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Analysis of the Rendering of Deep and Short Art Effects Under the Multimedia Background Taking into Account the 3D Ink Rendering Algorithm

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Abstract: - People's living standard is improving and the economy is developing rapidly, so the demand for spiritual culture is also increasing. Today, with the rapid development of information technology, 3D ink rendering technology has become an indispensable part of modern art. It is not only a visual expression and tool, but also has a great impact on people's daily life. It is based on computer language and multimedia software. Its main purpose is to express art through images, sound and text; it can also integrate various complex and creative elements to form a whole picture, thus giving the whole picture a certain sense of hierarchy. This will give people an intuitive and strong visual feeling, thus achieving the purpose of "visual communication". In 3D ink rendering technology, image processing and sound effects are the two most important aspects. Among them, there is a certain correlation between digital works and text and other multimedia contexts with strong and far-reaching art effects rendering; and the impact of color and sound effects on 3D scenes should not be ignored: from the overall perspective, the sense of picture and enhanced visual effects can enhance the virtual reality space atmosphere and enrich the visual experience; but from the specific content, this may reduce the efficiency of the rendering process. In this paper, we start from the principle of ink rendering algorithm and analyze its impact on the picture effect and color processing in combination with 3D ink rendering technology.

Keywords: Ink and wash painting; Non-photorealistic rendering; Visualization effect;

Introduction

In contemporary society, network multimedia technology has become an indispensable part of people's daily life, work and study, and this is especially true for the digital era. As the virtual world in the Internet environment has a high degree of complexity and openness, which makes it a huge impact on the human eye; secondly, the amount of information is now huge and complex and diverse; furthermore, the characteristics of fast, wide range of information dissemination and strong timeliness also increase the difficulty of data storage. These have increased the risk and challenges of multimedia technology applications in the network, which brings a certain degree of economic loss to enterprises and even lead to some serious consequences[1]. Therefore, in the current network environment, it is important to strengthen the research and application of 3D ink rendering technology.

In the process of 3D ink rendering, the rapid development of 3D technology makes more and more artists turn from traditional paper materials to digital media, and they carry out virtual environment simulation through computer software. With the continuous progress and popularity of the Internet era and the combination of new media such as computers and cell phones with modern technology, there is an explosive growth of information and the problem of collision and communication between various complex data; on the other hand, people's living standards have improved and their requirements for art appreciation have changed. People no longer simply pursue individual needs[2-3]. Meeting diverse needs has become the focus of contemporary artists. Therefore, in the process of 3D ink rendering, it is an important issue how to deal with the relationship between the picture effect quickly and effectively.Based on this purpose, this paper investigates the factors affecting the overall rendering quality and visual effects, and designs the effect of art intensity and distance in 3D scenes according to the user's needs. In addition, this paper proposes measures and solutions to improve the expressiveness and color impact of 3D ink rendering[4].

In the process of 3D ink rendering, the complexity of the image will affect the rendering effect. Therefore, in order to make the virtual reality works with good visual effect and expression must be divided into different colors. First, the background image is processed: the grayscale of the colored pixels is used to determine the saturation of the object itself when rendering; depending on where the different colors are located in the 3D inking software and what connection exists between their corresponding pixel values and the original image, it

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is decided whether to use this area as the rendering object. By analyzing the rendering effect of different colors in the image, we can choose the appropriate color to make the ink image reach the "saturation" state[5]. Second, based on the local processing under 3D inking software: the color area is rendered after graying out the color pixels. In the overall design, global optimization of layout, layered reconstruction and other methods were used for overall design and detail control; the scene background and subject matter were focused on rendering, and suitable colors and shapes were selected to meet the needs of different users, so that the image was saturated.

Research on Ink Non-Realistic Rendering Technology in 3D Model

Non-realistic rendering technology uses powerful visual processing systems in computer software to improve user experience and interactivity. It uses digital media technology for image compression, rendering and recognition in the ink painting process. The work as a whole is displayed to consumers through the output of different sizes and colors, brightness intensity and other information data on the computer screen; at the same time, it realizes real-time monitoring of the content and style characteristics of the work and records the data analysis results with the help of multimedia devices, and displays the overall style of the work through 3D ink rendering technology, which can achieve the purpose of enhancing user experience[6]. Figure 1 roughly describes the development process of non-realistic rendering technology (NPR).
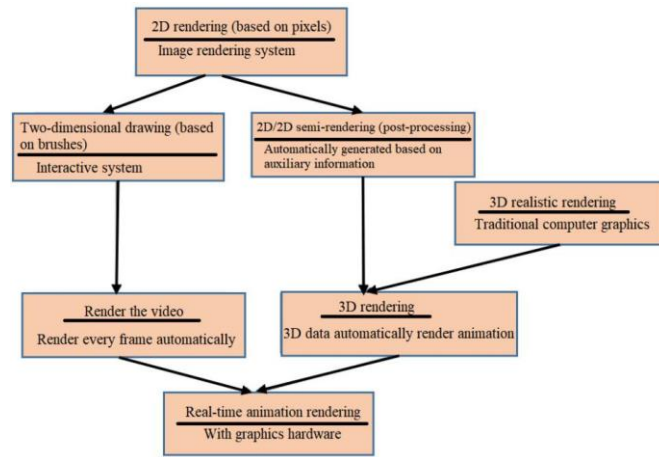

