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Research on Rendering Technology of Ink Painting based on NPR

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Abstract:

Chinese ink painting is bred by excellent traditional culture with the integration of water and ink and the alternation of black and white. It began in the Tang and Song Dynasties and still has strong artistic vitality. This paper first describes the application prospect of ink painting rendering technology, then analyzes the research status and development trends at home and abroad, finally focuses on the non photorealistic real-time and implementation method of ink painting style, and tries to put forward a novel ink painting rendering model with great flexibility and expansibility from the essence of ink painting.

Keywords: *Ink painting style, Ink painting textures, Rendering technology, Contour extraction*

I. INTRODUCTION

Chinese ink painting, also known as traditional Chinese painting, it means a painting made entirely of ink. The painting tool of traditional Chinese ink painting is "pen, ink, paper and inkstone". Its creation pays attention to "vivid charm" and "Writing Spirit in form". Ink painting with Chinese cultural gene is bred by excellent traditional culture. It began in the Tang and Song Dynasties and still has strong artistic vitality. With the integration of water and ink, alternating black and white, the strokes are sometimes thick, sometimes light, sometimes deep, sometimes light, sometimes heavy, sometimes real-time and empty. It can express thousands of Meteorology and rich meanings of the world [1-3].

The world of ink and wash is simple, so simple that there are only black and white. However, the world of ink and wash is extremely rich. The connotation contained in Ink and wash is dense and colorful. It not only breeds Chinese ink and wash painting itself, but also introduces art masters such as Qi Baishi, Xu Beihong, Huang Binhong, Li Keran, Zhang Daqian and Lin Fengmian [4-7].

After the 1980s, Shanghai's ink animation produced deer bells, landscape feeling and so on (as shown in Figure 1)."Landscape feeling" fully shows the painter's meaning contained in brushwork and ink, with a sense of hierarchy and rhythm, vividly conveys the philosophical thought of Taoism, and has a free and easy, ethereal and elegant aesthetic painting style. The clouds of the mountain, the mist of the water, the carefree mood of the zither player... Express their feelings and blend their feelings with the scenery [8-10].One pen,

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one painting, one paper and one ink, outline the clearity of large and simple mountains and rivers; one mountain, one water, one flower, one tree, copy the broad and far-reaching of alienation.

Fig 1. deer bell and landscape

NPR is a kind of computer graphics, that is, non photorealistic rendering. In recent years, with the rapid development of graphics processor (GPU), the speed of 3D graphics rendering has been greatly improved, especially the development of NPR technology, which is widely used in simulated oil painting, sketch, technical drawing and animation cartoon. The research object of NPR rendering technology of Chinese ink painting is mainly the physical simulation of painting tools, such as brush, paper and so on. In addition, it also includes the simulation of painting process, such as ink halo effect [11-16].

II. APPLICATION PROSPECT OF INK PAINTING RENDERING TECHNOLOGY

The research on the rendering technology of Chinese ink painting has far-reaching significance and broad application prospects in both art and science:

First of all, use the powerful expressiveness of 3D to create 3D ink images in 3D space, so as to create a rich and colorful virtual world of ink and wash, and show the movement space that traditional ink and wash painting cannot create, which inherits and surpasses the aesthetic theory of traditional ink and wash painting and the aesthetic thought of "freehand lyricism", and more widely expresses and disseminates the aesthetic achievements of ink and wash painting, it is of positive significance to the reform and development of Chinese ink painting.

Secondly, ink rendering expands the expression language, which is not a small breakthrough in the field of modeling and rendering. The research on ink painting rendering technology can play a positive role in guiding ink painting simulation research to the field of rendering, enriching the processing means in the field of graphics rendering, promoting the development of computer simulation technology, promoting the development of non photorealistic rendering technology and even promoting the development of computer graphics.

