Rendering and Presentation of 3D digital ink landscape painting

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Abstract

:Explore the digital rendering mode with texturing brush and ink effect, analyze and simulate the brush and ink characteristics of traditional Chinese ink painting, especially the art of landscape painting, and try to integrate the texture of wrinkle method synthesis map and modeling technology based on particle deposition and stacking (overlapping) to render, thus realizing the computer simulation of small freehand brushwork and large freehand brushwork (splash ink) ink effects in traditional landscape painting. This research inherits and develops the aesthetic theory and thought of traditional ink painting art, and makes some beneficial exploration in the field of digital freehand ink painting, which has positive reference value and promotion significance for the development of Chinese ink painting.

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Abstract: Explore the digital rendering mode with texturing brush and ink effect, analyze and simulate the brush and ink characteristics of traditional Chinese ink painting, especially the art of landscape painting, and try to integrate the texture of wrinkle method synthesis map and modeling technology based on particle deposition and stacking (overlapping) to render, thus realizing the computer simulation of small freehand brushwork and large freehand brushwork (splash ink) ink effects in traditional landscape painting. This research inherits and develops the aesthetic theory and thought of traditional ink painting art, and makes some beneficial exploration in the field of digital freehand ink painting, which has positive reference value and promotion significance for the development of Chinese ink painting.**Keywords:**Freehand brushwork, Chinese ink landscape painting, Rendering and Presentation

Introduction

At present, the most successful research in the field of digital ink painting art both domestically and internationally is mainly based on virtual two-dimensional flat space ink effect painting (also known as watercolor). For Chinese ink and wash painting, especially for “Shan shui”, the model theory and algorithm of the paper inking effect has great reference value, but it cannot perfectly express the 3D dynamic ink and wash effect[1][2][3][4][5].

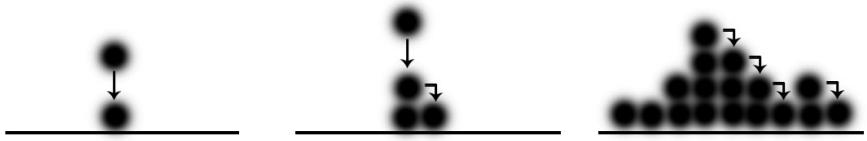
Due to the complexity, diversity and uncertainty of Chinese traditional landscape painting, its simulation is extremely difficult, so the digital simulation of 3D digital ink landscape painting is extremely challenging. For the field of 3D ink rendering, how to simulate the ”vivid charm and dripping with ink water ” artistic effect of Chinese ink and wash painting, especially big freehand and small freehand ink and wash landscape painting, through computer programs is a topic of high research value. Because traditional Chinese ink painting

presentation tends to reflect artistic spirituality, such as the appeal of flower and bird painting, the charm of landscape painting, the vividness of figure painting, etc., how these "hidden" or "potential" artistic spirits are realized through computer program algorithms, and how to combine and choose between art and science, seems to be crucial. The ultimate goal of Rendering and Presentation of 3D digital ink landscape painting is to reflect the beauty of "artistic conception" in the aesthetic theory of Chinese landscape painting through a digital presentation, that is, "vigorous and colorful" as said by Mr. Huang Binhong, a landscape painting master [5].This paper attempts to use 3D modeling and rendering software Maya to simulate landscape painting and solve the above problems.

