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THE BRUSH STROKE RENDERING FOR CHINESE COLORED INK PAINTING

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ABSTRACT

Chinese ink painting is a traditional art over three thousand years old. Differing from Western art, Chinese ink painting emphasizes the meaning of the picture and spirit of the artist rather than portraying realistic space relations and shadows. Simulating Chinese colored ink painting is challenging because ink brush and diffusion are complex. This paper presents the idea of using shape contours and skeleton streamlines as substitutes for trajectories in interactive ink painting. Accordingly, the brush path estimation has been formulated as an optimization of a vector function for contours or skeletons. Moreover, this study also analyzes the effect of each term on the quality of the rendered brush stroke. The main contribution of this paper is providing a framework of Chinese colored ink painting creation. This paper does not only discuss the process of contours and skeleton streamlines, but also propose a novel method for ink diffusion.

Keywords: Non-Photorealistic Rendering, Chinese colored ink painting, Ink diffusion, Brush stroke, Streamlines, Contour.

1. INTRODUCTION

Chinese ink painting synthesis is one of approaches to complicated stylized processing in non-photorealistic rendering. Artists use the characteristics of ink, water and rice paper, as well as the interactions of these elements to express their creativity. Generally, a Chinese ink artist can apply thousands of styles while painting by combining different brush strokes with rich ink gradations. The key perception behind our work is the importance in the painting process of shaping areas and applying color, which are both geometrically rich and consistent with the scene. Previous works on the interactive simulation of brush strokes show that these require a user to specify the trajectory of the brush. The stroke shapes that can be generated by this simple interaction are very limited. Some previous works, based on image-based algorithms rendered by painters, automatically synthesized an image with color ink diffusion. Although, these approaches provided information about the color, they lacked the features of Chinese ink painting.

Literati painting is one of famous styles in Chinese painting. However, the literati lifestyle and attitudes are very important for the style of painting. The subject of literati painting is usually objects in daily life, such as flowers, fruit and vegetables, fishes, birds and other animals. Chinese paintings do not have a single perspective; every area of the painting is interesting to the eye. Another feature of Chinese paintings is that blank spaces are commonly used. In summary, Chinese ink paintings focus primarily on the combination of shape and color. Ink brush strokes delineate the subject. Additionally, color is utilized to flesh out the subject.

Based on the above analysis, this paper proposes a framework for synthesizing Chinese colored ink painting. User collages nature objects from any photos to create a picture without background. Our proposed algorithm automatically estimates the stroke path for objects. A complex shapes can be drawn with many strokes by means of automatic shape decomposition. This paper also presents a set of new methods for rendering the Chinese colored ink painting. The

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proposed drawing technique involves many fundamental parts. First, an object is extracted to detect the edges of the silhouettes. On this basis, all contour outline strokes are constructed. Second, streamlined skeletons of the object are generated according to the silhouettes and object's features. Third, brush strokes are then applied to create an outline drawing or boneless painting using vertical or slanted strokes along the lines path. A rich ink tone of brush stroke is specified by a photo's luminance map. Finally, the color ink diffusion on the rice paper is simulated.

2. RELATED WORKS

Recently, Many NPR (Non-Photorealistic Rendering) papers have been proposed to simulate traditional artistic media and styles, such as pen and ink illustration, graphite and pencil drawing, impressionist styles, paintings of various materials including oil, water color. More general surveys on computer simulation to NPR can be found in the literatures [6]. For drawing in NPR, there are two major research areas: the transformation from 2D images and direct rendering of 3D scenes. Many Researches has demonstrated artistic styles in the rendering of 2D paintings. In this section, only related papers are discussed briefly about stroke-based rendering and brush-stroke rendering. SBR (Stroke-based rendering) methods simulate the rendering effects directly on 2D canvas from real photos. Brush-stroke rendering methods construct the physical properties of the brush that interact with paper using the ink diffusion process.

2.1 Stroke-Based Rendering

Researchers have developed many SBR algorithms and styles such as painting, pen-and-ink drawing, stippling, streamlines visualization and tensor field visualization. This area incorporates a wide variety of methods for pen-and-ink paintings and visualization renderings. Stroke placement is very challenging in SBR. Each stroke's position, shape, size and orientation are specified manually in the early work. Some works proposed that a painting image filter might be created based on a scanned painting made by a famous artist. These approaches are far easier than writing a function to describe the painting skill of a famous artist. However, only some aspects of a style may be captured.

