

Rendering Technology of 3D Digital Chinese Ink-Wash Landscape Paintings Based on Maya

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Abstract. The work includes analyzing and simulating the techniques of traditional Chinese ink-wash landscape paintings, such as the ways of brush moving and ink painting, exploring the digital rendering modes with the characteristics of wrinkled-texture paintings. Besides realizing the simulation of traditional freehand ink-wash paintings by mixing the wrinkled-texture picture with the technique of modeling and rendering based on particle deposition and stacking. This study inherits and develops the traditional ink-wash painting's aesthetic theory and aesthetics, and has great significance and reference value of the change and development of the Chinese ink-wash landscape paintings.

Keywords: 3D, Chinese ink-wash landscape paintings, Modeling and rendering.

1 Introduction

At present, at home and abroad in the field of digital painting, the more successful research is mainly in the Ink-wash- effect painting (or watercolor) based on virtual two-dimensional flat space. For the Chinese ink-wash painting, especially the landscape paintings, it has great reference value about the model theory and algorithms in the effect of paper saturated with ink, but it can not be the perfect expression of the 3D dynamic ink effect [1][2][3][4][5].

For the traditional Chinese landscape painting, the simulation is extremely difficult due to their complexity, diversity and uncertainty, the digital simulation of three-dimensional digital ink painting art is challenging. In the field of 3D ink-wash rendering, to display the ink-wash artistic effects lively and thoroughly, especially those expressed in the large freehand or small freehand ink paintings through a computer program, is a research subject of high value. Because the creation of traditional Chinese ink-wash painting is more like a manifestation of spirituality, such as the taste about flowers and birds painting, the rhyme of landscape painting, expressive portraits and so on, the proper combination and options between arts and science is crucial for expressing this "hidden or potential" artistic spirit. By using three-dimensional modeling and rendering software Maya, this paper attempts to simulate the landscape painting to solve the above problems.

2 Modeling of the Ink-Wash Landscape Painting

Of all the ink-wash landscape painting modeling, the modeling of mountain-stones is the first problem we need to solve out. Because of the self-similarity of rocks' contour, According to the most typical fractal theory, most of the 3D mountain-stones landscapes models are generated by Fractal Graphics. However, here we mainly talk about the applications of particle deposition technology in building tree and rock models or rendering in Maya[6][7].

The theory of using the particle deposition and stacking technique simulating the ink-wash wrinkle of rocks is a kind of particle deposition algorithm[8][9]. The idea of particle deposition algorithm is to make the particles fall down in order, and simulate the floating on the surface forming by the particles fell before. Enough falling particles will make it look like the viscous fluid with a flow linear structure. When a single particle falls from a high point, which is shown in Figure 1(A), putting the second particle falls above the first one and moving it until it keeps still, i.e. until all the particles next to it are not lower than it, as it shows in Figure 1(B), the other particles keep falling down and cyclically change their landing spots until a proper-sized stack effect being formed, as it shows in Figure 1(C). While particle stack is another way of deposition, it could describe the different stacking (overlapping) results made by depositions of different particle properties.

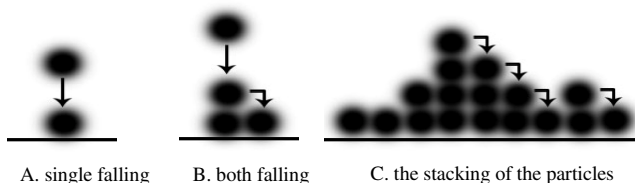


Fig. 1. The modeling theory of the particle deposition and stacking

In the process of particle deposition and stacking (overlapping), particles could penetrate each other (make it overlap), and allow adhesive or binding (make it stack). Under the constraints of gravity, buoyancy and viscous forces, the random particles will stack up various shapes. Sometimes, the unpredictability of the shapes right meets the requirements of rich rock shapes. Figure 2 shows that under the constraints of gravity and viscous force, particles may have several potential trends in movement and conformation in the process of deposition and stacking. In addition, because of particle size, transparency, stacking (overlapping) density and boundary integration, it could make various rendering effects, Figure 3 is a group of rocks landscape views built by the author based on 3D particle stacking (overlapping) technology on Maya.

