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Research and Design of Chinese Dragon Based on OpenScad

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Abstract. OpenSCAD, an open-source 3D modeling software, has been widely favored by creators for its powerful functions and flexible scalability. Although OpenSCAD has a wide range of applications in the field of 3D modeling, there are still few studies on how to use it to build animated models with specific cultural characteristics. As one of the important symbols of traditional Chinese culture, the Chinese dragon has unique morphology and cultural connotation. Therefore, we hope to provide new ideas and methods for related fields by studying the application of OpenSCAD in building animated models of the Chinese dragon.This study mainly explored the process of using OpenSCAD, an open-source 3D modeling software, to construct animated models with Chinese cultural characteristics - the Chinese dragon. In the modeling process, we adopted a block-based modeling strategy, dividing the overall structure of the dragon into several main parts: head, body, claws, and tail. For each part, we fully utilized the basic primitive construction and transformation functions provided by OpenSCAD for fine shaping. Through this study, we successfully used OpenSCAD to construct an animated model of the Chinese dragon with distinct Chinese cultural characteristics. This achievement not only demonstrates the powerful functions and flexibility of OpenSCAD in modeling complex shapes, but also provides new ideas and methods for related fields.

Keywords: 3D; design; Chinese dragon; openScad.

1. Introduction

OpenSCAD is a software used to create solid 3D CAD objects. It is a universal software that is suitable for various mainstream systems such as Linux/UNIX, MS Windows, and Mac OS X. [1-2] Unlike most free software for creating 3D models (such as the famous application Blender), OpenSCAD focuses on CAD aspects rather than artistic 3D modeling. Therefore, it is a tool for creating machine parts for 3D models rather than making computer animated movies. OpenSCAD is not an interactive modeling tool. Instead, it is more like a 3D compiler that reads script files that describe and render objects. This software provides complete control over the modeling process, enabling users to easily change any step or design in the modeling process. In addition, OpenSCAD provides two main modeling techniques: constructive solid geometry (also known as CSG) and the creation of 2D contours [3]. As a data exchange format for these 2D contours, Autocad DXF files are used. In addition to the 2D paths used for creation, design parameters can also be read from DXF files. Apart from DXF files, OpenSCAD can also read and create 3D models in STL and OFF file formats.

This project mainly studies how to design and implement the shape of the Chinese dragon using OpenSCAD. By referring to the image of the Chinese dragon made of LEGO bricks as a modeling example, we call the built-in functions of OpenSCAD to generate the image of the Chinese dragon through modeling basic primitives including cubes, cylinders, cones, and other related operations on basic 3D and 2D primitives such as stretching, rotation, twisting, and translation.

2. Structure and Design of the Chinese Dragon

The common image of the Chinese dragon consists of several parts: head, body, claws, and tail. Therefore, the structure of the Chinese dragon is decomposed, and each part is modeled separately. In the end, all parts are combined, and the position and size of each part are adjusted to make the

entire dragon more vivid. This article will mainly introduce the modeling process of the body of the Chinese dragon and the main modeling ideas of other parts[4].

2.1. Analysis of the Structure and Design Ideas of Each Part of the Chinese Dragon

Before modeling the Chinese dragon using OpenSCAD, it is necessary to conduct research on the image of the Chinese dragon. After consulting a large amount of information online, we decided to adopt a Chinese dragon image similar to LEGO bricks (as shown in Figure 1 below). This not only makes the dragon image more vivid, but also modularizes the modeling code, making the structure clearer and facilitating subsequent rendering work.

Fig. 1. Schematic Diagram of the Chinese Dragon Image(Photo/Picture credit :Original)

By decomposing the various parts of the Chinese dragon, the dragon's overall body can be roughly divided into four parts: head, body, claws, and tail. Each part has different design and modeling methods. The head design should be majestic but not lacking in delicacy, with the dragon's eyes being bright and piercing, and the horns upright and powerful, demonstrating the dragon's majesty and strength. The body part adopts a streamlined design, which not only conforms to the dragon's shape but also makes the entire model look more vivid and flexible. The claw part focuses on detailed portrayal, making the dragon's claws more realistic. The tail, like a flowing flame, adds a sense of mystery. Below, we will design each part of the dragon separately.