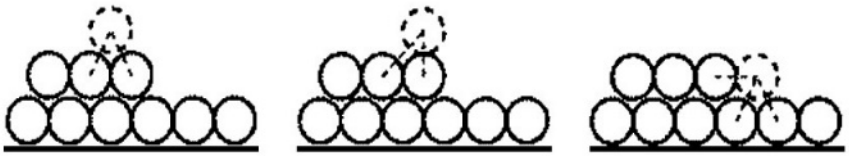
2 Modeling of Landscape Painting

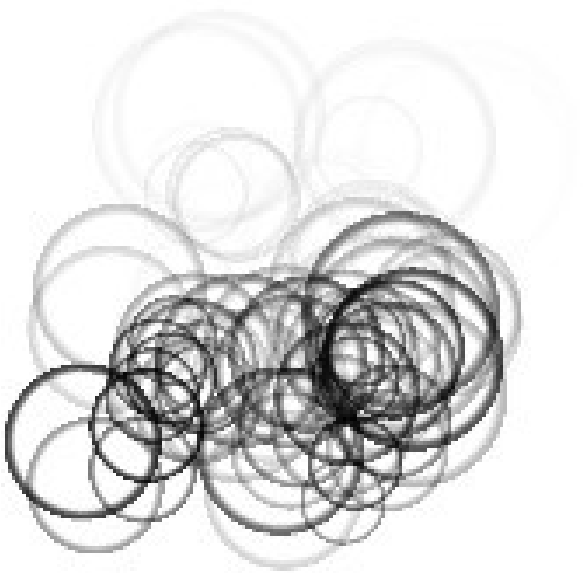
The mountain stone modeling is the first problem to be solved in the modeling of Chinese ink landscape painting. Due to the self-similarity of the mountain stone contour, it is the most typical fractal theory. At present, most of the 3D mountain stone landscape models are constructed by using the generation method of fractal graphics. However, this paper mainly uses the particle deposition method of non-fractal technology to model and render mountains and trees in Maya. [6][7]。

The principle of ink wash wrinkle texturing, which simulates mountains and rocks by using particle deposition and stacking (overlapping) technology, belongs to a particle deposition algorithm [8][9]. The idea of the particle deposition algorithm is to make particles fall in sequence and simulate their flow on the surface composed of a previously fallen particle. A sufficient number of particles falling will produce a flow linear structure that looks like a viscous fluid. The formation mechanism is that a single particle is dropped from a high place, as shown in Figure 1 (a), and then the second particle is dropped on top of the first particle, and moves it until it is still, that is, until the height of its adjacent particles is no lower than it, as shown in Figure 1 (b), continue to drop the particle, and periodically change the drop point until a stacking effect of appropriate size is formed, as shown in Figure 1 (c). Particle stacking is another way of deposition, which can describe different stacking (overlapping) results generated by the deposition of different particle attributes.



In the process of particle deposition and stacking (overlapping), particles can penetrate each other (overlapping), or they can only be sticky or binding (stacking). Under the constraints of gravity, buoyancy and viscosity, randomly generated particles will stack into various ever-changing shapes. Sometimes, the unpredictability of shapes is just the need for the richness of mountain and stone shapes. Figure 2 shows several potential movements and tectonic trends generated during particle deposition figure and stacking under the constraints of gravity and viscosity. When rendering, the ever-changing rendering effect is generated due to the different particle sizes, transparency, stacking (or overlapping) density, and boundary fusion degree. Figure 3 is a set of the left, middle, and right rock modeling views based on 3D particle stacking (overlapping) technology built by the author.





3 Rendering of Chinese Ink Landscape Painting

Three-dimensional digital landscape painting that simulates the freehand ink effect needs to solve several problems: first, it is necessary to analyze the characteristics of freehand brushwork ink effect based on an in-depth understanding of traditional freehand landscape painting; Second, the computer simulation process must be decomposed and integrated into program processing. Traditional landscape painting can be divided into meticulous landscape painting (such as the Green Landscape painting) and freehand landscape painting in terms of painting style. Freehand brushwork landscape painting can also be divided into heavyweight freehand brushwork landscape painting and lightweight freehand brushwork landscape painting. In traditional landscape painting works, there are few pure heavyweight freehand brushwork, and more is the combination of heavyweight freehand brushwork and lightweight freehand brushwork, which creates a feeling of misty rain, emptiness, richness and deep beauty. This is a rendering technology that combines procedural texture with a procedural model. Therefore, the 3D rendering technology of Chinese ink landscape painting includes wrinkle texture synthesis technology, rock and tree rendering technology.