Hertzmann [8] surveyed the state of the art in the stroke-based rendering. This paper describes an approach that automatically creates non-photorealistic images by applying distinct strokes such as paint strokes or stipples. Some papers emphasized algorithms with higher degrees of automation and the possibility of generating a variety of stroke shapes. These are mainly guided by the low-level features of the image, such as the gradient at multiple scales [10], geometric moments and texture orientations [14], weighted edges and ridges [11], or the medial axis of regions obtained after segmentation [7]. Other developments were concerned with the use of global saliency maps [4] or human perception models [5] to determine the position and the order in which strokes are placed. Zhao [22] provided an interactive image parser which performs the tasks of segmentation and hierarchical organization. They also automatically generate corresponding abstract painting images. Zeng [23] addresses the issue of semantics in the rendering of paintings using parsing techniques. Any input image is hierarchically segmented producing a wide range of semantically plausible visual patterns.

2.2 Brush-Stroke Rendering

Brush-stroke approaches are attractive, since they allow the user more flexibility and control over the type of NPR effects without requiring any painting expertise. A number of papers have addressed methods for simulating brush strokes and the behavior of ink in colored ink painting. The brush has been modeled as a collection of bristles that move in the course of the stroke. Jintae Lee [12] rendered black ink paintings that applied new paper and ink diffusion models. Our previous work [16] implemented the effects of brush stroke that combines two mechanisms: stroke geometry and brush profile. Baxter [1] presented a geometric and dynamic model that exploits the bristle-to-bristle coherence to simulate only a fraction of the bristles. Chu and Tai [3] extended their previous work to simulate ink painting in real applications with the lattice Boltzmann equation. We also proposed a method that simulates various tonal expressions on different papers by employing a Kubelka-Munk model to simulate optical effects [17]. Elucidation of the effect of mixing simulated strokes with different brushes is a significant contribution by the proposed method. Baxter [2] simplified and accelerated the simulation of the constrained dynamics of the brushes by using a small lookup table that efficiently encodes the range of feasible states of constraints.

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In the latter approaches, many methods were created for special purposes. We developed a novel method for rendering wrinkles in Chinese landscape painting [18]. A three-dimensional terrain is drawn as an outline and wrinkles using information on the shape, shade and orientation of the terrain's polygonal surface. Li [13] proposed another object-controlled, multi-level texture synthesis algorithm that could control the synthesis result efficiently using a control picture. Using this method, a photo or a simple script could automatically be converted into a Chinese-style picture. Wang [15] offered an image-based rendering algorithm for automatically synthesizing an image with colored ink diffusion. Zhang [24] presented a novel algorithm for synthesizing animations of running water, such as waterfalls and rivers, in the style of Chinese paintings, for applications such as making cartoons. Xie [19] provided an novel idea that use shape contours instead of trajectories for interactive to imitate Sumi-e painting. They also provided a sketch-based system for rendering oriental brush strokes on complex shapes from real photos [20].

3. INK DIFFUSION

Ink diffusion is an important skill to show stereo and gradation. Normally, water diffusion happens above and inside the paper. Water flows above the paper. After a while, it is absorbed into the paper and diffused by a capillary phenomenon. Yu [21] proposed a layer model which represents the movement of water and pigment between neighboring cells into the paper. A rice paper is composed of paper cells. Each paper cell is called a papel. Each papel has eight neighboring papels which are connected by fiber. The number of fibers which connect two neighboring papels is determined randomly. To represent the diffusion phenomenon, the layer model is proposed. In the layer model, each papel inside the paper is divided into three layers: surface layer, absorption layer and deposition layer. Besides, there is also a "shallow-water layer" above the paper. Figure 1 represents the layer model.

