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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 13 (7): 1401-1405, 2014
ISSN 1812-5638 / DOI: 10.3923/itj.2014.1401.1405

A NPR Technique of Pyrography Art Effects

Qian Wenhua, Yang Xiaoyu, Xu Dan, Yue Kun, Guan Zheng and Pu Yuanyuan
Department of Computer Science and Engineering, Yunnan University,
School of Information Science and Engineering, Kunming 650091, China

Abstract: To provide with an effective method for non-photorealistic rendering for computer generated images with pyrography artistic appearances from 2 D images motivates work in this study. The methods proposed in this study are inspired by the improved bilateral filter method and the smooth appearance of the image can be simulated. The character of lines, details in the real pyrograhpy can be simulated by the technique of boundaries enhancing. In addition, the simulating foreground image can be mapped to the background image such as wood, silk etc., in real time. Experimental results show that the proposed method can simulate the real pyrography effect. Because the filter and boundaries enhancing is fast, so the whole rendering can produce final result in several seconds.

Key words: Non-photorealistic rendering, pyrography effect, texture transfer

INTRODUCTION

In the past few years, non- photorealistic rendering has attracted much interest for its wide application in the real world and many research findings have been achieved, such as oil painting (Hsueh *et al*., 2012), sketch painting (Obrenovic and Martens, 2011), pencil drawing (Heekyung *et al*., 2012) etc., NPR methods make up the difficulty to convey a specific mood in a photorealistic scene. It can be used for illustrative purposes or artistic effects but this representation style is also interesting due to its appealing ability to abstract away detail, to focus on important information while downplaying extraneous or unimportant features.

Some NPR techniques are designed to realize artistic work and this work can help artists or laymen reduce their laborious. Though there are many research works to render many kinds of artistic works (Hsueh *et al*., 2012; Obrenovic and Martens, 2011), some techniques must be advanced to enrich and reflect different artistic appearances. The algorithms which are existed can not cover all the artistic works in the real world and this need us to explore more new techniques. In addition, there are few methods to simulate the traditional Chinese pyrography style.

Pyrography is arrived using burn hot soldering iron to iron out carves and art creation in the formation of fine wood, study, silk and other materials. Figure 1 shows the real pyrography style art painting. This work maintains the traditional Chinese painting national style and performances with a strong stereoscopic sense, loved by the people.

Fig. 1: Real pyrography style painting

In this study, from 2 D images, the technique for computer painting the pyrography artistic can be proposed. Reasonable quality and art effects of pyrography can be generated without any user intervention. Some contributions in this study are: (1) Simplify method is used to simulate Chinese pyrography artistic effects, (2) Bilateral filtering technique can be used to realize pyrography prospects of abstract hand-painted art style, (3) Texture mapping is applied to the foreground image and background image and the final results are more close to the real pyrography effect.

Traditional computer graphics can use color blending or image analogizing operations to synthesize artistic effects. However, the technique of color blending can not realize abstract freehand effect. The method of image analogy cost considerable time to calculate. So, there are few researchers simulate pyrography art effect through

Corresponding Author: Qian Wenhua, Department of Computer Science and Engineering, Yunnan University, School of Information Science and Engineering, Kunming 650091, China

computer. Wang used texture mapping method to realize pyrography style simulation and gourd pyrography style is also can be simulated in conjunction with image morphing (Heekyung *et al*., 2012). However, the rendering effects (Heekyung *et al*., 2012) can not outstanding abstract freehand brushwork style and the rich details and impressionistic effect does not display in the final effects.

In this study, a novel technique of pyrography artistic appearances based on bilateral filter is proposed. Observing the real pyrography image, the structure of the artistic background image of pyrography is simple. The burn hot iron can paint lines in many kinds of materials, such as wood, study, silk or gourd. The different materials can be chosen as the background image from the real world.

The foreground image of the pyrography artistic often prominent theme through abstract effect and this artistic style also can bring to the people great imagination. So, the background and foreground image can be simulated, respectively. Figure 2 shows overview of this system. The simulating foreground image can be mapped to the background image. This simulating method merges different background image and foreground image together, so this method enriches the artistic of pyrography.

PYROGRAPHY STYLE RENDERING

Filtering and quantization technique can be used to simulate pyrography's abstract freehand effect. Because the technique of bilateral diffusion filtering is fast and the abstract effect is close to the real pyrography, so this method is applied to process the input image first. In addition, real line of pyrography artistic is concise, rich and exquisite details. So, the technique of boundary enhancing method can be used to realize this character.

