Mathematics

Name Cheng XuQiang number 13211113
Zhejiang Normal University
Advanced Game Engineering

ABSTRACT

3D games have become mainstream products of the computer games. Truly reflecting the characters of the game roles and per- forming the bump effects of the scenes are the important parts in the development of a realistic game. By using the normal mapping technology, it can still ensure the better performance of the bump effect without increasing the model grid and remain the good bump effect after changes in perspective.

In this paper, it will discuss the basic mathematical methods of the normal bump mapping technology used to show the dump effects in the process of computer games development in terms of following parts, the construction of bump mapping, tangent space and tangent vec- tor. These mathematical methods will provide the mathematical solutions of the normal mapping technology in the engine programs design during the game development.

INTRODUCTION

Characters of facial wrinkles in the game can see, the stone relief and so on the bump effect is accomplished by 3D bump technology, the effect of the performance of the 3D. Making method of the concavity of the performance there are two ways, one is in creating the model, increase the number of mesh models produce concavity The advantage of this method is accurate and true. But the disadvantage is that the model data is larger, the number of points is higher, and the requirement of hardware is very high. It's hard to apply in game development. Another way is through the material performance to achieve bump effect. That is, in the material editor using a bump (BUMP) is the map or normal (NORMAL) map to show the effect of bump texture. Bump (BUMP) map is only a kind of visual effect, the model of the real grid does not occur the corresponding deformation, if the perspective changes, it seems a simple plan. In the normal (NORMAL) map, the map in the process of a certain processing, so as to ensure that in the perspective of the transformation is still guaranteed to have a more obvious effect.

Normal map is currently more advanced technology, the normal map changed the original information is black and white, but the use of blue, purple to represent the corresponding concave and convex information. Using the normal map model, the concave and convex information will produce corresponding high light and shadow under the irradiation of light, there is no change in the number of polygonal models under the premise, and access to higher polygon details. Therefore, normal mapping technology widely used in game engine.

Normal vector

Normal mapping technology is a kind of virtual 3D technology. Reason why people can the object that is mainly because of human eyes due to the difference in the scene to see, can distinguish the scene sense of three-dimensional stereoscopic. But the computer screen is a plane, resolution 3D effect can only rely on light effects to achieve, normal mapping is to a

irregularities on the surface of the situation down with each point of the normal vector records, in maps based on conversion of normal maps do light, so as to realize the bump effect. Light calculation is the basis of the normal mapping technology.

The RGB value of the normal map is not the color of the RGB, but the three component of the normal vector of each point. When the map is based on the three components of the normal vector to do the transformation of light, and the light intensity of each pixel is calculated by the light of the method used to calculate the vector and the tangent vector. If you will be a map of all the pixels and the normal vector and the tangent vector recorded, and then RGB color encoding way to record, so you can achieve the effect of the concave convex.

Bump mapping

When the object is viewed from any non edge direction, the details of the surface are usually determined by the light of the performance. In the normal map is to record a need to carry out the illumination light transformation maps each point of the concave convex texture and illumination of each pixel is by the illumination formula used to calculate the normal vector. To record the normal vector information of all the pixels in the texture, it needs to be done by mathematical method, the bump mapping technology can solve the problem of light and normal vector. In each pixel of the normal vector disturbance using texture mapping, which can provide more detailed illumination details.

The high resolution information which is disturbed by the normal vector is stored in a two-dimensional array of a normal map of a three dimensional vector. Each vector in the concave convex mapping map represents a direction, in which the normal vector is relative to the interpolation method. Vector <0,0,1> represents a normal vector that is not perturbed, and any other vector represents a modification of the vector that affects the light intensity formula. With a height map (map Height) of the gray map to store the plane height of each pixel, the different levels of the gray value of the plane height, so as to construct a concave and convex mapping.

Two dimensional texture coordinates are used to find the texture elements in 2D texture maps. Set the width and height of the two-dimensional texture map with s, t direction of the coordinate value, the value of the area between 0 to 1.