Third, the research results of ink rendering technology have very wide application prospects in film art, animation production, non photorealistic panoramic tour, virtual games and so on, those make the visual sense of ink painting art, or the symbols expressing things, can be introduced into 3D film and television and

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various media, which lead the ink animation that is not easy to be expressed in 2D can be expressed easily and efficiently.

Fourth, the scientific research achievements of computer ink style rendering have broad application prospects for computer simulation technology, especially in various technical difficult fields in the field of graphics and images. Just like today's video game industry, the progress in the field of computer art simulation has far-reaching significance for enriching graphic rendering means, virtual simulation of particle physical phenomena, enriching work rendering effects and visual feelings, developing human-computer interaction means, extending the processing field of computer technology, etc.

III. ANALYSIS OF RESEARCH STATUS AND DEVELOPMENT TRENDS AT HOME AND ABROAD

Chinese ink painting embodies the artistic crystallization of Chinese calligraphy and painting for thousands of years and the spiritual sustenance of Chinese humanities, and has far-reaching artistic and cultural value. Chinese ink rendering technology is the integration of the highest point of art and the highest point of science and technology. Both artistic value and scientific and technological value are unlimited [17-23].

Domestic research is relatively early. Strassmann (1986) first simulated the writing and painting effect formed by brush movement based on CG technology, and determined the pen position and width by obtaining control points through sampling position and pen force; Lansdown (1995) first summarized the general problems in non photorealistic rendering;Eurographics'99 and SIG-GRAPH'98 both set up special topics for the theme of non photorealistic rendering. Since then, non photorealistic rendering technology has entered a period of steady development; Teece (1998) and Kalnins et al (2002) respectively proposed the method of painting directly on 3D objects; Guo and kunii (1991) simulated the diffusion effect of ink based on CG technology; Hertzmann (1999) proposed an algorithm for edge and contour detection and extraction based on 3D non photorealistic rendering (Lutz K and emo w 1997);Way et al (2002) proposed using texture synthesis based on probabilistic model to render 3D tree model. Yeh and Ming (2002) studied the automatic rendering method of three-dimensional animal model; Yu (2003) et al. Proposed a model of the interaction between ink and rice paper; Nelson et al (2005) proposed a fluid simulation method to simulate ink diffusion based on LBE (lattice Boltzmann equation);Lee et al (2013) divided the space of the reference image according to the image significance, controlled the brush size based on the division results, and increased the brush detail level of important areas; Dong et al (2014) proposed a fast ink painting synthesis method, which simulates the motion of ink particles by randomly disturbing pixels; Seo and Lee (2015) proposed a new brush generation method by extracting the area that can be painted in a brush, which replaces the traditional method of using the gradient in the reference figure to determine the brush direction, so that the user can better control the brush synthesis.

Domestic research is relatively late, but due to the characteristics of Chinese ink painting, domestic research is in a leading position. Sun Jizhou, Professor of Tianjin University (2009), summarized the shape and distribution characteristics of PI Ma Cun brush path in Chinese landscape painting, proposed a fractal modeling method based on sketch line to construct 3D mountain stone model, and generated "Pi Ma Cun

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baseline" based on the main direction of the model; Professor Yu Jinhui of Zhejiang University (2012) proposed a traditional Chinese painting style water animation model, which can efficiently generate a variety of traditional Chinese painting style water animation according to user's needs; Xu Shibo (2013) extracted contour information based on multiple natural landscape images; Li Dajin and Bai Chengjie (2014) proposed an image-based ink stroke synthesis method; Jin Weiwei (2014) realized the wrinkle of rice paper skirt by using Perlin noise; Chen Tianding et al. (2015) proposed a new real-time and automatic framework to convert images into Chinese ink style, and proposed a multi-channel three-dimensional (or 3D) ink rendering model with contour optimization; Zhu Chenxi (2018) proposed a new method of extracting feature lines, and non photorealistic rendering of feature lines, highlighting the artistic characteristics of mountain images, and applying graphic non photorealistic visualization to the field of geographic information rendering [24-28].

