4th WSEAS Int. Conf. on COMPUTATIONAL INTELLIGENCE, MAN-MACHINE SYSTEMS and CYBERNETICS Miami, Florida, USA, November 17-19, 2005 (pp76-81)

Simulating of *Kasure* Focused on the Change of Energy

ATSUSHI TAKEDA, JUNGPIL SHIN
Department of Computer Software
University of Aizu
Aizu-Wakamatsu City, Fukushima, 965-8580
JAPAN

Abstract: - This paper has discussed the phenomena of *Kasure* in the calligraphy system, that is, the phenomenon in which the location where a remarkable decrease is observed in the same stroke in the uniformity of the ink concentration occurs. The location where a remarkable decrease is observed in the same stroke in the uniformity of the ink concentration occurs. The reason it causes that occurs is because the speed of taking note on the same stroke differs and the quantity of the ink that is included by the brush differs. A novel method focused on the change of the energy is proposed. When ink is included in the brush, such energy that holds ink exists. Similarly, such energy that holds ink exists even when ink is included in the paper. Areas that the brush sweeps on the paper increase as the brush moves. The energy changes by moving ink from the brush to the paper. *Kasure* can be examined by a point of view from the energy change. We present some examples of *Kasure* as results. The emotion like power and passion of the writer is expressed by our research. The oriental mood and the expression ability of character as a medium are extracted and the artistry of rises more.

Key-Words: - Non-photorealistic Rendering, Oriental Pen Writing, Brush Modeling

1 Introduction

Black ink painting is a traditional Asian art. Ink painting consists of a few simple strokes intended to convey an artist's ``deep feelings" regarding the painted object. Feelings are expressed by speed, placement, pressure, movement of the brush, as well as by the resultant degree of shading produced by the brush strokes. In outline-based approach, the user describes the outline of brush strokes as a sequence of connected Bezier or B-spline curves developed using 2D drafting software in conjunction with a mouse or pen input and editing control points. The strokes produced are filled with image patterns incorporated a set of shade variation effects. However, the drawing process limits the mode of access, since stroke editing is restricted to alter knot points that determine stroke boundaries.

Kasure is a phenomenon that the ink concentration shows remarkable decrease at one stroke (see Fig. 1). The reason it causes that occurs is because the speed of taking note on the same stroke differs and the quantity of the ink that is included by the brush differs. For example, because the speed of brush movement at the beginning and the end of the stroke is slow in the case of Chinese character of ``1," *Kasure* is difficult to result. Conversely as for the middle of the stroke, because the speed of brush movement is fast, *Kasure* is easy to occur. If the speed of brush movement is slow, *Kasure* does not result. By using low speed taking notes, the ink included in the brush is able to permeate into the paper sufficiently. If the ink in the brush runs short, the brush cannot give ink to the paper, and *Kasure* occurs.

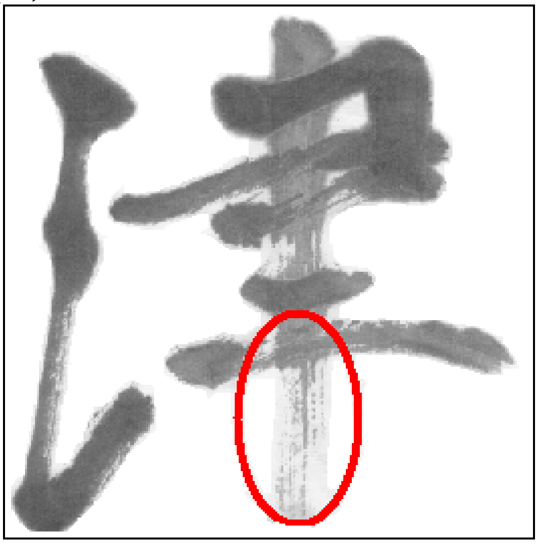

Fig. 1. An example of *Kasure* in Chinese character *Tsu*.

When ink is included in the brush the energy which holds ink exists. Similarly, the energy exists even when ink is included in the paper. When the brush, including ink, is placed on the paper, the ink in the brush transfers to paper by capillarity. When ink transfers to paper, the energy in the brush and in the paper changes.

