Generation of Indian Ink Painting Image from Two-Dimensional Image Data

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ABSTRACT

Recently, non-photorealistic image rendering (NPR) has become the subject of research and development by many researchers due to a rapid improvement in computer graphics. NPR has been used for communication by emphasizing an image or to simulate existing painting techniques. In this paper, we propose a generation method for Indian ink painting image which is an Oriental painting technique from two-dimensional realistic image. In general, Indian ink painting has three kinds of drawing techniques, "Senbyo " technique to draw only contours of objects, "Mokkotu**"** technique to draw only the interior of objects and "Senzen" technique to draw both contours and the interior of objects. In this paper, we simulate Indian ink painting by "Senzen" technique. We extract the contours from two-dimensional realistic image and decide the interior of the object in order to generate the image which is drawn by "Senzen" technique. The final image is generated by combining the inner area of the object with the contours. We generated several Indian ink painting images by our method. The experimental results show that the proposed method is effective for Indian ink painting image rendering.

Keywords

NPR, Indian ink painting , bilateral filter, Fourier transform

1. INTRODUCTION

The driving force behind computer graphics has been photorealism until now. Recently, NPR has been active area of research with most of the wrok concentrating on generating images in various traditional styles. NPR is classified in a method for communication and a method to express existing painting techniques. Many methods to express existing painting techniques are proposed. Haeberli [Haeberli] describes a stroke based algorithm using the haloed line effect. Kim et al. [Kim] describe a method by pointillism. Kang et al. [Kang] describe a method of generating many kinds of images, such as oil painting, watercolor painting and stripping, by changing the feature of the stroke. However, Indian ink painting has not received as much focus. Satoh et al. [Satoh] give a method of generating Indian ink painting.

It is necessary to use a three dimensional object as an input data to their method. Therefore, we propose a method for generating Indian ink painting from a two-dimensional realistic image. In general, Indian ink painting has three kinds of drawing techniques, "Senbyo " technique to draw only contours of objects, "Mokkotu" technique to draw only the interior of objects and "Senzen" technique to draw both contours and the interior of objects. In this paper, we simulate Indian ink painting by "Senzen" technique.

2. PROPOSED METHOD

We generate Indian ink painting by giving several filter processings against two-dimensional objects in an input image. After smoothing input image by bilateral filter, we extract the contours and decide the interior of the object in order to generate the image which is drawn by "Senzen" technique. The final image is generated by combining the interior with the contours. A flow of the method is shown in Figure 1.

2.1 Smoothing

The features of Indian ink painting are as follows;

1) Line is drawn along a boundary of the object by a painting brush.

2) The light and shading of India ink changes smoothly along the boundary.
3) There are few blurs of India ink near the boundary of the object and the boundary is clear.

Based on these features, we use bilateral filter [Tomasi],etc. along the boundary in order to smooth the image while maintaining contours of the object.

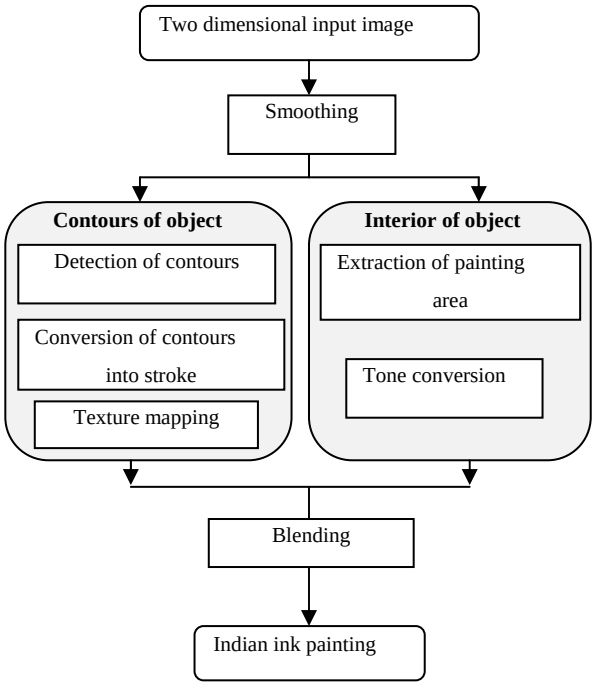


Figure 1. A flow of the method.