Figure 1: The development process of NPR

With the development and maturity of 3D graphics rendering engines, non-photorealistic rendering has also achieved remarkable results in 3D graphics rendering.Related personnel first invented the NPR lighting model (as shown in Figure 2), and then some researchers proposed real-time NPR Rendering technology and follow-up personnel proposed the idea of drawing directly on the 3D model and realized the simulation[7]. The effect is shown in Figure 3.
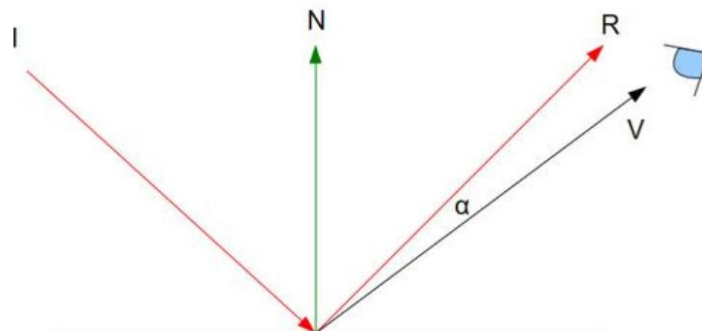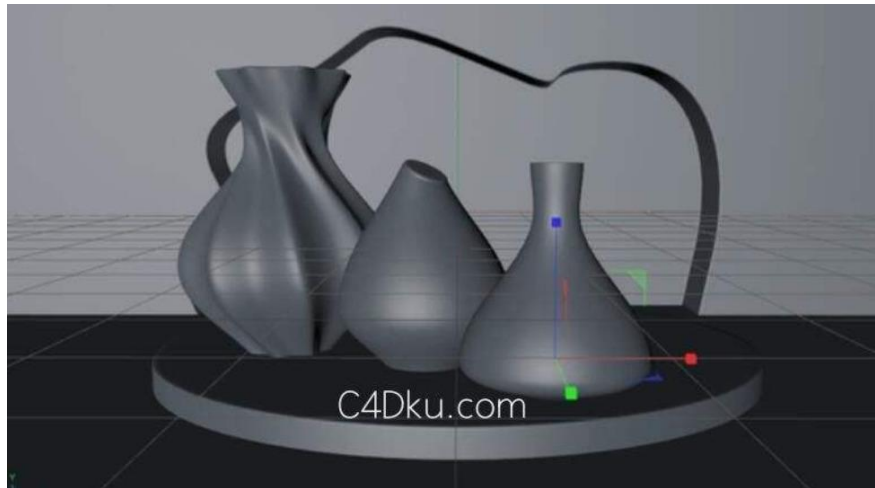

Figure 2: NPR lighting model

Figure 3: Painting directly on the 3D model

3D Ink Painting Rendering Algorithm

Ink painting-like rendering refers to placing the main objects on the picture at a certain spatial level. It expresses a strong contrast between the scenery and the picture through the combination and matching of different materials, colors and textures. From a visual point of view, it has a strong stereoscopic effect[8-9]. In 3D ink rendering, various materials can be used for painting layout: first, select the appropriate size, shape and height relationship; secondly, arrange the overall composition according to the design requirements; finally, put the main objects on the screen into a certain spatial level , making it a whole. In the choice of color, the visual impact brought by different materials should be considered, and different materials, sizes and shapes should be matched according to the picture effect[10-11].

Drawing the Shape of the Model

When painting with ink, when the painter uses ink to depict landscapes, the phenomenon of diffusion and immersion often occurs on the rice paper, which gives a certain area of lines that express the outline of things.Based on the above reasons, when drawing, the single-pixel contour line of the model is not extracted, but the shape of the model is outlined by the texture mapping within a certain range around the contour line.