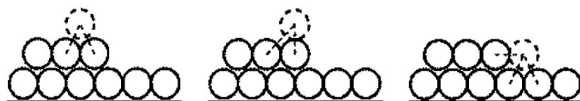


Fig. 2. Under the constraint of the gravity and viscous force, some kinds of potential movements and the structure trends of the particle deposition and stacking

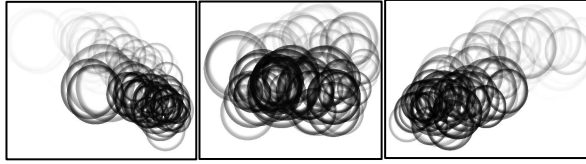


Fig. 3. A group of rocks models based on the 3D particle stacking (overlapping) technique—left, middle and right views

3 The Rendering of the Ink-Wash Landscape Painting

The 3D digital landscape painting simulation of freehand ink-wash painting need to be solved several problems: First, they must make a feature analysis of the freehand ink-wash effect based on the deep understanding about the traditional freehand landscape painting; Secondly, computer simulation process must decomposed and integrated in the process of the program processing. Traditional landscape painting can be divided into meticulous painting style (such as the green landscape painting), and freehand landscape Painting. Freehand Landscape Painting also composed by two parts, which are large freehand landscape painting and small freehand landscape painting.

Large freehand landscape painting is rare in the works of traditional landscape painting; most of these works combine these two styles to generate the atmosphere of misty rain and vigorous, lush feeling. This is a rendering technique, which combines the program texture and the program model. Therefore, 3D rendering (drawing) technology of ink-wash landscape painting contains two parts, which are the wrinkled-texture synthetic technique and the rendering technique of the rocks and trees.

3.1 The Wrinkled-Texture Synthetic Technique of the Freehand Ink-Wash Painting

The Texture synthesis is a popular technique, which can deal with the self-similar image. It uses a given input sample images to generate the output image which size is unlimited, with the naked eye you can find that the output image with the original samples are extremely similar, but not strictly the same. The author solves the problem of texture variety by using a number of the small sampling of the rocks wrinkled-texture to complete the large rocks wrinkled-texture.

The wrinkled-style is combined by linear, wrinkled, scratched, stained, and spotted, so you can get multiple combinations. Wrinkled-style usually composed by tiny stroke-lines, which combined tightly, sometime rendering layer after layer. Sometimes, the texture is just wrinkled without stained or spotted, and then it can form the texture of the local self-similarity. However, the wrinkled-texture structure is not very obvious and the shape is irregular. Because of these characteristics of wrinkled landscape painting and the complexity of the algorithm, we try Ashikhmin's natural texture synthesis method[10][11], combining with the characteristics of

Chinese landscape painting wrinkled rendering to improve and optimize this algorithm. Because the wrinkled-texture of landscape painting has a certain direction, so in the final rendering, we uses an alpha channel mask to guide the synthesis in the 3D space, designed to achieve a lively, ink-dripping, colorful artistic effect.

Ashikhmin presented the synthesis of natural texture. The so-called natural texture is the texture that combined with the small modules that very similar, but with irregular shape and size. Ashikhmin used of relevant principle, to limit the search range to the current point in the neighborhood. The method of natural texture synthesis is also using the current point of L-shaped neighborhood. The neighborhood size is Neighbor-size. It is not the direct proportion with the texture quality, the best value depends on the texture structure, too large neighborhood is not only affect the synthesis rate, but also result in a large number of repeat regions, but it needs increase the neighborhood when the texture is much smoother.