First, the input image is converted to a gray scale image. We calculate the gradient vector of every pixel of the gray scale image and the tangent vector that is perpendicular to the vector by using sobel filter. Using the tangent vector, bilateral filter is applied to the gray scale image along the boundary of the object. The weight of Gaussian distribution σ_g of the gradient vector direction in every pixel is calculated using the gradient vector ***g***, as follows;

$$\sigma_g(x,y) = (1 - g(x,y))\sigma_t \qquad (1)$$

where σ_t is the weight of Gaussian distribution of tangent vector direction.

2.2 Detection of object contours

We apply Laplacian filter to the image which was smoothed and extract the pixels to constitute edges by image thresholding. Figure 2 shows an example of the input image and the boundary image.

(a) **(b)**

Figure 2. Edge extraction:

(a) Input image; (b) Binary image.

Extracted pixels are converted to poly line data by vector trace method [Agui] and B-spline stroke data are generated by vertices of the ploy line data. We map the brush texture data shown in Figure 3 on the stroke data by texture mapping technique. As a result, we get the image shown in Figure 4.

Figure 3. Texture data of contour.

Figure 4. The result of texture mapping.

2.3 Extraction of painting area

The interior of the object is painted with light Indian ink in “Senzen” technique. It is necessary to extract the interior of the object to be painted. Our method extracts the area in the smoothed image by frequency filtering. The image is converted into spatial frequency domain image by Fourier transform. In general, the light and dark shading near the contour is thicker than the shading of the inner part in Indian ink painting.

Therefore, we emphasize middle frequency of spatial frequency domain image and remove the low frequency using the equations;

$$H(u,v) = H_{high}(u,v) + H_{b-emph}(u,v) \qquad (2)$$

$$H_{high}(u,v) = 1 - G(u,v,\sigma_1) \qquad (3)$$

$$H_{b-emph}(u,v) = N(G(u,v,\sigma_2)G(u,v,\sigma_3)) \qquad (4)$$

$$G(u,v,\sigma) = \exp\left(-\frac{u^2+v^2}{2\sigma^2}\right) \qquad (5)$$

where u is the frequency component of the X axis direction, v is the frequency component of the Y axis

direction, and N is a function to normalize a value to 1 from 0, σ_1 is the variance of high-pass filter, and σ_2, σ_3 are the variances to emphasize the light and dark shading near the contour.

Indian ink painting has the characteristic that the part of low brightness is painted with Indian ink. We reverse the sign of frequency before inverse Fourier transform process is executed in order to express this characteristic. We get the Indian ink painting image for the interior of the object shown in Figure 5 by reversing the image.

Figure 5. Indian ink painting for the interior.

2.4 Tone conversion

Indian ink painting has the characteristic that we sometimes paint the interior of the object over again by the different light and dark shade. The inner part of red circle in Figure 6 shows an example of this characteristic.

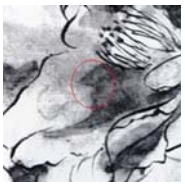


Figure 6. Expression of the area of an object.

We emphasize the boundary of light and dark shade by using tone conversion function [Winnemoller] in equation (6)-(8) in order to express this characteristic. Converted image *R(x,y)* is calculated as follows;

$$R(x,y) = q_{near} + \frac{\Delta q}{2}\tanh\left(\varphi\left\{I(x,y) - \left(q_{near} + \frac{\Delta q}{2}\right)\right\}\right) \quad (6)$$

$$q_{near} = \frac{[(q-1)f(x,y)]}{q-1} \quad (7)$$

$$\Delta q = \frac{1}{q} \quad (8)$$

where *I(x,y)* is the image before conversion, φ is the parameter of smoothness of tone boundary, and q is the number of the tone for conversion.

For example, the image of the result in Figure 7 is generated when we use the function in Figure 8 ($q = 5, \varphi = 30$).

Figure 7. Converted image.

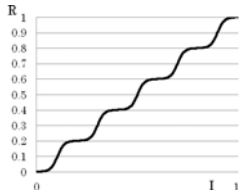


Figure 8. Conversion function.

