Development of a Japanese Calligraphic Brush Writing Simulation System Using Leap Motion

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***Abstract*—Calligraphy by brush has a long history and tradition in Japanese culture. The calligraphy is not only drawing aesthetic expressions of letters but also mental activity. And there are many peoples in the world who are interested in writing brush. For the Japanese calligraphy, ink stone (called in Japanese as "Suzuri"), brush("Fude"), special paper("Hanshi"), and ink("Sumi") are the minimum tools required. In addition, it is necessary to have a permissive environment to dirt and smell caused by ink. It is difficult to align them completely. As a solution to the problem, there is a method of virtually performing a brush on a computer.**

In this research, we develop a system that implements virtual brush writing on a computer aimed to fun the calligraphy easily, without losing the real brush writing techniques. In this system, using Leap Motion[1], a display and a virtual rod which becomes a writing instrument, we can write something very similar to the handwriting of the actual writing brush.

According to results of the questionnaire, it was found that a high evaluation can be obtained from many people with respect to the texture of the handwriting.

Keywords—Japanese calligraphy: Simulation System: Leap Motion

I. INTRODUCTION

There are many researches[2][3] to realize a brush virtually on a computer. These studies can be highly appreciated as a system that fully simulated calligraphy. However, expensive equipment and special equipment are necessary and we can not easily prepare and use them.

On the other hand, a pen tablet can be used as a device for inputting handwriting on a computer, and is intuitive and easy to use. However the pen contacts with the surface of tablet, there is a problem that three-dimensional movement of a brush will be lost. In order to solve these problems, we developed a brush writing simulation system using Leap Motion which can capture three-dimensional movement of hand. In this paper, we describe outline and result of our system.

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II. SYSTEM OVERVIEW

A. Configuration of our system

In the Japanese calligraphy, the movement of the brush in three-dimensional space is represented on the two-dimensional paper surface. This creates handwriting peculiar to the brushlet.

In this research, the system gets a three-dimensional coordinates and orientation of the tip of rod by tracking tool using Leap Motion, and draws handwriting based on it on screen. And if user writes a character on desk while looking at display screen set front of user, a reality as calligraphy will be lost. Therefore, it is necessary to set a screen lying down on desk, and to input by moving a rod on this screen. The position of tip of rod and the position of drawing handwriting is match by arranging like this. Then a user can feel more realistic calligraphy.

We construct the system on platform of PROCESSING, so the handwriting is drawn by the platform, and also we use the library of LeapMotionForProcessing for operation of Leap Motion. Fig. 1 show an overview and configuration of the system.

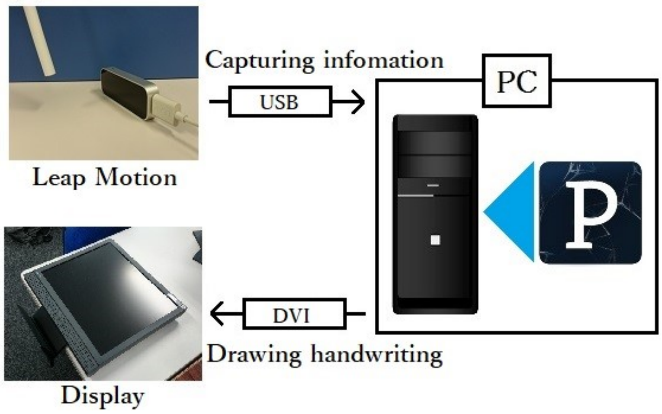

Fig. 1. Overview of our system

B. About Leap Motion Controller

The Leap Motion Controller is a motion capture device for movement of hands, fingers, and rods. It can track hands, and put information of hands, for example, position of hands, position of fingertips, direction of fingertips, and so on. Also, Leap Motion can track tip of rod held by hand.

We can get an information of rod using Leap Motion, for example, length, thickness, direction and so on. Our system uses tool tracking by Leap Motion Controller. Fig. 2 shows the body of Leap Motion Controller.

Fig. 2. Leap Motion Controller

III. IMPLEMENTATION

In this system, a user treats a surface of monitor that set up lying down on desk as paper surface. The system gets information of rod by Leap Motion, and draw handwriting on monitor in real time. The system will virtually reproduce the brushlet with this method.