3.1 Texture Synthesis Technology of Freehand Ink Painting

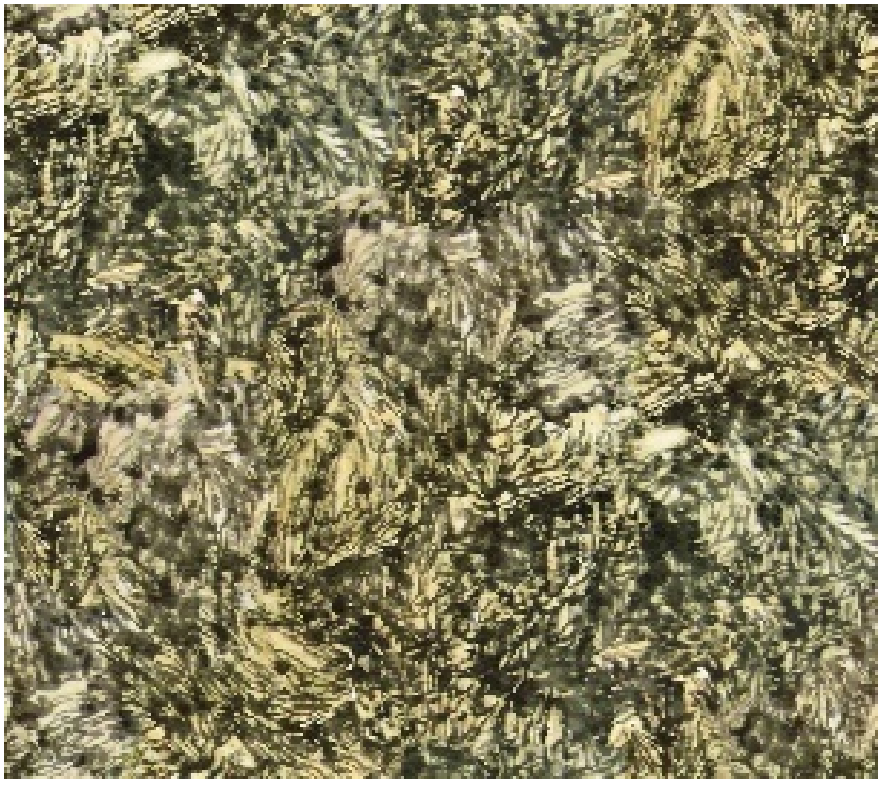
Texture synthesis is a popular technique for processing self-similar images. It is a method to generate an output image with unlimited size from a given input sample image. The output image is very similar to the original sample by visual observation, but not strictly consistent. It is through some small samples of mountain stone texturing that the author synthesizes a large block of complete mountain stone texturing texture, which solves the problem of the richness of texturing texture. Because the texturing method of Chinese landscape painting is formed by the combination of texturing, wiping, dyeing and spotting on suitable paper with a brush dipped in ink, which is rich in changes. The texturing method is usually composed of fine lines, which are closely combined. Sometimes the lines are rendered layer by layer, and sometimes only the texturing is wiped without stippling, thus forming the local self similarity of the texturing method texture. However, the texture structure of texturing method is not very obvious, and the shape is irregular. Given these characteristics of the texturing method of landscape painting, and considering the complexity of the algorithm, we try to use the natural texture synthesis method [10] [11] proposed by Ashikhmin, and combine the characteristics of the texturing method rendering of Chinese landscape painting to improve and optimize the algorithm accordingly. Finally, considering that the wrinkled texture of landscape painting

has a certain directionality, in the final rendering, we use an alpha mask channel to guide its synthesis in three-dimensional space, aiming to achieve an artistic effect of freehand mountain and water painting similar to vivid charm, incisive ink and rich colors.

Ashikhmin proposed the synthesis method of natural texture. The so-called natural texture refers to the texture composed of some very similar but irregular small units in shape and size. Ashikhmin uses the correlation principle to limit the search scope to the neighborhood of the current point. The method of synthesizing natural texture also uses the L-shaped neighborhood of the current point, and the neighborhood size is Neighb-siz. It is not in direct proportion to the texture quality, and the optimal value depends on the texture structure. Excessive neighborhood not only affects the synthesis speed but also leads to a large number of repeated regions. when the texture is smooth, the neighborhood needs to be increased. Firstly, a large number of texturing methods in landscape paintings are collected and stored in the system as input sample images. For simplicity, we first assume that both the input sample image and the output image to be synthesized have regular sizes. Using the principle of correlation, the algorithm limits the search range to the neighborhood of the current point. According to the L-neighborhood point, candidate pixels are obtained after the corresponding position in the input image is shifted by a corresponding amount. We define an array structure for each pixel in the output image to store the position of the pixel in the input sample image, to facilitate the search for matching points of neighboring pixels. Suppose we copy the q point in the sample image to the pixel P in the output image, we can establish a data structure s (.) with p as the index, which has the following equation:

$S\ (p\ )=q$

In the calculation process, for each pixel synthesized, its position in the input sample image is recorded in the structure. The algorithm first initializes the array that records the positions of matching points\sout,and sets it as a random point in the input image. For each pixel in the output image, it is calculated according to the scanning line order. In the output image, consider the L-neighborhood of the current point, and for each point in the neighborhood, according to the position of the matching point in the array, after offsetting the corresponding position, select the point as the candidate point, to form a list of candidate points and clear the duplicate candidate points. Select the point with the least L-neighborhood error with the current point of the output image from the selected point, copy it to the current point of the output image, and record the position. If necessary, perform secondary or multiple syntheses until a satisfactory texture image is obtained. Figure 4 is the texturing texture effect picture synthesized by the author through texturing sampling for a traditional Chinese landscape painting.