2.5 Blending of image

We compose the image of the contour generated in 2.2 and the image of the interior generated in 2.3 by using alpha blending. The final image *O(x,y)* is calculated by equation (9) and (10).

$$O(x,y) = \alpha(x,y)T(x,y) + (1-\alpha(x,y))R(x,y) \quad (9)$$

$$\alpha(x,y) = 1 - T(x,y) \quad (10)$$

where *T* is the image of the contour generated in 2.2 and *R* is the image of the interior generated in 2.3. Figure 9 shows the image that blends Figure 4 and Figure 7.

Figure 9. Blended image.

3. EXPERIMENTS AND RESULTS

We experiment to verify the effectiveness of our method.

Figure 10 shows three kinds of two-dimensional image that we use as input images. There is one object in each image, Japanese persimmon, leaf and Japanese maple.

(a)

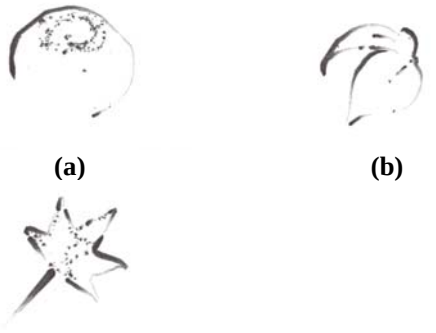
(b)

(c)

Figure 10. Input images: (a) Persimmon; (b)Leaf; (c)Japanese maple.

Figure 11 shows the results of contour painting and Figure 12 shows the results of interior painting. The

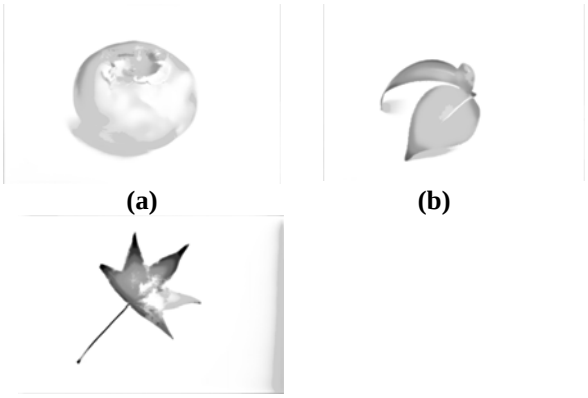
final blending image shows in Figure 13. The contours of Indian ink painting are expressed on the boundary of the object in Figure 11 and light and dark shading near the contour is thicker than the shading of the inner part shown in Figure 12.



(a) **(b)**

(c)

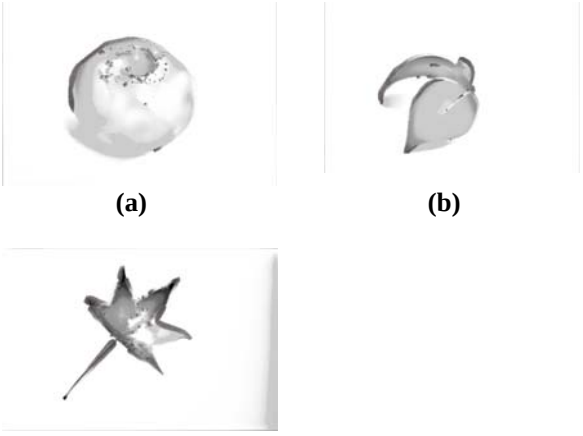
Figure 11. The result of contour painting: (a)Persimmon; (b)Leaf; (c)Japanese maple.



(a) **(b)**

(c)

Figure 12. The result of area painting: (a)Persimmon; (b)Leaf; (c)Japanese maple.



(a) **(b)**

(c)

Figure 13. Blended images: (a)Persimmon; (b)Leaf; (c)Japanese maple.

4. CONCLUSION

In this paper, we proposed an automatic generation method of Indian ink painting image from a two-dimensional image. Our method generates two kinds of Indian ink painting images to express the painting by "Senzen" technique. One is contour painting of the object and the other is interior painting of the object. We achieved Indian ink painting image by blending these two kinds of images.

Experimental results showed that our method is effective.

Future work will explore the automatic generation of the tone function. The values of q and φ in equation (6)-(8) depend on the input image. In this study, we decided these values through trial and error. It is necessary to conceive a method to calculate the values of q and φ automatically according to the input image.

5. REFERENCES

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