First, collecting a large number of wrinkled textures in landscape paintings saved into the system as the input sample images. For simplicity, assume that the input images and the output images have the same regular size. Using of relevant principle, the algorithm limit the search range to the neighborhood of the current point, getting the candidate pixel after inputting the offset of the corresponding position according to the L-points in the neighborhood. We define an array structure for each pixel in the output image to store the location of the pixel in the inputted image, so it is convenient to search the matching points of the neighborhood pixel. Assuming that we copy the point q in the image to the pixel p in the outputted image, and then we can build a data structure $s(\cdot)$, which make pixel p as the index and the equation like this:

$$S(p)=q$$

In the process of the calculation, you need to record the location of the synthetically pixel, which was shown in the input sample image. At first, the algorithm needs to initialize the array of the matching point's locations, and setting them as the random point of the inputted image, for each pixel in the outputted image, calculated in accordance with the order of scan lines. In the outputted image, considering the L-neighborhood of the current points, offsetting the corresponding location according to the location of the matching points in the array, we select this point as the candidate point to get the list of candidate points and remove the repeat points. Select the candidate point with the minimum error, which compared to the L-neighborhood of the current points in the outputted image, and copy it to the current point in the outputted image and record the location, if necessary, a second or more synthetic is acceptable, until getting a satisfactory texture. Figure 4 shows a wrinkled-texture effect of a conventional Chinese landscape painting which used the synthesis of wrinkled-sampling.

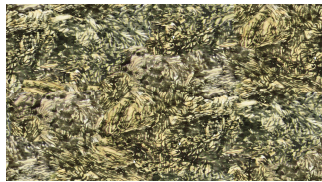


Fig. 4. The final synthesis effect of wrinkled-texture looked like folded ribbon

3.2 The Rendering Technique of the Digital Freehand Landscape Ink-Wash Effect

Using the texture synthesis algorithm just obtained the output images with a regular contour, so it is just the preparatory stage for the simulation of the digital ink-wash landscape painting. It only gets a general effect of the mountain and stone textures, and can not achieve the feeling of ink dripping, vivid spirit, if you use these textures and rocks models make mapping directly. For landscape painting of the rocks, the rock shape of the freehand landscape painting is mixed with clear and fuzzy, so it will produce a mixed effects looked like smoke or fog. Synthesis wrinkled-texture must produce a fusion effect, which combine the texture and the rocks by self-adaption. Therefore, we propose the introduction a concept of the Alpha channel mask in the process of the synthesis, thus achieving the virtual fusion effect of the irregular contours of the rocks and the wrinkled-texture.

3.2.1 The Acquisition and Definition of the Alpha Mask Channel

Alpha mask channel is an image with the similar out shape with the rocks, which is got by defining the particle density, hardness level and the degree of integration of the particle stacking (deposition) modeling. During the rendering process of the synthesis mapping about texture and the modeling, with the Participation of the alpha mask channel, for achieving a best result of the wrinkled-texture and the rocks shape, some part just shows the light ink without the wrinkle line, or (some part)just shows the wrinkle line without the light ink. In Maya, we redefined the black layer, white layer and grey layer of the Alpha mask channel and set the threshold, set the param-weight of the wrinkled-texture visibility between the grey value $0 < \text{RGB} < 255$. the grey value of RGB changed from 255 to 0, the visibility of the wrinkled-texture is weaken gradually, and the visibility of wrinkled-texture in black area RGB (0,0,0) is 0%, the visibility of wrinkled-texture in the white area RGB(255,255,255) is 100%. Figure 5 A and B, represent the grey value of each area in the Alpha channel mask image and the corresponding display of the texture. Finally, it can generate the Alpha mask channel image by user-defining rendering.

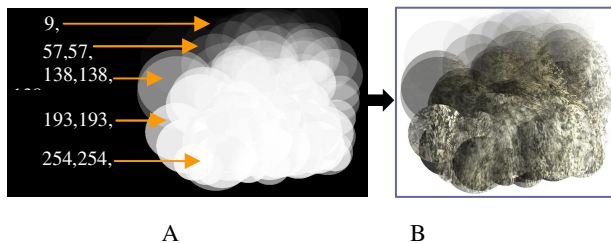


Fig. 5. A: The final synthesis effect of wrinkled-texture looked like folded ribbon. B: Texture display with the grey value.