3.2 Rendering Techniques of Chinese Ink Landscape Painting

The above texture synthesis algorithms are all output images with regular contours, which are just the preparation stage of digital ink landscape painting simulation. If these textures and stone models are directly used for texture mapping, only ordinary mountain and stone textures can be produced, and the effect of incisive ink and vivid charm cannot be achieved. Because the shape of the rocks in freehand landscape painting is both imaginary and realistic, it will produce an effect of misty rain and misty sky. The synthetic texturing texture must produce a fusion effect of texture and mountain stone adaptively according to the virtual and real effect of mountain stone. Therefore, we propose to introduce the concept of an alpha mask channel in the synthesis process, thereby realizing the virtual fusion effect of the model inside the irregular stone contour and the texturing texture.

3.2.1 Acquisition and definition of alpha

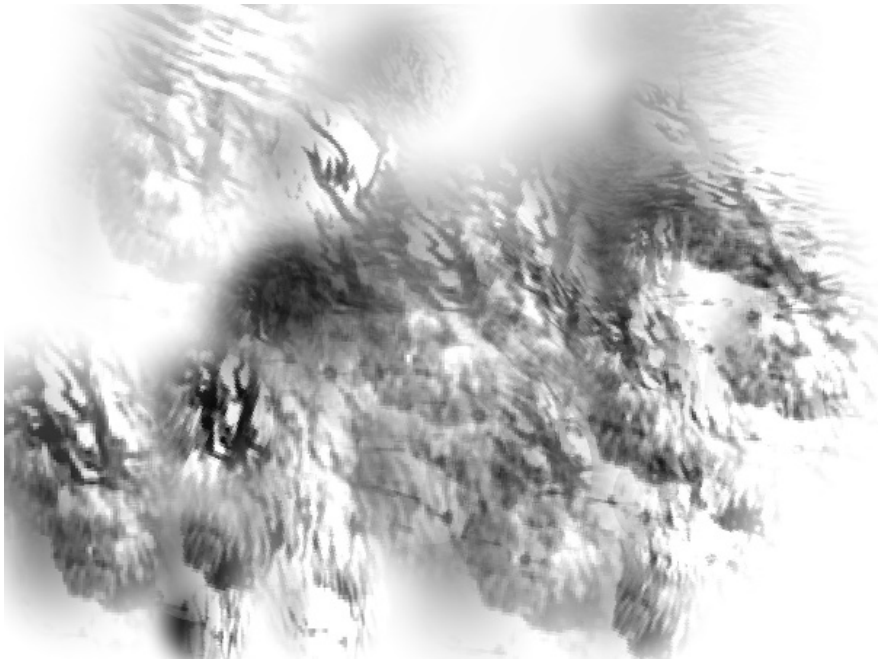
The alpha mask channel is a channel image that is consistent with the basic appearance of the mountain stone by defining the particle density, hardness and fusion degree in the particle stacking (or overlapping) model according to the needs of digital landscape painting freehand effect. The mask channel image participates in the rendering process of texture and model composite mapping. In order to achieve a better fit between the texturing texture and the shape of the mountain stone, that is, the ink and texturing texture can blend and complement each other, or some places only display light ink without texturing lines, and some places only display texturing lines without light ink. In Maya software, we redefine and set threshold values for the black, white, and gray levels in the alpha mask channel, and set the weight value of the texturing texture display degree between the block gray value 0<RGB<255. Among them, the RGB gray value starts from 255 to 0, and the display degree of texturing texture rendering gradually weakens. When the texturing texture display degree of the darkest block (that is, pure black with RGB of 0, 0, 0) is 0%, The texturing texture of the whitest block (that is, pure white with RGB 255 255 255) is 100%. Figure 5-A and Figure 5-B show the

RGB gray value of each block of the mask image of the alpha channel and the texture display corresponding to the gray value. The final alpha mask channel image generated by custom rendering is shown in Figure 6.

