Evaluation of Tone Mapping for Multi-band High Dynamic Range Images

(0258)

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1 Introduction
The "Natural Vision" [1] project studies the video and still imaging using color reproduction based on spectral information. Our goal is to reproduce highly-natural images with true color, gloss and texture by using the visual telecommunication systems. We have researched and developed multi-band cameras (6 and 16 bands still IPC camera and 6 band IP-TV camera) and multi-primary display(6 primary display) [2], to break through the limitations of conventional RGB systems.

As recent important image processing, a number of successful makings of high dynamic range (HDR) images[3] and tone mapping operators have been proposed to visualize HDR scenes. Then we attempted to make HDR image of multi-band using existing method and reproduce them using existing tone mapping operator on low dynamic range devices. To make an effect and problems clear, we are conducting a subjective and quantitative evaluation experiment by using images that applied some existing tone mapping operators. Multi-band HDR images and conventional HDR images are compared with their corresponding real scene by human eyes.

2 Multi-band capture
The spectrum estimate accuracy from the camera signal improves by increasing the number of bands of cameras. We think that the highly precise estimate of spectrum is synonymous with having caught an accurate color. As a result of evaluating the color reproducibility of the 6-band still camera using Macbeth color checker, the CIELAB color difference average is \( \sqrt{E^{*ab}} = 1.7 \). In the case of the conventional RGB camera(NIKON D200) with spectral characterization, average is \( \sqrt{E^{*ab}} = 3.6 \). For reference, in case of using conventional color management system ICC profile(sRGB), average is \( \sqrt{E^{*ab}} = 5.6 \). The Macbeth color checker was measured by a spectrometer (TOPCON SR-3) under daylight illuminant (almost D65).

Especially it is effective to take objects and scenes including structure color and the high chroma color with a multi-band camera. Since spectrum of those colors has a tendency towards a narrow wavelength, a conventional RGB (3band) camera cannot capture them precisely. In addition, object having structural color tends to create images that have high dynamic range.

For making HDR image of multi-spectrum, we used 6-band camera. We took image which included double Macbeth color checkers (Figure 1_a) with 6-band camera while changing the exposure time(4, 1/4, 1/16, 1/60, 1/160, 1/500, 1/1000s) and we generated radiance map from them[3]. Using a method of Wiener estimation, we estimated the spectrum from a pixel value of 6band radiance map image. They are wave patterns almost same as a spectrum measured by a spectrometer. The color difference average of Macbeth color chart is \( \sqrt{E^{*ab}} = 2.2 \) (bright regions) and \( \sqrt{E^{*ab}} = 0.34 \) (dark regions). It is possible to estimate accurate spectrum from dark and bright regions of multi-band HDR image.

3 Tone Mapping Operation
To represent high dynamic range images on low dynamic range devices, a number of successful tone mapping operators have been presented. We need to reproduce actual color based on spectrum information. In order to develop or investigate tone mapping techniques that satisfy our aims, we conduct a subjective and objective experiment of multi-band HDR images by using existing methods. We chose linear mapping that we usually use to reproduce actual color, logarithmic linear mapping and iCAM model [4] based on color appearance model. 6band HDR images and conventional HDR images which displayed on wide guma RGB display (AdobeRGB) were compared with their corresponding real scene. Figure 1 shows the acquired images for our evaluation experiment. We applied order from the one with a high evaluation. We show a result of subjective evaluation in Table 1. "Overall realistic" is a result that compared the impression of overall image with the real scene. "Bright regions" was evaluated paying attention to the bright Macbeth. The iCAM image was reproduced well overall. But the color difference average of iCAM image which made from 6band HDR is \( \sqrt{E^{*ab}} = 23 \), and normal(conventional) HDR is \( \sqrt{E^{*ab}} = 25 \). Color reproduction precision becomes about the same. Though it depends on the purpose, a good reproduction result seems to be provided by modifying existing methods.

4 Conclusion
We have shown that it is possible to estimate accurate spectrum sufficiently from multi-band HDR images. And we attempted evaluation of existed tone mapping operation. Our future work is to develop tone mapping techniques focusing on accurate color reproduction. Additionally, we will develop an appropriate method to display multi-band HDR images on multi-primary displays.

References


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