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Expression of Lines Drawn by Chalks Based on Scanned Images

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Abstract. In this paper, we propose a computer graphics algorithm to represent lines drawn by chalk. Chalk lines have very coarse texture. We use a scanned image of textures drawn by real chalk. When two chalk lines cross to each other, we adopt alpha blending technique for obscuring part of the existing texture by a new texture. We obtained realistic chalk lines by a simple algorithm. The drawing process is not real time in our current implementation, but further improvement of the efficiency can be expected.

Key Words: non-photorealistic rendering, chalk line, cubic Bézier curve, alpha blending

MSC 2000: 68U05

1. Introduction

The purpose of drawing pictures has always been the exchange of information and feelings between humans. In some thousand years, humans have invented a lot of ways for the expression of information and feelings with various drawing material and drawing tools. In 1940s, the computer was invented and became another drawing tool: computer graphics. The main purpose of computer graphics was to make very realistic pictures, but in recent years, non-realistic expressions have also been pursued. Such techniques are called non-photorealistic rendering. In the research in this area, various drawing materials have been modeled, including oil painting, water-color painting, pencils, pens, but there doesn't seem to have been much research on chalk.

2. Related works and our approach

As far as we have checked, little research in this area of drawing by chalk in computer graphics literature has been conducted so far. Pencils have somewhat similar characteristics with chalk, and in [1], Sousa et al. made a computer simulation model of the physical interaction between

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lead and paper based on electron microscope photographs. They considered the hardness and the shape of the lead. The amount of graphite particles attached to each small area of paper is expressed as a height field. Takagi et al. [2] also modeled color pencils. Their model consisted of three sub models: a microscopic structure model, a pigment distribution model, and a watering effect model. Yano et al. [3] proposed an efficient statistical model of graphite adherence.

The research mentioned above gave excellent expressions for pencils, but did not seem suitable for chalk. Chalk has a coarser structure, and many particles in the texture are identifiable even to the naked eye. The chalk particles easily drop from the board by brushing with finger or by overwriting. Therefore, the crossing area of chalk lines cannot be expressed as a union of overlapped textures. Chalk needs its own model for such rendering.

We have generated a chalk texture based on the characteristics of chalk lines obtained from the scanned images of real chalk. We have also developed an algorithm for the expression of crossed areas of chalk lines. Our model is based on the observation of drawn lines. It is not based on the physical behavior of the chalk and the blackboard. It is efficient and gives realistic results.

3. The algorithm

Our algorithm consists of two steps: the obtaining of chalk line characteristics, and the rendering of chalk lines.

3.1. Scanning of chalk lines

We directly scanned the lines drawn by real chalk on a small blackboard. The scanning was done for six pressure levels: 31 g, 63 g, 127 g, 255 g, 511 g, and 1023 g. The blackboard was put on a weight measurement device, and the lines were drawn so that the device would show the constant value. Therefore, the pressure could not be kept to an accurate value during the

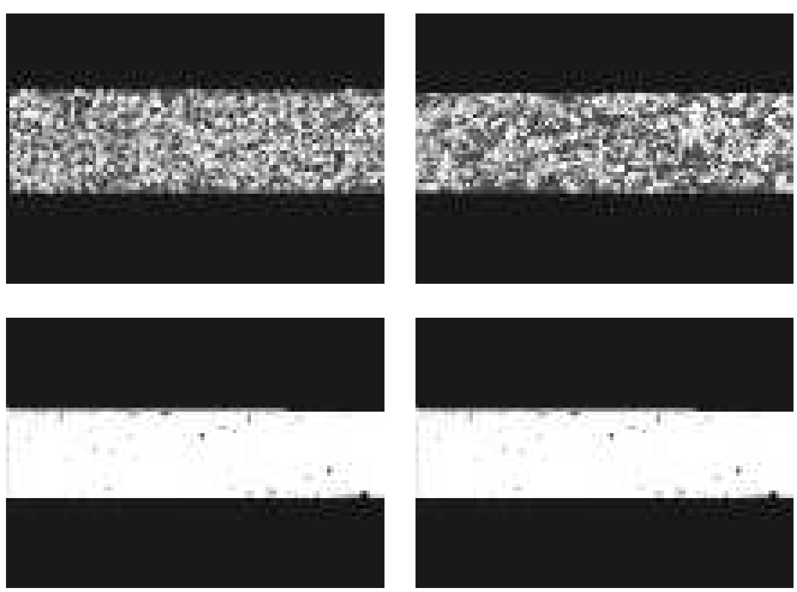


Figure 1: Scanned images of real chalks drawn with various pressures (left column) and the generated textures using the data with corresponding pressures (right column)

