortion and pincushion distortion.

In order to simulate the more vividly targeting distortion Need to use Bezier surfaces,The Bézier surface equation:

$$P(u,v)=\sum_{i=0}^{m}\sum_{j=0}^{n}P_{i,j}B_{i,m}(u)B_{j,n}(v) \quad u,v\in[0,1]$$

The values of $P_{i,j}$ is a set of control points, At the same time ,The value of $P_{i,j}$ can also be used to represent the vertices, normals, colors and texture coordinates. $B_{i,m}(u)$ 、 $B_{j,n}(v)$,is m and n Bethesda Wilkie function Respectively.

IV. virtual target and test analysis

A targets Category

The target is generally divided into hard and soft, the hard such as metal, wood, etc., and soft, such as cloth, paper, etc..The deformation of a hard material target is relatively small by natural environment. However, it is difficult to stand target in windy weather. The deformation of a soft material target is relatively large by natural environment, but the soft materials has good air permeability, standing target convenience, it is suitable for the production of a large area of the field target.

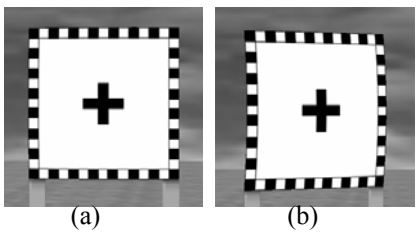
B target image geometric distortion

Studying the image from geometric, the image is the projection images of the object in a projection plane. Therefore, even with a same target object, due to the projection plane and perspective the geometric shape of the image is different. In the process of the actual image acquisition, the phenomenon of the change of spatial relationship between the pixels in the image called the geometric distortion of the image.

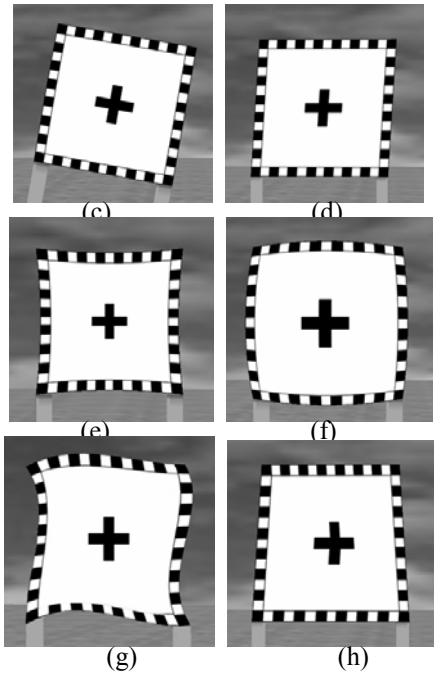
Due to the relative positional relationship of the target and the camera , Lens distortion and camera quality, as well as the effect of the natural environment ,such as wind , rain, fog , snow, visibility, target acquisition, etc. The acquisition of target image exists geometric distortion.

C analog target test analysis

Since the acquisition target images from a different location, angle and distance, Dimensional dynamic target subscript simulation through the set target subject center position coordinates, the camera's X, Y, Z-coordinate, the camera moving, and the camera rotation angle, etc. parameters, which can simulate a camera in a different position and angle of the shooting of the target image .As shown in Figure 5:



(a) (b)



(c) (d) (e) (f) (g) (h)

Figure 5 The image of target

In Figure 5, Figure (a) is Orthoscopic image captured when the camera vertical to the target, Figure (b) (c) is Hermitian transform, figure (d) for the affine transformation, which is due to certain displacement and rotation of the camera to the target, Figure (e) is a frame-shaped distortion, Figure (f) is a barrel distortion, Figure (g) is a distortion caused by camera imaging lens curvature uneven, Glass material texture inconsistent, Target surface is uneven, geometric distortion which caused by Natural environmental impact such as the wind and other reasons, Figure (h) is the projection transformation, the target distortion caused by the camera and the target do not maintain absolute vertical shooting at a certain inclination angle.

V. Conclusion

Through the simulation of real-time dynamic 3D Targets, which vividly simulate several common geometric distortion of a target, verify the feasibility of the design of the target, and provides a theoretical basis for making a real target.

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