After completing the modeling of each part separately, the position of each part is adjusted through translation to complete the splicing and realize the modeling of the Chinese dragon.

2.2. Design and Implementation of the Body of the Chinese Dragon

Starting with the body of the dragon, as the most important and largest part of the dragon, modeling a vivid dragon body requires a modular approach. The dragon's body is divided into multiple repeating sections to construct its massive form. Each section is an independent module, and by performing different rotation, translation, and scaling operations on these modules and connecting them, a continuous curve is formed, making the dragon's body appear powerful yet elegant. At the same time, to enhance the vividness of the dragon's body, elements such as scales and horns are added. This modular modeling approach not only improves modeling efficiency but also creates a harmonious and unified look for the entire dragon body [5-6].

After dividing the body of the Chinese dragon into identical sections, modeling is performed for each section. Firstly, the main body of the dragon's torso is modeled by calling the cube() and cylinder() functions in OpenSCAD to create appropriately sized cubes and cylinders. The RGB values of the color are set using the color() function. Secondly, the horns on the dragon's back are modeled by creating cylinders using the cylinder() function. By performing translate() and rotate() operations on the horns on the dragon's back, multiple horns are added. The modeling result is shown in Figure 2.

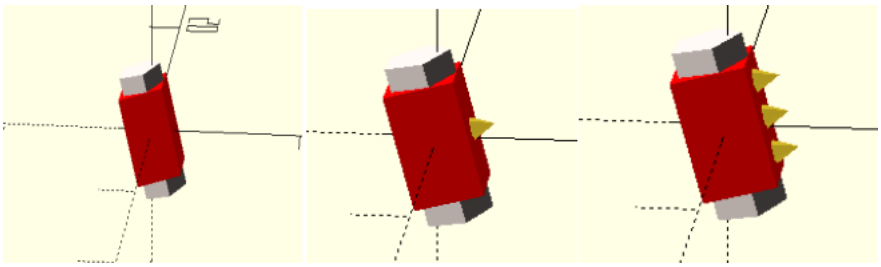

Fig. 2 Basic Modeling of the Dragon's Body (Photo/Picture credit :Original)

Next, details are added to the dragon's body. Multiple points are defined using the points() function, and the polygon() function is used to connect and fill the points into a two-dimensional planar figure. The figure is then stretched to complete the creation of a custom cylinder. The created graphics are encapsulated into the scale() and horn() functions for convenient direct invocation during subsequent modeling processes for translation, rotation, and scaling operations.

When calling scale() and horn(), since these two functions default to modeling at the origin, they need to be adjusted in position through translation and rotation. The scale() and horn() functions are called multiple times and the positions are adjusted to add details to the body. So far, each section of the dragon's body has been designed, but to make the entire dragon look more robust, a belly needs to be added to the dragon's body. A cylinder is created using the cylinder() function to simulate the dragon's belly. The result is shown in Figure 3 below:

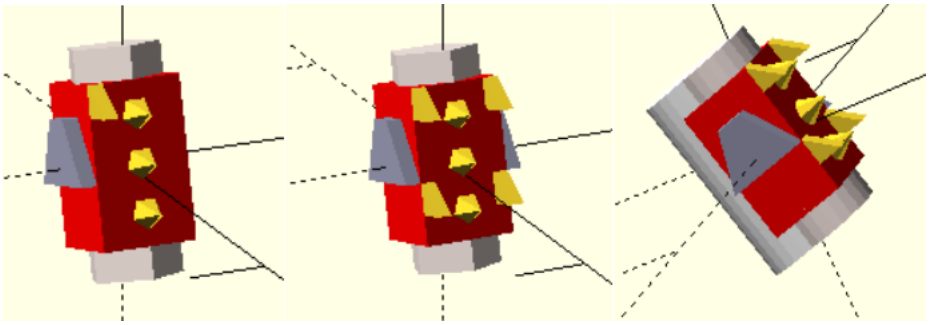

Fig. 3 Detailed Addition to the Dragon's Body (Photo/Picture credit :Original)