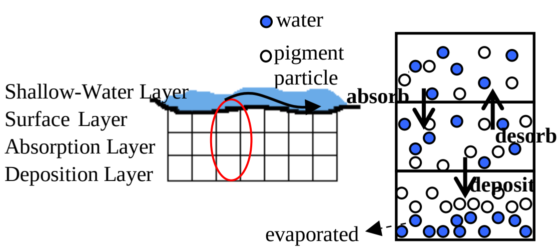

Figure 1. *The layer structure of papel.*

3.1 Diffusion Phenomena Simulation

The initial water and pigment quantity is $F(W,P)$. When water particles move, pigment particles move with them. Pigment particles are suspended and move in this liquid since they collide with water particles. In hydrodynamics, the Navier-Stoke Equation describes fluid motion which considers viscous fluid. Equation (1) is the 2D Navier-Stokes Equation:

$$\frac{\partial u}{\partial t} = -(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}) + \mu\nabla^2 u - \frac{\partial p}{\partial x}$$
$$\frac{\partial v}{\partial t} = -(u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}) + \mu\nabla^2 v - \frac{\partial p}{\partial y} \qquad (1)$$

where u is velocity in x direction, v is velocity in y direction; μ is viscosity and p is water pressure.

The water and pigment quantity movement to neighboring papels in x direction is $u \cdot F(W,P)$ and y direction is $v \cdot F(W,P)$. The Navier-Stokes Equation is used to simulate water flowing above the paper. At the same time, water and pigment also are absorbed by the surface layer; the quantity absorbed in the surface layer is determined by the constant ratios:

$$W^f_{i,j} = W_{i,j} \cdot s$$
$$P^f_{i,j} = P_{i,j} \cdot s \qquad (2)$$

where $W^f_{i,j}$ and $P^f_{i,j}$ denotes the quantity of water and pigment absorbed by the surface layer. $W_{i,j}$ and $P_{i,j}$ denote the quantity of water and pigment in the shallow-water layer. In the surface layer, water flows to neighboring papels if $W_{i,j} > W^k_{i,j}$. $W^k_{i,j}$ denotes the water quantity of the k'th neighboring papel. The quantities of $W^k_{i,j}$ and $P^k_{i,j}$ are determined by the following equations:

$$W^k_{i,j} = \varepsilon \cdot W_{i,j} \cdot (\alpha_1 \frac{N(f^k_{out})}{N(f_{out})} + \alpha_2 \frac{(W_{i,j} - W^k_{i,j})}{W_{sum}}) \qquad (3)$$
$$P^k_{i,j} = \varepsilon \cdot P_{i,j} \cdot (\alpha_1 \frac{N(f^k_{out})}{N(f_{out})} + \alpha_2 \frac{(W_{i,j} - W^k_{i,j})}{W_{sum}})$$

$$W_{sum} = \sum_{k=1}^{8} u(W_{i,j} - W^k_{i,j}) \qquad (4)$$

where $N(f_{out})$ denotes the total number of neighboring fibers which are connected to the papel $P_{i,j}$ and the water quantity is smaller than $W_{i,j}$. $N(f_{out})$ denotes the number of fibers which connect $P_{i,j}$ and $P^k_{i,j}$. α_1 and α_2 are weights and ε is an adjusting parameter. The unit function is $u(x)$. (i.e., if $x \geqq 0$, then $u(x)=x$; otherwise, $u(x)=0$.)

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The water and pigment absorbed by the absorption layer are determined by the following equation.

$$W^a_{i,j} = W_{i,j} \cdot (\alpha - (\alpha - \beta) \cdot \frac{W^d_{i,j}}{W_t})$$
$$P^a_{i,j} = P_{i,j} \cdot (\alpha - (\alpha - \beta) \cdot \frac{W^d_{i,j}}{W_t}) \quad (5)$$

where $W^a_{i,j}$ and $P^a_{i,j}$ denote the absorbed quantity of water and pigment. α and β denote the maximum and minimum absorption ratio, respectively. W_t denotes the maximum quantity of water which could be deposited in the deposition layer. $W^d_{i,j}$ denotes the remaining water quantity in the deposition layer.