In the actual calligraphy, the writer's emotion and personality are expressed by making *Kasure* occurred by the writing speed and pressure intentionally. Evaluation rises from the artistic point of view. Other researches have been performed by changing the thickness of the stroke and the shade of the color of the ink, and expressed gently or intellectually. This system has the ability (1) to express the emotion like power and passion of the writer, (2) to extract the oriental mood and the expression ability of character as a medium.
As a result, the artistry of rises more.

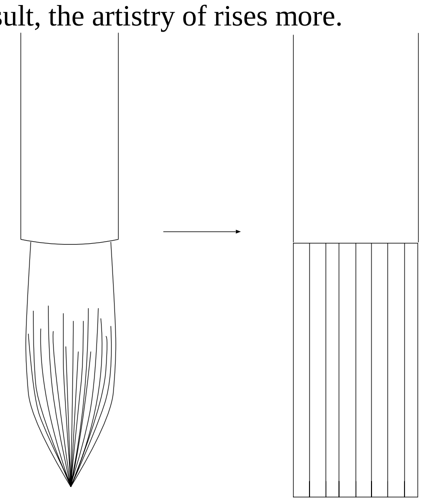

Fig. 2. Modeling of the oriental writing brush.

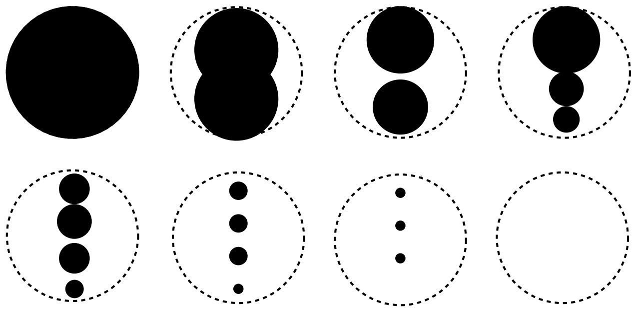

Fig. 3. Variations of the droplet models.

A novel method focused on the change of the energy is proposed. When the speed of the ink permeating to paper is slow, even though the brush speed is slow and the amount of the ink in the brush is sufficient, *Kasure* occurs.

2 The Droplet Modeling

The splitting effect occurs when the amount of ink contained in the brush decreases. Some variations of droplet are used to express the splitting effect in Fig. 3. Putting the droplet in the input position data and connecting them express the splitting stroke. Which type of the droplet is automatically determined by the stroke speed and the pressure. When the amount of enough ink is contained, left droplet is chosen in Fig. 3. On the contrary, when the amount of ink decrease, right droplet is chosen and splitting effect is examined. There is interactive because pressure and a stroke speed are being used at the time of the input. How to connect each droplet is described in the next section.

3 The Paper Field Modeling

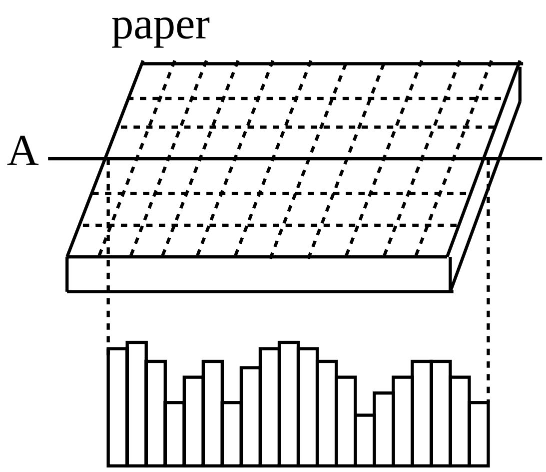

Fig. 4. The vertical cut view of paper.