In order to get a high degree of difference between a pixel from the grayscale, first to calculate the tangent vector in the direction of S and T, and the tangent vector is dependent on the height difference between adjacent two pixels. In a grayscale image with W x B pixels, H (I, J) is used to represent the gray value of the <i, j> position, so that the tangent vector S (I, J) and T (I) and t (, J) in the direction of S and can be expressed as:

$$S(i,j)=<1,0,aH(i+1,j)-aH(i-1,j)> \quad (1)$$
$$T(i,j)=<0,1,aH(i,j+1)-aH(i,j-1)>$$

The constant a in the formula is used to adjust the scale factor of the range of the gray scale value, which can be used to control the degree of the disturbance of the normal vector. If Tz and Sz are expressed by S (I, J) and T (I, J) Z components, the normal vector N (I, J) can be obtained by the following cross product:

$$N(i,j)=\frac{S(i,j)\times T(i,j)}{\|S(i,j)\times T(i,j)\|}=\frac{\langle -S_1,-T_1,1\rangle}{\sqrt{S_1^2+T_1^2+1}}$$

Let s, t, R for the coordinates of the center from the cube point to the direction of the texture pixels to be sampled vector, and these coordinates re mapped to the interval [0,1], in order to generate the 2D texture coordinates <s, t>. In this way, the corresponding texture coordinates can be used to realize the sampling of the 2D texture map.

2D coordinates <s', t'> calculation formula for:

正负 X 面: $<\frac{1}{2} \quad -\frac{r}{2s} \quad \frac{1}{2} \quad +\frac{1}{2s}>$ (3

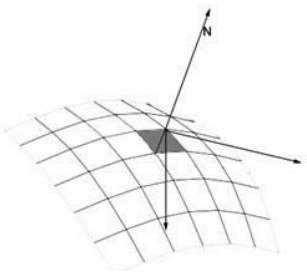
正负 Y 面: $<\frac{1}{2} \quad +\frac{s}{2t} \quad \frac{1}{2} \quad +\frac{r}{2s}>$

正负 Z 面: $<\frac{1}{2} \quad +\frac{s}{2r} \quad \frac{1}{2} \quad -\frac{1}{2r}>$

Tangent vector 1

Because vector <0,0,1> in bump mapping said without the disturbance of the normal vector and obtained normal maps and can't get good bump effect, so the need for it and light brightness formula frequently used interpolation method corresponding to the vectors. This can be achieved by constructing a coordinate system at each vertex position, and the vertex normal vector in the coordinate system always points to the direction of the Z axis. In addition to the normal vector, vector at each vertex position and tangent to the surface two. These two vectors form an orthogonal basis. The coordinate system which is formed is called tangent space.

In the vertex position, the tangent space is corresponding to the vertex tangent plane and normal vector. Tangent space coordinates of each vertex of the triangle mesh is established, you can in each vertex position calculating the pointing in the direction of the light vector L and L transform tangent space, then the tangent space of the vector L on the triangular surface of interpolation.



Tangent vector 2

Select the tangent vector of each vertex to keep them in line with the texture space of the concave and convex map. Then there is a more general calculation method to calculate the tangent vector of each vertex.

At each vertex, a 3 * 3 matrix is found, which can be used to convert vector from object space to tangent space. In order to achieve this goal. The first consideration is to compare the intuitive problem, that is, in the opposite direction, how to transform the vector from the tangent space to the image space. Because the normal vector of the vertex corresponds to the <0,0,1> in the tangent space, it can be known that the Z axis in the tangent space is always mapped to the normal vector of the vertex. The X axis is consistent with the s direction of the concave convex map, and the Y axis is consistent with the T direction of the concave convex map, and the P is a point inside the triangle network:

$$P-E=(s-sE)T+(t-tE)B$$

CONCLUSION

The normal mapping technique is realized by the mathematical method of concave convex mapping and tangent space.With the continuous development of 3D game development, the application of the mathematical method of normal mapping to achieve real-time 3D concave and convex effect, for the development of the game engine to provide a mathematical method.

REFERENCES

1. Jeanne. '. Game design complete tutorial [M]. Mi Xiaobo transl. Shanghai: Shanghai people's fine arts publishing house, 2008
2. Rongqin technology.JAVA game programming [M]. Beijing Kehai Electronic Press, 2003
3. Kautz,Jan.Achieving Real-Tine Realistic Refectons[Z].Game Developer.