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A Cross-software Computer Graphics Design of Chinese Biscuit Based on OpenSCAD and ShaderFrog

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Abstract: Nowadays, Chinese culture has shown its unique charm around the world, and while diverse Chinese cultures such as Tai Chi, Hanfu, and tea culture are widely spread, there are actually many Chinese cuisine modeling that do not have enough space to display. In this article, the author has chosen the theme of "Chinese New Year biscuits", with the intention of using OpenSCAD and ShaderFrog as a powerful assistant in modeling and rendering, and through computer graphics to show more the culture of Chinese New Year biscuits. This article will introduce the modeling methods and details of biscuits, including the layering of biscuits and the engraving and stitching of Chinese character image models, as well as the thinking and editing process made by the author of the rendering part to achieve a certain degree of fidelity. After the production is completed, this paper draws some conclusions about improving the convenience and advanced rendering of models, and at the same time thinks about how to further improve the realism in subsequent research.

Keywords: CG modeling, shading, Chinese biscuit, OpenSCAD

1. Introduction

With the advancement of society and the economy, the field of digital technology has drawn increasing attention. Computer Graphics (CG), with its close relationship to graphics hardware, image interaction technology, virtual physical modeling and geometric design, has gradually turned into an indispensable aspect of people's lives. It is now firmly ingrained in a variety of societal sectors, including molecular biology, business, art, and multimedia [1]. However, this paper points out that one of humanity's most fundamental needs, food, along with its associated economy and culture, is not making the best use of CG possible. This paper discovers that young people are igniting a "national style" boom in Chinese pastry [2]. Accordingly, this article contends that Chinese pastry can seize the chance to use digital tools to promote its culture and fuel the economy in connected industries. In order to address the shortcomings in the current Chinese pastry culture promotion, this paper uses the opportunity to create a set of Chinese Spring Festival biscuits using OpenSCAD and ShaderFrog and the pertinent knowledge of computer graphics. The main production steps of this work are OpenSCAD modeling and ShaderFrog shading, and the main concepts of these two steps are described below.

"3D modeling" is generally speaking, the use of 3D production software to build a model with 3D data through virtual 3D space. It can be roughly divided into two categories: NURBS and polygon

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meshes. NURBS has a good application for models that require fineness, elasticity and complexity, and is suitable for quantitative production purposes. Polygon mesh modeling is based on ramen method, which is suitable for renderings and complex scene animation.

Rendering in computer graphics is the process of generating images from models using software. A model is a description of a three-dimensional object in a strictly defined language or data structure, including geometry, viewpoint, texture, and lighting information. In addition to post-production, shading is the last step in the CG process and is where the image is eventually adjusted to fit the 3D scene. A shader is an editable program that implements image rendering instead of a fixed rendering pipeline. Vertex Shader is mainly responsible for vertex geometric relations and other operations, Pixel Shader is mainly responsible for chip color calculation.

This paper contributes to the bridge between Chinese New Year food culture and the digital world through the use of computer graphics. An example of food modeling is also given for computer graphics novices.

2. Method

The process of making digital biscuits is mostly broken down into two sections: creating the geometric model using OpenSCAD, loading and editing shaders with Shaderfrog. The specific details will be described using these three components as hints.

2.1. Modeling-Using OpenSCAD

In order to bolster the participation of some typical Chinese culture elements, the picture above which contains Chinese characters is considered typical and picked (Figure 1). At the same time, as one of the main culture carriers, Chinese character which provides the author some modeling difficulties, and the complexity and morphological variety of Chinese characters also enable modelers with some free play. The creator separated the biscuit into three sections after precisely beginning the modeling work: a cookie-like bottom layer, a red middle layer, and the layer with the Chinese characters. The benefit of chunking is that it not only streamlines and clarifies the modeling process but also helps with the next step—the shading—which will be covered in more detail later.

Figure 1: Biscuit Reference Picture.

In the process of modeling, this paper follows the basic form of the reference diagram, and combines the basic principles of model design, and is committed to using the actual effects of three-dimensional forms such as size, weight, direction, center of gravity, virtual reality and other psychological effects such as emotion, concept, beauty, etc., so that the viewer can produce strong visual effects [3].

