Study and implementation of algorithm for pencil drawing automatic generation based on computer

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Abstract

Non-photorealistic rendering (NPR) as the iconology branch corresponding to photorealistic aims to generate artistic effect using computer. At present, NPR technology can successfully simulate oil painting, watercolor, cartoon, pencil drawing, etc. and has been widely applied in many fields. Pencil drawing is the monochrome that uses lines to present light and shade of objective image, and its rendering mainly includes detection and rendering of contour line and rendering of textures. This paper first introduced the research status of pencil drawing, then analyzed operator and improved algorithm based on effect implementation, used algorithm to rendering the input image into pencil drawing, and finally made the rendering effect closer to the practical drawing style of artists.

Keywords: non-photorealistic rendering, stylized silhouette, contour line, pencil drawing

1 Introduction

The objective of non-photorealistic rendering (NPR) is to assign a method for presenting painting in form, and then code and generate computer program for non-photorealistic painting works [1]. It combines the drawing principles of art and scientific technical method, processes the input image into image with handing drawing, among which, pencil drawing technology is a kind of common artistic effect form [2]. Pencil drawing style, also called sketch drawing style in art field, is the monochromes that use lines to present the light and shade of objective image. In algorithm, the rendering method of sketch is generally divided into detection and rendering of contour line and rendering of textures [3]. The detection algorithms of contour line include: using operator to process image and gain contour line (segmentation and visualization of pencil drawing is mostly Candy operator, Laplace gradient evaluation operator); customer algorithm. Algorithms of rendering of textures mainly include: add transparent texture images to contour mapping; using linear convolution to obtain pencil brush strokes; using brush filter [4]. Sun Dandan et al. proposed to adopt line integral convolution to simulate pencil texture, finally obtained good pencil drawing lines and satisfactory effects. Ren Xiaokang [6] et al. put forward a new method that use wavelet transform hierarchical processing to simulate texture of pencil drawing, and the transformation speed improves compared to the same kind of method. A kind of pencil drawing automatic generation algorithm based on texture and edge contour propose by Sang Sang [7] can realize automatic transformation of pencil drawing without image segmentation. The main task of this paper is to propose a kind of algorithm that can render input image into pencil drawing, optimize and improve the algorithm to make rendering effect closer to the drawing style of

artist, thus to achieve higher efficient rendering effect. This paper first introduced the research status of pencil drawing, then described the core algorithm in structure flow, understood the detailed implementation process of algorithm, improved the algorithm based on experiment to implement high efficient rendering effect, finally foreseen the future development of NPR technology.

2 Research status of pencil drawing

NPR refers to a graphic technology that can use computer to automatically generate image with hand drawing style but without sense of reality. Pencil drawing rendering is an important branch of NPR. Its synthetic methods can be divided into 2D image rendering and 3D model rendering. With the development of digital camera and internet, 2D rendering is advantageous over 3D rendering. In recent years, new methods for pencil drawing automatic generation appear. Lu Yan et al. proposed a new kind of expression method of pencil drawing. The method is to use image segmentation and line integral convolution to confirm the direction of line and texture, thus obtain texture of local regional pencil drawing, and then adopt contour enhancement and gray tone control implementing the edge and gray tone of artistic effect of pencil drawing, thereby obtaining the artistic effect of colorful pencil drawing. In the article of Research on Chinese Ink Painting Drawing Method Based on Image, Cao Yi [8] implemented the shaping of ink painting style through brush strokes, internal color and paper model. Among them, brush strokes is realized by confirming the length side boundary of a continuous outline, then stimulating the stroke feature according to the line weight and finally generating the effect of brush stroke. Studies found that, only a part of pencil drawing image is selected as the automatically generated calculation result in rendering

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process, and the most is supplemented by materials. The leading cause is that, automatic generation algorithm need a large amount of data calculation, thus complex the algorithm. This paper optimized and improved the solution for algorithm efficiency based on pencil drawing paper research.