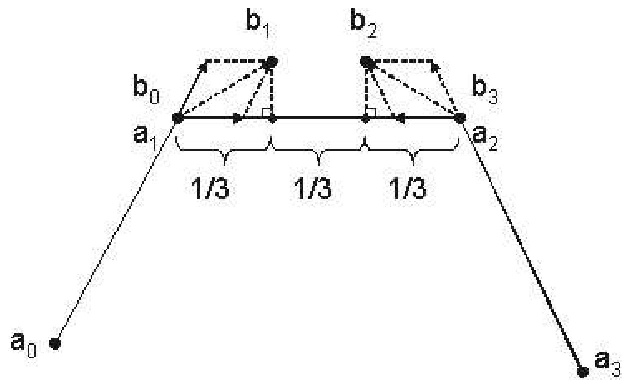


Figure 2: Determination of two internal control points of a cubic Bézier curve that interpolates two points a_1 and a_2.

drawing, but such a way of drawing gave the scanned texture a very natural impression: a human being never draws with constant pressure.

The scanning was done ten times for each pressure level. The density distribution of the chalk lines was obtained across the lines as an average. From this distribution, we can observe how many chalk particles are put along the center of the line and along the edge of the line. The density at each position is expressed as an eight-bit integer. The scanning resolution is 3200 dpi, and the typical width of the drawn line is 250 pixels.

Some scanned images of real chalk and the generated lines based on the scanned data are shown in Fig. 1.

3.2. Application of the texture

When a user draws a curve by a stylus on a pressure-sensitive tablet, the position and pressure information are sampled in a small time-interval. The pressure is expressed as a 10-bit integer in our tablet. When the user moves the stylus very fast, there arise gaps between consecutive stylus positions, and the positions must be interpolated. We used a cubic Bézier curve for the interpolation. For the interpolation of two positions a_1 and a_2, a cubic Bézier curve with control points $b_0 = a_1$, b_1, b_2, and $b_3 = a_2$ is used. The two internal control points b_1 and b_2 are determined locally as shown in Fig. 2. The pressure data are also interpolated similarly between the measured points.

For the cubic spline curve, we sample positions at an interval of pixel size, and assign a normal line to the curve at each position. Along the normal lines we generate a density distribution based on the measured data. The density distribution corresponding to the interpolated pressure is needed here. It is computed as the weighted average of two density distributions corresponding to the nearest larger pressure and the nearest smaller pressure.

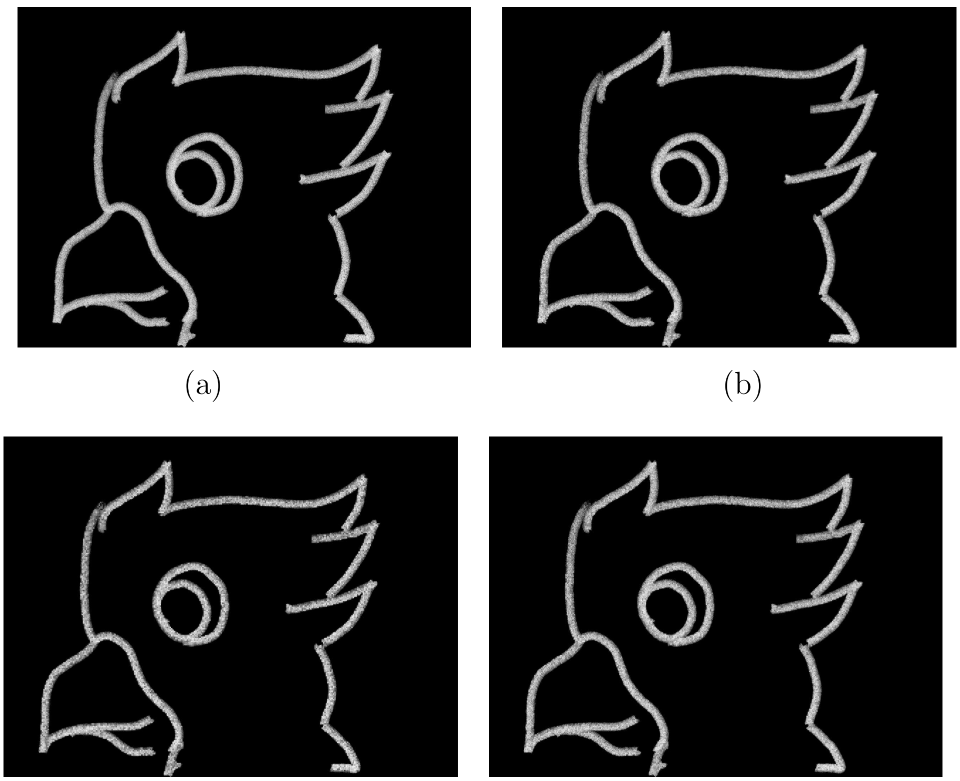
For the reproduction of the coarse structure, we composite the texture and an enlarged texture with lower resolution as the weighted mean (see Fig. 3):

$$(1 - b) * (\text{original texture}) + b * (\text{enlarged texture}). \quad (1)$$

This technique is a heuristic one, but it turned out that it works well. The coarseness of the chalk can be controlled by the value b. The effect of this technique is shown in Fig. 4.

