Wearable Display System for Handing Down Intangible Cultural Heritage

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Abstract. In recent years, most of traditional craftsmanship is declining because of aging skilled craftspeople and fewer successors. Therefore, methods for digital archiving of such traditional craftsmanship are needed. We have constructed a wearable skill handing down system focused on first-person visual and audio information and biological information of a craftsman. We used instrumental information associated with the usage of the tools for evaluating the effect of proposed wearable display system of intangible cultural heritage. In this paper, we show the result of archiving and training on the skills of Kamisuki, Japanese traditional papermaking.

Keywords: Intangible cultural heritage, Skill transfer, Tacit Knowledge, Wearable computer.

1 Introduction

These days most of traditional craftsmanship has declined to the brink of extinction, mainly due to shrinking number of successors and aging experts. Even though there are urgent needs for preservation of declining traditional craftsmanship, it takes quite a long time to transfer skills from experts to learners with conventional methods. Traditionally, these skill-transfers have been carried out by word-of-mouth between a master and apprentices, relying heavily on the existence of the master as a teacher. Within this teaching framework, only limited number of apprentices can learn the craftsmanship.

Therefore, new methods for archiving and transferring of skills that do not entirely depend on the existence of experts are required. Although it is possible to record these skills in a form of videos or textbooks with pictures, those visual information do not contain enough information to master these skills. In order to achieve a better

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understanding of the skills, it is necessary to have invisible information that is not observable from outside.

So far, little research has been done on digital preservation of traditional craftwork skills. There is plenty of research on digital preservation of static cultural heritage such as paintings, craftworks and buildings [1, 2, 3]. Some researches focus on the artistic movements such as dance [4]. However, focus of these studies is on the existing art objects or artistic movements themselves, not on the artisanship to create those art objects. Saga et al. developed a unique system to transmit calligraphic skills using haptic feedback [5]. Our approach takes a similar attitude toward preservation and transmission of skills, but in a more integrated way with various sensors, taking deeper look at the tacit knowledge of experts numerically.

We have created an integrated framework for the digital preservation of artisanship [6, 7]. In this paper, we explain our framework for digital archiving of craftwork skills, and show a verification experiments in which we applied the system to a Japanese traditional craftworks, Kamisuki.

2 Kamisuki, Japanese Traditional Paper-Making

As the research object, we chose Kamisuki, Japanese traditional papermaking. We conducted pilot survey for preservation of this craftsmanship.

Traditional papermaking has more than 1,300 years of history. After the industry reached its peak with 68,562 production sites in the beginning of the 20th century, it followed a course of decline and the number of production sites decreased to 392 [8]. Even though traditional Japanese paper gains attention again in recent years, acceptance of new apprentices is difficult for most of the production sites which are family-owned small factories. Therefore, new framework for digital archiving and transferring of skills are needed.

The whole process of papermaking starts with the preparation of materials. Raw materials such as kozo, gampi and mitsumata go through boiling, bleaching and cleaning. Then those materials are crashed into a collection of fiber and put to water with *Neri*, viscosity improver made of grass roots. The papermaking part follows. This part consists of three main movements: scooping, swinging and draining. Figure 1 shows those three main movements.

Fig. 1. Three main movements in Japanese papermaking; scooping, swinging and draining (from the left)

We chose the papermaking part as a research object, because it determines the quality of the final product as well as it is a combination of dynamic movement and subtle control of the body. In order to capture such dynamic movement and subtlety at the same time, our approach seemed suitable.

3 Methodology

We focused on the development of the system to capture integrated information of the working environment, including visual information of the workspace, biological information of a craftsman, and instrumental information on the physical quantities of tools. The biological information includes the artisan's myoelectric signals, breathing and the eye-gaze during creation. On the other hand, the instrumental information of the tools is their physical quantities such as their position and load on them. It is important to record such invisible information numerically, because even experts are not consciously aware of how they moves their body and how they handle their tools, thus they do not have precise words to describe their movement.

The aim of this framework is summarized into three parts. First of all, we want to archive the knowledge as a whole. We want to capture as much information as possible, so that we can hand down enough information on the craftworks for future generations. Secondly, we want to find cause-and-effect relationships among those data. Those relationships among data considered as tacit knowledge that has never been clearly analyzed. Finally, we want to develop new skill-transfer methods for traditional craftworks with the help of digital technology.

We constructed HD camera (Canon XH-G1s). Camera captures the movement of the master and his way of handling tools through several viewpoints.

As a key tool for capturing biological data, myoelectric potential was measured with Nihon Koden WEB-100. Sensors on the artisan send information remotely, so that they do not bother craftspeople with cables.