3.2.2 Texturing rendering synthesis of ink Mountain stone

Based on the above, we carry out texturing rendering synthesis of 3D ink mountain stones with the style of splash-ink effect. This synthesis is done in Maya's internal 3D rendering engine. We only need to input

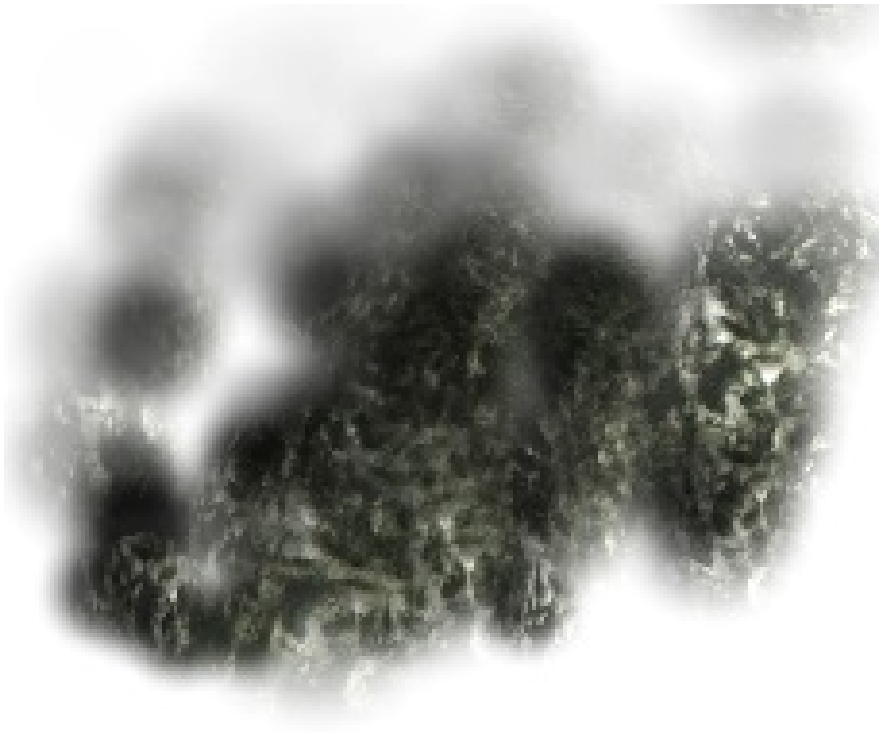
the texturing image synthesized above and define the rendering index of the stone model stacked with particles. The system will automatically generate the mask image with alpha channel and finally render and synthesize the complete freehand landscape painting effect map. Figure 7 shows the freehand brushwork landscape painting effect of different texturing methods by using the band folding texturing map and under the framework of unified rock modeling and alpha mask channel rendering image. Figure 8 shows the work generated by this technology (the magnified effect of Figure 7-D).



3.2.3 Further Experiment of Ink and Wash Rendering Effect

Based on the above rendering technology of digital freehand landscape painting using particle deposition and stacking (overlapping) technology, we conducted further rendering experiments, such as trying to simulate the effect of heavy freehand splash ink landscape painting with dripping ink and vivid charm. Before rendering, it is necessary to predict the effect of freehand brushwork (or splash ink) of digital mountains and stones according to the presentation intention of digital landscapes and to create the desired rendering effect of mountain and stone models by defining the particle density, hardness and fusion degree in the particle stacking model. Table 1 is a group of comparisons after repeated experiments on the ink and texture effects of mountain stones in freehand landscape painting based on the above technologies. Each group of images is divided into two layers for comparison. The upper layer is mainly for various pure ink rendering effects of mountain stone models, and the lower layer is the final rendering after adding texturing texture. Figure a shows the state when the particle softening is - 0.9 and the density is 0.5, which is a process of particle positioning and deposition; Figure b shows the state when the particles soften to - 0.5 and the density is 0.5. At this time, the particles have not been fused, and the texture and model have not been organically combined; Figure c shows the state when the particle softening is 0 and the density is 1. At this time, the particles have started to fuse, but the fusion is not sufficient. There are obvious traces. The texture has started to combine with the model, but there are still some hard edges; Figure d shows the state when the particle softening is 0.3 and the density is 1. At this time, the particles are further fused, and the combination of texture and model is relatively sufficient, but the splash effect has not been fully reflected; Figure e shows the state when the particle softening is 0.7 and the density is 1; Figure f shows the state when the particle softening is 1 and the density is 1. Finally, the author repeatedly reviewed the ink splashing effect and believed that both Figure e and Figure f were successful, and their ink splashing effects had their own advantages, one was tight and meticulous, and the other was loose and incisive, which could be chosen according to personal aesthetic preferences. On the basis of Table 1, further define and set the threshold value for the black, white and gray layers in the alpha mask channel, and set the weight value of the texturing texture display degree between the block gray value 130<RGB<255, where the RGB gray value below 130 is defined as no texture display, and the rest remains unchanged. Finally, we can render a splash ink landscape painting with a large freehand effect, as shown in Figure 9.