At this point, the design of each section of the dragon's body is complete. The entire function is encapsulated into a body() function. By repeatedly calling the body() function and performing rotation and translation, the entire torso is assembled, as shown in Figure 4 below:

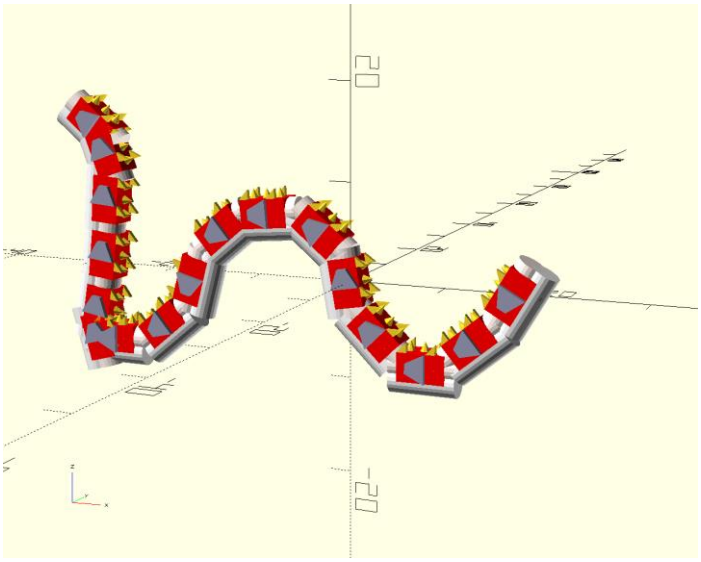

Fig.4 Completed Assembly of the Dragon's Body Torso(Photo/Picture credit :Original)

Finally, the various parts of the dragon's body are scaled. The scale() function is called to scale different sections of the dragon's body. The section near the neck is enlarged, and the section near the tail is gradually reduced, ultimately completing the body section.

2.3. Main Modeling Approaches for Other Parts

Next is the design of the dragon's head and claws. The dragon's head is the soul of the entire dragon image. To make the entire dragon appear more vivid and majestic, the modeling process of the horns on the dragon's head is particularly crucial. Using the stretching and twisting operations in OpenSCAD can skillfully shape the upright and powerful look of the dragon's horns, making them both consistent with the majestic temperament of the dragon and full of artistic beauty. As for the other parts of the dragon's head and its claws, a basic 3D model splicing approach is adopted to complete them. By selecting appropriate 3D models, such as round eyes and arched mouths, and then performing precise splicing and combination, the shapes of the dragon's head and claws become more vivid and realistic [7].

The design of the dragon's head mainly adopts a mirroring concept, using the mirror() function to complete the design of one side of the head and making it symmetrical.

The key implementation of the dragon's horns adopts the twisting function linear_extrude(). By adjusting the twisting angle and position of the horns, a cylinder is first created using the square() function, and then the cylinder is twisted to create the completed horn section. The result is shown in Figure 5 below.

Fig. 5 Dragon Horns (Photo/Picture credit :Original)

Finally, modeling the dragon's tail was undertaken. In the reference model, the dragon's tail is formed by the stretching of irregular curves. Therefore, in the modeling process using OpenSCAD, Bezier curves will be employed to simulate the irregular curves. Multiple Bezier curve control points will be defined to outline the basic shape of the dragon's tail. These control points are carefully arranged to ensure the smoothness and dynamism of the curve, fully exhibiting the elegance of the dragon's tail. Next, the 2D Bezier curves will be transformed into 3D solid models using the stretching function of OpenSCAD. By adjusting the direction and degree of stretching, a certain thickness is given to the dragon's tail, making it appear more three-dimensional and full. To enhance the layered look and visual impact of the dragon's tail, models of different sizes and thicknesses are further stacked. This stacked design not only enriches the shape of the dragon's tail but also makes the entire model appear more vivid and realistic. Through this series of operations, the modeling of the dragon's tail in OpenSCAD is successfully completed.

