

Multisensory Capture System for the Preservation of Traditional Painting

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Safeguarding intangible cultural heritage such as traditional painting is getting more critical, but the conventional way to preserve intangible heritage has been to simply record the performance and explanations of Living Human Treasures using video cameras. It cannot preserve the whole procedure and detailed performances of human experts. In this paper, we suggest a multisensory system that captures the core activities of Korean traditional painting while minimizing interference with their activities. The system captures the whole procedures of the activities by tracking the three-dimensional movements of the painter and the brushes, and recording information of the pigments and canvas. We captured the activities of two professional painters and analyzed the brush movements in various ways.

Index Terms—Intangible Cultural Heritage, Traditional Painting, Multisensory Capture

I. INTRODUCTION

Intangible cultural heritage (ICH) is traditions or living expressions inherited from our ancestors and passed on to our descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts. The importance of ICH is not the cultural manifestation itself but rather the wealth of knowledge and skills that is transmitted through it from one generation to the next. ICH has usually been succeeded to the next generation by an apprentice system; however, in modern society the number of successor is drastically diminishing on economic grounds. Due to such trend preserving ICH encountered difficulties although its importance is increasing. Difficulties in preserving ICH originate because it is abstract and invisible by its own nature. Therefore governments of many countries have constructed digital archives such as UNESCO Multimedia Archives eServices [1] for ICH preservation. However, such approaches for ICH preservation based on multimedia systems simply record the performance and explanations of Living Human Treasures using video cameras. This method can only record an outward look of the expert's performance and it is not appropriate for ICH transmission because it cannot preserve enough information to effectively preserve ICH.

Recently, novel approaches to rigorously preserve ICH have been suggested. i-Treasures brings together the intangible cultural heritage of the past and modern technologies of the



(a) Buddhist Painting



(b) Dancheong

Fig. 1: Traditional paintings. Images reprinted from Wikipedia.

present [2][3]. It used multi-sensor technology in capturing European traditional songs, dance interactions, pottery, and contemporary music compositions. They used the acquired data in developing software modules for sensorimotor learning. Hiyama *et al.* proposed a wearable display system for handing down the skills of Japanese traditional paper-making [4]. Their system consists of HD cameras, myoelectric sensors, CoG (Course over Ground) sensors. It measured the human experts' activities and working environment in the first-person viewpoint. They trained apprentices or successors using their training system consisting of a wearable display and vibration sensors. Syu *et al.* investigated a method for digital preservation of Ba Jia Jiang Performance, a Taiwan religious performing art, using a motion capture system [5]. Most of such approaches have critical interference problems because a lot of markers or sensors are attached directly on the performer's body that affects the performance that requires the highest concentration for conducting delicate movements.

The history of painting reaches back in time to artifacts from pre-historic humans and spans all cultures. Figure 1 shows a Buddhist painting and a traditional decorative coloring on wooden buildings called Dancheong. Buddhist painting and Dancheong are two important branches in typical Korean traditional painting. Both of them go through two major steps called Chulcho and Chaesaek which mean sketching and coloring, respectively. Because the number of successors in these fields is also falling, we are experiencing difficulties in the transmission of the Korean traditional painting.

In this paper, we suggest a multisensory system that captures the core activities of Korean traditional painting. The system captures the whole procedures of the activities by tracking the three-dimensional movements of the painter and the brushes

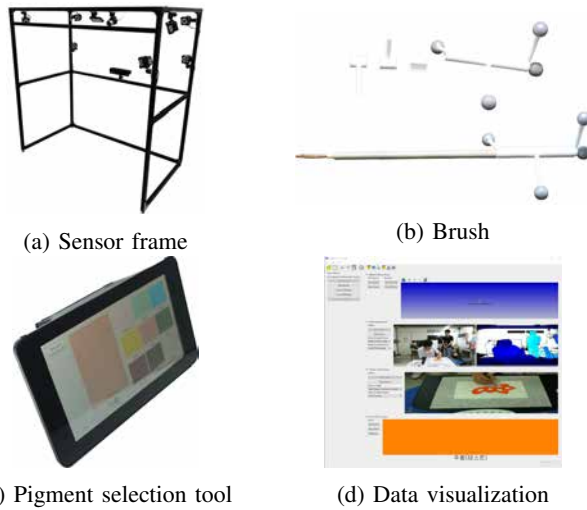


Fig. 2: The proposed system for painting activity capture.