2.2. Underlying Design and Construction

Concentrate first on the underlying models. The lace-like serrations surrounding the square are the reason why this layer may be readily identified as a cookie (Figure 2(a)). The function *polyhedron ()*

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is used to create a regular tetrahedron, but if we use tetrahedrons directly to serve as serrations, it will make the edges sharp and stiff. Therefore, some circular functions, such as *cylinder ()* and *sphere()*, are needed to lubricate the boundary to make the tetrahedron become a cone (Figure 2(b)). The underlying cookie is then finished after the copying the cone and arranges it in equal intervals on the bottom body (Figure 2(c)) by using method *for ()*.

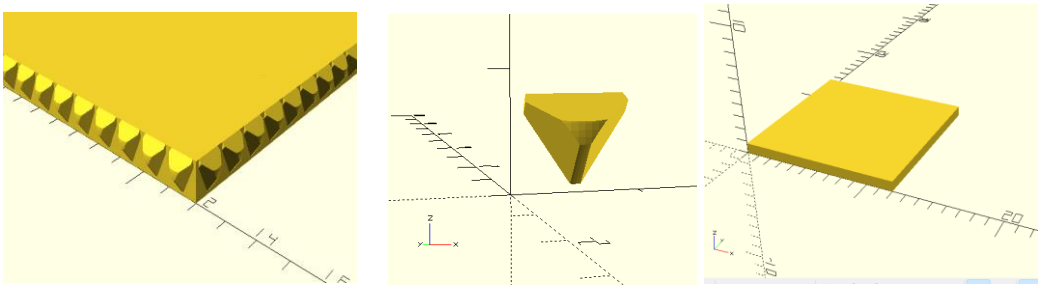
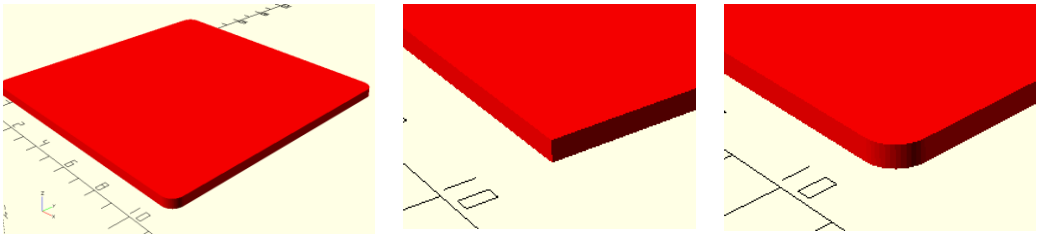


Figure 2: (a) Completed Bottom, (b) A single lace-like serration, (c) The bottom body.

2.3. Modeling of the Interlayer and the Character “春”

The middle layer’s modeling is extremely straightforward. A thin square piece can be used. The straight line, however, is more prominent in the sense of layering and three-dimensionality, and generally has a sense of rigor and order [3], which is inconsistent with the style of food we want to make. As a result, the author hopes to add curved elements to the model to create a stretchy and flexible feeling. This is achieved by hiding acute right angles by rounding the four corners of the object and covering them with cylinders (Figure 3).



(a) (b) (c)

Figure 3:(a) Final Interlayer, (b) Sharp Conner, (c) Round Conner.

Modeling process of the character “春” (Which means the season spring) (Figure 4).

Figure 4: The Character “春”.

The character “春”’s modeling procedure is what needs to be the center of attention. Instead of simply imitating the cream font in the reference image, regular calligraphic form of was thought to be appropriate and valuable since it is round, lively, elegant and free, sleek and smooth, with strong ink charm, suitable for title and propaganda decoration words [4]. The relationship between the four

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calligraphic strokes of the character “春” and the modeling procedure will now be thoroughly explained in detail in the following paragraphs.

- **Horizontal**

Because of the peculiar movement of the brush, horizontal strokes have pause written at the beginning and the end, therefore a horizontal stroke model requires a starting block, a rod-shaped block, and a terminal block, rather than a simple rectangle. For the middle part of this stroke, it should be noted that cubes or conventional cylinders cannot be used since calligraphy would create consistent thickness variations, so frustum is an appropriate shape that should be employed (Figure 5).

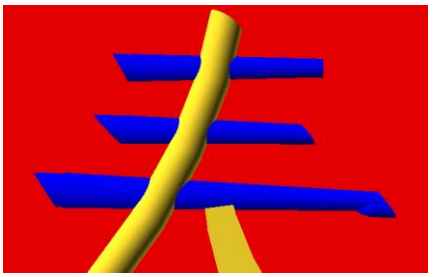

Figure 5: Some Horizontal Strokes in “春”.