Bilateral diffusion filtering: Filter technique can be used to simulate freehand effect of pyrography. Tradition median filter or average filter can not produce sequential filter result. Based on the improved bilateral diffusion filtering, smooth freehand effect can be generated. Given an input image input which maps pixel locations into some feature space. Let x be a pixel location, Sur be neighboring pixels and Blur be related to the blur radius and parameter Output represent filter (Winnemoller *et al*., 2006):

$$\text{Output}(x) = \frac{\int e^{-\frac{1}{2}\left(\frac{x-\text{Sur}}{\text{Blur}}\right)^2} \text{Weight}(\text{Sur}, x) \times \text{Input}(\text{Sur})\,d\text{Sur}}{\int e^{-\frac{1}{2}\left(\frac{x-\text{Sur}}{\text{Blur}}\right)^2} \text{Weight}(\text{Sur}, x)\,d\text{Sur}} \quad (1)$$

The range weighting function weight, determines where in the image contrasts are smoothed or sharpened by iterative applications of output:

$$\text{Weight}(\text{Sur}, x) = (1 - u(x)) \times \text{Weight}'(\text{Sur}, x) + u(x) \times s(x) \quad (2)$$

$$\text{Weight}'(\text{Sur}, x) = e^{-\left(\frac{\text{Input}(x)-\text{Input}(\text{Sur})}{\text{theta}}\right)^2/2} \quad (3)$$

Generally, u and theta can be computed by a more elaborate visual salience model, derived from eye-tracking data (DeCarlo and Santella, 2002). Then u(x)! = 0, the range weighting function Weight turns into a weighted sum of weight' and an arbitrary importance field s(x) defined over the image.

Tomasi suggested computing the bilateral filter on a perceptually uniform feature space, such as CIELab, so that image contrast is adjusted depending on just noticeable differences. The Reinhard's method is used to transfer the color space from RGB to LAB (Reinhard *et al*., 2001) and the operation of nonlinear diffusion can be computed only in the L channel. Figure 3 shows freehand abstraction effects and these effects are close to the foreground of pyrography.

Boundaries enhancing: The outline of sense is sequential in the real pyrography. Edges are defined by high local contrast, so adding visually distinct edges to regions of high contrast further increases the visual distinctiveness

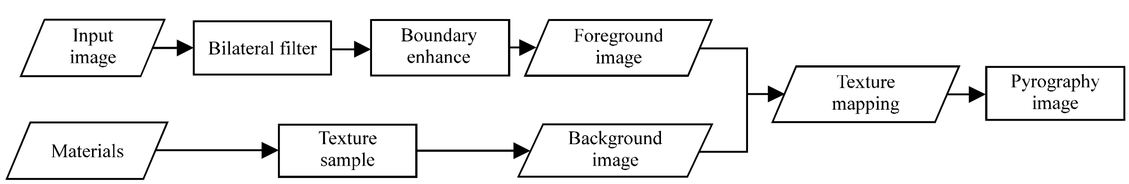

Fig. 2: Pyrography simulating process (foreground can be generated based on bilateral filter and boundary enhancement, background can be obtained from input texture sample, the final pyrography image is generated using texture mapping)