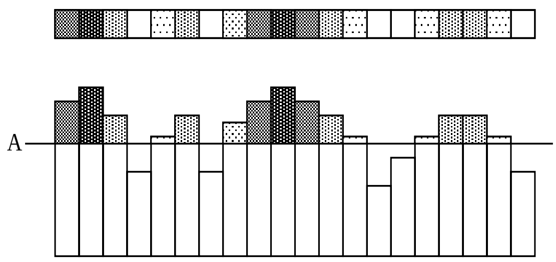

Fig. 5. The ink density of each paper cell.

The paper used in calligraphy is consist of irregularly distributed fiber mesh; a mesh of randomly positioned fibers. The entire mesh in the paper is separated into many layers, each of which are divided into two-dimensional array cell $\{pc_{ij} \mid i = (1 \cdots N_x), j = (1 \cdots N_y)\}$. Where N_x, N_y is size of array. Each cell is a basic unit of paper structure and corresponds to a pixel. Our research, height is given to each cell as expansion information. The paper is modeled as height field in Fig. 4. When a brush sweeps on the paper, paper cells beyond the fixed height are touched. For example, paper cells are touched higher than *A* in Fig. 4. The amount of ink absorbed from the volume that they touched each other, and the number of fibers inside each paper cell from the brush to the paper is calculated. The workload of *t*-th paper cell $\{pc_{ij}\}$ to absorb ink is:

$$W'_t = \sum_s F'_{t_s} \cdot d'_s, \tag{1}$$

$$F'_{t_s} = 2\pi R'_s \gamma' \cos\theta'_s, \tag{2}$$

where *s* is number of fibers in a cell, F'_{t_s} is power applied to the meniscus, θ'_s is the contact angle, R'_s is the capillary vessel radius, and γ' is the surface tension in paper. The amount of ink absorbed more as there are more volume and number of fibers increases. The amount of ink inside the brush decreases, and *Kasure* is easy to occur.

The brush has two conditions, one is wet and another is dry. Especially, *Kasure* occurs under the dry condition. The way of ink permeates paper is different under the two condition. Ink particles permeate paper with water under the wet condition. Water is a little under the dry condition, and ink particles stick only to the surface of the paper fiber. Paper cells are colored when the brush is dried in Fig. 5. Brush stroke is constructed by the set of these colored paper cells.

4 The Oriental Writing Brush Modeling

The brush used in oriental black-ink painting made from the soft hair of animals such as rabbits, martins or horses. The model of an oriental pen as shown in Fig. 2. Ink is contained by a capillarity in the writing brush. The brush is made from a bundle of hair of an animal. There are capillary vessels between hairs. Capillary vessels are $b_0, b_1, \cdots, b_{k'}, \cdots, b_{n'}$. $b_{k'}$ is divided into cells $a_0, a_1, \cdots, a_n$, which contain ink. The *y* coordinates is bottom to up. $\rho = \rho(y)$ is the density of ink. Supposing that ink is always supplied from the root of the writing brush, $\rho = \rho_{\max}$. The ink is always moved from the high concentration to the low concentration even if it is made uniform when concentrations aren't the same. The density of ink becomes $\rho = 0$ in the bottom of writing brush as ink is absorbed to the paper.

$\rho(y)$ is, therefore, monotone increasing function. $m(y) = c\rho(y)$ is the ink amount of that component in unit volume. $m(y)$ is discreted as follows:

$$\frac{\Delta a_k}{\Delta y} = \frac{m(y+\Delta y) - m(y)}{\Delta y}. \tag{3}$$

a_k is the *k*-th cell of $b_{k'}$.

When $\frac{\Delta a_k}{\Delta y}$ is constant *r*,

$$a_k = a_0 r^k, \tag{4}$$

where a_0 is first cell of each capillary.

a_k is the ink amount of *k*-th cell of a capillary.

$r > 1$ as $\rho(y)$ is monotone increasing function.

The total amount of the ink contained in each capillary is obtained:

$$M_k = a_0 \frac{r^n - 1}{r - 1}. \tag{5}$$

4.1 Energy of the Brush

There is the meniscus of a capillary vessel in the brush. The number of cells contain ink changes *d* which is the distance the meniscus moves. The workload of the meniscus of the *k*-th capillary vessel is obtained:

$$W_k = F_k \cdot d, \tag{6}$$

$$F_k = 2\pi R \gamma \cos\theta, \tag{7}$$

where F_k is power applied to the meniscus, θ is the contact angle, *R* is the capillary vessel radius, and γ is the surface tension.