The absorbed water and pigment are desorbed into the surface layer or deposition layer. The desorbed quantity that passes to the surface layer is determined as follows.

$$W^{ds}_{i,j} = W^a_{i,j} \cdot (\gamma + (\rho - \gamma) \cdot \frac{W^d_{i,j}}{W_t})$$
$$P^{ds}_{i,j} = P^a_{i,j} \cdot (\gamma + (\rho - \gamma) \cdot \frac{W^d_{i,j}}{W_t}) \quad (6)$$

where $W^{ds}_{i,j}$ and $P^{ds}_{i,j}$ denotes the desorbed quantity, γ and ρ denote the maximum and minimum desorption ratio, respectively. The quantity deposited in the deposition layer is determined by the constant deposited ratio d:

$$W^d_{i,j} = W^a_{i,j} \cdot d, \quad if \quad W^d_{i,j} < M_{cup}$$
$$P^d_{i,j} = P^a_{i,j} \cdot d, \quad if \quad W^d_{i,j} < M_{cup} \quad (7)$$

where $W^d_{i,j}$ and $P^d_{i,j}$ denotes the quantity of water and pigment deposited. M_{cup} is the maximum quantity of water able to be stored in the deposition layer.

3.2 Diffusion Process

Normally, water particles in the outermost region of an area diffuse first. Water particles in the next outermost region diffuse right after the first diffusion. In reality, the wet region will dry out gradually. This phenomenon is called evaporation. The evaporation of water is a complicated process in which many factors play a role. One important factor is the area in contact with the air [9]. If all other factors are equal, a larger contact area results in a higher rate of water evaporation. Based on the equality of the contact area of all papels, the rate of water evaporation in each papel of the paper is approximately equal. There is another important factor which is contrary to the evaporation of water, namely humidity [9]. For the sake of simplicity and the demands of our theorem, the number of water particles evaporated in papel p at step t-th, E^t_p, depends on the humidity H ($0 \leqq H \leqq 1$) and is expressed by the equation $E^t_p = h(1-H) \times Water_p$, where $Water_p$ is the number of water particles in papel p, and function $h(x)$ yields a coefficient for the evaporation of water, where $0 \leqq x \leqq 1$. Figure 2 shows an example of the function $h(x)$. The lower the humidity, the greater is the amount of water evaporated.

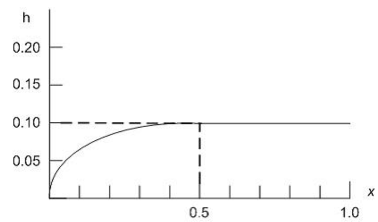

Figure 2. *Function h(x) for determining the quantity of water evaporated.*

Figure 3 show the result of ink diffusion. The results of the process which only uses one layer model are shown in the first row. The results of our proposed model are shown in the second row.

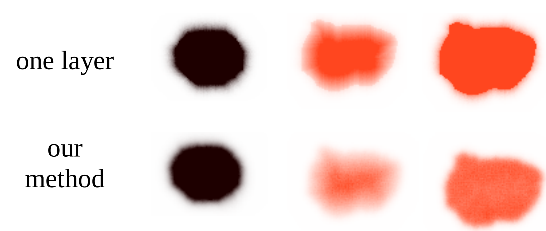

Figure 3. *Samples results of ink diffusion*

4. CONTOUR AND SKELETON STREAMLINES GENERATION

Contour detection is important in image processing. Many researchers have studied the processing of contour figures. Boneless painting is a Chinese painting skill whereby the artist does not use an ink brush to draw the contours of the object, but rather shapes it using skeleton streamline to draw the brush stroke. In summary, they usually paint in the direction of the longer length, thus using fewer strokes to complete an object in a simple style. However, all lines drawn based on the above characteristics are explicit in changeful thickness. The stroke line model is modified from our previously proposed method [17, 18]. The stroke line simulation is constructed

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considering the line width change features. This paper presents the idea of using shape contours and skeleton streamlines as substitutes for trajectories in interactive ink painting. Accordingly, the brush path estimation has been formulated as an optimization of a vector function for contours or skeletons.

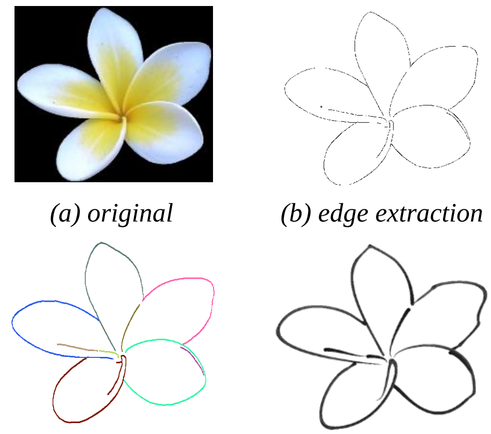
4.1 Contour Sketching

In Chinese ink painting, sketching the contour is the first step. A contour is usually the draft for dyeing. Then, an artist sketches contours again by using thick ink or any other preferred color which may make the creations more vivid. Many edge detector algorithms find object's the silhouettes in an image. The gradient of color in an image could be computed to determine the location of outlines.