Instrumental information is captured through various ways depending on the types of tools the craftwork adopts. Physical quantities are mainly measured, such as position, acceleration and distribution of load.

4 Measuring Kamisuki Skills

We conducted pilot servey with two subjects. Subject A has about thirty years of experience in this field. Subject B has about ten years of experience. We captured the data while both subjects make 10 pieces of paper. Sensors were set at the position shown in Figure 2.

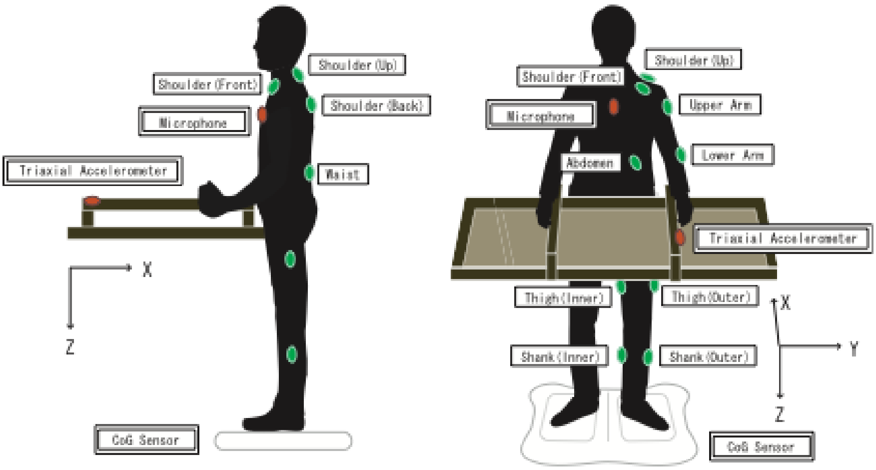

Fig. 2. Allocation of sensors

First of all, movies, CoG, sounds, EMG, acceleration are aligned on the viewer for analysis (Figure 3). As a result, acceleration of the tool showed significant periodicity (Figure 4). We further analyzed the data based on the periodicity of the movement.

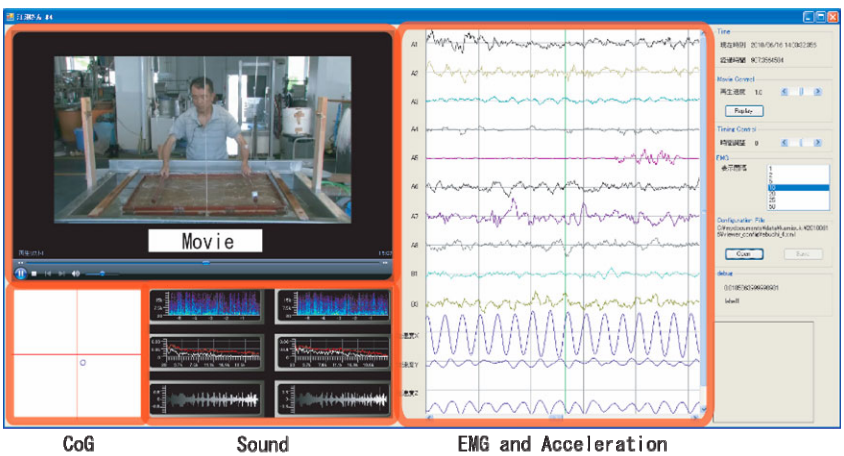

Fig. 3. Sensor data viewer for analysis

The periodicity of the movement of the tool was observed for both subjects. The periodicity is also associated with the movement of the body, which is shown in the EMG.

The result of subject A showed especially high periodicity. In addition, there were a sign of external force in the data of Z-axis acceleration. It is suggested that subject A uses the power of string of bamboo which support the tool (Figure 5).