4.2 Formulation of the Energy Change

The paper is made of a thin membrane being piled fiber. There are many spaces between the fibers in the sectional plan of the paper. The space is called a capillary vessel. A winding capillary vessel is doing the structure that got complicated complicatedly in paper. When the ink permeates to a capillary vessel in the paper, the workload by the meniscus occurs as well as the writing brush. The ink contained by the brush moves into the paper. The density of the ink is changed in the brush and the paper. The brush moves on the paper in time Δt, a capillary vessel b_k touches paper fiber. As the ink amount of δ_k permeates the paper, the amount of ink in a capillary vessel b_k is changed.

$$M_{t_2} = M_{t_1} + \delta, \tag{8}$$

$$n_{t_2} = n_{t_1} + d, \tag{9}$$

where M is the total amount of the k-th capillary vessel. When ink permeates through paper, the amount of each capillary is changed and the number of cells which contain ink changes. Initially, M_{t_1} is contained in a capillary. When M_{t_1} is changed to M_{t_2}, ensuring the number of cells changes n_{t_1} to n_{t_2}.

Eq. 5 is rewritten as follows:

$$r^{n_{t_1}} = M_{t_1}\frac{r-1}{a_0}+1, \tag{10}$$

where n_{t_1} is the number of cells contains ink of M_{t_1}.

$$\begin{aligned} r^{n_{t_2}} &= M_{t_2}\frac{r-1}{a_0}+1 \\ &= (M_{t_1}+\delta)\frac{r-1}{a_0}+1 \\ &= r^{n_{t_1}}+\delta\frac{r-1}{a_0}. \end{aligned} \tag{11}$$

Take logarithms of both sides,

$$n_{t_2} = \log_r(r^{n_{t_1}}+\delta\frac{r-1}{a_0}). \tag{12}$$

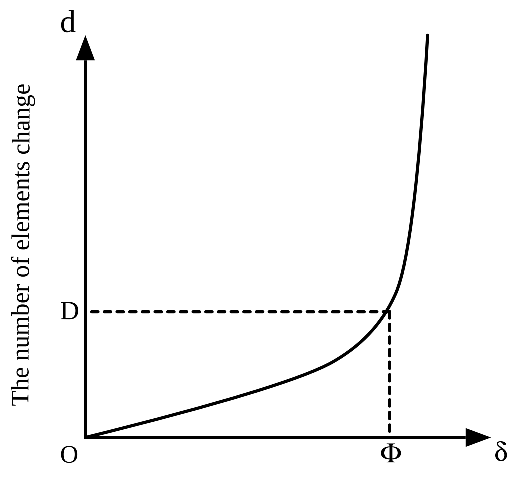

Fig. 6. The relation between the amount of ink change and the number of elements change.

By Eq. 9,

$$\begin{aligned} d &= n_{t_2} - n_{t_1} \\ &= \log_r(r^{n_{t_1}}+\delta\frac{r-1}{a_0}) - \log_r(r^{n_{t_1}}) \\ &= \log_r(1+\delta\frac{r-1}{a_0 r^{n_{t_1}}}), (a_0>0, r>1). \end{aligned} \tag{13}$$

When the amount of ink changes δ, the number of cells contain ink changes d. The relation between δ and d is expressed by Eq. 13.

4.3 The Occurrence of the *Kasure*

Fig. 6 shows the amount of the ink change and ensuing the number of cells. The amount of the ink changes rapidly at Φ. When the ink permeates the paper more than Φ, d is changed, i.e., the amount of the ink in a capillary vessel changes rapidly.

D is value of function δ at Φ. D means the meniscus in a capillary vessel can move maximum distance at time Δt. There is a difference is occurred between the energy of paper and the brush.