To more realistically represent the tail morphology of the Chinese dragon, we first call the crtl_pts() function to accurately create multiple control points in three-dimensional space. These control points will serve as key nodes for the Bezier curve, laying the foundation for subsequent curve generation. Subsequently, we utilize the bezier_curve() function to fit a smooth and natural Bezier curve through

the previously created control points. This curve not only exhibits an elegant shape but also perfectly captures the flow of the dragon's tail[8].

Next, the generated Bezier curve is filled into a two-dimensional plane and given thickness to construct a three-dimensional model of the dragon's tail. This step makes the dragon's tail more three-dimensional and lifelike. Finally, to further enhance the realism of the dragon's tail, we perform a series of transformation operations, including rotation, scaling, and translation, to make the pose of the tail more vivid, as if a real dragon is dancing in the air. Through these steps, we successfully create a realistic and vibrant model of the Chinese dragon's tail. The implementation effect is shown in Figure 6 below:

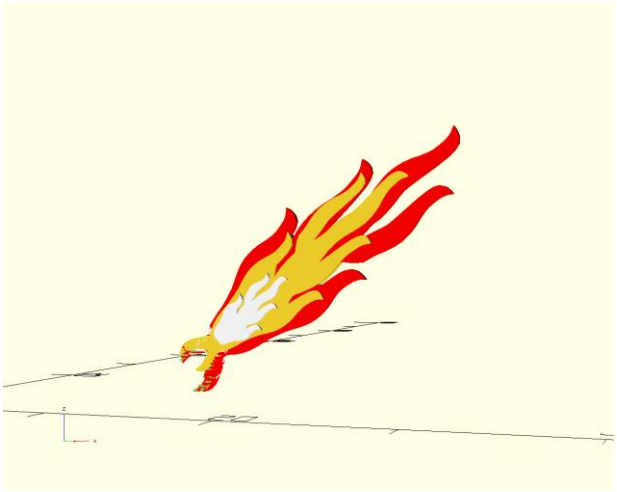

Fig. 6 Realization of the Chinese Dragon's Tail (Photo/Picture credit :Original)

2.4. Overall Assembly

After completing the design of each part, the dragon's head, claws, body, and tail will be assembled through operations such as translation and rotation, ultimately realizing the overall presentation of the image of the Chinese dragon, as shown in Figure 7.

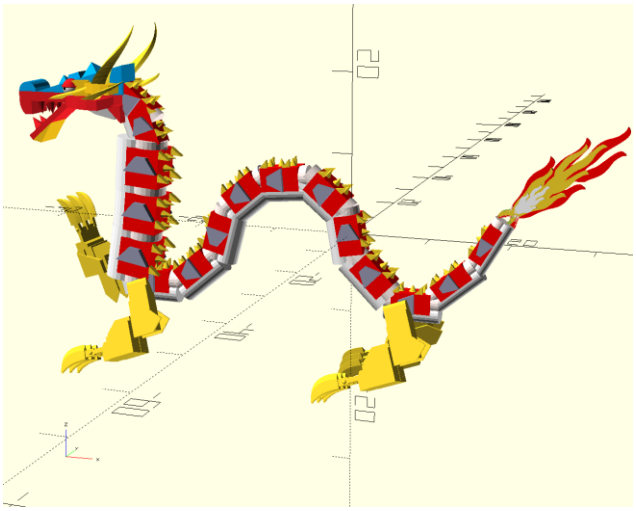

Fig.7. Overall Realization of the Chinese Dragon (Photo/Picture credit :Original)

3. Result Analysis

In the process of creating the image of the Chinese dragon using OpenScad, a powerful open source 3D modeling tool, careful design and production were carried out for different parts such as the dragon head, body, claws, and tail. The following is a detailed evaluation of the Chinese dragon image by 50 people surveyed, as shown in the table 1 below.

