Strokes for Drawings Using Illuminated Paper Surfaces

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1. Introduction

A stroke drawn bydrawing tools that have a soft tip such as pencils, pastels, charcoals, chalks, or crayons, is highly interfered by sufrace irregularity of the support medium such as paper, and the texture of the paper appears on it. Without simulating interaction between those materials, "realistic" art tools are not represented. However, an elaborate simulation takes a lot of time for a drawing tool that is preferable to work in real time.

In this study we focus on the similarity between the appearance of strokes that are drawn on paper using pastel and paper texture illuminated by a light. Therefore, we use 12 illuminated paper textures as a "height field" [Curtis et al. 1994] for simulating pigment deposition by a stroke drawn in one direction. In fact, when a stroke is drawn, the stroke uses the height field, the gray value of converted paper texture illuminated by a light, from the same direction as the stroke. This technique takes less time.

2. Implementation

A stroke is defined as a 2D stroke mask based on that of Kalnins et al [2002]. The parameters of the stroke mask are described in figure 1. Inside the stroke mask, we use gray value g for deciding the amount of depositing pigments.

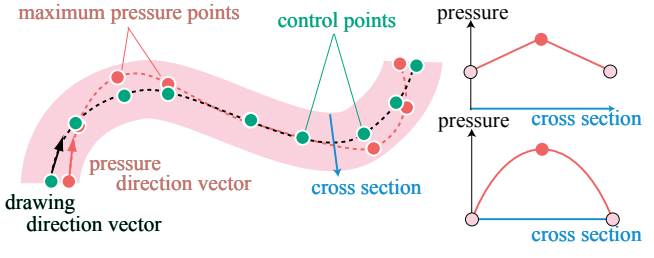

Figure 1. A 2D stroke mask. Pressure distribution over cross sections is calculated by interpolation either linear or quadratical.

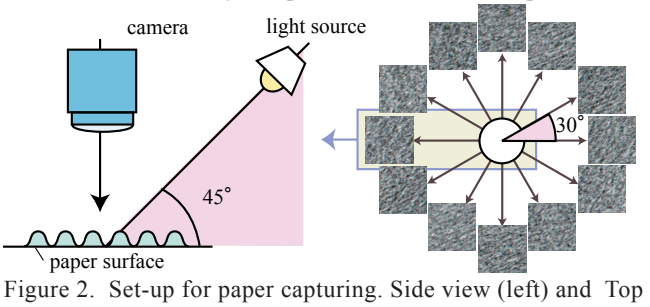

Figure 2. Set-up for paper capturing. Side view (left) and Top view (right). Photographed images are converted to 0-1 gray values.

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THRESHOLD = 1−PEN PRESSURE
if (THRESHOLD > g){
 if (THRESHOLD − g ≦0.02)
  TRANSPARENT = 1 − (THRESHOLD+0.02−g)×DECRESCENCE
 else TRANSPARENT = 1
 deposit pigments with color and transparent
}
```

Figure 3. Pigments deposition function.

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Figure 4. A result image.

Paper textures that appear on the stroke are selected in accordance with a drawing direction vector of the stroke and a pressure direction vector. We prepare 12 paper surface images as shown in Figure 2. Each texture t_i has a light source direction vector $\boldsymbol{l}_i$. When a stroke is drawn with a direction vector $\boldsymbol{s}$, paper textures t_1 and t_2 are selected that have $\boldsymbol{l}_1$ and $\boldsymbol{l}_2$ in close directions to $\boldsymbol{s}$. The gray value for the stroke g_s is calculated as follows:

$$g_s = g_1 \times (1\text{-ratio}) + g_2 \times \text{ratio}$$

with g_1 and g_2 as gray values of t_1 and t_2, and ratio as $\cos^{-1}(\boldsymbol{s} \cdot \boldsymbol{l}_1) / \cos^{-1}(\boldsymbol{l}_1 \cdot \boldsymbol{l}_2)$. Because the movement of the maximum pressure point inside the stroke alters the appearance of the textures, the same process is used for selecting textures for it and gray value g_p, where we use pressure direction vector $\boldsymbol{p}$. The resulting gray value g is the average of g_s and g_p that is used as a height field. The pigments are deposited in a pigment buffer that has the same size as a screen, with anti-aliasing. This process is summarized in Figure 3.

3. Results and Conclusion

Figure 4 shows a result image. We implemented stroke overlaps for realistic drawing-like images. New pigments were deposited on the paper surface where some pigments already existed, in inverse proportion. For color blending, we used simple subtractive color mixing using an OpenGL function. The values of the height field that were calculated from the gray scale of illuminated paper surfaces simulated real drawing strokes in any direction. This texture based simulation generated "realistic" drawing strokes in real time on a 2 GHz-Pentium 4, with 512MB RAM, WindowsPC. We expect that the method described here can be used for a realistic drawing system by adding properties inherence in each drawing tool.

References

Curtis, C. J., Anderson, S. E., Seims, J. E., Fleischer, K. W., and Salesin, D. H. 1997. Computer-generated watercolor. In *Proceedings of ACM SIGGRAPH97*, ACM Press / ACM SIGGRAPH, New York. E. Fiume, Ed., Computer Graphics Proceedings, Annual Conference Series, ACM, 421-430.

Kalnins, R. D., Markosian, L., Meier, B. J., Kowalski, M. A., Lee, J. C., Davidson, P. L, Webb, M., Hughes, J. F. and Finkelstein., A. 2002. WYSIWYG NPR: drawing strokes directly on 3d models. ACM *Transactions on Graphics*, 21, 3, 755-762.