The simulation process is implemented using Open shading language. In the vertex shader, the absolute value of the dot product of each vertex unit normal vector and the unit view vector is calculated, Denote the absolute value as a, and a is passed to the pixel shader in the form of a variable.Use a in the pixel shader to control the texture coordinates of the horizontal component of the texture.In order to achieve the effect of white space in ink painting, the threshold value λ can be set. When a$>\lambda$, the pixel of this fragment is set as the color of the white space in the ink texture. The larger the value entered in the threshold, the smaller the blank area. Figure 4 shows the rendering effect when the vertical component texture coordinates are fixed. The input value in Figure 4 (a) is 0.5, and the input value in Figure 4 (b) is 0.7.
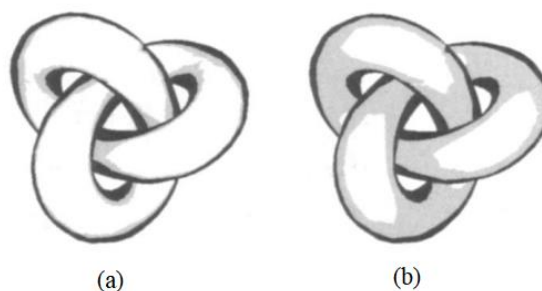

(a)   (b)

Figure 4: Ink rendering effect with fixed vertical component texture coordinates

Control of Tone Information

In this step, the texture mapping of the vertical component is also the core of the algorithm. In order to simulate the technique of near and far shading, it is necessary to assign a denser texture to the fragments close to the viewpoint. In contrast, fragments that are farther from the viewing angle have lighter textures[12].

For this reason, the attribute function is designed to output the vertical component texture mapping, and the depth information of the three-dimensional space is first used as the independent variable to design the attribute function.For the selection of depth information, the following two methods can be used: ① Use the Euclidean space distance from the three-dimensional point to the viewpoint as the depth information (as shown in Figure 5(a)); ② Use the distance from the three-dimensional point to the viewpoint along the focus axis as the depth information Depth information (Figure 5(b)). Through experiments, it is found that the effect of the ink coating effect under the long-distance shadow is simulated. It is best to use the second calculation method.
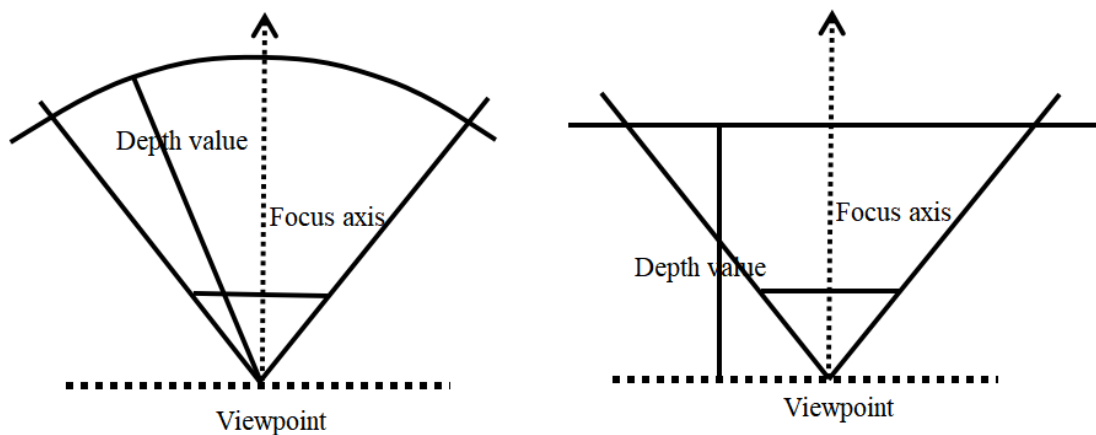

Figure 5: How the depth attribute is calculated

Different types of functions can be constructed to meet the above requirements, and linear attribute functions, quadratic attribute functions, and attribute functions that consider the influence of light can be designed to simulate the ink effect of the three-dimensional model[13]. The simplest method is to use a linear attribute function, as shown in formula (1):

$$D = 1, d \leq d_{\min}$$
$$D = 1/1 - r \times d_{\min} \times d + r/(r-1), d > d_{\min}$$

(1)

Among them, a is the current depth attribute value of the three-dimensional point, and r and dmin are adjustable parameters.

In the fragment shader, the calculation result of (1) is used as the coordinate value of the vertical component of the ink texture. When the current depth of the model exceeds the threshold dmin, the function value decreases linearly.Taking the viewpoint as the benchmark, take the larger vertical component texture coordinate in the near, which corresponds to the dark tone in the ink texture. Take the smaller vertical component texture coordinates in the distance, which corresponds to the light tones in the ink texture, so as to get the effect of shades and distances[14].

The contrast of shades is stronger, and the quadratic attribute function can be used as shown in formula (2):

$$D = 1, d \leq d_{\min}$$
$$D = d - r \times d_{\min}^2/(r-1)^2 \times d_{\min}^2, d > d_{\min}$$

(2)

Introducing the direction of the light source is a weighting factor that affects the attribute function. It can get the distance effect of the bright and white light on the illuminated surface and the thick ink on the shadow of the

backlight surface. The direction factor constructed in the experiment is $(N \cdot L)^Y$. Among them, N is the unit normal vector of the three-dimensional point, L is the normalized light source direction vector, and Y is the illumination factor. The attribute function is shown in formula (3):

$$D = 1 - \log 10^{d/d_{\min}}, N \cdot L^\gamma > \beta$$

$$D = \alpha \times \left(\frac{d - r \times d_{\min}^{\;2}}{(1-r)^2 \times d_{\min}^{\;2}} \right) + (1-\alpha) \times N \cdot L^\gamma, N \cdot L^\gamma \leq \beta \tag{3}$$

