Visualizing Lost Designs in Degraded Early Modern Tapestry Using Infra-red Image

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Abstract. This paper shows how to experimentally visualize lost designs in damaged early modern tapestries used in the Kyoto Gion festival. Unlike cloth weaving, tapestry is weft-faced weaving. As the surface welt threads become worn or turn over time, the design in a tapestry is gradually lost. On the other hand, weft threads hidden by warp threads still remain. In the tapestries of the Kyoto Gion festival, gold and silver threads were often used as weft, and they reflect infrared radiation. In experiments, a tapestry woven in the seventeenth century was used. Six-band images were taken for accurate color reproduction and infrared images were taken for visualizing the lost design. The viewing angle and image resolution of both types of images were the same. Superimposing the infrared image on color image after correcting registration errors revealed the original design of the tapestry.

Keywords: Tapestry · Visualization of degraded design · Infrared image · Multiband image · Giga-pixel image · Color reproduction

1 Introduction

1.1 Background

The float procession of the Kyoto Gion festival started in the fourteenth century. It was registered in the Representative List of the Intangible Cultural Heritage of Humanity by UNESCO in 2009. The floats, called “Yamaboko”, are known as “moving museums” for their elaborate decorations with tapestries and wooden and metal ornaments. Although civil wars in the fifteenth century destroyed several Yamaboko, many of the surviving tapestries and ornaments are still in use as are many imported from Europe and China or made by Japanese craftsmen from the seventeenth to nineteenth centuries.

Some tapestries have been damaged through long-term use and their original colors and designs have been lost. There are few records of their weaving method and original designs, which makes it difficult to restore them to their original state. Recording and analyzing existent original tapestries are quite important to gain a better understanding of traditional craftsmanship and the cultural background of that time.

High-resolution image capturing is one of the effective approaches for recording and analyzing the woven structures of tapestry. Today’s craftsmen have said that resolution

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from 0.05 to 0.01 mm/pixel (> 500 dpi) is required for this purpose. Using the digital cameras with 50 M-pixel image sensors available on the market, we can take high-resolution images of a part of a tapestry. However, special equipment and techniques for obtaining an image of whole tapestry with sufficient resolution are still under development and have been not generalized yet.

Accurate color reproduction is also important for analyzing the weaving method. The spectral reflectance of an object can be measured by using multiband and hyperspectral imaging technology [1–5], although this requires special and expensive equipment.

To meet the above spatial and spectral resolution requirements, a two-shot type six-band camera system has been developed [6, 7]. The system consists of an RGB image sensor (i.e. a digital camera), a large format camera and a custom interference filter. An object is divided into several parts and an image of each part is captured. The obtained images are synthesized into a large pixel-number image. To take divided images, the image sensor is shifted horizontally and verticality by using a function of the large-format camera. An advantage of this method is that the effects of lens aberration can be ignored when images are synthesized. This camera system can also take infrared (IR) images when IR cut filter on the image sensor is removed.

1.2 Motivation and Overview

Our final goal is to achieve the visualization and virtual restoration of the lost original designs of the tapestries featured in the Kyoto Gion festival. In this work, we focuses on the visualization of the lost designs of damaged tapestry using IR images.

In Sect. 2, we describe the principle of the visualization of the lost designs. In Sect. 3, we introduce the camera system used in experiments and show experimental results. Visible six-band images and IR images of a tapestry were captured. Finally, we summarize the paper in Sect. 4.

2 Principle of Visualization of Lost Design of Tapestry with Gold and Silver Threads

Tapestry is a form of textile art woven on a vertical loom. It is weft-faced weaving, where weft threads of different colours work over portions of the warp threads to form the design. Figures 1 shows a tapestry of the float “Hachiman-yama”, woven in the seventeenth century and used for experiments in this work. Although the back of the tapestry is covered by cloth, we can see the woven structure from the front. The warp threads are dark navyblue, and gold and silver threads are used as weft to form the design, such as the chinese characters in the top and bottom areas of the tapestry. Around the center of the tapestry, we can find animal and human figures. Some of them are blurred or lost because the weft threads in these erea have worn to rags. Detecting the weft threads remaining behind the warp ones is an approach for visualizing lost designs.