An artist sketches a line once based on the shape of the object. Accordingly, all connected pixels form one stroke. The first task is to make judgments of connections to link points in the neighborhood. Figure 4 illustrates the contours of petals. To avoid the disconnections, a 5×5 pixel window is used for connection checks. Based on the following rules, Figure 4(c) illustrates the connection lines of pixels in the same color which are considered to be a stroke line. By applying the following rules, the connection between two petals could be cut off to get more reasonable and suitable stroke lines.

1. The pixel whose links are fewer than threshold pixels will be eliminated to avoid lines that are too short or that have noise interference.
2. If two connected pixels accumulate a variation of the gradient's direction by more than 90 degrees, they are cut off.

The goal of vectorization is to allow the pixels of a stroke to be represented by a polynomial. Thereby, a curved stroke could be formed according to the tangent line gradient, starting point and end point. The input of this algorithm is a group of sequential pixels. Then the algorithm will output several Bezier curves to approach the inputs. Our algorithm mainly uses the mathematical least-squares fitting method to generate the four control points of a cubic Bezier curve. First, an approximated curve approaches the input pixels. If this curve is far from the original inputs, all of the pixels will be divided into two parts by a pixel p that has the largest deviation. A Bezier curve will approach each sub-part. All pixels will be subdivided again, if the deviation is still too large. According to above process, all pixels will be recursively subdivided into two subsequences until acceptable curves are generated. A smooth curve can show the resilience of a flower. After vectorization, the brush model is applied to generate each stroke. Figure 4(d) demonstrates the contour sketching of ink brush stroke.



(a) original *(b) edge extraction*

(c) stroke line path *(d) ink brush stroke*

Figure 4. *A contour sketching example*

4.2 Skeleton Streamline Generation

Generally, the skeleton of an object may be defined as the set of all points equally distance from border by the medial axis transformation (MAT). A good thinning method should produce skeletons including the shape information of original object. In Chinese boneless painting, a skeleton is the trajectories of a filled ink brush stroke's center. Skeleton streamlines are the set of all brush stroke trajectories in a boneless painting. This paper presents a novel method for skeleton streamlines generation for ink brush stroke from an input image.

Skeleton streamlines are generated from previously defined silhouette strokes. First, each stroke is shrunk in an inner direction according to its center. Then, the overlap of the new shrunk stroke and the original stroke is computed. If the overlap ratio is over the user-defined threshold, the stroke will be defined as a contour stroke; otherwise, it is identified as the skeleton streamline. Figure 5 explains the process of boneless painting.

During painting, the brush size of a skeleton streamline should change with the size of the sub-area. In order to avoid exceeding the range that needs to be filled, the skeleton streamline is adjusted by the following method. First, the shrunk distance of the

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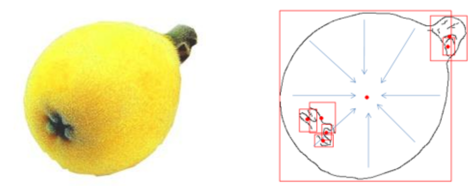
radius is the largest width of brush size. Next, if the shrunk stroke cannot maintain the original shape, adjust the distance till it passes the test. Then the width is the brush size for that stroke. Finally, various brush sizes for each skeleton streamline would be obtained.