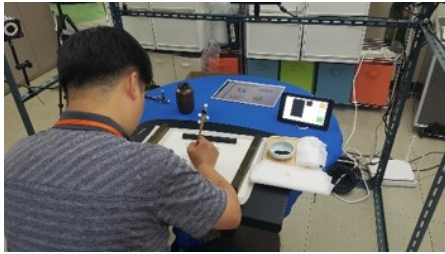


Fig. 3: A painter working in the sensor frame.

and recording information of the pigments and canvas while minimizing the interference with the painter. Especially, the system focuses on Chulcho and Chaesaek.

Little research has been done in recording painters' activities. The main contribution of this paper is to suggest a novel multimodal approach to monitor and record the rigorous activities of the painters to preserve the intangible cultural heritage such as the performance of a Living Human Treasure.

The rest of this paper is organized as follows. We explain our proposed system in Section 2 and describe the experimental results in Section 3. We finally provide some concluding remarks in Section 4.

II. PAINTING ACTIVITY CAPTURE FOR PRESERVING CULTURAL HERITAGE

The proposed system for painting activity capture consists of a sensor frame, brushes, and a pigment selection tool as shown in Figure 2. When a painter paints a picture on a canvas in the space of the sensor frame, the system captures the activities using the sensors equipped on the sensor frame. The sensor frame employed three different types of sensors on a cube-shaped iron frame of the size 1.6m x 1.6m x 0.9m. Figure 3 shows a painter working in the sensor frame.

The system employed contact-less sensors to minimize the interference with the painter's activity. A Kinect sensor is used to analyze the painter's movements. The system extracts



Fig. 4: Canvas image captured by the cinema camera



Fig. 5: Notification of the new pigment through the pigment selection tool

the painter's skeleton data as well as color and depth image data using the sensor. Captured image data are encoded and compressed using a GPU-based hardware system and stored on hard disks.

Optitrack motion capture system identifies brushes used in the painting activity and tracks their movements in 120Hz frequency. Retro-reflective markers were used to detect and track the three-dimensional position of the brushes. The system registers the set of markers that have been attached on a brush as a rigid body so that it can recognize the position and orientation of the brush. Figure 2(b) shows several different markers attached to a brush. We have made the variants by adjusting the relative positions among the markers to make it possible to use several different brushes simultaneously in painting activities. Here, we note that the painters can naturally focus on their work because the brushes used in the system are those to which they are accustomed and the marker complex mounted on the brushes are designed as light as possible.

A cinema camera records the canvas in full HD resolution. The video data captured by the cinema camera are also compressed and saved on hard disks. Figure 4 shows an example of a canvas image captured by the cinema camera.

It is difficult to automatically identify which pigment the painter daubs the canvas with. To overcome this difficulty the system provides a wire-less pigment selection tool. The pigment selection tool consists of a Raspberry Pi, a touch screen display and a battery as shown in Fig. 2(c). When the painter would daub the canvas with a new pigment, he can notify information about the new pigment to the system by touching the corresponding icon to the pigment on the pigment selection tool. Figure 5 shows a painter notifying the new pigment through the pigment selection tool.

The system visualizes the data from the sensors in real-time

TABLE I: Analysis of Two Experts' painting activities

Painter	Cho	Tip Points	Strokes	Length	Time	Speed	Tremor
#1			57	367 cm	2m 54s	2.11 cm/s	0.13 mm
#2			25	148 cm	0m 49s	3.03 cm/s	0.17 mm
Painter	Chocha	Tip Points	Strokes	Length	Time	Speed	Tremor
#1			446	1,014 cm	4m 33s	3.71 cm/s	0.42 mm
#2			517	1,591 cm	2m 52s	9.22 cm/s	0.93 mm



Fig. 6: Drawing imitation by a robot.