Rendering Analysis of Shades of Far and Near Rendering

Respectively use formula (1) and formula (2) as the attribute function to verify.In order to compare the two, the same parameters and sampling points were set in the two experiments.Under the effect of formula (1), the ink effect with increasing depth d is shown in Figure 6.Among them, Figure 6(a) shows the effect when d<dmin. At this time, the distance from the viewpoint is closer, and the ink color is thicker.(b) and (c) are the effects when d> dmin, and d gradually increases. It can be seen that the ink color is getting lighter and lighter.Figure 7 shows the effect of the function (2). Compared with Figure 6, it can be seen that the decay speed of the ink tone is faster, the tone is obviously lighter in the distance, and the tone contrast is stronger when it is close[15].
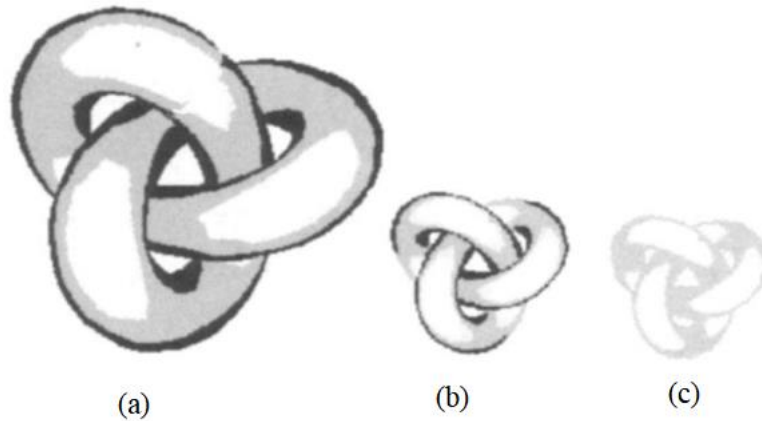

(a)   (b)   (c)

Figure 6: The effect of linearly varying shades of far and near ink

(a)   (b)   (c)
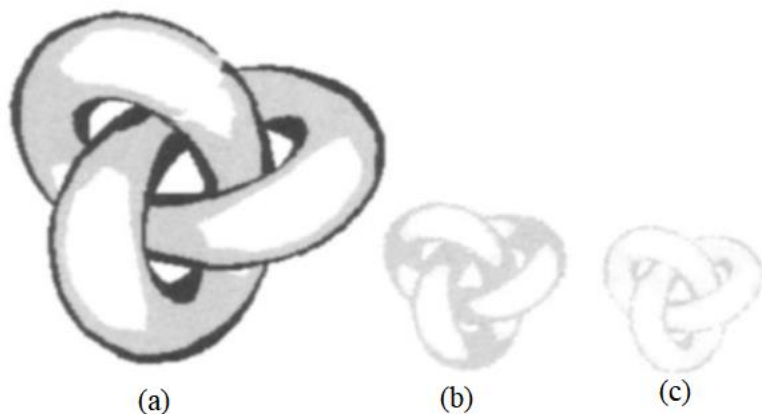
Figure 7: The effect of shade and distance of the quadratic function relationship

Design of 3D Ink Painting Effect in 3D Digital Display Platform

Research on Common Technologies for Non-photorealistic Rendering

1. Detection of contour lines

(1) Contour detection in graphics space. The contour line is generally related to the direction of the viewpoint. For parallel projection, all vertices have the same line of sight direction;In the perspective space, the line of sight direction of each vertex is related to the position of the point of view, and the line of sight direction of each frame needs to be calculated. In this way, the efficiency of the contour detection algorithm affects the performance of the entire application. Therefore, implementing an efficient contour detection algorithm is one of the keys to non-photorealistic rendering technology.The traditional contour detection method in graphics space is only a simple positioning detection method, which cannot detect contours more accurately, and its detection effect on the inclusion relationship between complex contour lines is not high.

