

Research and Design of Toy Chinese Dragon Model based on OpenSCAD and Render based on Three.js

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Abstract. Nowadays, there are a lot of 3D models in the world, but how to build a Chinese Dragon is relatively few methods. Aiming at this problem, this paper put forward a method which made up for the deficiency in this aspect. In order to build this model, OpenSCAN software was used in this paper. This paper also divided Chinese Dragon into four parts: head, body, claws and tail, and used different methods to model these four parts. At the same time, in order to make the Chinese Dragon look more realistic, this paper also implemented basic lighting and shadows on Three.js. The methods used are the Phong model and shadow maps. What's more, In order to achieve the dragon in Chinese people's imagination, this paper also simulated the appearance of dragons breathing fire and surround fire. In the process of doing this, in order to make the effect of fire more realistic, this paper used Perlin noise to simulate the burning of fire. Meanwhile, in order to compare the effects of different surround fires, some people were invited to evaluate the effects of various surround fires. For the final experimental results, a cartoon style Chinese Dragon was made, and the fire effect was achieved very well.

Keywords: OpenSCAD; 3D modeling; Chinese Dragon; Three.js, lighting; shadows; fire.

1. Introduction

One of the most well-liked types of multimedia expression is computer animation, which has been invented and is now widely used due to the popularity of computers and digital information technology [1-3]. A wide range of top-notch animation production software has progressively surfaced in recent years as 3D virtual animation technology has developed and advanced, greatly raising the production quality and efficiency of 3D virtual animation [4-5]. However, there are not many methods on how to model a Chinese dragon, so this paper uses OpenSCAN to study how to use basic polygon to model a dragon. Although various excellent animation software has gradually emerged in recent years, such as 3Dmax and ZBrush to build a three-dimensional digital animation character model [6]. However, this paper still chooses OpenSCAN as the modeling software because it has the most original 3D modeling method. And as a common element of computer animation, fire is not much about how to render it, so this article introduces how to render it. Besides, to better show what the dragon looks like, we implemented basic shadows and lighting. What's more, in order to conform to the Chinese people's imagination of the dragon, this paper also focuses on the dragon breathing fire.

2. The Design of Toy Chinese Dragon

Our curtail work was to create a Chinese dragon which used LEGO style, so this paper called it Toy Chinese Dragon [7]. An original software named OpenSCAD was used to build the model which have basic graphics and graphic transformations.

Toy Chinese Dragon has four main parts: head, body, claws and tail. Therefore, this paper divided into four parts to model.

2.1. Toy Chinese Dragon's Head

Dragon's head are mostly made up of simple geometry. This paper used cubes, cylinders and polyhedrons to make the outline of the dragon's face by adjusting the size, shape and position of these



geometries. Later, in order to make the dragon look more dignified, cylinders and cubes were used to make the face of the dragon. What's more, dragon's teeth are made from pyramids, and the eyes from the spheres and the cylinders. In this way, this paper can get a beautiful dragon's head (Figure 1).

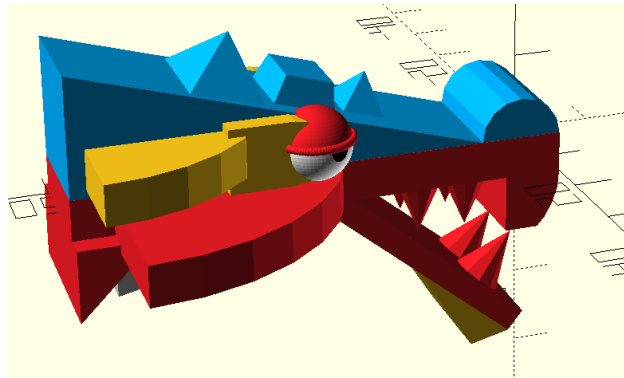


Fig. 1. Toy Chinese Dragon's head (Picture credit :Original)

2.2. Toy Chinese Dragon's Body

The body of a dragon is composed of many similar parts, so the main idea of making the body of a dragon is to first make a section of the body, and then combine these sections into a complete body of a dragon through certain rotation, translation and scaling.