- **Vertical**

This section is constructed in the same manner as the horizontal rod-shaped part, but it differs in that it has sharp ends. This paper employed the difference () cutting method while modeling to recover this, and the remainder of the frustum ensures the authenticity of the findings (Figure 6).

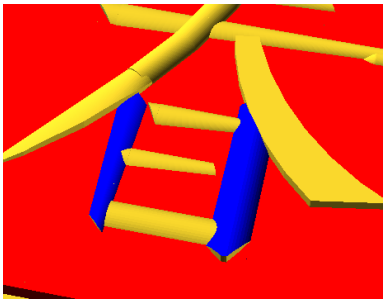

Figure 6: Vertical Strokes in “春”.

- **Pie**

Pie—A Chinese calligraphy stroke that is drawn from upper right to lower left. It starts off in a straight line, and its finish is gradual and perfected, much like the vertical finishing approach. The author used circles to cut the ends of Pie based on the fact that Pie acts along a curved trajectory, and the author continuously adjusted the radius and other pertinent parameters to make the straight part of the stroke and the curved part smoothly connected (Figure 7).

Figure 7: Pie Strokes in “春”.

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- **Na**

Na—Chinese calligraphy contains a stroke called Na, which is dragged from the upper left to the lower right. Although it is directionally symmetrical with Pie, this is not the case from the shape. Chinese characters typically conclude with a Na stroke, which carries the character's last power and emotion, particularly in the character "春". Na must therefore be more resilient than Pie. This stroke goes from thin too thick in normal front, which is another crucial detail to focus on while modeling. In order to restore Na, the author used scale (), rotate (), linear_extrude () and other functions to create cylinders with different sizes, angles, and positions, and through a series of logical operations such as taking intersections, a trace from thin to thick was formed (Figure 8).

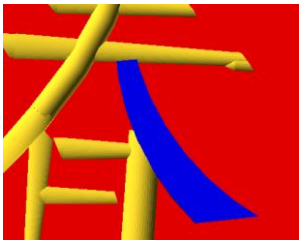

Figure 8: Na Strokes in "春".

The following "春" character model can be created using the aforementioned guidelines (Figure 9). It should be noted that each stroke takes into account not only the top-down shape but also the thickness of the embedded intermediate layer.

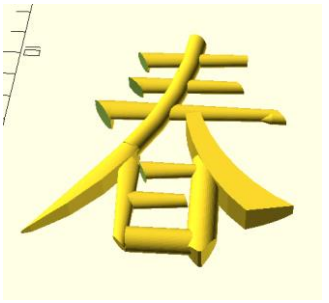

Figure 9: Final Result of "春".

2.4. Plate Modeling

In order for the cookie model to have a foil when it is finally presented, the author also constructed a plate to serve as an appropriate backdrop. In the modeling process of making the edges, the author wanted the edges of the plate to be smoothly upward, so the edge was nested using the incut ball and the function difference (). The innermost nesting is to subtract a ball with a smaller one, so a hollow spherical shell was got. Then the author subtracted a large cube from this spherical shell to get a bowl with a curving bottom. In order for the plate to fit steadily, we need to subtract a cube that has a lower position. Finally, fill the bottom gap with a disc of the right size. The graphical process and plate's details are shown in the following figure 10 -11.

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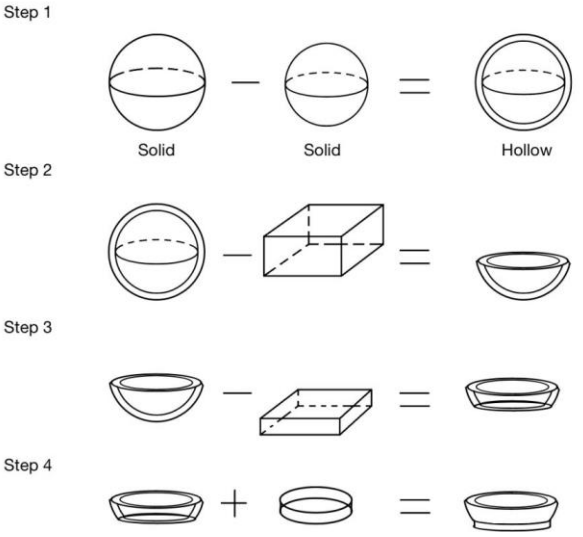
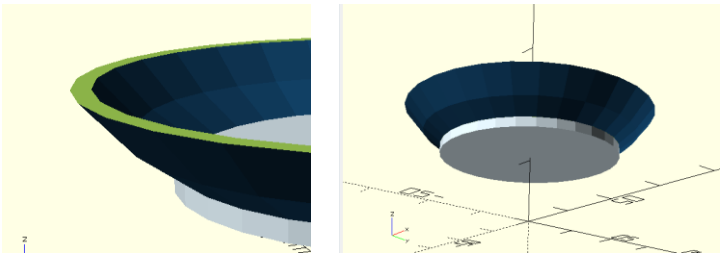