IV. DESIGN AND IMPLEMENTATION OF NON PHOTOREALISTIC REAL-TIME INK PAINTING STYLE

The basic idea of this paper is "the combination of science and art", and drawing on the results of many non photorealistic rendering studies at home and abroad, this paper attempts to propose a set of novel ink painting rendering model with great flexibility and expansibility from the essence of ink painting (as shown in Figure 2).

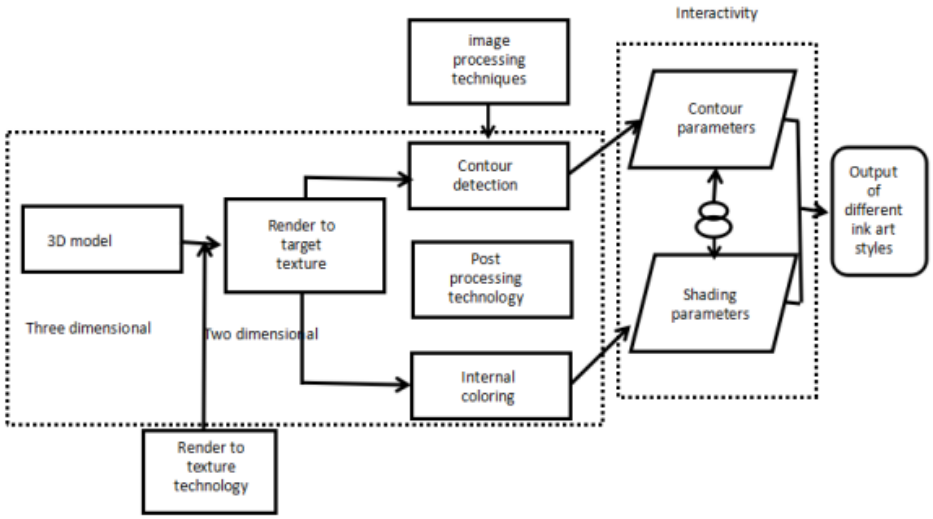

Fig 2. Rendering model of ink painting

4.1 Image Edge and Contour Extraction

Three methods are usually used to convert the original image into gray-scale image, i.e. maximum value, average value and weighted average value. Because human eyes have different feelings for the three primary colors, generally speaking, pure green is brighter, pure red is darker and pure blue is the darkest. Considering this actual feeling, this study adopts the weighted average method, that is, the following formula to convert RGB image into gray-scale image the gray value is suitable for the change of gray color that people actually feel.

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$$Y = 0.299 \times R + 0.587 \times G + 0.114 \tag{1}$$

Because the image may have noise interference, in order to improve the image quality, this study uses Gaussian low-pass filter for smoothing, so as to minimize the noise impact as far as possible. The Gaussian low-pass filter function is:

$$g(x) = \exp(-x^2 / 2\sigma^2) \tag{2}$$

After Gaussian low-pass filter smoothing, the image may appear blurred due to the removal of high-frequency details, and the edge contour is not very clear, so it is difficult to extract the edge directly. Therefore, image enhancement technology needs to be used to further process the image for contour edge extraction. In this study, histogram equalization is used to enhance the image contrast.The basic idea is to redistribute the brightness and distance the approximate gray scale in a large area, so as to make the color distribution on the image relatively balanced and enhance the image details. The histogram equalization function is expressed as:

$$g(i, j) = c \times \log_{10}(1 + f(i, j)) \tag{3}$$

Edge detection: the purpose is to find the edge between the object and the background. Generally, the first-order inverse operator or differential operator is used to extract the image edge contour and obtain the line image, such as Laplace differential operator, Sobel derivative operator, etc. in this study, the Laplace function of Gauss of the second-order derivative equation is used as the edge detection operator:

$$L = \begin{bmatrix} 00 & 00 & -1 & 00 & 00 \\ 00 & -1 & -2 & -1 & 0 \\ -1 & -2 & 16 & -2 & -1 \\ 0\,0 & -1 & -2 & -1 & 00 \\ 00 & 00 & -1 & 00 & 00 \end{bmatrix} \tag{4}$$