Cubes and cylinders were used to form the main parts of the body. Then in order to add more such as scales and horns to the dragon's body, linear stretching and polygons were used. These parts need to be the right size, not only to surround the dragon's body, but also to be small enough to achieve the effect of dense scales. Finally, these components were put together to form a part of the body (Figure 2). In this paper, these techniques were employed to achieve the desired result.



Fig. 2. a part of Toy Chinese Dragon's body (Picture credit :Original)

Therefore, this paper had a part of body. It was replicated, translated, rotated and scaled to get the whole body. In general, the body is thinner at the ends and thicker in the middle. Then this paper got the good dragon's body(Figure 3).

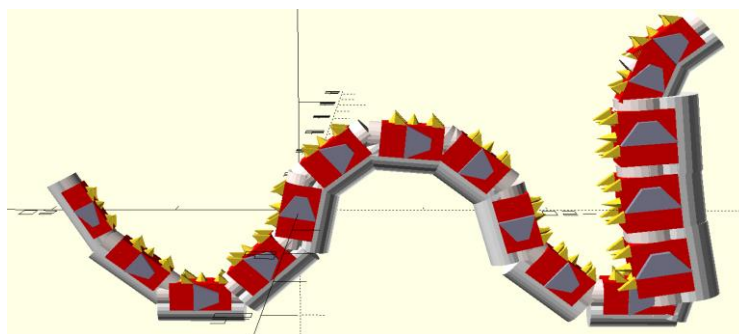


Fig. 3. Toy Chinese Dragon's body (Picture credit :Original)

2.3. Toy Chinese Dragon's Claws

The dragon generally has four claws, and the four claws of the dragon are similar in shape and size, the main difference is the difference between position and direction. For this reason, this paper only need to model a claw, and then copy it.

The main claws of the dragon was mainly created using polygons, which transforms given coordinate points into surfaces, and through the linear stretching, two-dimensional planes are extruded into three-dimensional models (Figure 4).

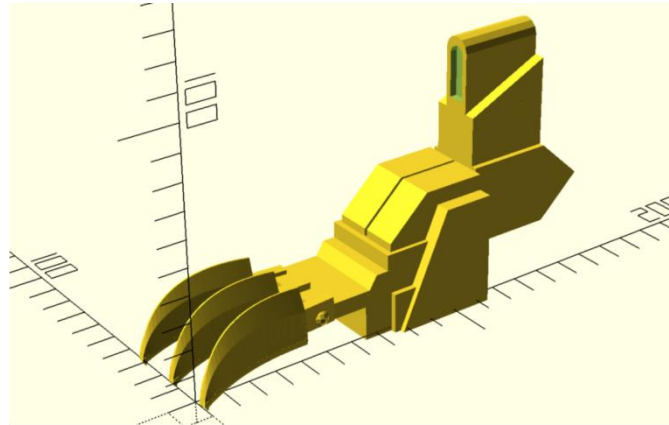


Fig. 4. Toy Chinese Dragon's claw(Picture credit :Original)

2.4. Toy Chinese Dragon's Tail

The design concept for the tail is inspired by fire. This makes the dragon appear as if it has come straight out of mythological legends. In order to build a smooth tail, this paper used over 40 points to describe the curve of tail. Then, linear stretching was used to extrude into three-dimensional models. So a one-layer fire model was got, but in order to give the fire a better three-dimensional sense and a burning effect. This paper decided to make three copies of it and put it together to get a better effect. The dragon's tail(Figure 5) is a model of the tail.



Fig. 5. Toy Chinese Dragon's tail (Picture credit :Original)

2.5. Toy Chinese Dragon

Now this paper had the parts of the dragon, so the head is placed at the front of the body, the tail is placed at the back of the body, and the claws are placed at the sides of the body. It is worth noting that in order to make the dragon look more natural, the individual claws take different rotation angles (Figure 6).