Figure 10: Plate Modeling Process.



(a) (b)

Figure 11: (a) Plate Edge, (b) Plate Bottom.

2.5. Modeling Presentation

A whole set of the biscuit and plate has now been established with the form of STL(Sterelithography). STL format is the most widely used format in 3D printing. It adopts triangular small surface pieces to approximate the surface to show the shape of three-dimensional solid body mold. It can contain very few or many triangular surface pieces. Simultaneous trigonal surfaces can also be large or small [5]. The model in the Figure 12, however, is not the final product due to a defect in OpenSCAD, which is that the exported STL models are white models with only geometric characteristics but no color,so the shading step then starts.

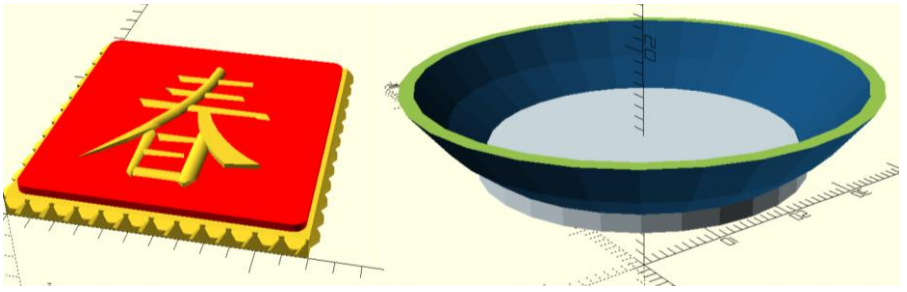


Figure 12: Models Presentation.

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3. Shading

3.1. Principle of Shading

A code snippet known as a shader offers programmers control over the shading procedure. Vertex shaders and fragment shaders make up the two primary categories of shader. The steps for a shader's shading are as follows:

(1) The model data is sent to the vertex shader by the system.

(2) The model data is transformed by the vertex shader into the format required for transmission to the system and later needs. The output data includes: position information of all vertices of the model, UV coordinates of textures, and more.

(3) The system interpolates the vertex data produced by the vertex shader and sends the fragment shader the interpolation output.

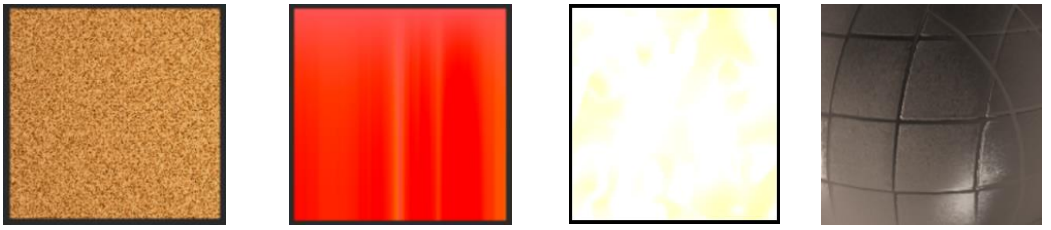
(4) Using the results of the interpolation, the fragment shader determines the colour of each pixel on the finished display.

Shader requires the writer to have program knowledge and debugging skills, while familiarise themselves with a variety of mathematical operations and visual effects calculation methods, which is too difficult. There are many web pages out there that have been developed to solve this problem, of which ShaderFrog is a good example. It uses the form of graphic building shader programming method, the user can in the visual interface, drag and drop and connect different calculation modules and calculation variables, define their direct input and output and calculation methods so as to finally export the coloring file [6].