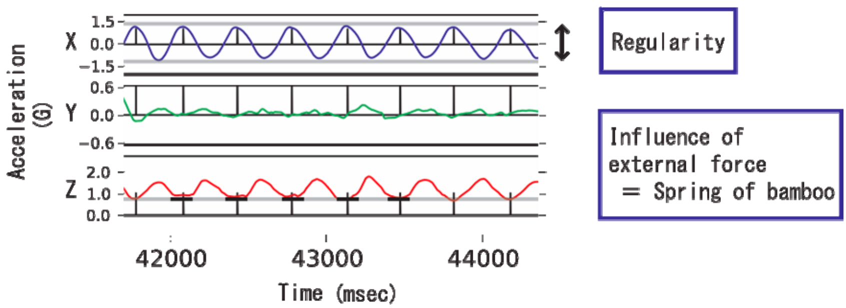

Fig. 4. Acceleration during X-axis swinging movement

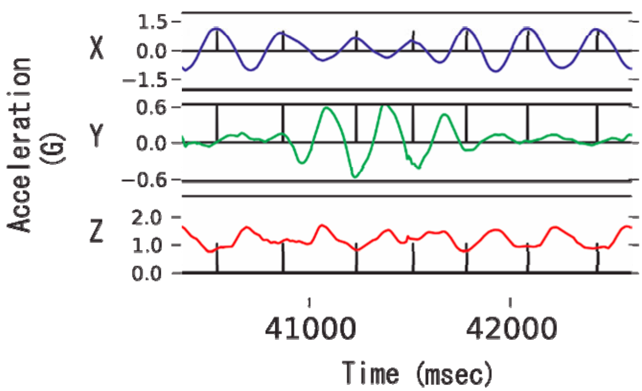

Fig. 5. Acceleration during X-Y combined swinging movement

5 Wearable Display System

From the result of measuring Kamisuki skills, remarkable periodicity have found in motion of tool and myoelectric signals. In traditional Japanese paper making, it is important to entwine paper fiber uniformly. Stable periodic motion will be one of the significant elements of its skills. According to previous researches result in induction of periodic motion by using motor-sense synchronization of human body in sound and vibration stimuli [9, 10]. We developed first-person wearable display system that induces periodic motion in Kamisuki by visual, audio and vibration stimuli. Figure 6 describes overall system. Vibration motors are placed on exact position where we measured myoelectric signals. Vibration stimuli are produced according to smoothed myoelectric potential data recorded in measuring experiment.

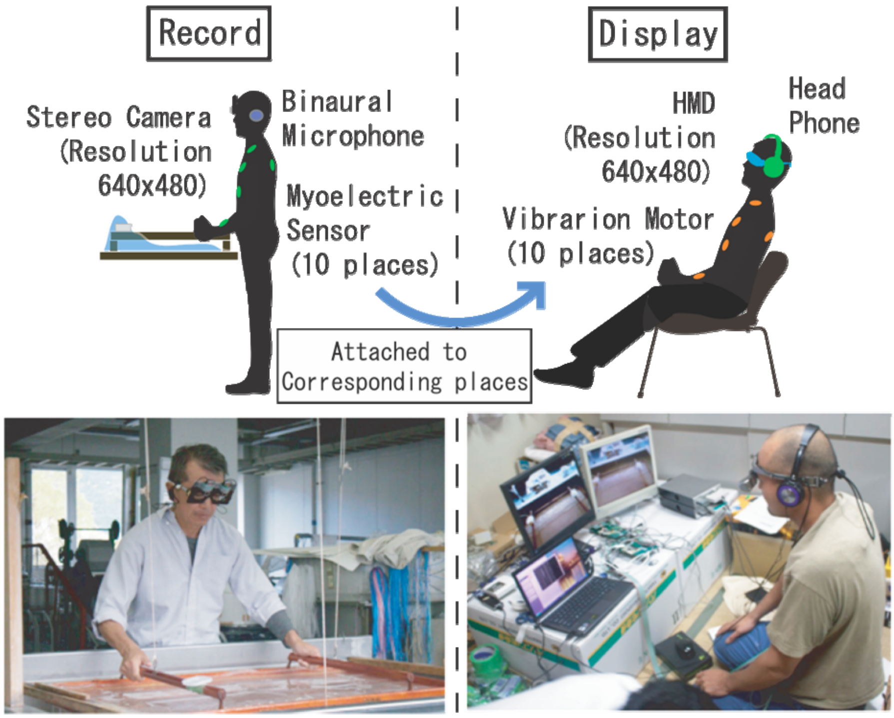

Fig. 6. Wearable recording system and displaying system

6 Experiment of Handing Down Kamisuki Skill

We conducted training experiment of developed wearable display system to 10 male subjects. One of the subjects is working as Kamisuki craftsman for ten years (subject B in skill measuring survey) and other subjects are all beginners. We asked subjects to observe subject A's (same subject in skill measuring survey) recorded first-person data through three different types of medium (wearable system with vibration stimuli, wearable system without vibration stimuli and video) and try to follow his motion in paper making process. Experiment procedure is shown in Figure 7.