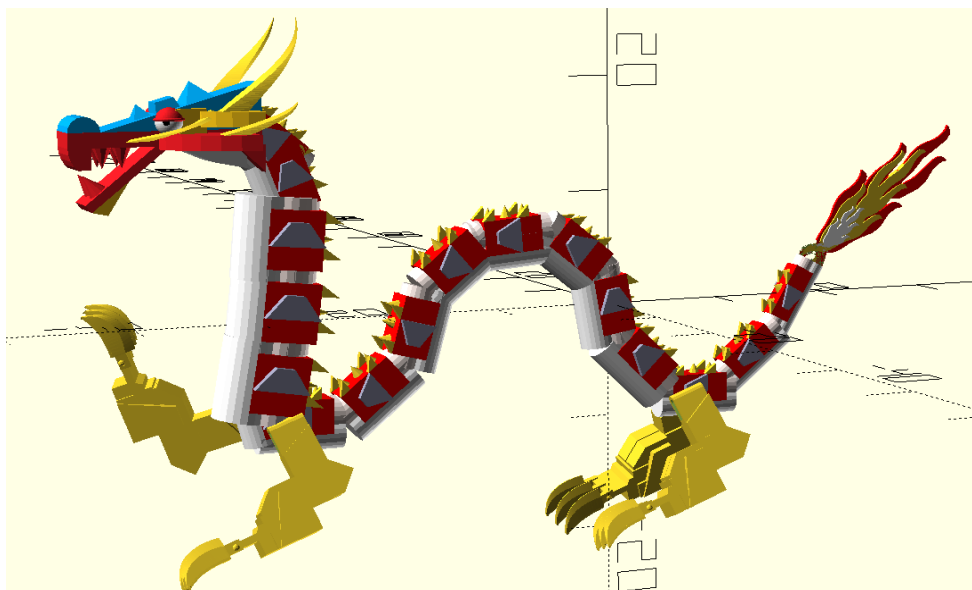


Fig. 6. Toy Chinese Dragon (Picture credit :Original)

3. The Render of Toy Chinese Dragon

3.1. Load Dragon

Because the model file type exported by OpenSCAN is STL which do not have vertex colors, and OpenSCAN cannot make texture. Therefore, this paper needed to export the parts of the dragon with different colors into the corresponding STL file. For example, yellow part was exported the into an STL file and the red part into another STL file.

However, this paper encountered some problems when exporting the dargon model from OpenSCAN, and this problem is not easy to solve on OpenSCAN. For example, when exporting the entire model of the dragon, some meshes are not closed like tail's meshes and it's difficult to solve on OpenSCAN. However, it's easy to solve on Three.js. So this paper exported the tail as a separate module from OpenSCAN and adjusted the position of the tail on Three.js. In this way, this paper can avoid solving difficult problems by solving simple ones, improve our speed to complete the dragon, and also achieve the same effect.

In order to make the dragon closer to the Chinese imagination, this paper also added the dragon ball to the scene and gave it a certain texture.

3.2. Phong Lighting

Then, this paper added light sources to the scene and used the phong illumination mode to illuminate the dragon. As a result, a pretty Phong dragon is obtained (Figure 7).

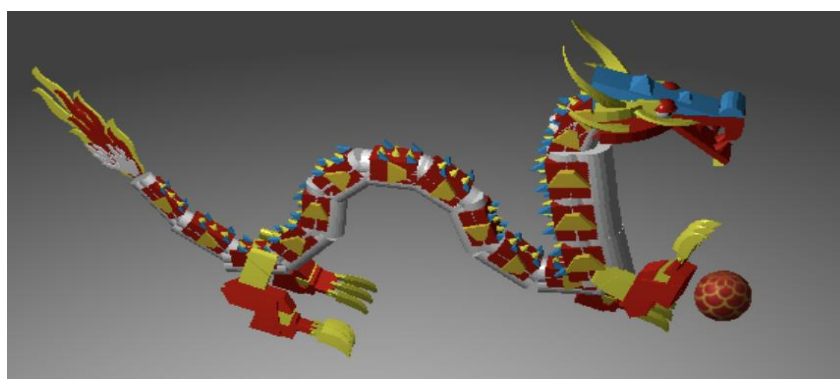


Fig. 7. phong dragon (Picture credit :Original)

3.3. Shadow

Now this paper had the model and the lighting, but there is still a disadvantage, which is that there is no three-dimensional feeling. Therefore, a shadow was needed to add to the scene. This paper used Shadow Map to complete this function. Basic principle of Shadow Map is that generate a depth map from the light source, recording the positions closest to the light source. When rendering, compare the distance of the observation point to the light source with distance of that point on the Shadow Map. If it is further away, it is in shadow, if it is closer, it is illuminated by the light source. Then the shadow picture is obtained (Figure 8). This paper also used PCF to achieve soft shadow [8]. The Percentage Closer Filtering algorithm (PCF) significantly reduces aliasing artifacts in shadow mapping applications.