3.2. Concrete Editing Process of Shaders

In terms of biscuit bottom, the author modified a substance that takes on a yellow tint with little holes and increase the size of this shader, making the holes smaller and denser, resulting in a smoother biscuit surface (Figure 13(a)). In terms of the interlayer and the character, the author took into account the process of making a real biscuit: the red cream can be applied in one direction with a larger brush, so the cream trail should be straight (Figure 13(b)); However, Chinese characters have the complexity of their own structure and should reflect unevenness in different directions. So the author edited the white cream material with a yellowish shader to make this layer more realistic (Figure 13(c)).

When coloring the plates, to compensate for the aforementioned OpenSCAD inability to export colors,a shader similar to clay is opted(Figure 13(d)).



(a) (b) (c) (d)

Figure 13: (a) Bottom's Shader, (b) Interlayer's Shader, (c) Chun's Shader, (d) Plate's Shader.

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3.3. Building Method of Shading Loader

We must configure the material loader after exporting the three.js file from ShaderFrog so that the material can be associated to the model. To accomplish this, the author visited the ShaderFrog website where the STLLoader.js plugin for three.js could be found, which will assist in loading the STL model.

In this part, the author adjusted the position of the camera and each model, and overlapped the two biscuits to create the following effect (Figure 14). At the same time, a point light source on the upper right is added, which can enrich the cold and warm color relationship of the scene and the atmosphere of the dark area, making the shadow effect more vivid [7].

Figure 14: Models with Light Environment.

4. Result Evaluation

4.1. Result Presentation

In the result presentation section, the author will present the modeling and rendering results from three perspectives: global, local and detailed.

Global perspective: The overall layout of the final display is two biscuits floating on a plate (Figure 15).

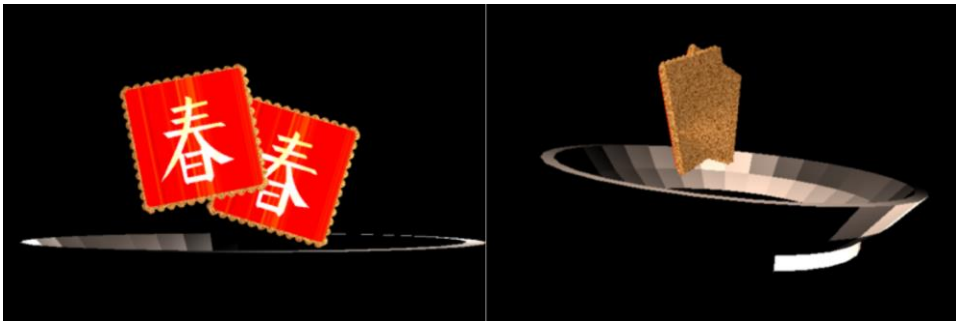

Figure 15: Global perspective.

Partial perspective: Partial layout showing different angles of a biscuit (Figure 16).

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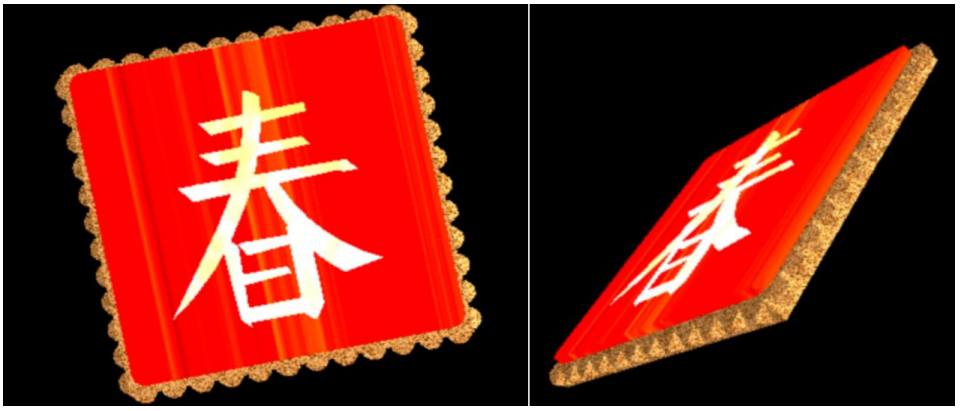

Figure 16: Partial perspective.

Subtle perspective: In the details section, the fine restoration of Chinese character strokes and the simulation of lace are mainly displayed (Figure 17).