Without texture
Without texture With texture Parameters Figure a. -0.9; 0.5 Figure b. -0.5; 0.5 Figure c. 0; 1 Figure d. 0.3; 1 Figure e. 0.7

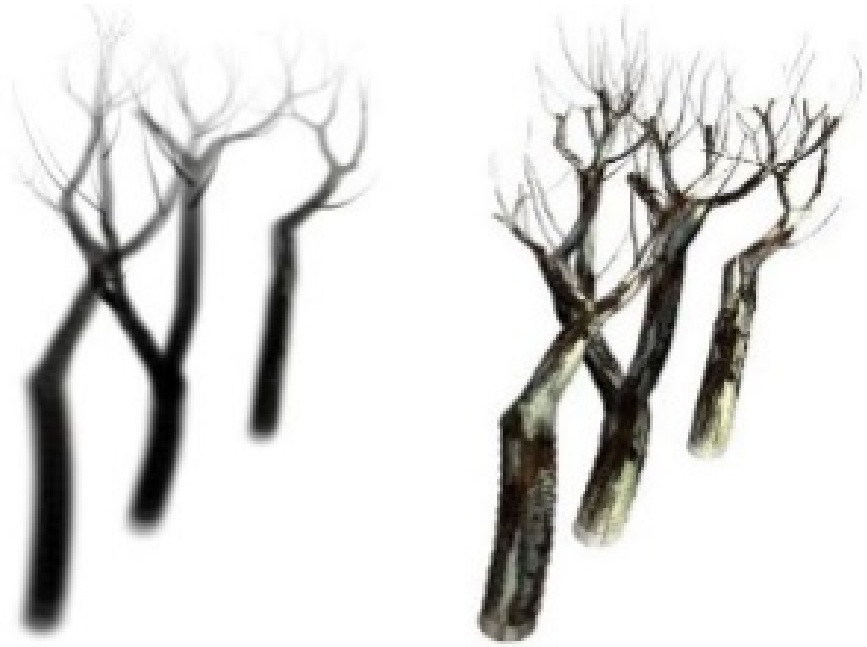


3.3 Other particle-based rendering technologies

The above mainly discussed the modeling technology of mountain stone, an important component of landscape painting. Other modeling techniques based on particle deposition described below are only a supplement and example of the above modeling methods. These modeling concepts are completely consistent with the above mountain stone modeling based on particle deposition and stacking (overlapping) technology, except that some landscape painting objects, such as ink trees and raindrop textures, do not necessarily need textures, or only need a color ink setting method similar to shallow landscape painting.

1)Particle\sout-based tree rendering

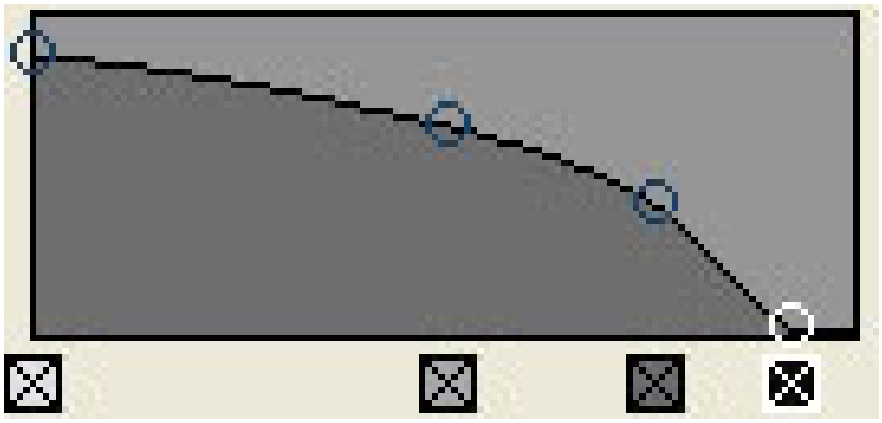
Suppose that particle deposition is stacked according to the tree growth model of the extended L system to generate a particle swarm, and the particle size is adaptively constrained according to the tree shape defined by the extended L system, then the boundary formed by the periphery of the particle swarm can produce a shape similar to a tree. Figure 10 shows the particle tree generated by particle stacking. In addition, we made a comparison between normal rendering and ink rendering. In ink rendering, set the color of the overall shader to grayish black, the transparency of the tube shader to completely transparent, the color to grayish black, and the tip fade to about 0.6. Set the softening degree of the brush to above medium level, as shown in Figure 11.