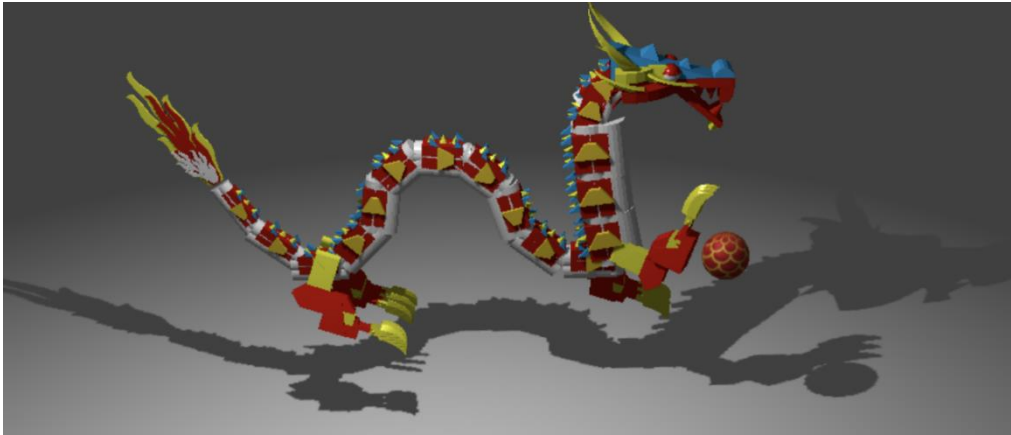


Fig. 8. shadow picture (Picture credit :Original)

3.4. Spitting Fire

In the Chinese imagination, dragons are closely related to fire, so this paper decided to add an effect like dragon spitting fire [9]. Therefore, this paper needed to know how to simulate the effect of fire.

To simulate this effect, firstly, this paper determined the base of the fire, the width and direction of the fire shape. For example, coordinate (0,-2) was used as the base of the fire in the scene. Secondly, the linear distance and angle of the pixel point to the fire base are calculated in order to create the shape of the fire and the edge wave effect. In order to create a smooth transition around the edge of the fire, this paper chose 4.5 as the basis for the smooth transition. Thirdly, to make the fire had a more realistic effect, random numbers were used to get the noise value. Next, The Perlin noise technique was used, which combines multiple frequencies to create more complex and natural fire effects [10]. Finally, rotation was added to allow the fire to swing in the wind. In this case, the shader of the fire was completed.

Then, in order to complete the model of the flame, a combination of spheres and cylinders was used. Next, the completed shader effect was loaded onto the model, resulting in the spitting fire. At the same time, this paper also used the fire from the dragon as a light source. Therefore, the scene had two light sources, one was the added light source, and the other was spitting fire. What's more, both of these light sources generated shadow maps, so readers could see two dragon shadows on the floor (Figure 9).

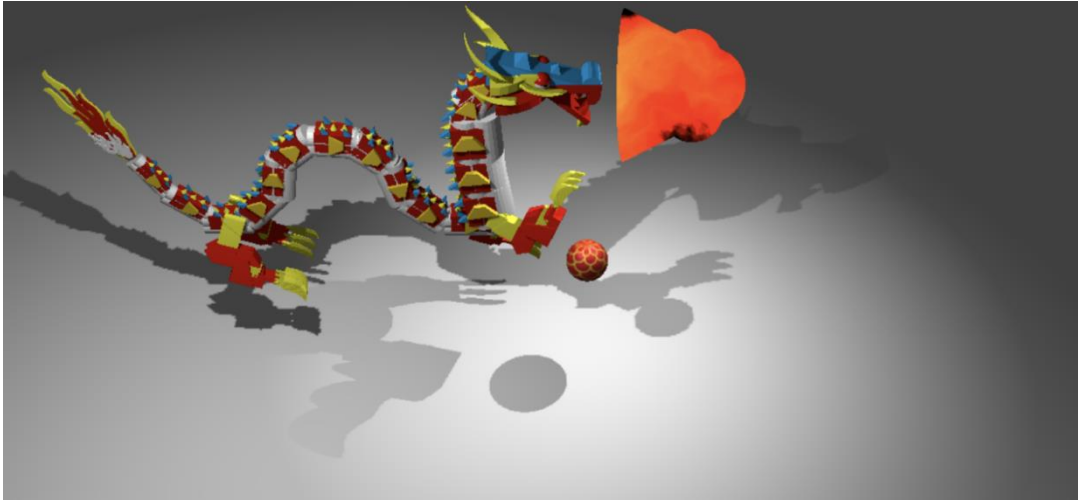


Fig. 9. spitting fire (Picture credit :Original)