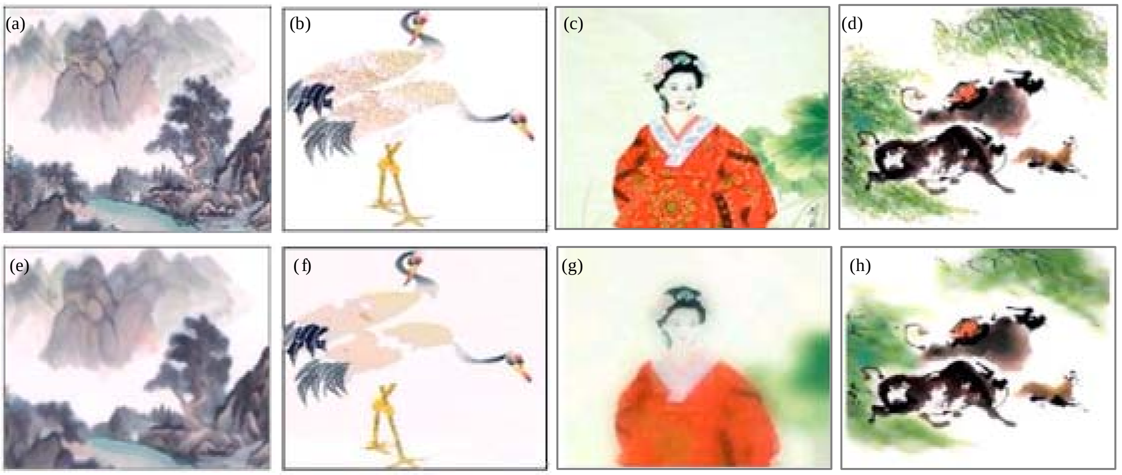

Fig. 3(a-h): Freehand effects generating (the images in first line are input image, the images in second line are freehand abstraction effect based on the bilateral filter method)

of these locations. On the other hand, the thickness of brim and brightness of tone can change with the transformation of light in rendering scene.

Let f(x,y) express input image and i(x,y) represent output image. The value of pixels in both of these images must be regularized 0 to 1. Then, the gradient of (x,y) can be defined by following vector:

$$\nabla f = \begin{bmatrix} Gx \\ Gy \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \tag{4}$$

The gradient module of *(x,y)* can be expressed:

$$\begin{aligned} \nabla F &= mag(\nabla f) \\ &= \left[\left(\frac{\partial f}{\partial x} \right)^2 + \left(\frac{\partial f}{\partial y} \right)^2 \right]^{1/2} \end{aligned} \tag{5}$$

In order to find out ideal prim of image, the color space should be transformed from RGB to YIQ and by this easy operation to decorrelate color space. The gradient modules of (x,y) are calculated, respectively in Y, I and Q. Then, prim information of every pixel can be produced. This process can be expressed by following:

$$i(x, y) = (1-\alpha) \times \nabla F_Y + \alpha \times \frac{(\nabla F_I + \nabla F_Q)}{2} \tag{6}$$

Figure 4 shows some results based on the boundaries enhancing method. From the enhancing effects, the lines are more concise and smooth and the details are richer than the input image.

Texture transferring: During the process of improved bilateral filter and boundaries enhancing, the output will show NPR artistic effect. However, the real pyrography is produced in the material such as wood, study, silk etc. So, after simulating the foreground image of the pyrograpy like Fig. 4, the foreground and background image should be merged together. The background image can be sampled from the real world.

Because the correlation characteristic is the minimum among the three channels in the LAB color space, the different images can be merged in this color space and the texture feature can be transferred to the background image. The brightness of the image is the most sensitive to the human's eyes, so the foreground image's brightness information can be changed with background image.

Let F is foreground image, B is background image, P is the final image after texture transfer. Using Reinhard's method, the color space of F and B should be changed from RGB to LAB color space (Reinhard *et al.*, 2001). Then, the texture of F and B can be merged:

$$\begin{aligned} P_L(i, j) &= F_L(i, j) \times a + B_L(i, j) \times (1-a) \\ P_A(i, j) &= F_A(i, j) \times \beta + B_A(i, j) \times (1-\beta) \\ P_B(i, j) &= F_B(i, j) \times \lambda + B_B(i, j) \times (1-\lambda) \end{aligned} \tag{7}$$

The parameter (i, j) is the pixel position in the foreground and the background image, L, A, B is the three channels in the LAB color space. The parameter α is 0.35-0.45, β is 0.2-0.3 and λ is 0.25-0.3.