Fig. 3 shows illustration of our system. The monitor size is about 29cm x 36cm.

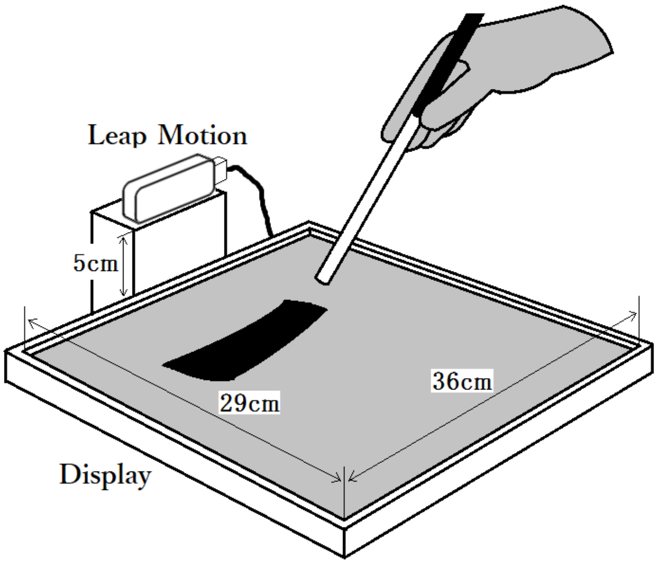

Fig. 3. Illustration of proposed system

A. Set up of Leap Motion

Leap Motion is usually used in a horizontal place with the sensor facing upward. However, in this system Leap Motion was set up in front of monitor to increase recognition accuracy.

And Leap Motion was fixed at a height of 5 cm from the monitor. When Leap Motion set at a height of 5 cm, the range of recognizing the rod with high accuracy is 30 cm x 45cm. Therefore, we decided to use the monitor of the mentioned.

B. Constitution of simple brush

In this system, a rod is used as a virtual brush, and it is captured and input by tool tracking of Leap Motion.

The recognition accuracy of Leap Motion varies depending on the color of rod because it uses infrared ray. For example, the rod colored by white is easy to recognize, the black one is difficult to recognize. And the tool tracking of Leap Motion is supposed to hold tip of rod. Therefore, if user holds center of rod, recognition accuracy decreases.

So, we made two tone rod which wrapped paper around transparent acrylic rod. The recognition accuracy is increase by color-coding each half from center. We call “virtual brush” to this two tone rod (Fig. 4). When user inputs characters, user writes characters by virtual brush in the air on monitor surface.

Fig. 4. Virtual brush

C. Drawing of Handwriting

The algorithm for drawing handwriting character consists of two elements. First, a shape of brush (we call "basic shape") is drawn at the specified coordinates. Next, shape is drawn that connecting basic shape of previous frame and the basic shape of current frame. Fig. 5 shows basic shape.

At this time, use the three-dimensional value and orientation vector of the tip of the rod acquired by Leap Motion. The thickness of handwriting changes according to the height from the monitor of the tip of rod, and the basic figure rotates following the inclined direction of the rod. A cubic Bezier curve is used for the outline of the basic figure.

The frame rate at execution is set to 100 fps in consideration of the tracking speed of Leap Motion. The purpose of the system is to realize a writing brush, so we suppose that user do not enter intense movements. Therefore, the frame rate was determined to be sufficient.

Fig. 6 shows wireframe of handwriting without fill. Fig. 6 is executed by lowering the frame rate to 10 fps in order to make the result easy to show.

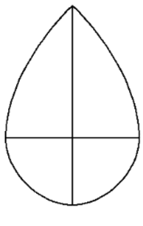

Fig. 5. Basic shape

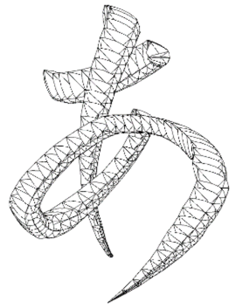

Fig. 6. Wireframe of handwriting

IV. SYSTEM RESULT

Fig. 7 shows the proposed system being executed. And Fig. 8 shows a handwriting character of written by our system. A handwriting character of proposed system can represent basic calligraphic expression such as "tome", "hane" and "harai". Accordingly we could draw calligraphic handwriting by computer. We could smoothly see a contour of handwriting is smooth shown by Fig.8 because it's enough framerate.
And there is no unnatural disturbance, Fig. 8 shows that Leap Motion can be tracking simple brush at high recognition rate. "Fig. 9" shows same character as Fig. 9 written by real brush. Comparing Fig. 8 with Fig. 9, we can say that the results are very similar. From the above, it can be said that our system can roughly simulate calligraphy. Fig. 10 shows more examples that written by our system.