3.5. Surround Fire

Also, in the Chinese imagination, a dragon is surrounded by fire, so the paper required simulating this effect as well. Currently equipped with a fire shader, the remaining step was to finalize the model of surrounding fire.. Therefore, a lot of tiny spheres were added around the dragon to simulate the particle effect. Then, the shader of the fire was used to complete the effect of surrounding fire(Figure 10).

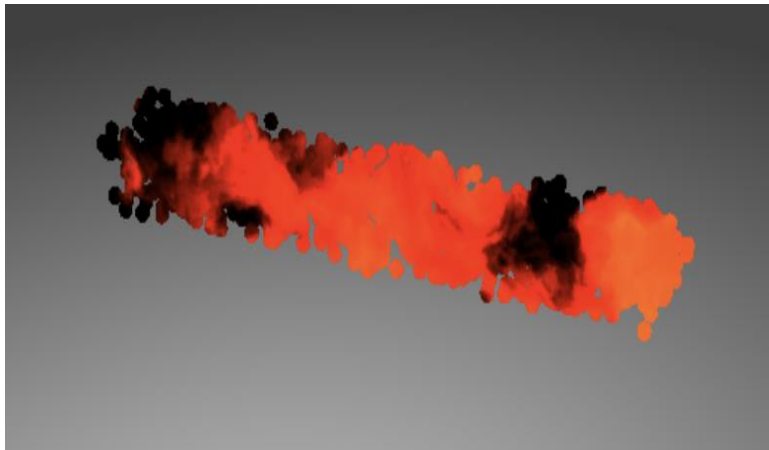


Fig. 10. surround fire (Picture credit :Original)

4. Result

4.1. Result Display

After the modeling process and rendering process are done. The full of Toy Chinese Dragon effect is completed. So this paper asked 50 people to evaluate the various parts of the dragon modeling such as head, body, claws and tail, the whole dragon, and the rendered results (Figure 11).

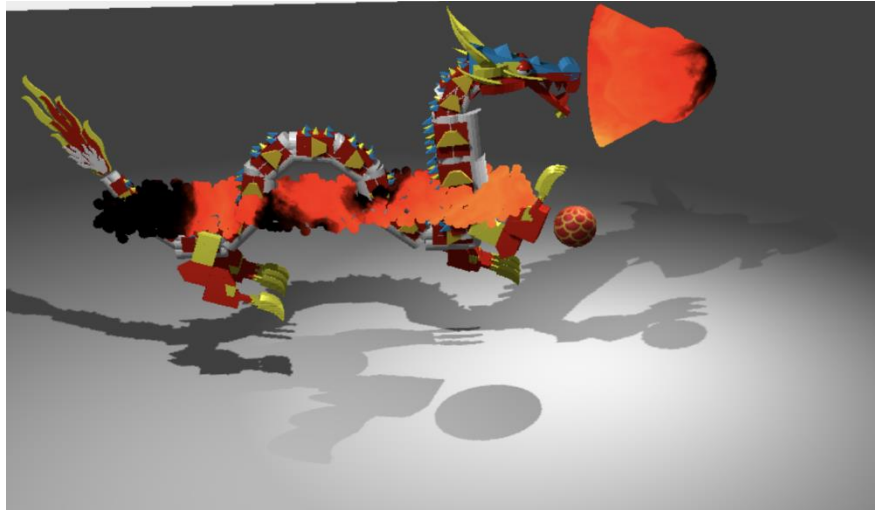


Fig. 11. Toy Chinese Dragon (Picture credit :Original)

4.2. Evaluation

According to the table 1, it showed that nearly two thirds of respondents scored general effect of the dragon model as “Excellent”. And people's evaluation of various parts of the dragon is also very high. This is due to the adjustments this paper made to the details of the various parts of the dragon, for example, when this paper made the dragon's claws, the position of the nails was adjusted again and again in order to make the dragon's nail more symmetrical. And when this paper spliced the various parts of the dragon, The rotation of the claws was repeated multiple times in order to keep them facing different directions.

