Self-Training System of Calligraphy Brushwork

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ABSTRACT
In this paper, we describe a self-training system of brushwork of calligraphy. For writing a well-shaped character, the brushwork should be controlled properly. In the developed system, the motion of the student's brush is measured by Leapmotion sensor, and if the handwriting is not proper, the student's wrist is stimulated by a pressure presentation device at the moment as an instruction of a handwriting. Although the mechanism of the developed pressure presentation device was so simple, it could induce the student to correct the handwriting. The developed system can be an effective instruction device for self-training of calligraphy.

Keywords
Motion instruction; Inducing training; Pressure presentation; Calligraphy.

1. INTRODUCTION
Number of craftsmen who have traditional techniques is decreasing. Therefore, it is required that their techniques are archived and are handed down to the next generations by using mechatronics technologies.

In this research, brushwork of calligraphy is focused on as a traditional technique that should be handed down. The fundamental training method in a calligraphy school is that a teacher holds the student's hand that grasps a brush, and the teacher affects force to the student's hand if the student's handwriting is not proper. As a result, the student can recognize whether the writing motion is right or wrong. In other words, it is expected that the involvement from the teacher induces the student's ambition of the self-training.

The goal of this research is to develop a self-training system of brushwork of calligraphy that reproduces the trainings that are carried out in calligraphy schools. For this purpose, a pressure presentation device that induces the student to correct his/her brushwork was proposed in the previous research (see Figure 1) [1]. It is assumed that this device is attached to the student's wrist, and its two levers stimulate the student's wrist only if the student's handwriting is not proper. By using this device, the student can practice writing motions by his/her self as if the student is instructed by a teacher directly. The significant of this device is that this doesn't stimulates the student's wrist if the student's brushwork is proper. This means that the developed device does not obstruct the student's subjective motion, and this is a significant advantage of the proposed self-training system.

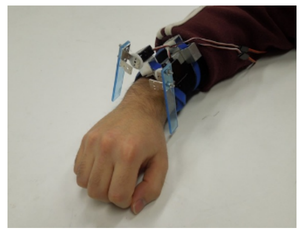

Fig. 1. Pressure presentation device.

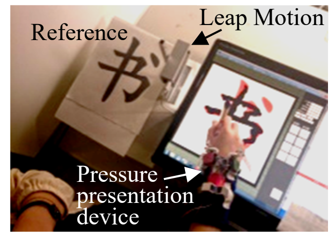

Fig. 2. Training system.

So far, several motion instruction methods have been proposed [2, 3]. If a robotic arm is introduced for a reproduction of the teacher's role, the student's hand can be guided by the robotic arm forcibly. However, with a robotic arm guidance, the student is apt to move his/her hand passivity, and this methods may reverse the effects of the training if the student's hand is guided forcibly. On the other hand, the student's hand is not guided forcibly and a low-key instruction can be carried out with the developed device.

In the authors' previous research, a touch panel display was used as a brush position measuring device, however, it caused an extension and a complexity of the system. Therefore, a new self-training system for calligraphy is developed in this paper; Leapmotion sensor is newly introduced as a brush position measurement device. The possibility of measurements of the brush is confirmed, and pilot experiments are carried out for the evaluation of the developed system.

2. TRAINING SYSTEM
The developed calligraphy training system consists of a pressure presentation device, Leapmotion sensor and a computer (see Figure 2).

2.1 Brush Position Measurement
Leapmotion (see Figure 3) is an input device for a computer that is dealt by Leapmotion Company. Leapmotion has two infrared cameras, and it can measure the position and the orientation of a stick object like a finger or a pen in space of 50cm radius with 0.01mm precision up to 295Hz. For example, a user can operate a computer by gestures of the hand with Leapmotion. In this research, the tip position and the orientation of the brush are measured by Leapmotion at 20Hz sampling, and the brush point ${}^{XYZ}\boldsymbol{p}$ is calculated by (1)

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Fig. 3. Leap motion.