3.2.2 The Wrinkled Rendering Synthetic of Freehand Ink-Wash Rocks

Based on the theory above, we conduct the wrinkled rendering synthetic of the 3D ink-wash rocks with the splash-ink effect. The synthetic completed in the 3D rendering engine of Maya. We enter the synthetical wrinkled-texture image, and set the rendering index of particle stacking rocks model. The system will produce the Alpha mask channel image automatically, and finally render a complete freehand landscape Painting. Figure 6(from A to B) is a mapping with the wrinkled-texture looked like folded ribbon, under the unified rocks modeling and the framework of Alpha mask channel rendering image, it formed the freehand ink-wash landscape painting effect with different wrinkled-texture.

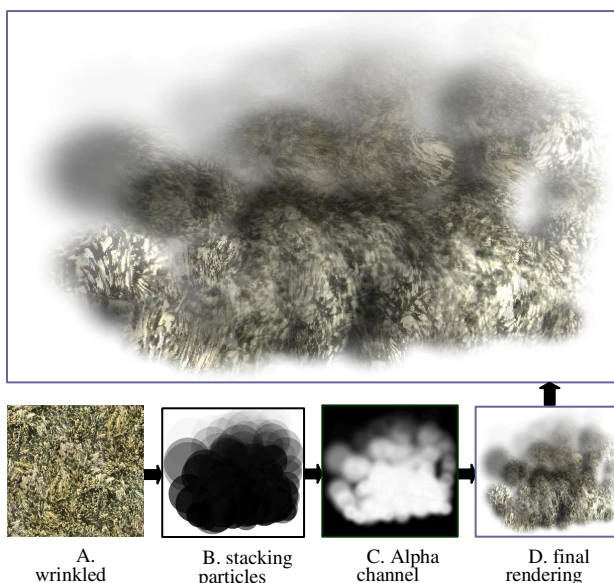


Fig. 6. The final rendering effects which produced by two different wrinkled-textures and rocks models


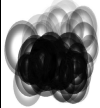
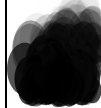
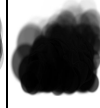
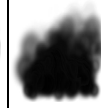



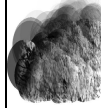
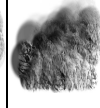
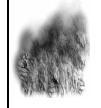

3.2.3 The Further Testing of the Ink-Wash Rendering Effect (Large Freehand Landscape Painting)

We conducted a further rendering tests based on the technique, which using the particle deposition and stacking for the achievement of the digital freehand landscape painting, to simulate the ink-dripping,vivid-spirit effect of the large freehand landscape painting. Before the rendering, you need to preconceive the effect you want about the digital freehand rocks based on the creation intention of the digital landscape painting, then generate the expected effect by defining the particle density, hardness level and the degree of integration of particles stacking model.

After repetitious comparing between the rocks ink-wash and the texture effects that based on the above technology, the author got the relative results that are shown in the Table 1. Each image group was divided into upper and lower Photos for the compare,

the upper ones are variety of rocks with pure ink-wash rendering; the lower ones are the final rendering images with the wrinkled-texture. Figure a shows the status about particle, which softening degree is -0.9 , density is 0.5 , this is the process of the particle orientation and deposition. Figure b shows the status of the particle, which softening degree is -0.5 and the density is 0.5 . At this status, the particles are not fusion yet, the texture and the model could not merge organically; for figure c, the softening degree of particle is 0 , and the density is 1 , then the particles start to merge but not very completely, there is a visible hard edge. The softening degree of particle in figure d is 0.3 , density is 1 , by then the particles achieve further merging, the combination of the texture and the model is more complete, but the splash-ink effect isn't clear yet. In figure e, the softening degree of the particle is 0.7 , the density is 1 ; figure f shows the status of the particle which softening degree is 1 and the density is 1 . Finally, after repetitious examination, the author thought both of figure e and figure f are successful. Their splash-ink effects have the different feeling, one is rigorous , the other is unrestrained, and you can choose any one base on the personal taste. Based on the table 1, making the further definition of the black, white and the grey layers in the alpha mask channel and threshold, setting the param-weight of the wrinkled-texture visibility between the grey value $130 < RGB < 255$, define the texture is invisible when the grey value below 130 , the rest remain the same.