3 Pencil drawing algorithm and style effect implementation based on image

3.1 STEPS OF PENCIL DRAWING TECHNOLOGY

Pencil drawing technology based on image is to transform the image specified by user into pencil drawing picture with painter's hand drawing style. The framework of pencil drawing algorithm based on 2D image is as shown in Figure 1. The steps are as follows:

1) make proper processing on the input image;

2) generate the original image into black noise image;

3) make regional segmentation on the original image according to the characteristics of texture;

4) make convolution operation on the treated black noise image (different algorithms have different operators);

5) extract contour of the image to generate the contour line diagram of pencil drawing;

6) integrate texture image and contour line, to obtain the final pencil drawing effect picture.
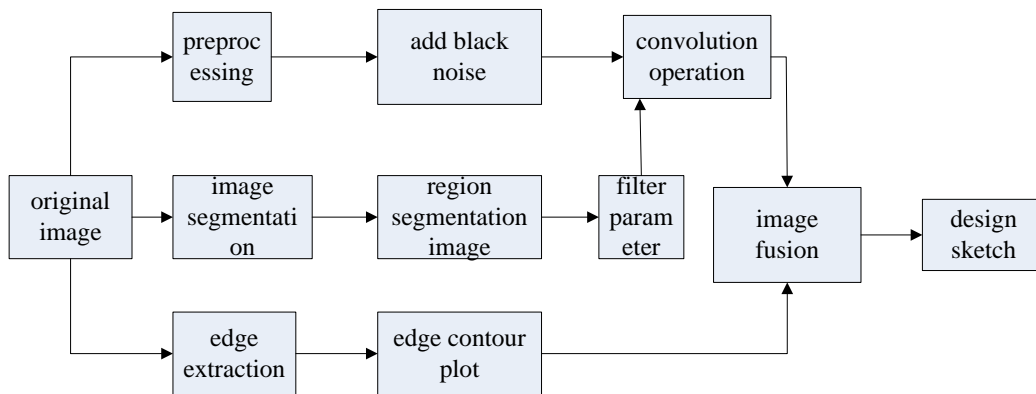

FIGURE 1 Framework of pencil drawing algorithm based on 2D image

In the process of drawing pencil drawing for image, the source image is generally underwent image segmentation in order to confirm the direction of stroke texture [9]. However, until now, there is still no good general algorithm that can meet segmentation demand of all images. This paper proposed a new method for processing contour and texture that can obtain the direction angle corresponding to every pixel in image more accurately and regard it as the image drawing direction. In addition, although the color spatial switching and white noise generation can meet the drawing demand of gray pencil drawing, they can not be used for the whole pencil drawing. This paper made a detailed improvement analysis process for implementing pencil drawing style effect, that is, the rendering of contour and texture combining with study result, aiming to provide a reference for completing pencil drawing conforming to artist drawing style.

3.2 IMPLEMENTATION OF PENCIL DRAWING STYLE EFFECT

We first, should render the extracted contour line of original image, then render the texture of image, finally overlay into an automatically generated image with pencil drawing style. The detailed analysis is as follows:

1) Contour line rendering: contour line, as the basic component of NPR, is a method generated by simulating pencil drawing. Gray-scale diagram is regarded as the basis of image while detecting. In the generation structure of contour line, convolution and operator generation is the most reused technologies in the process. This paper rendered contour line according to the order of process, and the process is as shown in Figure 2.
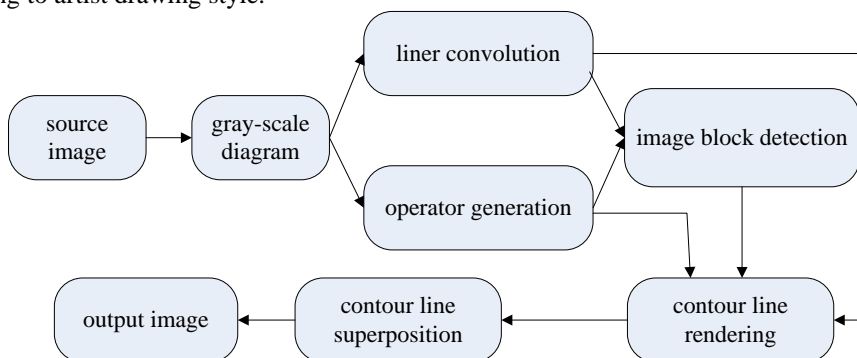