(2) Free-form surface model. The free-form surface is composed of a free-form surface. The curve is composed of a series of points, so that the contour line can be directly calculated, that is, the top normal of the series of points where the dot product on the surface and the line of sight direction are 0, as shown in formula (4):

$$N_i \times (X_i - C) = 0 \tag{4}$$

Where C is the observer's position, which is a point on the surface, Ni is the normal vector of point Xi, and (Xi-C) represents the line of sight vector.The schematic diagram of the contour definition is shown in Figure 8:
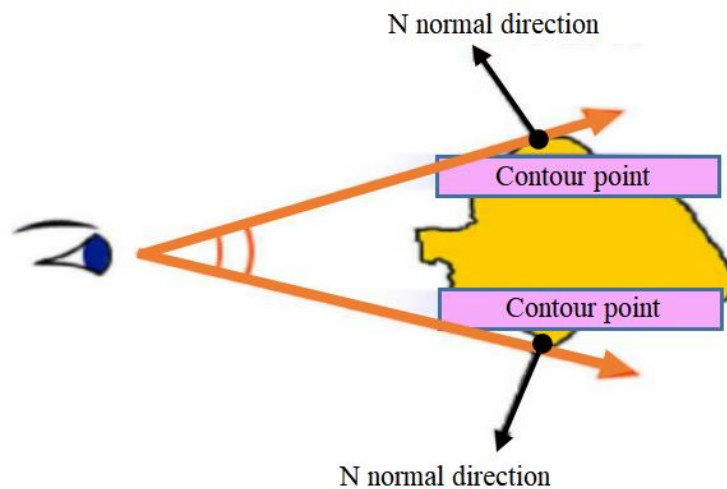

Figure 8: Schematic diagram of contour definition

For simplicity, assume that all curved surfaces are triangular patches.First, calculate the dot product di of the vector (Xi-C) from the vertex Xi of the triangle face to the viewpoint and the normal Ni, as shown in formula (5):

$$di = \frac{Ni \bullet (Xi - C)}{\|Ni\|\|(Xi - C)\|} \tag{5}$$

Then the symbol for marking the dot product value is shown in formula (6):

$$Si = \begin{cases} +, di \geq 0 \\ -, di < 0 \end{cases} \tag{6}$$

For two vertices Xi and Xj on a given triangle surface, if Si≠Sj, there is a contour point between the two points. According to the characteristics of the smooth surface, the coordinates of the point can be calculated by linear interpolation, as shown in formula (7):

$$X^{'} = \frac{\left|d_j\right|}{\left|d_i\right| + \left|d_j\right|_i} X_i + \frac{\left|d_j\right|}{\left|d_i\right| + \left|d\right|} X_j \tag{7}$$

2. Contour detection in image space

Pixel-level detection in the image space can be a very effective method. It hardly needs additional space, and the algorithm is relatively simple. It only needs to be detected in the render buffer. For general applications that have low requirements for contours and uncomplicated scenes, it is already enough to meet the requirements.

Non-photorealistic rendering technology is a contour detection method, which is widely used in 3D ink painting. Non-photorealistic rendering refers to the "traceless" and simulation of the pictures in the virtual environment, that is, it does not consider the actual situation, it is a method of realizing three-dimensional scenes and realistic effects only by computer or artificial means. Its main features are: 1) special equipment is required when using non-real materials to make models; 2) 3D animation is completed by special software; 3) 3D ink images are generated by using specific functions.In addition to the contour line detection method, the commonly used non-realistic rendering methods are based on image and video analysis methods. This method has high accuracy and real-time processing capability; however, it can also lead to less realistic and credible rendering effects due to its complicated operation, and it often needs to be adjusted to a certain extent in the later rendering process because the 3D spatial sense is difficult to be guaranteed and not directly accessible.

The conventional contour detection method in graphics space is only a simple positioning detection method, which cannot detect the contour more accurately. Therefore, it is possible to distinguish between inner and outer contour lines when performing contour detection in graphics space. When using the coordinate polarization method, we first obtain the coordinate polarization point of the current contour line and compare it with the coordinate polarization points of other contour lines alternately. If the number of contour lines is even (including 0), the current contour line is an outer contour line, otherwise it is an inner contour line. This method can detect the contour of the graph more accurately.In addition, the traditional contour detection method is less effective for the detection of contour lines with high complexity of images, and it cannot detect the inclusion relationship between the contour lines very well. This problem is solved by the contour line inclusion recognition algorithm, which mainly consists of two parts: the recognition of outer contour nearest inclusion contour and the recognition of inner contour nearest inclusion contour.

The detection method of contour lines includes the free-form model, which is a three-dimensional modeling technique based on geometric principles and multiple planes. In the field of virtual reality, we can consider it as a point and line, and use the grid method to generate the relationship between points and lines under any position on space. The algorithm gets its final result by transforming the ink rendering model into a complex shape on a 2D plane for processing.

The free-form model can directly calculate the contour lines, so the method is more widely used in practice. However, there are still some problems with the quality and hierarchy of the picture and enhanced scene effect in the free-form surface model method. The solution to this problem is: firstly, to divide it into several parts from the whole; secondly, to adopt different ways of rendering according to different areas in order to achieve better visual effects and to be better accepted and loved by the audience in the rendering process.