Table 1 Result analysis

Index	Dragon's Claws	Dragon's Head	Dragon's Body	Dragon's Tail	Dragon	Rendering
Excellent	35	35	37	36	36	42
Good	9	12	10	10	10	5
Medium	4	2	2	3	2	3
Poor	2	1	1	1	2	0

Firstly, as the main body of the entire model, the dragon's body occupies a significant proportion, and its design is quite vivid. Among the 50 participants in this survey, 37 believed that the modeling of the dragon's body was excellent. In OpenScad, through the combination and adjustment of a series of basic shapes such as cylinders and prisms, the powerful and smooth form of the dragon's body was successfully shaped. Especially the smoothness of the body curve and the delicacy of the muscle texture both convey the strength and vitality of the dragon's body. In addition, by adjusting the color and size, a realistic texture was given to the dragon's body, making it appear more three-dimensional and vivid in the three-dimensional space.

The dragon's head, as the soul of the dragon's image, is of utmost importance in its design. The design of the dragon's head was considered excellent by 35 out of 50 people, receiving significant recognition. Through precise calculations of the position and size of each component, as well as careful adjustment of every detail parameter, the dignified and mysterious temperament of the dragon's head was successfully captured. Especially the detailed design of the dragon's horns is vivid and expressive. The shape, size, and angle of the horns were optimized through multiple iterations, ultimately presenting an effect that not only matches the morphological characteristics of the dragon but also exudes artistic beauty. In addition, parts such as the dragon's eyes, nose, and mouth were also carefully depicted, making the entire dragon's head appear lifelike.

The restoration of the dragon's claws is also a major highlight of this creation. Among the 50 participants in the survey, 35 rated the design of the dragon's claws as excellent. Through in-depth research on the morphological structure and movement patterns of the dragon's claws, we successfully reproduced their authentic forms in OpenScad. Whether it's the shape, size of the claws, or the curvature and strength of the joints, all exhibit a high degree of restoration. This made the entire dragon image more complete in detail and more aligned with people's imagination and expectations of the dragon.

Lastly, the design of the dragon's tail also received recognition from many of the 50 survey participants. By adopting the method of spline curve fitting and repeatedly adjusting the values of the control points, a smooth and natural dragon tail curve was successfully generated. This allowed the dragon's tail to naturally connect with the body while also exhibiting its unique dynamic beauty.

In summary, the Chinese dragon image created using OpenScad this time demonstrated a high level of proficiency in all aspects. Whether it's the overall design or the handling of details, it showcases the designer's ingenuity and profound skills. This image not only possesses high artistic value but also provides valuable references for subsequent 3D modeling work. In the future, integrating traditional Chinese cultural elements into OpenSCAD modeling, such as phoenixes, qilins, Peking Opera facial makeup, and traditional architecture, can inherit and promote traditional culture while injecting creativity into modern design [9,10].

4. Conclusion

In this paper, the modeling of the Chinese dragon image was achieved using OpenScad. By dividing the Chinese dragon into several parts including the head, body, claws, and tail, and modeling each part separately, polygon modeling and curve modeling were employed, combined with twisting and other functions. Through continuous iteration, fine grinding, and adjustment of the model image, all parts were successfully assembled into a complete Chinese dragon image, demonstrating that OpenScad can effectively perform basic graphic modeling while maintaining many of the original features of the model. In addition, the Chinese dragon image created in this paper can provide different ideas and inspiration for workers in fields such as animation design and game design. The successful case of modeling the Chinese dragon image provides a useful reference for modeling other traditional cultural elements. In the future, we can try to integrate more traditional Chinese cultural elements into OpenScad modeling, such as mythical creatures like phoenixes and qilins, or cultural symbols like Peking Opera facial makeup and traditional architecture. By presenting these elements in a digital form, we can not only inherit and promote traditional culture but also inject more creativity and inspiration into the modern design field.

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