Fig. 7. Propose system

Fig. 8. Written by our system

Fig. 9. Written by real brush

V. EVALUATION EXPERIMENT

As an evaluation experiment, we took questionnaires for 24 male and female users aged 10 to 40 who used this system.

Questions used in questionnaire is shown below, and the questionnaire result is shown in Table 1. All questions except question (1) were done in 5 grades. Evaluation 5 is the highest-grade evaluation, evaluation 1 is the lowest-grade evaluation.

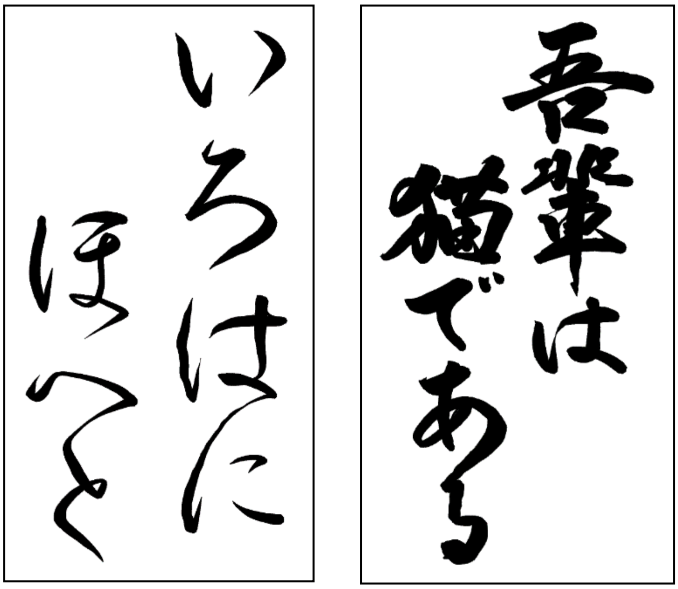

Fig. 10. Examples of illustration

(1) Have you ever studied calligraphy other than school lessons in the past?

(2) Do you think easy to write characters and lines in this system?

(3) Do you feel the handwriting drawn in this system is like Japanese calligraphy?

(4) Do you feel resistance to digitizing calligraphy?

The result shows three important points:
I. With respect to the feature that simple brush does not touch the screen, it can be said that many people are judged as having no problem from the answer result in question (2). Therefore, this input method is suited to simulation system of Japanese calligraphy.
II. We can see that the system can be securing enough recognition rate of Leap Motion from question (2).
III. About the texture of the handwriting drawn, it is highly evaluated by many people and it can be see that this system can express brush stroke. This result was independent from question (1).

TABLE.1. Result of questionnaire

Question No.	Ev.5	Ev.4	Ev.3	Ev.2	Ev.1
(2)	3	10	8	3	0
(3)	12	10	1	0	0
(4)	1	1	4	2	16

VI. CONCLUSION

In this paper, we proposed a Japanese calligraphy simulation system with Leap Motion as input device. This system has two features below.

First, it is possible to capture the movement of the original brush of Japanese calligraphy as it is. By acquiring the coordinates in the space, it is possible to perform the operation peculiar to Japanese calligraphy using the body.

The second is that the system operates with fewer devices. By using Leap Motion, information of simple brush can be acquired without attaching a physical sensor to the virtual brush.

In the future work, we improve the reality of handwriting in this system. Now, the handwriting character to be drawn is not taken into consideration of ink unique expressions such as "bleeding" and "blur". "Bleeding" and "blur" are one of the expression method, and it is also an element to enjoy Japanese calligraphy.

Finally, we should improve a rod that becomes a simple brush. As mentioned above, since a virtual brush does not touch the screen, feedback on sensation is poor. Hence, it is necessary to improve the system more user friendly, for example attaching hair to a simple brush.

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