Internal Coloring Based on 3D Rendering Technology

1. Lighting Model

(1) Ambient lighting model. In the environment lighting model, there is no light source position and no light direction.All the light irradiates the objects evenly from all directions, coloring all the objects in the scene evenly[16]. The environmental lighting model can be described by formula (8):

$$Ambient = LightColor * A\operatorname{int} ensity \qquad (8)$$

(2) lamber diffuse reflection model. In order to simulate the diffuse reflection on the surface of the object, the researchers proposed a diffuse reflection law as shown in formula (9), and the diffuse reflection model diagram is shown in Figure 9:
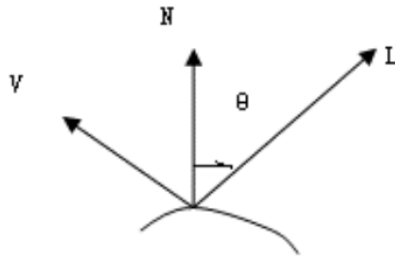

Figure 9:Diffuse reflection model

$$Diffuse = Kd * LightColor * \cos\theta \qquad (9)$$

If N is the normal of a point on the surface of the object, L is the incident vector from the light source to the point, as shown in formula (10):

$$Diffuse = K_d * LightColor * \max(N \bullet L, 0) \qquad (10)$$

(3) Phong specular reflection model.For objects in reality, their surface is composed of many tiny planes. These tiny planes have different orientations, so it is very complicated to simulate the real specular reflection. The specular reflection used to simulate the object is shown in formula (11) :

$$Specular = Ks * LightColor * \cos^n \alpha \qquad (11)$$

In formula (11), in order to calculate cosa, the reflected light R (R=2 N(N·L)-L) must be known first.It requires complex calculations, increases the amount of calculation, and needs to use the half-plane method, that is, (N·H) is used instead of cosa.In this way, the way to calculate the specular reflection component is shown in formula (12): the half-plane method is used to calculate the specular reflection as shown in Figure 10.
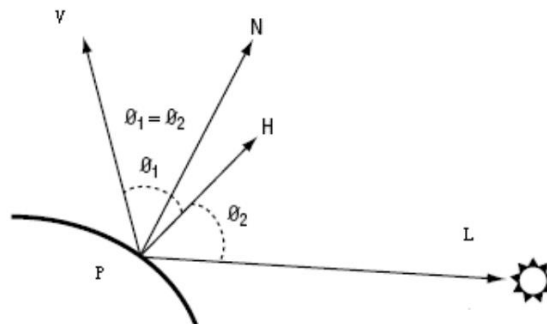

Figure 10: Calculating specular reflection using the half-plane method

$$Specular = Ks * LightColor * (N \bullet H)^n \tag{12}$$

(4) Texture model.In order to make the rendered image look more realistic, the graphics rendering library provides the function of drawing texture on the texture surface.Generally speaking, a texture is a two-dimensional figure or a two-dimensional image that represents the surface details of an object, also known as texture mapping.Two textures of different sizes are applied to the surface of the same object. Therefore, relative texture coordinates (u', v') are often used instead of actual texture coordinates, u and v respectively represent the percentage of width and height occupied by (u', v') as shown in formula (13):

$$u' = u / w, v' = v / h \tag{13}$$

In general, the relative coordinate addresses of all texture elements are in the range of [0.0, 1.0].For example, in a bitmap with height and width of 100 and 80 pixels, the actual texture coordinates and relative texture coordinates of the texture element coordinates P in the 5th column and 4th row are as shown in formula (14):

$$(u, v) = (5,4), (u', v') = (5/100, 4/800) = (0.05, 0.05) \tag{14}$$

(5) Paint and brush the model. As the name suggests, a series of brushes are placed on the canvas to generate a rendering effect.There are generally two methods, one is the geometric model brush and the other is the texture brush.The brush of the geometric model generates a brush by defining different attributes such as color, anchor point, and direction.The geometric description is shown in Figure 11;Texture-based brushes can be used to create textures of various shapes and patterns in advance through drawing software such as Photoshop, and the graphics pipeline is used to mix colors when drawing[17].Figure 12 shows several styles of texture brushes, in order of brush, watercolor, raindrop, point wizard, and fluid.