Figure 8 indicates that each subject's paper making motion has similar and stable periodic motion to subject A if the data is plotted near the origin. Data in practicing period are not plotted since all the beginner subjects were not able to make stable periodic motion. Subject B could already perform similar motion cycle to subject A, therefore, there are no remarkable changes in subject B's data (see B1-B3 in Fig. 8). On the contrary, beginner subjects are more likely to produce similar periodic motion of subject A in the following order, wearable display with vibration stimuli (see F1-F2, D2 and C1 in Fig. 8), wearable display without vibration stimuli (see H1-H2, D1 and E3 in Fig. 6) and video (see J1-J2, C2 and E2 in Fig. 8). However, subjects who were not able to make periodic motion said that they could not figure out what to

Subjects	Learn I	Learn II	Learn III
B	△ Video only	□ Wearable B	○ Wearable A
C	○ Wearable A	△ Video only	–
D	□ Wearable B	○ Wearable A	–
E	○ Wearable A	△ Video only	□ Wearable B
F, G	○ Wearable A	○ Wearable A	–
H, I	□ Wearable B	□ Wearable B	–
J, K	△ Video only	△ Video only	–

Fig. 7. Training experiment procedure

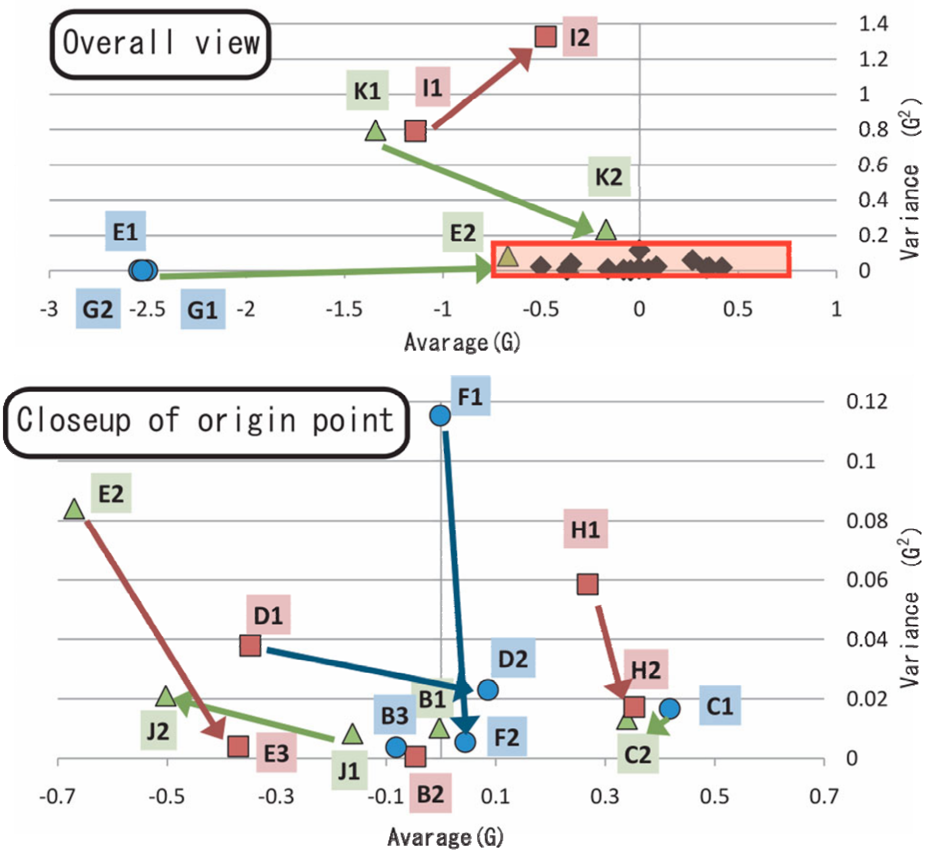

Fig. 8. Training experiment results

observe when experiencing wearable display systems (see K1-K2 and E1-E2 in Fig. 8). From the after experiment interview subjects who were able to make progress in producing periodic motion said that wearable display system can provide high immersive experience. Subject B said that he could observe the difference of his style of papermaking and subject A's style that is difficult to describe in words.

7 Conclusion

In this research, we measured craftsman’s motion of Japanese traditional papermaking and found the stable periodic motion in trained craftsman. In order to handing down this basic periodic motion, we developed wearable display systems that provides first-person experience and induces learner of craftsman's motion in Japanese traditional papermaking. From the result of evaluation experiment, proposing wearable display system had the best performance in inducing craftsman's periodic motion. Wearable display with vibration stimuli has stronger effect in inducing periodic motion. Video observation can be helpful for leaner who could not catch up with multi modal information displayed through wearable display. Combination of using wearable display and video according to learner's level is suggested to be effective in learning of basic motion of papermaking.

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