2)Modeling and rendering of 3d wrinkle texture in Chinese ink landscape painting

Cow-hair wrinkle texture: Cow-hair texturing in traditional landscape painting is a kind of brushwork lines similar to cow hair. In Maya, we try to simulate the 3D modeling and rendering of Cow-hair wrinkle texture by changing the linear way of particle stacking and the randomness of density and staggered distribution. In addition, we set the color of Cow-hair wrinkle texture according to the needs. The upper Color 1 is set as the ochre stone color in the color of Chinese painting, and the lower Color 2 is set as the ink color. Through gradual blending, this effect is very similar to the traditional Light-color ink painting method. The final effect is shown in Figure 12:

Rain-drop wrinkle texture: similar to the modeling concept of Cow-hair wrinkle texture, but the particles deposited by Rain-drop wrinkle texture are more symmetrical and regular in shape, and the particle groups are in a state of aggregation, dispersion and non-uniform random distribution. In addition, we can also control the length of the rain spots and the sharpness of the head and tail linearly. The Rain-drop wrinkle texture only needs the change of ink color, not the texture, and the final effect is shown in Figure 13.



4 The presentation Scheme of Digital 3D Ink and Wash Landscape Painting

4.1 The final presentation process of digital 3D ink landscape painting

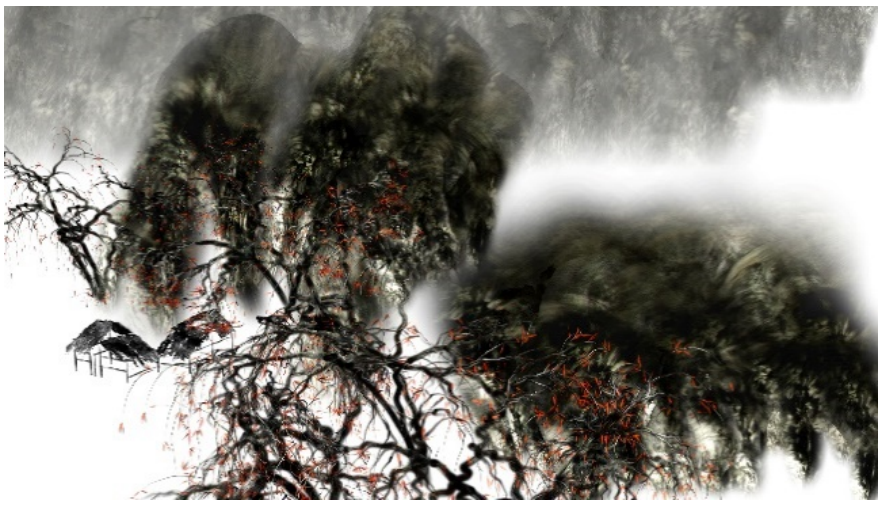
The final presentation of traditional ink and wash landscape painting is divided into three steps: conception (determining the presentation theme, content, composition, and expected artistic conception), drawing (out-

line, texturing, wipe, dyeing, and spotting), and signature (inscribing the theme name or poem, presentation time, author's name, etc. in the appropriate blank space of the picture, and stamping the seal). Among them, conception and drawing are the most critical two steps. Generally, we believe that form, content and style determine the success or failure of a landscape painting. Form, also known as the form of expression, mainly refers to all visual expression methods related to the expression of the content of the work through painting techniques, namely, the above-mentioned outline, texturing, wipe, dyeing, and spotting. The content of landscape painting is nothing more than mountains and rocks, trees, clouds and water, human beings, architecture, boat and other categories. The style is a general aesthetic image in the form of expression, which is produced by the interaction and influence of form and content, as well as the personal aesthetic tendency and subjective will of the creator.

