A stereo six-band motion picture capturing using 4K digital cinema camera

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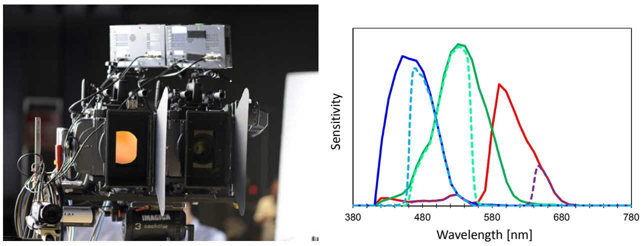

Fig. 1. 4K stereo six-band camera system and its spectral sensitivities.

1. Introduction

In digital archiving for cultural heritage preservation, in the medical field, and in some industrial fields, the high-fidelity reproduction of color, gloss, texture, three-dimensional (3-D) shape, and movement is very important. Multi-spectrum imaging can provide accurate color reproduction. Although several types of multi-spectral camera systems have been developed, all of them, except for the six-band HDTV camera system developed by Ohsawa et al [Ohsawa et al. 2004], are multi-shot and none can take still images of moving objects and moving pictures. However, Ohsawa et al.'s system requires very complex and expensive customized optics whose optical elements must be arranged precisely, which makes it far from practical. In order to make multi-spectrum video systems pervasive, the equipment costs must be reduced by ensuring they have as much compatibility with existing video camera systems as possible. To meet this requirement, several stereo one-shot six-band still image capturing systems that also combine multi-spectrum and stereo imaging techniques have been proposed [Tsuchida et al., 2010; Shrestha et al., 2011]. In this paper, we propose a system that applies their concept to existing 4K digital cinema cameras and show the possibility using the proposed system for cinematography.

2. 4K stereo six-band camera system

Our camera system consists of two digital motion picture cameras and a custom interference filter. The filter is mounted in front of the lens of one camera. It cuts off short wavelengths, the peaks of both the blue and red in the original spectral sensitivity of the camera, and also cuts off the long wavelength of green. The measured spectral sensitivities of the six-band camera used in experiments are shown in Fig. 1. The camera with the filter captures a specialized three-band image; the other camera captures an ordinary RGB color image as shown in Fig. 2.

3. Generating six-band image from stereo image

The two captured images have parallax. Therefore, to generate a six-band image from the pair of images, one image should be transformed to adjust it to the other. The generated six-band image is then converted into RGB image using the illumination spectrum and the characteristics of the display monitor.

There are two main steps for generating a six-band image: (i) sub-pixel correspondence matching and (ii) geometric correction. To find corresponding points between a stereo image pair, we use a sub-pixel correspondence matching approach that combines local block matching by the phase-only correlation method (POC) [Takita et al., 2003] and the coarse-to-fine strategy with image pyramids. POC is a high-accuracy image matching technique that uses phase information in the Fourier domain, which can estimate translation between two images in sub-pixel accuracy. POC is also robust against illumination changes and noise and color shifts caused by differences in the spectral sensitivity of a camera. The image captured with the interference filter is transformed using the detected corresponding points. The thin-plate spline (TPS) model [Bookstein, 1989] is used for image transformation in this system. The resultant two three-band images are combined into a six-band image. Note that the process of six-band creation does not use depth information.

4. Color reproduction using six-band image

Color reproduction based on the Wiener estimation method [Pratt et al., 2003] is conducted. Using the estimated spectral reflectance, spectral power distribution of illumination for observation, and the tone-curves and chromaticity values of primary-colors of the display monitor, we calculate the output RGB signals. Even when the illumination light used in at the observation site is different from that for image capturing (e.g., daylight is used for image capturing and a fluorescent lamp is used at the observation site), the color observed under the observation light can be reproduced as if the object is in front of observers.

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Fig. 2. Captured image
Left: image without filter, Right: image with filter.

Fig. 3. Resultant image of color reproduction.

5. Experimental results

In the experiments, we took images of dancer, who wore Japanese kimono, while she performed a classical Japanese dance in front of a golden folding screen. Two digital cinematography cameras (CineAlta™ F65RS, Sony) were used. The camera system can write out raw image data without any color correction and can take 4K (4096 x 2160 pixels) images, each of which has bit-depth of 16 bits at 120 fps. The baseline length of the two cameras was 15 cm and the distance between the cameras and the dancer was 10 m, which makes it possible to reduce the influence of image parallax between the two cameras in six-band image generation.

Six-band time-sequential images were generated by combining the image captured without the filter and the resultant image transformed from the image captured with the filter (Fig. 2). Figure 3 shows a result of color reproduction. Few artifacts (e.g., double edges or pseudo color) caused by image transformation error are observed. Comparing the resultant image to the real object, one can see that the color of the object is well reproduced. This system and two-shot six-band camera system [Hashimoto, 2008] that uses the same digital camera and filter reproduce almost the same image quality, especially with respect to color.

6. Summary

A 4K six-band motion picture acquisition and visualization system using stereo imaging has been proposed. The system consists of two commercially available digital cinematography cameras, which makes it easy to introduce a current cinematography system. The proposed system can be applied for stereoscopic 3D displays. The two captured images are transformed respectively to adjust the shape of one to that of the other and a stereo-pair of six-band image is generated. A stereoscopic six-band stereoscopic video system whose image size is XGA (1024 x 768 pixels) has also been developed. In this system, all image processing steps after image capture are implemented on GPUs and the frame rate of the system is 30 fps.

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