A stereo one-shot multi-band camera system for accurate color reproduction

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1. Introduction

In the digital archiving for cultural heritage preservation, in the medical field, and in some industrial fields, high-fidelity reproduction of color, gloss, texture, and shape are very important. Multiband or full-spectrum imaging technology is a solution for accurate color reproduction. Although several types of multi band camera systems have been developed [Yamaguchi 2000, Tominaga 2000, Helling 2004, Hashimoto 2008], all of them are multi-shot systems and they cannot take images of moving objects. Ohsawa et al. [2004] have developed a six-band HDTV camera system. However, the system requires very expensive customized equipment. In order to make multiband technology pervasive, equipment costs must be reduced and the systems have to be able to take images of moving objects. To meet these requirements, we developed a novel multiband image capturing system that combines multiband and stereo imaging techniques. This system can acquire both spectral color information and depth information at the same time. In this paper, we focus on the generation of six-band images from a pair of stereo image.

2. Stereo one-shot six-band camera system

Our system consists of two commercial digital cameras, a custom interference filter, and color reproduction software. The filter is mounted in front of the lens of one camera (see top-center photo of Fig.1). The spectral transmittance of the interference filter and spectral sensitivities of the camera used in experiments are shown in Fig.2. The filter cuts off the left sides (i.e., the short-wavelength domain) of 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). The camera with the filter captures a specialized three-band image; the other camera captures a an ordinary RGB color image.

3. Image transformation and generating six-band image

The shape of the image captured with the interference filter is adjusted to that of the other image by projective transformation. To calculate transformation parameters, correspondent points between the two images are detected by using the Phase-Only Correlation (POC) method [Takita 2003]. POC is a scale- and rotation-invariant pattern detection method that uses phase information. POC also has robustness against color. General detection methods cannot work well in cases where the color balance between two images is quite different. The resultant two three-band images are combined in to a six-band image.

4. Experimental results

As target objects, we used old paint drawn on cloth. These cloth, but their surface is gently undulating and uneven. Before starting the experiments, the spectral sensitivity of camera, illumination spectrum, and monitor characters (primary color and tone curves) were measured. First, we took two images of the objects using the proposed system at the same time (see Fig.1). Here, we used raw data images from the image sensor, which is why the color balance of the image captured without the interference filter looks incorrect. Second, the image transformation process was carried out and a six-band image was generated. Next, the six-band image was converted into a spectral reflectance image through Wiener estimation [Pratt 1976]. Finally, the spectral reflectance image was converted into a RGB image by using the illumination spectrum of observation and monitor characters. The resultant RGB image was compared with the paint and the image generated by the two-shot six-band camera system [Hashimoto 2008]. The image obtained with the proposed method is the same color as the paint and has the same quality as the image obtained by conventional methods. No registration errors remain among the band image generated by the proposed method.

5. Summary

A novel one-shot multiband image capturing system was introduced and effectiveness of the method shown in experiments. Although the projective transformation was used for image reshaping in the experiments, this method is currently available for only almost flat objects. To apply the proposed system for three-dimensional objects, a non-linear transformation algorithm should be implemented, which remains as future work. In addition, the method could be extended by using three or more camera systems.

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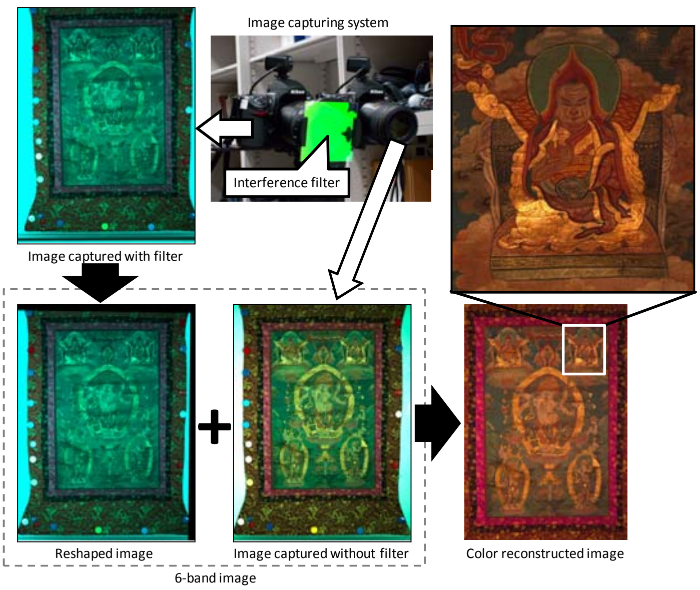

Figure.1

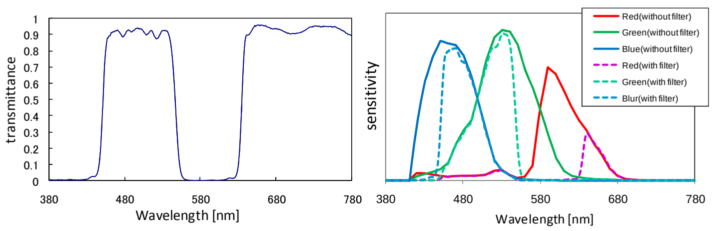

Figure.2

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SIGGRAPH 2010, Los Angeles, California, July 25 – 29, 2010.
ISBN 978-1-4503-0210-4/10/0007