The final presentation of digital 3D ink landscape painting can also follow the steps of traditional landscape painting presentation. As the final display of digital 3D graphics cannot be separated from rendering technology, we propose four major steps for the presentation of digital 3D ink and wash landscape painting: conception, 3D drawing, rendering, and closing, as shown in Figure 14. In the actual digital art presentation, the drawing content is modularized according to the features of outline, texturing, wiping, dyeing, and spotting techniques, and the form, content and style are unified. The 3D drawing is done in the way of a modularized brush plug-in.

4.2 Final Presentation of Digital 3D Ink and Wash Landscape Painting

For those with Chinese painting presentation experience and some computer operation experience, using the modular 3D ink landscape painting component developed by the author can quickly complete the presentation of a digital ink landscape painting. For those who have no traditional Chinese painting presentation experience, or even computer operation experience, the author has developed a series of digital ink landscape painting samples or templates containing complete theme ideas and drawing content. With this template, as long as the variable values such as the number of distribution, shape and appearance, volume and size of mountain stone trees are changed, the texture of mountain stone texturing method and the variety of trees in the template works are adjusted, and the effects of thick, light, light, heavy and bleeding of ink rendering are adjusted, a three-dimensional digital ink landscape painting that is completely different from the template can be created. Figure 15 is a series of templates for digital 3D ink landscape painting; Figure 16 shows the presentation steps of digital 3D ink landscape painting based on modularization; Figure 17 shows several presentation results after modifying or replacing various parameters, variables and textures of a template. Figure 18 is a three-dimensional digital ink landscape painting sketch (lightweight freehand brushwork) completely drawn with a modular program brush.



5 Conclusion

This research solves the problem of painting mountains, rocks, trees and other objects in landscape painting through the deposition stack (overlapping) rendering technology of particles. In addition, particle rendering technology is used to simulate the texturing method (raindrop texturing) in traditional Chinese painting. Compared with pure geometric modeling and rendering technology, particle-based rendering technology has greater flexibility and more traditional ink painting style and characteristics. Use particle rendering technology to customize the presentation of mountains, rocks and trees with Chinese painting ink effect, to achieve an integrated and incisive dynamic 3D ink landscape painting artistic effect. Of course, our research has just started, and there are still many problems to be solved, such as how to draw 3D digital ink landscape painting closer to the traditional presentation mode, how to simulate more traditional texturing methods through digital 3D technology, and how to realistically simulate more complex and diverse rock modeling. We will continue to explore this aspect in the future digital art practice.

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reference

[1] Ching Chan, Ergun Akleman. Two methods for creating Chinese painting. In: Proceedings of the 10th Pacific Conference on Computer Graphics and Applications(PG02), Beijing, 2002. 403˜413.

[2].Der-Lor Way, Zen-Chung Shih. The synthesis of rock textures in Chinese landscape painting. In: Proceedings of Eurographics'2001, Manchester, 2001. 123˜131.

[3] Baxter, B. , Scheib, V. , Lin, M. et a1.. DAB: interactive haptic painting with 3D virtual brushes. in Proceedings of SIGGRAPH'01, Los Angeles, USA, New York: ACM Press, 2001, 461˜468.

[4] Strassmann Steve, Hairy brushes. In: Computer Graphics Proceedings, Annual Conference Series, ACM SIGGRAPH, Dallas, 1986. 225˜232.

[5] Lee J. Simulating oriental black-ink painting. IEEE Computer GraphicsApplications, 1999, 19(3): 74˜81.

[6] Millet,GaviE S P.The Definition and rendering of terrain maps[J].ACM SIGGRAPH Computer Graphics,1986,20(4):39˜48.

[7] Voss,Richard D..FRACTALS in NATURE:characterization,measurement,and Simulation[C].SIGGRAPH 1987.

[8] Wang Shuli, Zhang Lei. The Essence of Game Programming l [M]. Beijing: Posts and Telecommunications Publishing House, 2003.451-458

[9] Barabasi,A.L.,Stanley,H.E.,Fractal Concepts in Surface Growth[C]. Cambridge University Press,1995.

[10] Michael Ashikhmin.Synthesizing natural textures[C].Proceedings of ACM Symposium on Interactive 3D Graphics.North Caorlina,2001,217˜226.

[11] Sun Meijun, Li Dan, Sun Jizhou. System Simulation of Chinese Landscape Painting Based on Texture Synthesis [J]. Journal of System Simulation, 2004, 16 (10), 2317˜2320.