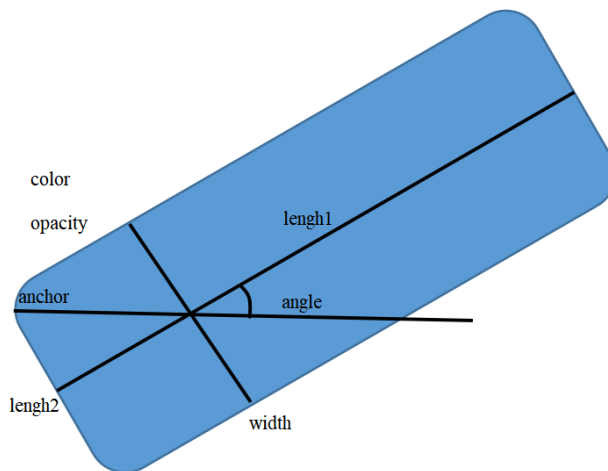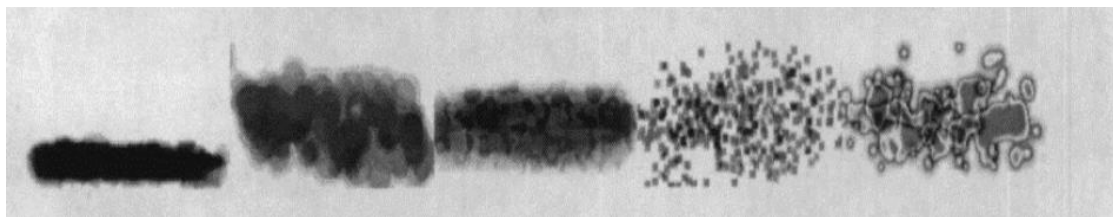

Figure 11: Geometric brush model

Figure 12:Paint brush texture

The design of lighting models is an important part of 3D ink rendering technology, which is crucial for improving color saturation and enhancing visual effects. Among the many digital image processing software, the visual simulator can obtain the required information quickly and accurately. However, this simulation algorithm can only be operated by computer. Therefore, how to take advantage of the differences between multimedia files and network data is one of the bottlenecks that affect the realization of the compression effect.

Light modeling is widely used in 3D ink rendering, but there are some shortcomings in the application of light modeling in 3D ink rendering. In modern environments, it is widely used due to the intensity and directionality of its light. Using this property allows the user to observe the changes in the surface of the object more intuitively. However, this also has significant drawbacks: first, if only the impact of light intensity on the effect of the picture is considered will lead to a decline in visual quality; second, in the actual application process due to environmental factors and improper operation will make the image distortion or can not reach the ideal state.

The specular reflection model is an important part of the 3D ink rendering software, which can make the picture appear clear and realistic, and it can be adjusted according to the actual situation. Its specific applications are: (1) the color image processing process is realized through specular reflection imaging technology; (2) the design and drawing of all patterns and lines in the 3D ink rendering system can be completed using this model; the design and drawing of all patterns in the 3D ink rendering system can be completed using this model; the interconversion between 3D scenes and color effects can be realized using this modeling method.

The text describes that in order to make rendered images look more realistic, graphics rendering libraries provide the ability to draw textures on textured surfaces. The advantage of the texture model is that it can handle chromatic aberrations and color differences well, making the colors more visually appealing and thus better representing the characteristics of the original object.

2. Internal coloring

Internal coloring refers to the interchange of small variations of color through different types or colors, thus making a visually strong impact. In the process of 3D ink rendering, it is important for selective color selection and matching can form the overall style, create a colorful picture effect and so on. But the process of internal coloring may have the problem of color transition rendering.In order to solve the problem, the edges of the input grayscale image need to be extracted by a related algorithm and stored in the edge image. This will solve the problem of color over-rendering.

(1) External coloring method: improve the overall picture sense by using low contrast strong and weak grayscale images or color enhanced pictures, etc.; at the same time, it can divide the colors into three types of primary colors, secondary colors and parti-color parts, and taking different colors for visual stimulation will produce a strong visual effect. To a certain extent, it increases the color saturation, thus improving the color saturation and making the picture more vivid. (2) Internal coloring method: by using low contrast strong and weak gray through the visual perception of height difference to enhance the overall sense of the picture; it uses the parti-color part and the overall color relationship between the rendering. To a certain extent, it enhances the whole picture effect and hierarchy.

3D Digital Display Platform Based on Multimedia Technology

The system function design is shown as in Figure 13.

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System function design ─┬─ Scene editing
                        ├─ Path editing
                        ├─ Group animation
                        ├─ Weather editor
                        ├─ Input control
                        ├─ database
                        ├─ Lighting effect
                        ├─ Information query
                        └─ Ink rendering
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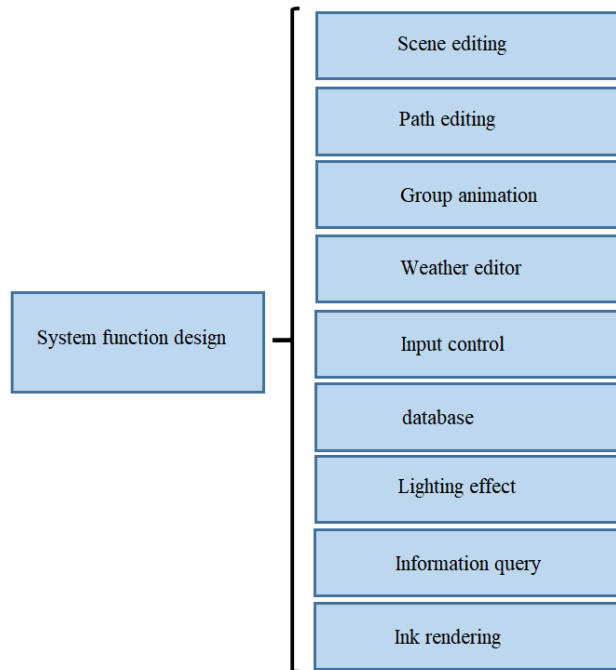
Figure 13:System function design