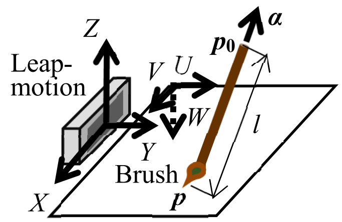

Fig. 4. Coordinate systems.

$$^{XYZ}\boldsymbol{p} = {}^{XYZ}\boldsymbol{p}_0 - l\boldsymbol{\alpha} \tag{1}$$

where $^{XYZ}\boldsymbol{p}_0$ is the brush tip position, $\boldsymbol{\alpha}$ is the brush orientation and l is the brush length (see Figure 4)[4]. In the Figure 4, *XYZ* is the Leapmotion coordinates, and *UVW* is the writing area coordinates.

As a result, the brush point $^{UVW}\boldsymbol{p}$ can be derived by a homogeneous transformation expressed as (2).

$$^{UVW}\boldsymbol{p} = \begin{bmatrix} 0 & 3.5 & 0 \\ 3.5 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix} \cdot {}^{XYZ}\boldsymbol{p} + \begin{bmatrix} 0 \\ -542.5 \\ -115 \end{bmatrix} \tag{2}$$

The student's handwriting is presented on the display based on the derived brush point $^{UVW}\boldsymbol{p}$. The width d of the handwriting trajectory is calculated from the height of the brush $^{UVW}p_z$ by (3). In this paper, a constant k is tuned to be 2.3 through a trial and error process.

$$d = k\, {}^{UVW}p_z \tag{3}$$

2.2 Pressure Presentation

During a training, the measured student's handwriting is compared to the reference handwriting in real time. The pressure presentation device has two acrylic plates that are driven by two servo motors individually, and stimulates the student's wrist from the right or left side when the difference between the reference handwriting and the student's one is greater than 20mm. Namely, the right side of student's wrist is stimulated by driving the right side acrylic plate if the student's grasping brush goes far beyond the proper position in the right side. The left side of student's wrist is stimulated by driving the left side acrylic plate if the student's grasping a brush goes for beyond the proper position in the left side. Thus, the pressure presentation device induces the student to correct his/her handwritings.

3. EXPERIMENTS

3.1 Method

Experiments were carried out in order to evaluate the developed system. A participant was instructed to write an unknown Chinese character with seeing a presented reference (see Figure 5). If the participant's brush went far from the proper trajectory, the pressure presentation device was activated and the each side of the participant's wrist was stimulated. During this experiment, the participant's brush motions and the motors' activation states were recorded.

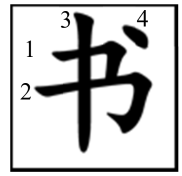

Fig. 5. Reference Handwriting. (Numbers are stroke orders.)

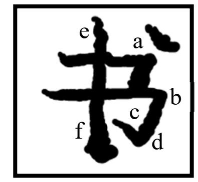

Fig. 6. Handwriting (Result).

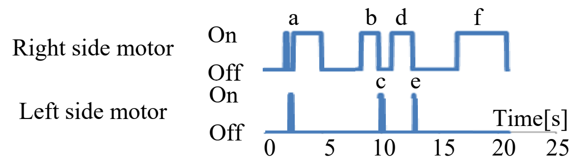

Fig. 7. Presentation pattern.

3.2 Results

Figure 6 is the recorded participant's handwriting of an experiment, and Figure 7 is the patterns of the motors' activated patterns. These show that most of the pressures were presented at the instances when the direction of the handwriting should be changed properly. In other words, the pressures were presented properly when the student's handwriting tended to go far away from the reference trajectory.

4. CONCLUSION

In this paper, the self-training system of calligraphy was developed. It was confirmed that newly introduced Leapmotion was enough to measure the brush motion of calligraphy, and the system operated as a self-training system of calligraphy. Although the mechanism of the pressure presentation device are so simple, it is expected that the developed system will be effective for calligraphy self-trainings.

5. FUTURE WORKS

In the future, the proper timing and the proper strength of the presented pressure should be investigated. Statistical analyses of experimental results are also required.

6. ACKNOWLEDGMENT

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7. REFERENCES

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