Areas that the brush sweeps on the paper increase as the brush moves high speed. The energy changes by moving ink from the brush to the paper. The number of cells contains ink changes rapidly when there is change of energy. This state of a capillary vessel occurs *Kasure*. The occurrence of *Kasure* is related the change of energy.

5 Experimental Results

The example of a stroke simulated *Kasure* as shown in Fig. 7.

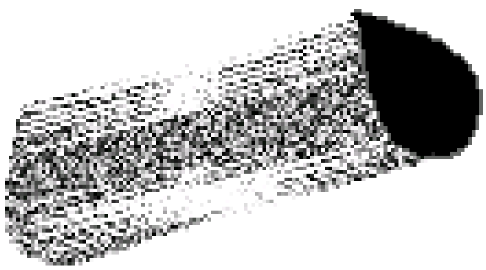

Fig. 7. An example of simulated *Kasure.*

The different of both ends and the middle of a stroke are worthy of attention. Both ends of a stroke are black as the brush moves low speed. The middle is white because ink cannot permeate the paper as the brush moves high speed. Another example is *Harai*, which means that the brush moves high speed at the end of a stroke, as shown in Fig. 8.

4th WSEAS Int. Conf. on COMPUTATIONAL INTELLIGENCE, MAN-MACHINE SYSTEMS and CYBERNETICS Miami, Florida, USA, November 17-19, 2005 (pp76-81)

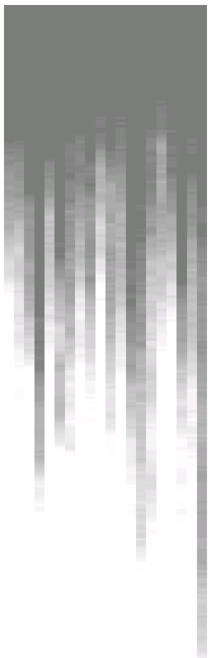

Fig. 8. An example of simulated *Harai*.

Kasure is also simulated at the end of a stroke. When the ink permeates the paper more than Φ at time Δt, the amount of the ink in the brush changes rapidly in Fig. 6. The explanation was proved experimentally by the middle of a stroke in Fig. 7 and the end of a stroke in Fig. 8.

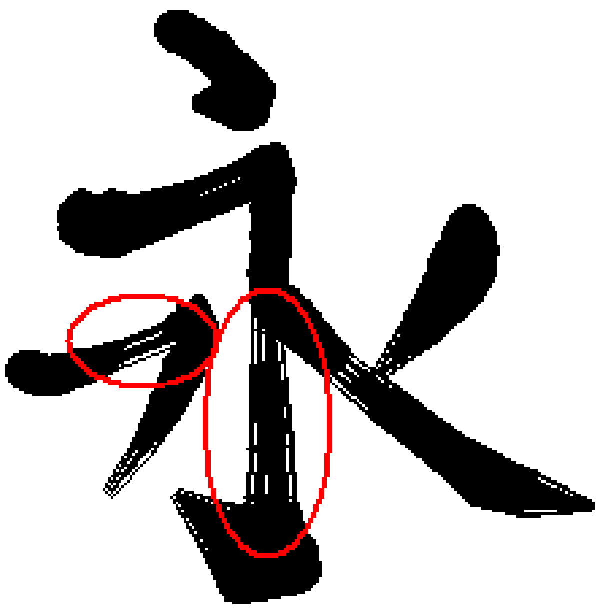

Fig. 9. An example of simulated Chinese character *Ei*.

Fig. 10. An example of simulated Chinese character *Migi*.

Kasure occurs in the part where a stroke is fast in Fig. 9, 10. The volume that the brush touches paper increases, and a decrease of ink becomes remarkable in the part where a stroke is fast. The splitting droplet is examined that is chosen effectively from a result of experiments. The Chinese character of these examples expresses the emotion like power and passion of the writer.

6 Conclusion

This paper has discussed the phenomena of *Kasure* using the oriental writing brush. When ink moves from the brush to paper, energy changes. As for the phenomenon called *Kasure* the difference of the change of energy is important.

This paper has described a novel method focused on the change of the energy.