(a) original image *(b) shrink the pixels*

(c) streamlines *(d) boneless painting*

Figure 5. *Example of boneless painting*

Normally, skeleton streamlines of an object are approximate straight line strokes, circular strokes or half circle strokes. First, the width and longest distance of a stroke are computed. Then it is possible to compute the ratio of the length and width. If the object is small enough and the length almost equal to the width, then the circular stroke will be used, such as drawing a cherry. If the object is bigger and needs more than one stroke to fill it, then it is cut and new streamlines are grown with former computed brush sizes, according to the following algorithm pseudo code:

```
if (the length almost equals to the width)
{
  stroke's direction as original;
  while (not filling the subarea)
  {
    stroke's direction is the direction of the length;
    streamline grows inside by shrinking the distance
    of brush size;
  }
}
else
{
  stroke's direction is max(length, width);
  streamline grows inside by shrinking the distance of
  brush size;
  if (not filled the subarea)
  {
    While (not filling the subarea)
    stroke's direction is another one;
  }
}
```

Figure 5(b) shows silhouettes. Figure 5(c) shows many streamlines for loquat flesh. Since streamlines and the brush size in a stroke are vary after vectorization. The final result of strokes will not be as regular as the streamlines shown in Figure 5(d).

5. EXPERIMENTAL RESULTS

As mentioned before, the subject of literati painting is usually objects in daily life. Additionally, non-single perspective and blank space are two important features in Chinese painting. Base on these principles, user collages many objects in a picture with a white background. A colored ink painting is created using our proposed methods. Figure 6 demonstrates the simulation process of fine-brush flower painting. First, the flower's contours and the branch's skeleton are extracted. Then, Figure 6(b) shows contour line drawing and Figure 6(c) shows ink diffusion. Finally, the result of this example is shown in Figure 6(d). Figure 7 shows another Chinese colored ink painting of orchid.

Figures 8 illustrate a boneless painting. Figure 8(a) shows an original image, and the final result of this example is shown in Figure 8(b). More simulated results are shown in Figure 9. After our system had combined the results of contour sketching and ink diffusion, we applied a background. The background was generated according to the position of the fishes. The pixel body of the nearer fish body is a deep green color and the color changes gradually as the distance of the fish increases. Figure 10(b) shows the results of contour line sketching. Figure 10(c) shows the result of fish colored ink painting.

6. CONCLUSION AND FUTURE WORK

This paper developed a set of novel methods for Chinese colored ink painting. The main contribution of this paper is providing a framework of Chinese colored ink painting using traditional Chinese brush ink and diffusion techniques. First, an object is extracted to detect the edges of the silhouettes. Once detected, all contour outline strokes are constructed. Second, the streamlines of the object's skeleton are generated according to the silhouettes and the features of the object. Third, brush strokes are applied to create an

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outline drawing or boneless painting using vertical or slanted strokes along the lines path. Finally, the ink color diffusion on the rice paper is simulated. Therefore, users without any painting skill may generate Chinese colored ink painting easily by using the proposed system.

This work has opened up some topics for future research. Future studies should address the following issues to build upon the ideas presented here. Chinese painting is one of the oldest traditional art forms in the world, especially as different schools were developed in different dynasties. This work focuses on contour line drawing, boneless painting and colored ink painting. Although these are the most common techniques in Chinese painting, there are many others schools that could be developed in future work. The division and planning in a painting is an important work. How should objects in a scene be placed and arranged? It would be very interesting work to do research into the correspondence of composition, space and depth.

Reference

[1] Baxter, W. V. and Lin, M .C. (2004). A versatile interactive 3d brush model. *Proceedings of the 12th Pacific conference on computer graphics and applications.* IEEE Computer Society, 319–328.

[2] Baxter, W. and Govindaraju, N (2010). Simple data-driven modeling of brushes. *Proceedings of the ACM SIGGRAPH symposium on interactive 3D graphics and games.* 135–142.

[3] Chu, N. and Tai, CL. (2005). MoXi: real-time ink dispersion in absorbent paper. *ACM Transactions on Graphics*, 24, 504–511.

[4] Collomosse, J.P., Ay, B.B., Hall, P.M. (2006). Salience-adaptive painterly rendering using genetic search. *International Journal on Artificial Intelligence Tools*, 15, 551–575.

[5] DeCarlo, D. and Santella, A. (2002). Stylization and abstraction of photographs. *Proceedings of ACM SIGGRAPH*. 769–776.

[6] Geng, W. (2010). The Algorithms and Principles of Non-photorealistic Graphics. *Springer-Verlag Berlin Heidelberg.*

[7] Gooch, B., Coombe, G., Shirley, P. (2002). Artistic vision: painterly rendering using computer vision techniques. *Proceedings of NPAR*. 83–90.