The following formula is used to extract the edge lines in the binary image $\beta(A)$ express:

$$\beta(A) = A - (A \Theta B) \tag{5}$$

Where a is the binary image of the original image, B is the structure image, $A \Theta B$ Indicates that B erodes a so that a shrinks inward by one pixel, $\beta(A)$ Produces a boundary that is one pixel wide.

Skeleton extraction: there are many linear skeleton extraction algorithms, most of which use structural elements to establish removal rules, and remove the pixels with composite rules from inside to outside until there are no pixels with composite removal rules in the object. In this study, Canny edge detection operator is used for edge detection based on binary gray image, and the detection process is to smooth the image

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based on low-pass filter.Canny edge detection is a relatively new detection operator with better edge detection ability. On this basis, each 8-connected region on the binary image is detected to judge whether the pixels in this region are in the edge detection result. If they are in the edge detection result, it is determined to be non-specific.Otherwise, it is retained in the binary image as a feature image.

4.2 Ink Texture Rendering

Ink texture usually refers to the different characteristics of paper due to different material structures. The most commonly used parameters to express this characteristic are direction and intensity. In this study, Sobel gradient operator is used to obtain the horizontal and vertical gradient components:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{6}$$

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{7}$$

Based on, calculate the direction and gradient (i.e. direction strength):

$$\theta = \tan^{-1}(G_x / G_y) \tag{8}$$

$$R = \sqrt{G_x^2 + G_y^2} \tag{9}$$

4.3 Ink Contour Node Drawing

For the contour of ink-jet effect material with line drawing, various outlines (including contour lines and pleats) are found on the image through programmable graphics hardware technology, and then these lines are expanded and antialiased, and finally superimposed on the 3D model to be drawn. In this study, the contour line adopts spherical mapping drawing technology to draw the contour line with width change on the 3D model. The formula used is:

$$R = 2(N.E)E - F \tag{10}$$

$$M = \sqrt{R_X + R_Y + R_Z + 1} \tag{11}$$

$$V = \frac{R_X}{2^m} + 0.5 \tag{12}$$

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$$a = N.E \tag{13}$$

$$a = N.E \tag{14}$$

Where n is the normal vector of the vertex on the model, e is the viewpoint vector from the viewpoint position to the vertex position, R is the reflection vector of e relative to N, Rx is the x-axis component value of R, Ry is the y-axis component value of R, (U, V) is the generated texture coordinates. When drawing the contour line, the action range of spherical mapping can be controlled by limiting the value of A.

V. SUMMARY

Non photo realistic rendering (NPR) is a hot issue in the field of computer graphics rendering and a research field closely integrating computer graphics technology and painting art. NPR does not aim to pursue the rendering effect as real as photos, but follows the objective needs of cognitive science, art, graphic design and other fields, structures and abstracts information, and realizes hand-painted style rendering. The combination of Non photorealistic rendering (NPR) technology and Chinese ink painting has historical contingency, but it also has its inevitability.

Next research work plan and plan.

The processing of complex boundary and special effects (such as flying white) by non-realistic 3d rendering technology of ink painting completely relies on the simulation of Fall off program mapping technology, which is a little inadequate, and this is also the content to be further studied in the future.

Interactive design of non-photo realistic 3D rendering technology. At present, users of ink painting non-photo realistic 3D rendering technology cannot interact with each other, so interactive design is the direction of future research.

How to better combine various advanced non-realistic 3d rendering technology of ink painting with traditional Chinese culture and fully display the characteristics of ink painting animation is the basic direction of the development of non-realistic 3D rendering technology of ink painting in the future.

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