The main points of this paper are summarized as follows:

1. When the ink permeates the paper from the brush, the change of energy occurs according to wetting.
2. The change of the number of cells containing ink can be obtained by the energy change.
3. The relation between the change of the number of cells and the amount of ink can be expressed by Eq. 13.
4. *Kasure* occurs at the rapid changing point of ink increase.

5. The Chinese character that the emotion and the expression ability rises more is drawn by combining splitting effect.

The emotion like power and passion of the writer is expressed by our research. The oriental mood and the expression ability of character as a medium are extracted and the artistry of rises more.

By incorporating the Character Learning System we have already developed, the economization of calligraphy education can be achieved. *Kasure* can help the high calligraphy education of quality more, to really reflect the taking notes in calligraphy.
We will be able to educate calligraphy with higher quality if the stroke is written as if it is real.

References:

[1] Junji Mano, Tsuyoshi Nakamura, Hirohisa Seki, Hidenori Itoh, A Scratched-look Expression and a Blurred-look Expression on Calligraphic Characters Using Renormalization Group, *IPSJ*, Vol.38, No.4, pp.806-814, Apr. 1997.

[2] Saeko Takagi, Issei Fujishiro, Masayuki Nakajima, Volume Graphics Modeling of Colored Pencil Drawing, *IPSJ*, Vol.40, No.3, pp.1177-1187, Mar. 1999.

[3] Saeko Takagi, Issei Fujishiro, Masayuki Nakajima, Volume Modeling of Colored Pencil Drawing Techniques with Allied Materials, *IPSJ*, Vol.41, No.3, pp.616-624, Mar. 2000.

[4] Suguru Saito, Masayuki Nakajima, 3D Physics-based Brush Model for Interactive Painting, *IPSJ*, Vol.41, No.3, pp.608-615, Mar. 2000.

[5] Nelson S.-H. Chu, Chiew-Lan Tai, An Efficient Brush Model for Physically-Based 3D Painting, *Proc. of Pacific Graphics 2002, Oct. 9-11, Beijing, China, IEEE Press*.

[6] Sheng-Wen Huang, Der-Lor Way, Zen-Chung Shih, Physical-Based Model of Ink Diffusion in Chinese Ink Paintings.

[7] Songhua Xu, Min Tang, Francis Lau, Yunhe Pan, A Solid Model Based Virtual Hairy Brush, *Proc. of Eurographics 2002*, Vol.21, No.3, C299-C308, 2002.

[8] David Small, Modeling Watercolor by Simulating Diffusion, Pigment, and Paper Fibers, *Proc. of SPIE 1991*, Feb. 1991.

[9] Der-Lor Way, Zen-Chung Shih, The Synthesis of Rock Textures in Chinese Landscape Painting, *Proc. of Eurographics 2001*, Vol.20, No.3, C123-C131, 2001.

[10] Cassidy J. Curtis, Sean E. Anderson, Joshua E. Seims, Kurt W. Fleischer, David H. Salesin, Computer-Generated Watercolor, *SIGGRAPH 97 Conference Proceedings*, pp.421-430, Aug. 1997.

[11] Young Jung Yu, Do Hoon Lee, Interactive Rendering Technique for Realistic Oriental Painting, *Journal of WSCG*, Vol.11, No.1, 2003.

[12] Q. Guo, T. Kunii, Modeling the diffuse painting of `sumie' , *Modeling in Computer Graphics*, pp.329-338, 1991.

[13] Aaron Hertzmann, Painterly Rendering with Curved Brush Strokes of Multiple Sizes, *SIGGRAPH 98 Conference Proceedings*, pp.453-460, 1998.

[14] Xiaofeng Mi, Jie Xu, Min Tang, Jinxiang Dong, The Droplet Virtual Brush for Chinese Calligraphic Character Modeling, *Journal of Computer Science and Technology*, Vol.19, No.3, pp.393-404, 2004.

[15] Landau L, Lifshitz E., *Fluid mechanics, Course of theoretical physics*, Vol.6, 2nd ed. Oxford, Pergamon Press, 1987.