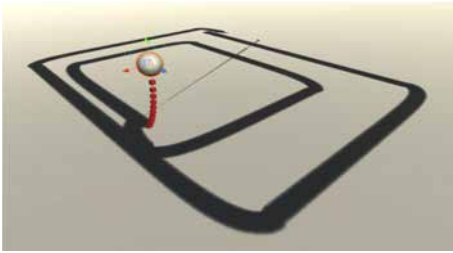


Fig. 7: Virtual replay based on acquired brush movements.

as shown in Fig. 2(d).

The suggested system can be used to visualize, analyze, and understand the valuable details of the cultural heritage. We have applied the acquired multimodal data from the proposed system to various fields. Figure 6 shows the imitation of the drawing by a robot which utilizes the brush movements. Figure 7 shows a virtual replay of the process of being drawn on the canvas with the use of the brush movements. In addition, a painter's style or habit can be estimated through the analysis of the acquired data. In this paper, two experts' strokes were extracted and investigated from the acquired data.

III. EXPERIMENTAL RESULTS

We requested two professional painters in Korean traditional paintings to paint a simple lotus pattern and captured their activities and analyzed the brush movements. Firstly, we divided the brush movements into two classes: strokes and

others. When we registered the brush in the motion capture system, we set the tip point of the brush as its pivot point while its hair has its natural shape. Strokes were detected when the pivot point of the brush is under the canvas, where a stroke is a series of the positions of the pivot point. By doing this, we extracted useful information such as the number of strokes and time interval for each stroke. We defined the degree of brush tremor for a stroke as follows:

$$t = \frac{1}{n-2k} \sum_{i=k+1}^{n-k} |\mathbf{p}_i - \bar{\mathbf{p}}_i|$$

where $\mathbf{p}_i$ is i th brush tip position in a stroke and $\bar{\mathbf{p}}_i = \frac{1}{2k+1} \sum_{j=i-k}^{i+k} \mathbf{p}_j$ is the corresponding position in the smoothed stroke. Here we set the parameter k to 6.

Table I shows the experimental results. In this experiment, we analyzed both sketch and coloring respectively. Cho is the result of Chulcho and Chocha is the first result of Chaesaek. Column *Tip Points* shows the distribution of brush tip positions where colors denote progress of strokes in the time axis; blue denotes the initial moment and red denotes the final moment of the time interval during painting. Column *Strokes* denotes the number of strokes in the painting. Column *Length* denotes the total length of the strokes in the painting. Here, time is the total amount of time for all the strokes and Column *Speed* denotes the stroke drawing speed. and tremor denotes the average t for them.

From the experiments, we observed that there exist significant time differences even for painting similar patterns. The second painter drew the picture faster than the first painter while the order of painting procedures was similar. In other words, both of them started drawing from the left side inside the lotus flower and finished drawing at the right side outside. The tremor of the first painter was less than the second painter's one. In addition, both experts have spent more time on performing Chulcho than Chaesaek considering the drawing time per stroke. For more rigorous validation, more experimental data are required.

IV. CONCLUSIONS

In this paper, we suggested a new system for capturing intangible aspects of painting activities which consists of a sensor frame, brushes, and a pigment selection tool. This system records the painter's activity, the movements of the brush, and information about the pigments and canvas used in the painting activity while minimizing the interference with the painter. The data acquired using this system can be used in various analyses and modeling such as sensorimotor learning, estimation of painting style, the level of the painter's technical skill, and brush modeling.

The experimental results showed that each painter has his own traits in painting activities from multimodal data analysis. However, more samples are needed to make the experimental results statistically more stable. In the future work, we intend to build various analysis models by acquiring a lot of their painting activities from various levels of painters.

ACKNOWLEDGMENTS

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