The spectral reflectance charasteristics of gold and silver threads are such that they strongly reflect IR radiation, unlike ordinary cotton or wool threads. IR light penetrates the surface of tapestry (e.g., warp threads) and is reflected from gold or silver ones, and

Fig. 1. Tapestry of the float “Hachiman-yama”, woven in the seventeenth century (called “keiju-gire no maekake”).

an IR camera can capture their distribution. IR image capturing is often used for visualizing sketches under paintings. We adopted this technique for tapestry in this work.

3 Experiments

3.1 Image Capturing Setup

Figure 2 shows the whole experimental setup and the geometrical setup for image capturing. The tapestry was put on the floor to avoid movements caused by air vibration and prevent the possibility of damage caused by its own weight had it been hung. Images were taken from overhead using the seven-band camera system (six-channels for visible and one for IR) mounted on the end of the arm of the camera stand. The tapestry was divided into several parts to enlarge image resolution. The arm was extended one dimensionally, and the tapestry was moved in the orthogonal direction. Then images of each part were captured. Finally, the obtained images were synthesized into a large pixel-number image.

The camera system consisted of a large format camera (TOYO-VIEW 45GII), a digital camera back (Hasselblad H4D-50MS) whose IR-cut filter was removed, a digital-controlled shutter system (Horseman ISS-G3), and a camera lens (Rodenstock Apo-macro-sironar 180 mm F5.6). A custom interference filter, an IR-cut filter and an IR filter (cut-off wavelength was 960 nm) were mounted infront of the camera lens. The custom interference filter cuts off the left sides (i.e., the short-wavelength domain) of

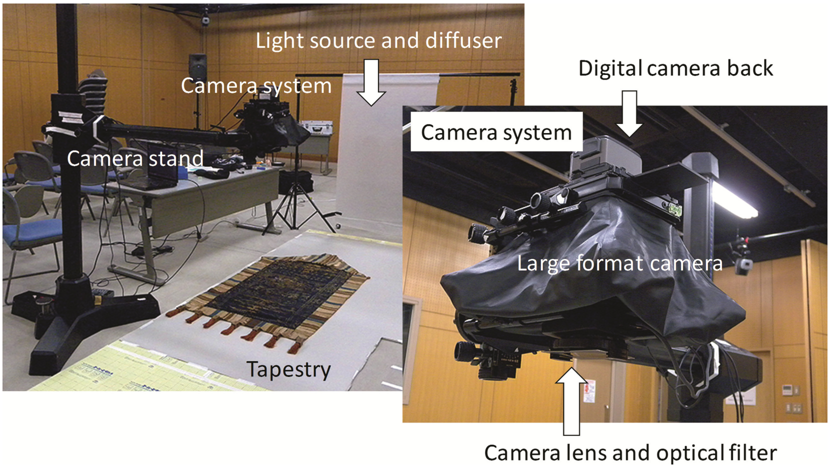

Fig. 2. Overview of whole experimental setup and geometrical setup for image capturing.

the peaks of both the blue and red in original spectral sensitivity of camera. It also cuts off the green's right side (i.e., the long wavelength domain) [4, 6]. An artificial solar lighting systems (XELIOS XG-500 series, SERIC Ltd.) were used for illumination. Figure 3 shows the spectral sensitivity of the camera system and Fig. 4 shows the spectral power distribution of illumination. The solid line represents the spectral sensitivity when IR-cut filter was used, while dashed line represents the spectral sensitivity when the interference and IR filters was used. Three images were taken from each viewing position; the first one with the IR-cut filter, the secound one with the IR-cut filter and the interference filter, and the third with IR filter.