Table 1. The rocks ink-wash effect rendering parameters that based on the 3D particle stacking technique (aim at the particle parameters of Softness and Stamp Density)

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. $0.7; 1$	Figure f. $1; 1$

3.3 The Other Techniques Based on the Particles

The content we discussed above mainly introduced the important components of the landscape painting - the rocks modeling techniques. The next modeling techniques based on the particle deposition is only a supplement to the above modeling method and examples. It is fully consistent these ideas about modeling and the rocks modeling which produced based on the particle deposition and stacking, but some objects such as ink-wash trees, raindrop wrinkle and so on do not need the texture necessarily, or they just need a kind of colored-ink painting.

3.3.1 The Trees Rendering Based on the Particles

Assuming that the particles deposition stacks produced the particle group in accordance with the tree growth model that expanded the L system. The particle size can make self-adaptation restriction due to the tree's shape which defined by the expansion L-system, the boundaries which generated by the outline of the particle groups can produce the shape which is similar to the tree. Figure 7 shows the particles tree's shape which generated by the particle stacking. In addition, we compared normal rendering with the ink-wash rendering. It can see in the ink-wash rendering, setting the ash black as the color of the renderer, the transparency of the tube shade is completely transparent; the color is ash black, the tip fade is about 0.6, setting the softness of the brush beyond middle level.



Fig. 7. The tree's rendering illustration base on the particles

3.3.2 The 3D Wrinkled-Texture Modeling and Rendering of the Ink-Wash Landscape Painting

Ox-hair wrinkle: the ox-hair wrinkle of the traditional landscape painting is similar to the ox hair-like strokes. In Maya, we simulated the ox-hair wrinkle 3D modeling and rendering by trying to change the stacking linear form and the randomness of the complicated distribution. In addition, we set the color of the ox-hair wrinkle due to the needs. We set the hematite-color as the upper Color 1, the bottom Color 2 is black, and the two colors will integrate gradually. This effect is very similar to the traditional colored ink painting. The result is shown in Figure 8:

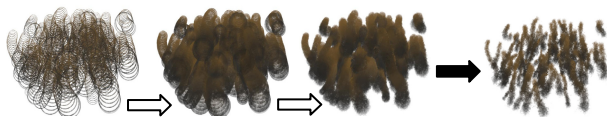


Fig. 8. Modeling and rendering of the ox hair wrinkle

Raindrop wrinkle: It is similar to the modeling concept of the ox-hair wrinkle, but the shape of rain wrinkle particle stacking is more symmetric and more inerratic, and it can make the groups of particles to maintain a non-uniform random state or random status. In addition, we can also make the linear controlling to the length of the raindrop wrinkle and the sharpness of the head and the end. The raindrop wrinkle just needs the shade change of the ink, and does not need the texture. The final result is shown in Figure 9.

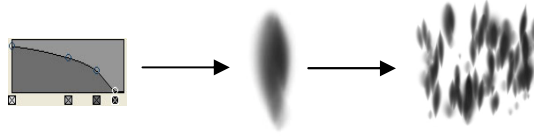


Fig. 9. The principle of raindrops wrinkle

3.3.3 The Example of the Creation About the Digital 3D Ink-Wash Landscape Painting

The For the person who has the experience about Chinese painting creation and the computer skills, creating a digital ink-wash landscape painting is quickly by using the 3D ink-wash landscape drawing modules based on above technology developed by the author. On the contrary, if you don't have any experience about such creation and the computer, you can use the templates which provide by the author to create a new work about 3D digital ink-wash landscape painting by modifying the variable values of the number, the shape, the size and the effect of the rendering. The templates include a series of theme conceptions and drawing content[12]. Figure 15 is an example about the ink-wash painting which be created by the modularized brushes.