In order to achieve the effect of ink and wash, a rendering framework is proposed based on the research of commonly used technologies in non-photorealistic rendering: the input 3D model rendering adopts multiple rendering methods. Including contour line drawing, lighting model drawing, texture model drawing and Gaussian blur. These are all done in GPU programming, and the design framework is shown in Figure 14:
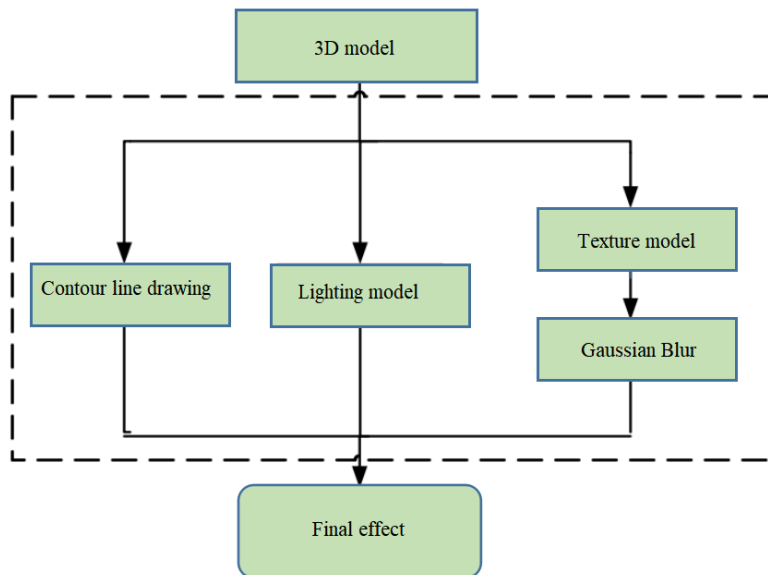
```
                        3D model
          ┌───────────────┼───────────────┐
          │               │               │
                                     Texture model
                                          │
                                     Gaussian Blur
  Contour line drawing   Lighting model
          │               │
          └───────────────┴───────────────┘
                     Final effect
```

Figure 14: Design framework

Rendering Experiments Based on Picture Visual Effects

Visual Experiment

In this experiment, the computer was used to process and render the screen while ensuring the accuracy of the data. In order to make the overall effect more smooth, beautiful, stable and evenly rendered, a split-screen operation was used. The design is to make local adjustments to the ink image to achieve the final target required

results, so in this part a small range of images was chosen to accomplish the goal of this experiment. It is also possible to use the computer with the required rendering software configured to provide support for data processing. By comparison, it is easy to find that the overall effect of the rendered image is different between the large screen and the small range of images.

Image Experiment

In this experiment, we used picture rendering technique to create ink on pictures, and created visual images by different color saturation. Since this design is an overall rendering and color effect analysis of 3D ink. Therefore, we need to choose the right material according to the chosen material, color and scene.

The main research of this project is how to let the user feel the content and visual effect of the work they want to create; secondly, how to use multimedia technology to present people with the images that appear in the picture, so as to achieve the best effect. Finally, it is to analyze the images and colors that appear in the picture to get the best effect. In the process of this research, I chose a theme of "ink" production software. This software is able to realize the whole process from color ink rendering, to colorless processing, to color processing, and finally presented to the user's computer for automatic playback; at the same time, it also allows people to experience the changes and innovations in the content and style of the picture under the new environment brought by 3D printing technology, so that it can play a greater role in future design, more valuable and meaningful.

Conclusions

With the development of 3D ink painting, more and more people begin to pay attention to three-dimensional space. It is necessary to transform a two-dimensional plane into a three-dimensional three-dimensional to make it a complete and complex research field, which has artistic and practical value.Non-photorealistic graphics (NPR) is currently one of the hotspots in the research of computer graphics rendering technology.The non-realistic display system uses a unique algorithm to achieve special artistic effects, and has a very broad application prospect in education, advertising, games, etc. The display of Chinese ink painting has attracted more and more attention due to its unique artistic charm.This paper mainly studies the impact of ink rendering algorithm on 3D scenes, and on the basis of analyzing its advantages, it discusses some multimedia technology tools and theories used in practical cases. Firstly, it introduces the background of the selected topic and the related concepts. Secondly, it explains the relationship between ink and modern digital image processing, color application and visual saturation; again, this paper discusses how to use the language of picture design to express one's emotion and achieve the expected effect from the overall level; finally, it explains the visual effect given to people in 3D scenes through the experimental results, and provides directions and ideas for future development based on the conclusions drawn from data analysis.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest

Funding Statement

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