The tapestry is 110 cm wide and 65 cm high. The distance between the camera lens and the tapestry was 95 cm and viewing area of the camera was 26 × 19 cm. The image size of the digital camera back was 8,000 × 6,000 pixels and size of synthesized image was 28,000 × 43,000 pixels. Resolution was 0.03 mm/pixel (800 dpi). Bit depth of each pixel value of each color channel was 16.

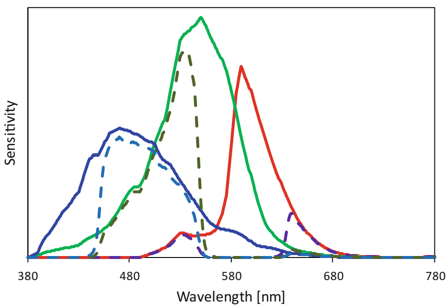

Fig. 3. Spectral sensitivity of camera system. (Color figure online)

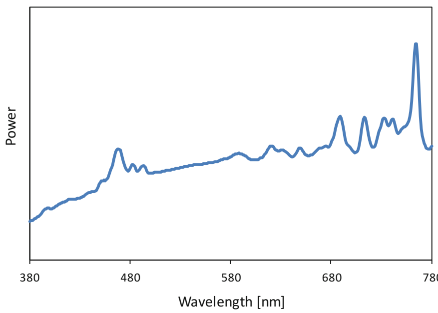

Fig. 4. Spectral power distribution of illumination. (Color figure online)