FIGURE 2 Process of contour line rendering

a) in the process of source image forming a gray-scale diagram, equation for converting RGB pattern into binary gray image is needed. Its integer arithmetic algorithm is:

$$Gray = (R^*299 + G^*587 + B^*114 + 500)/1000 . \qquad (1)$$

RDB is usually 8 bit precision. Now Equation (1) zooms 1000 times, and the obtained operation is a 32 bit integer operation. Round should be realized by adding 500. Therefore, another expression of that equation is:

$$Gray = (R^*30 + G^*59 + B^*11 + 50)/100 . \qquad (2)$$

We can use equation to obtain value, that is, to convert RGB with data ranging from 0 to 255 into binary gray-scale diagram expression formula with data ranging from 0 to 1 and presentation of white and black.

b) Calculation of gradient map and operator: gradient map is an important measure number for describing gradient of image change. The calculation equation is:

$$G = ((\partial_x)^2 + (\partial_y)^2)^{\frac{1}{2}} ,$$

where $\partial_x \partial_y$ is the difference value on the direction of x and y in of the image. *G* value of every pixel can be obtained through the formula. The image composed of *G* value of all elements is the contour line diagram of the image. Gradient map is method for finding gradient value of the image, and also a method for finding the contour line of the image. But this paper only regards it as the median of image process, that is, the preprocessing result in the process of obtaining image contour.

The generation of operators depends on three parameters: length, stroke and direction of operator. Length of operator is the matrix size of operator. The long operator has large calculated amount, otherwise, small. Stroke of operator reflects on the distance between operator elements and straight line at that angle. The thicker the operator is, the more accurate the direction tendency is. As to the thinner operator, we can only detect out the image tendency that is the same thick as it. In the

operator automatic generation algorithm, an operator that can change direction freely is realized. Meanwhile, due to the changeable direction, the number of directions of operator should also be changeable, thus to represent operator on multiple directions.

Image with pencil drawing style need to automatically generate two groups of operator. The first group is used for detecting the block of image, and the second group is used for implementing the rendering of pencil drawing style. In final pencil drawing automatic generation algorithm, thick and long operator is used for detecting, thin and short operator is used for rendering.

c) Detection and rendering of image block: this paper detected the image block using operator, and obtained the contour line of source image and direction block of image. Every image block represents a direction. Image block refers to that; the source image is composed of multiple direction blocks. The image block is rendered using line convolution after obtaining every image block. The obtained image is output as the result. However, in image detection, the result of linear convolution is assisting the algorithm to obtaining the final rendering result as the median of algorithm calculation. Image block detection uses thick and long operator while contour line rendering uses thin and short operator. They are associated but different.

d) Contour line superposition: the rendering images obtained in n directions are all independent. Their value distribute from 0 to 1. In the process of overlaying images on n directions, we use a function [10] to redistribute between 0 to 1 according to proportion. The principle of function is to find out the maximum of the image, obtain a new pixel image through superposition, then use every pixel of the new pixel image to divide the maximum of the image, and finally get the result of contour line.

Texture rendering is an important part of NPR. In contour line rendering, gradient field is taken as the source image. However, texture rendering uses another rendering source image as well as the algorithm and operator used in contour line detection. It is code reusing. Through that, higher efficient algorithm effect can be realized using less calculation amount in procedure operating. The concrete is shown in Figure 3.
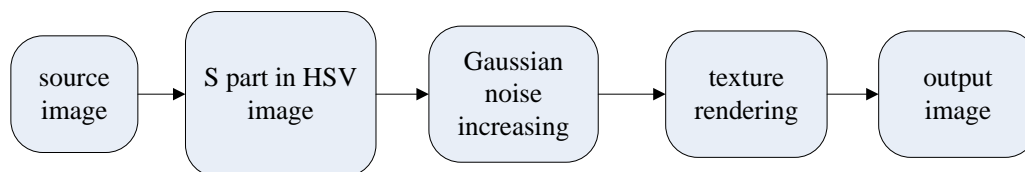