[8] Hertzmann, A. (2003). A survey of stroke-based rendering. *IEEE Computer Graphics and Applications,* 23, 70–81.

[9] Huang, S. W., Way, D. L., Shih, Z. C. (2003). Physical-based model of ink diffusion in Chinese paintings. *Journal of WSCG*, 10(3), 520-527.

[10] Kovacs, L. and Sziranyi, T. (2004). Efficient coding of stroke-rendered paintings. *Proceedings of the 17th international conference on pattern recognition*, IEEE Computer Society, 835–838.

[11] Kovac, L. and Sziranyi, T. (2004). Painterly rendering controlled by multiscale image features," *Proceedings of the 20th spring conference on computer graphic,* ACM SCCG2004, 177–184.

[12] Lee, J. (2001). Diffusion rendering of black ink paintings using new paper and ink models. *Computer & Graphics,* 25, 295–308.

[13] Li, D. (2009). Automatic rendering for Chinese landscape painting using texture synthesis. *Journal of Computer Applications*, 29(9), 2406-2410.

[14] Shiraishi, M. and Yamaguchi, Y. (2000). An algorithm for automatic painterly rendering based on local source image approximation," *Proceedings of NPAR,* 53–58.

[15] Wang, C. M. and Wang, R. J. (2007). Image-Based Color Ink Diffusion Rendering. *IEEE Transactions on Visualization and Computer Graphics,* 13, 235-246.

[16] Way D. L. and Shih, Z. C. (2001). The Synthesis of Rock Textures in Chinese Landscape Painting. *Computer Graphics Forum,* 20, 123–131.

[17] Way, D. L., Lin, W. J., Shih, Z. C. (2006). Computer generated Chinese color ink paintings. *Journal of the Chinese Institute of Engineers,* 29(6), 1041-1050.

[18] Way D. L. and Shih, Z. C. (2006). Wrinkle Rendering of Terrain Models in Chinese Landscape Painting. *IEICE Transactions on Information and Systems,* E89-D (3), 1238-1248.

[19] Xie, N., Laga, H., Saito, S., Nakajima, M., (2010). IR2s: interactive real photo to Sumi-e," *Proceedings of NPAR.* 63–71.

[20] Xie, N., Laga, H., Saito, S., Nakajima, M., (2011). Contour-driven Sumi-e rendering of real photos. *Computers and Graphics,* 35, 122-134.

[21] Yu Y. J. and Lee, D. H. (2003). Interactive Rendering Technique for Realistic Oriental Painting. *Journal of WSCG,* 11(1), 538–545.

[22] Zhao, M. and Zhu, S. C. (2010). Sisley the Abstract Painter. *Proceedings of the 8th International Symposium on NPAR,* 99-107.

[23] Zeng, K., Zhao, M., Xiong, C., Zhu, S.C. (2010). From image parsing to painterly rendering," *ACM Transactions on Graphics,* 29, 1–11.

[24] Zhang, S. H., Chen, T., Zhang, Y. F., Hu, S. M., Martin, R. (2009). Video-based running water animation in Chinese painting style. *Science in China Series F: Information Sciences,* 52(2), 162-171.

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(a) original image *(b) contour sketching*

(c) ink diffusion *(d) colored ink painting*

Figure 6. *Simulation process of fine-brush painting*

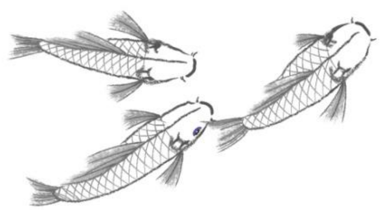
(a) original image *(b) colored ink painting*

Figure 7. *Orchid colored ink painting*

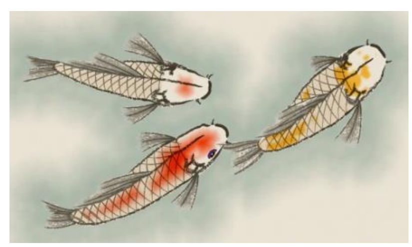
Figure 8. *Experimental result of boneless painting*

Figure 9. *Experimental result of boneless painting*

(a) original image



(b) contour sketching



(c) colored ink painting

Figure 10. *Fish colored ink painting*