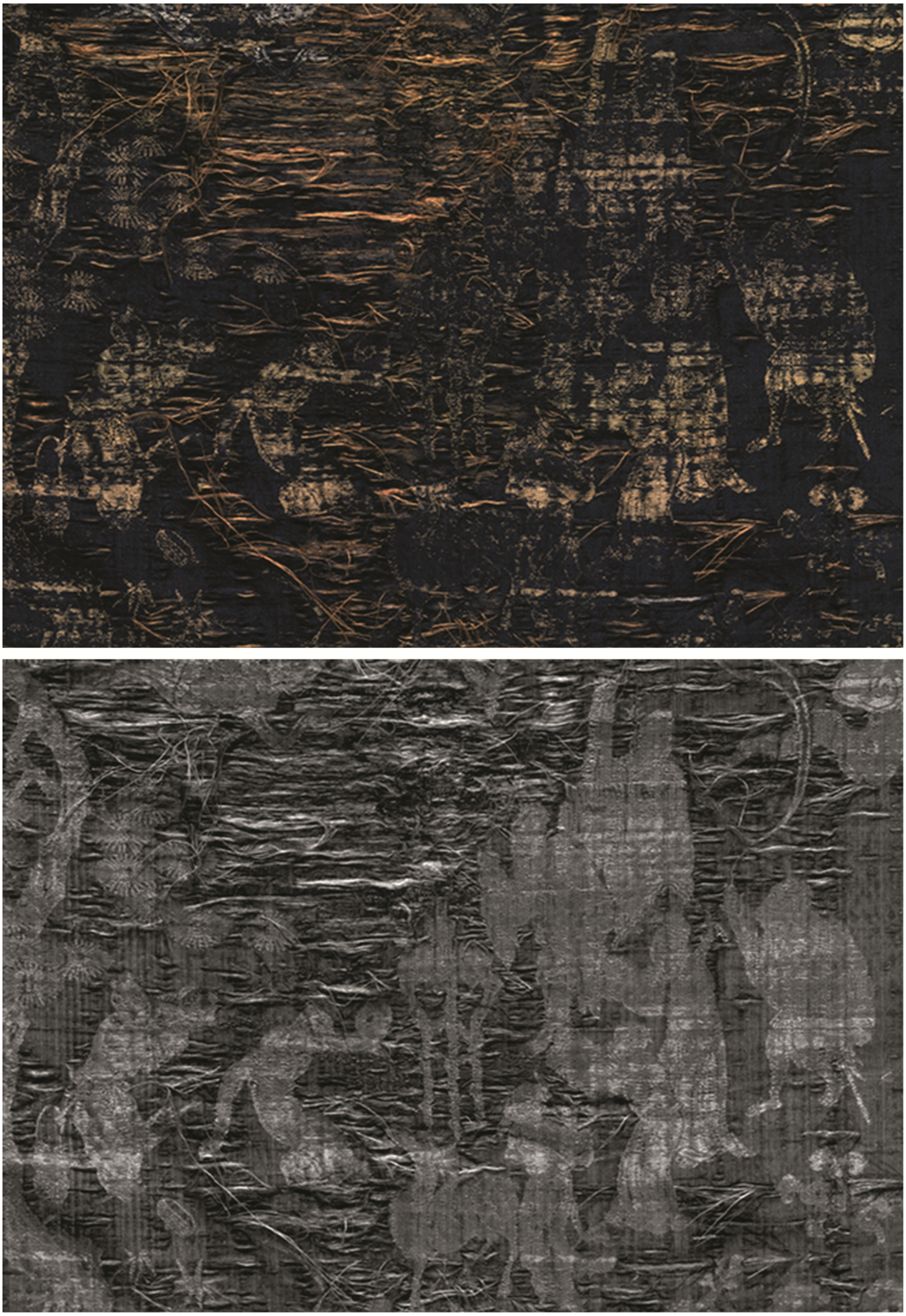

Fig. 5. Resultant images. Top: color image obtained from visible six-band images. Bottom: IR image.

3.2 Results

Figure 5 shows resultant images. The top one is a color image reproduced from the visible six-band images and the bottom one is the IR image. These are images of the center region of the tapestry. When we compare these two images, we can see totally two human figures on the left and right sides of the color image, but it is difficult to find animal and other human figures. On the other hand, at least two animals (perhaps deers) can be seen in the IR image at the center of the tapestry. Human figures in the IR image also look much clearer than those in the color image. In addition, we can see the woven structure from the IR image. These results show that IR light penetrated the surface of the tapestry and was reflected from the gold and silver threads behind the warp.

4 Conclusion

In this paper, we discussed the ability of IR imaging for digital archiving of tapestry. Experimental results show that lost designs caused by damage to weft threads on the surface can be visualized using IR images. IR image capturing is effective not only for visualizing sketches under paintings but also for analyzing tapestry weaving.

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References

1. Yamaguchi, M., Murakami, Y., Uchiyama, T., Ohsawa, K., Ohyama, N.: Natural vision: visual telecommunication based on multispectral technology, In: Proceeding of IDW 2000, pp. 1115–1118 (2000)
2. Tominaga, S., Okajima, R.: Object recognition by multi-spectral imaging with a liquid crystal filter. In: Proceeding of the International Conference on Pattern Recognition, pp. 708–711 (2000)
3. Helling, S., Deidel, E., Biehig, W.: Algorithms for spectral color stimulus reconstruction with a seven-channel multispectral camera. In: Proceeding CGIV, pp. 254–258 (2004)
4. Ohsawa, K., et al.: Six-band HDTV camera system for spectrum based color reproduction. J. Imag. Sci. and Tech. **48**(2), 85–92 (2004)
5. Pratt, W.K., Mancill, C.E.: Spectral estimation techniques for the spectral calibration of a color image scanner. Appl. Optics, OSA **15**, 73–75 (1976)
6. Hashimoto, M., Kishioto, J.: Two-shot type 6-band still image capturing system using Commercial Digital Camera and Custom Color Filter. In: Proceeding CGIV, pp. 538– 541 (2008)
7. Tsuchida, M., Yano, K., Tanaka, H.: Development of a high-definition and multispectral image capturing system for digital archiving of early modern tapestries of Kyoto Gion Festival. In: Proceeding ICPR2010, pp. 2828–2831 (2010)