Also, more than 80% of people think rendering is very good. This is because the current technology can already support rendering very good results. What's more, in the adjustment of the light source, this paper also made some efforts, such as the intensity of the light source, as well as the position of the light source, have been adjusted again and again.

Table 1. Investigating Chart

Index	Dragon's Claws	Dragon's Head	Dragon's Body	Dragon's Tail	Dragon	Rendering
Excellent	35	37	32	30	36	42
Good	8	10	9	7	10	5
Medium	4	2	7	10	2	3
Poor	3	1	2	3	2	0

When doing Surround Fire, many small spheres need to be added to the scene, which will consume a lot of GPU resources when rendering. Therefore, it was important to choose the right number of spheres, neither too few which would affect the appearance, nor too many which would affect the performance. So this paper gave people the three spheres rendered in different numbers. Hope people could evaluate them in order to find suitable choice of the number of spheres. Figure 12 shows different numbers of spheres, 500 on the left, 1500 in the middle, and 2500 on the right.



Fig. 12. Different Number of Spheres (Picture credit :Original)

From Table 2, readers can see that as the number of spheres increases, performance gets better and better, but when the number reaches a certain level, performance does not increase significantly, but the consumption of GPU resources does increase linearly. For example, when 500 spheres are selected, 240,000 triangles need to be rendered. If the number of spheres is 1500, 720,000 triangles need to be rendered. And if the number of spheres is 2500, 1200,000 triangles need to be rendered. So with this trade-off, this paper chose 1500 spheres as the surround fire. This can achieve good results, but also reduce the consumption of GPU resources.

Table 2. Investigating Chart of Spheres

Number	500	1500	2500
Excellent	20	33	35
Good	12	10	9
Medium	8	3	5
Poor	10	4	1

4.3. Limitations

From the user's research, Toy Chinese Dragon has generally achieved excellent evaluation, but it also points out some problems. Overall, the model basically matches some characteristics of Chinese dragons, for example, the effect of fire matches the Chinese imagination of dragons. Some people feedback, in the eyes of the Chinese people, the Chinese dragon represents good, is a symbol that can remove all evil. Therefore, the Chinese Dragon is a solemn image, but the details of the Toy Chinese Dragon's head are a little less, which does not reflect this effect. Therefore, in order to achieve better results, readers can add some whiskers to the head and build the head longer.

5. Conclusion

In this paper, the modeling method of Toy Chinese Dragon by using OpenSCAN and the rendering method of it by using Three.js are described in detail. In the process of modeling, this paper found that readers can use some very simple methods to create interesting models, for example, a sphere with a ring can create an eye, and a cylinder can be squeezed to create a distorted shape. With these methods, readers can make the desired model more easily when using more advanced modeling software such as 3Dmax and maya.

Besides, in the process of rendering, this article found that after completing the basic flame shader, it can be used in many scenes. For example, in this article, this shader is used in spitting fire and surround fire. This can reduce the GPU resources and achieve good results. This production method can be extended to a variety of scenarios using shader to increase the speed of development and reduce the cost of development.

What's more, when did Surround Fire, this paper has compared the effects of using different numbers of spheres. In terms of the result, the dragon model and the rendering effect are very good. In addition, when using shader to simulate Surround Fire, using 1500 spheres for shader can not only achieve good effects, but also reduce GPU resource consumption. This can give some ideas for how to achieve similar effects in some games. At the same time, this cartoon-style Chinese dragon model can provide inspiration for some games.

However, In the design of the dragon head, this paper mainly focuses on the shape of the dragon head, and does not pay much attention to the image that the dragon should have in Chinese culture, so part of the dragon's majesty is missing, which is the deficiency of this article. Therefore, when designing Chinese dragons in the future, readers should not only focus on the appearance of the dragon, but also understand the cultural significance of the Chinese dragon, so as to better display the image of the Chinese dragon.

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