FIGURE 3 Flow of texture rendering

RGB is the format of input image, however, the image obtained by this form can not visually represent the other hue, brightness, value besides three-primary colours. But HSV can restore the image. H refers to hue, S Saturation and V value. We can get rendering source image by extracting S layer in HSV. Suppose (R, G, B) is the numerical value of red, green and blue channel. Max

equals to the maximum among R, G, B. Among (h, s, l) calculated by calculation in HSV space, $h \in [0,360)$ refers to metric hue angle of angle, s, $l \in [0,1)$ refers to saturation and lightness channel. The calculation formula of s channel is:

$$s = \begin{cases} 0, \ if \ l = 0 \ or \ \max = \min \\ \dfrac{\max - \min}{\max + \min} = \dfrac{\max - \min}{2l}, \ if \ 0 < l \le \dfrac{1}{2} \\ \dfrac{\max - \min}{2 - (\max + \min)} = \dfrac{\max - \min}{2 - 2l}, \ if \ l > f \ \dfrac{1}{2} \end{cases} \quad (3)$$

In addition, it is necessary to increase noise of image, thus to add more blank into saturation channel image. As a result, image has more pixel with different direction orientation, thus to make effect rendering easy. PDF formula of Gaussian random variables is as Equation (4). Where z refers to gray level, u refers to mean of z and σ refers to standard deviation of z:

$$P(Z) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left[\frac{(Z-u)^2}{2\sigma}\right]. \quad (4)$$

Through the above equation, we can add a Gaussian noise in the saturation channel image, in order to increase

pixel with different direction in image. Texture is composed of lines, and line is automatically generated by algorithm, therefore, part of rendering on structure and contour line is similar. The needed effect can be realized without recomputation of operator, which saves the computation cost.

4 Experimental result

Improvement algorithms in this paper need the help of Matlab as implementation and experimental tool. Meanwhile, with operator using as the core, horizontal contract of algorithm is calculated through the length, stroke and hybrid parameter of operator. The detecting images in this paper come from internet. Select straight line and curve that cover detailed information of different degree. Image size in the experiment is: A (1280×898), B (715×1204). The predefined parameter values is as shown in Table 1. The result of the experiment is composed of number, letter and roman numerals, which is generally expressed as: image +D+L+S+texture.

TABLE 1 Experiment combination table

Experimental variables	Parameters of operator									texture		Combination experiment
	D (1,2,3) unit/pcs			L (A,B,C) unit/pixel			S (I,II,III) unit/pixel			Yes	No	
	1	2	3	A	B	C	I	II	III	Yes	No	
	8	16	24	5	10	20	0.5	1.5	3	T	N	

When making the final effect, this paper uses different operator for contour line and texture rendering. Contour line rendering uses thin and short operator while texture rendering uses thick and long operator. The result is as

shown in Figure 4. The first row is test image, the second row is the rendering result obtained by other literature [3], and the third row is the experimental result obtained by the algorithm in this paper.

FIGURE 4 Experiment result

It can be seen through the parameter change of operator controlled by experiment that, the algorithm effect in this paper can generate an artistic style rendering image that all components are composed of straight lines. It is a new kind

of artistic implementation method. When processing image, using bigger algorithm can more accurately detect the direction tendency in image. Using smaller algorithm can obtain more delicate rendering effect. Therefore, it is

the optimal implementation method that is closet to pencil drawing style to use thick and long operator for detection, thin and short operator for rendering.

5 Conclusion

NPR is the research key point in this paper, among which, contour line detection and drawing is the important step. This study took reusability of algorithm as key point, modified the steps and parameters of the algorithm for many times, in order to implement effect comparison of multiple groups of algorithm. As to the design, different parts used operators with different characteristics for rendering; as to algorithm implementation, rendering of pencil drawing style implemented by different operators greatly increased the delicate sense and realist style of image, thus make the algorithm effect closer to sketch; at last, texture used self-generated sketch texture to make the effect nature. The algorithm in this paper also has drawbacks: it is suitable for colorful image; as to the image with single color, its representation effect is inadequate. Therefore, in future works, we should further study experiment to improve algorithm, enhance automatic level as well as the quality of pencil effect picture.

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