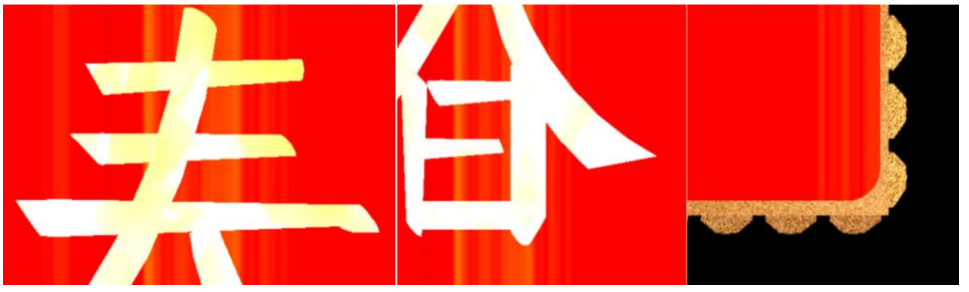

Figure 17: Subtle perspective.

4.2. Others' Appraisal

In order to evaluate the model, this paper asked ten unrelated individuals to score(X/10), as given in the accompanying table 1. Among them, referring to the evaluation method of iconology, two evaluation criteria were set up in this paper, namely Aesthetics and Harmony. Aesthetics is used to describe the tester's overall impression of the displayed icon, while harmony is used to describe the tester's perception of the weight distribution of left and right visual elements, rigid and flexible contrast and the fit between adjacent visual elements in the work respectively [8].

- **Analysis for the scores**

As what can be seen from the table 1, people have a relatively consistent good evaluation in terms of geometric modeling, highlighting traditional Chinese characteristics, and detail construction. In the geometric construction part, the reviewers believe that the matching concept of the square biscuit and the round plate is very exquisite, cleverly integrated into the Chinese "square circle" appearance, and also makes the visual effect not single; In terms of reflecting traditional Chinese culture, the design scored the highest. Some evaluators mentioned the articles they had read: The Spring Festival is the imprint of human will, can materialize human's essential power, and is the embodiment of cultural confidence [9]; In terms of detail reduction, the reviewer felt that the work restored the beauty of Chinese characters as well.

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Table 1: Quantitative evaluation of the viewer.

Personnel Number	Geometry	Detail Refinement	Cultural features	Harmony	Aesthetics	Fidelity	Average Score
1	7.5	7	8	7.5	7	7	7.25
2	7	8	7.5	6	7	7	7.08
3	8.5	8	7	8	9	7.5	8
4	8	7.5	8	7	7	7.5	7.5
5	8	8	7	7	8	8	7.67
6	8	8	8	7	9	7	7.83
7	9	8	9	9	9	8	8.67
8	8	8.5	9	7	7.5	8	8
9	8	8.5	8	8	7	7.5	7.83
10	8	8	9	7	8	7	7.83
Average Score	8	7.95	8.05	7.35	7.85	7.45	7.77

- **Prospects for improvement.**

There is still room for improvement in terms of other criteria. We'll concentrate on fidelity and harmony in this post, the two items with lowest ratings. In terms of fidelity, many reviewers pointed out that although the color of the biscuit is similar to the reference, it does not show the deliciousness of the food and does not stimulate the appetite. Following discussions with the reviewers, the authors came to the conclusion that the shader choice was too basic to accurately depict the food's grain textures. In terms of harmony, the evaluators say that the final model's depiction of the light environment lacks care, that the cookie lacks three-dimensionality due to poor lighting design, and that the color clashes excessively, which is rather incompatible. After receiving such an assessment, the author learnt about the pertinent classical Chinese color ideas, including the three-color rule, the effect of color gradients, and honoring the beauty of nature [10]. The author will employ more sophisticated coloring arrangements as well as better lighting and color matching in the subsequent study.

5. Conclusion

This article argues that there is much opportunity for improvement in the significance and attention given to Chinese traditional food culture, after studying the context of the current market, therefore it creates a model of Chinese Spring Festival Chinese character biscuits. Making layers of cookies and practising the connection between Chinese character calligraphy and modelling language are at the heart of this recipe for biscuits. During the modelling process, the author employed OpenSCAD, which offered others a chance to describe complex models in computer languages and use Chinese characters to explicitly highlight the Chinese New Year's cultural aesthetic. The author utilised ShaderFrog to modify the necessary shaders while rendering to produce the most realistic effect and finally completed the presentation of biscuits and plates. These have certain reference value for relevant researchers.

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