(a) (b)

Figure 3: An image with original texture (a), and an image with enlarged half resolution texture (b)



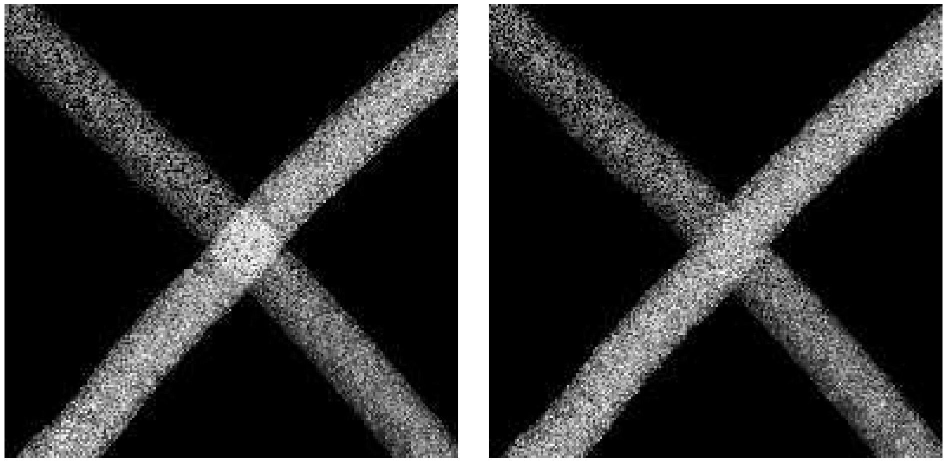
(a) (b)

(c) (d)

Figure 4: Images obtained with various values of b in eq. (1)
(a) $b = 0.2$ (b) $b = 0.4$ (c) $b = 0.6$ (d) $b = 0.8$

3.3. Expression of crossing lines

The particles of chalk are not very fine, and they drop easily when another line is drawn over them. Therefore, the union of the two textures does not generate good texture at the crossed area. Instead we achieve this effect using alpha blending. When we draw the new line with greater pressure, its particles remove most of the old particles; when we overwrite the new line using less pressure, most of the old particles remain. We express this by the following



(a) (b)

Figure 5: The effect of alpha blending. The cross area is drawn as a union of two textures in (a); as an alpha-blended texture in (b)

alpha blending:

$$\text{(composite density)} = a * \text{(previous density)} + (1 - a) * \text{(new density)} \tag{2}$$

Here, the alpha value a is determined as

$$a = \begin{cases} 0.25 * \text{(new density)}/255, & \text{for } 0 \leq k \leq 102, \\ 4 * \text{(new density)}/255 - 1.5, & \text{for } 102 \leq k \leq 153, \\ 0.25 * \text{(new density)}/255 + 0.75, & \text{for } 153 \leq k \leq 255. \end{cases} \tag{3}$$

The effect of the alpha blending is shown in Fig. 5.

4. Discussion and conclusion

We proposed an algorithm for the generation of lines with chalk texture. The density distribution is obtained from the scanned image of the lines drawn by real chalk. The line is generated based on the texture obtained by the scanning. To reproduce the coarseness of the chalk texture, we have used the composition of two images with different resolutions. For the reproduction of the texture at the line crossing, we have used an alpha blending technique. The obtained lines produced by the proposed algorithm in this paper look very real, and we can control the coarseness by adjusting the weight of the image composition.

The acquisition of density distribution data can be done as a preprocessing step when the drawing conditions such as the pressure range of drawing and the coarseness of the blackboard surface are specified. The amount of computation for the rendering of chalk lines is not very large, but in our current implementation, the lines cannot be drawn in real time. The efficiency must be improved for the interactive application: we believe that it can be realized by the collection of local improvements in our programs.

In our research, we restricted our range of research to the lines drawn by white chalk on a very homogeneous blackboard whose color is entirely black. For the color chalks, we must observe and model the mixing of different colors. Also, there often exist blackboards with rough surface: non-homogeneous with stains, dropping paint, and exposed annual ring structure of wood. To reproduce such tools, we may have to model physical interaction of chalk particles between a piece of chalk and the board. By constructing such a model, line variation with chalk angle and chalk wearing would also be expressed.

Acknowledgments

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