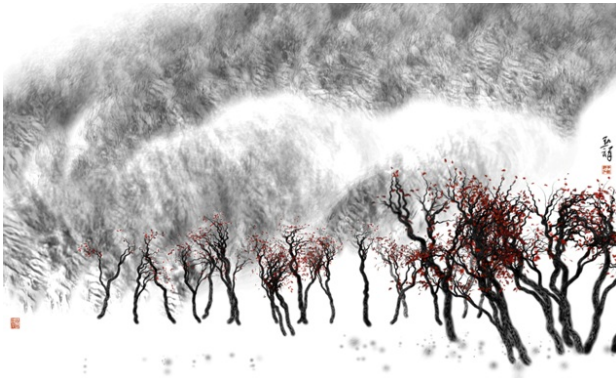


Fig. 10. A works of digital 3D ink-wash landscape painting

4 Conclusion

The work solved the problem of drawing rocks and trees of the landscape painting by using the particle stacking technique. In addition, the author made a realistic digital simulation of the traditional Chinese painting wrinkle strokes (raindrop wrinkle) by using the particle rendering technique. Compared to the pure geometric modeling and the rendering, the technique that based on the particle rendering is more powerful on the flexibility, it also has more traditional styles and characteristics. Making the rocks and trees' self customize with the Chinese painting ink-wash style by using the rendering technique to achieve the completely, thoroughly dynamic 3D ink-wash landscape painting effect. Of course, research is just the beginning, there are many

other issues to be resolved. For instance, how to make the drawing of the 3D digital ink-wash landscape painting get closer to the traditional creation mode? How to simulate more traditional wrinkle texture by using the digital 3D technique? How to simulate the rocks modeling more realistically and so on, are our new problems. We will make research on these parts in the future coming digital art practice.

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References

1. Chan, C., Akleman, E.: Two methods for creating Chinese painting. In: Proceedings of the 10th Pacific Conference on Computer Graphics and Applications (PG 2002), Beijing, pp. 403–413 (2002)
2. Way, D.-L., Shih, Z.-C.: The synthesis of rock textures in Chinese landscape painting. In: Proceedings of Eurographics 2001, Manchester, pp. 123–131 (2001)
3. Baxter, B., Scheib, V., Lin, M., et al.: DAB: interactive haptic painting with 3D virtual brushes. In: Proceedings of SIGGRAPH 2001, pp. 461–468. ACM Press, Los Angeles (2001)
4. Steve, S.: Hairy brushes. In: ACM SIGGRAPH Computer Graphics Proceedings, Dallas. Annual Conference Series, pp. 225–232 (1986)
5. Lee, J.: Simulating oriental black-ink painting. *IEEE Computer Graphics & Applications* 19(3), 74–81 (1999)
6. Millet, G.S.P.: The Definition and rendering of terrain maps. *ACM SIGGRAPH Computer Graphics* 20(4), 39–48 (1986)
7. Voss, R.D.: FRACTALS in NATURE: characterization, measurement, and Simulation. In: SIGGRAPH (1987)
8. Wang, S.-l., Zhang, L.: *Game Programming All in One*, pp. 451–458. Posts & Telecom Press, Beijing (2003)
9. Barabasi, A.L., Stanley, H.E.: *Fractal Concepts in Surface Growth*. Cambridge University Press (1995)
10. Ashikhmin, M.: Synthesizing natural textures. In: Proceedings of ACM Symposium on Interactive 3D Graphics, North Carolina, pp. 217–226 (2001)
11. Sun, M.-J., Li, D., Sun, J.-Z.: Texture Synthesis-based System Simulation for Chinese Landscape Painting. *Journal of System Simulation* 16(10), 2317–2320 (2004)
12. Li, X.-X.: Creating for 3D digital Chinese ink-wash landscape paintings based on Maya. In: Proceedings of International Workshop on Digital Media and Digital Content Management (DMDCM 2011), pp. 13–17. IEEE Press (2011)