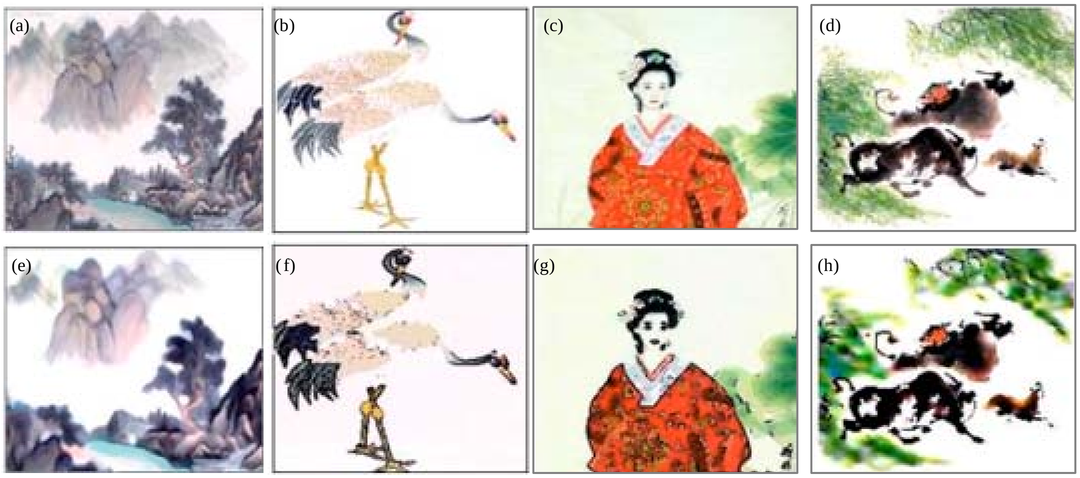

Fig. 4(a-h): Detail enhancing effects (the images in first line are input image, the images in second line are detail enhancing effect)

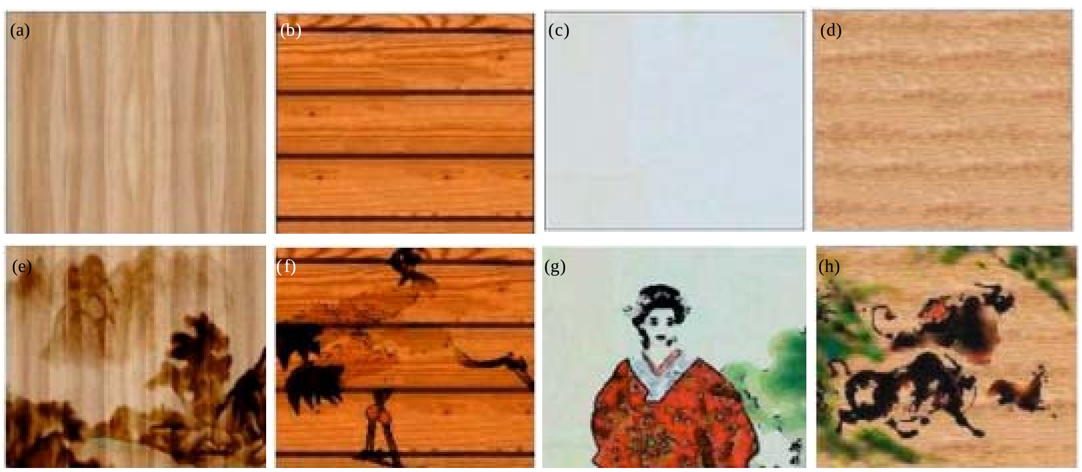

Fig. 5(a-h): Pyrography simulating effects (the images in first line are input background images, the images in second line are final artistic effects based on the texture transferring, the color and structure of freehand abstract image can be transferred to the background images)

EXPERIMENT RESULTS

To verify the feasibility and effectiveness of proposed methods in this study, the relevant algorithms are implemented and carried corresponding experiments. Figure 5 shows the experimental results. The first rows give the input images and these input images are sampled from some materials such as wood and silk. The second rows show the final effects. The whole system works on Intel Pentium (R) M processor 2.80 GHz, 1 GB PC and codes are written in Matlab 7.0. The operations are so fast that it takes less than one second for the method to synthesis final pyrography artistic effects.

From the results of Fig. 5, the lines in the final artistic are more concise and smooth; the details are richer and more prominent. The method obtaining foreground image and mapping to the background image can rich the theme of the pyrography. So, the proposed methods can simulate real pyrography artistic work.

CONCLUSION

In this study, a NPR method to simulate traditional Chinese pyrography style image is proposed. The techniques of improved bilateral filter and boundaries enhancing are used to realize smooth lines, highlight details etc. The foreground image can map to the background image such as wood and study etc. Experiments demonstrate that the approach is efficient and effective.

ACKNOWLEDGMENTS

This material is supported by the Natural Science Foundation of China No. 60663010 and 61163019, the Research Foundation of Yunnan Province Nos.2010CD024, the Research Foundation of the Educational Department of Yunnan Province No. 2012Z047, the Ministry of Education No. 20125301120008, the national experimental project of innovation of college.

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