Color Correction of High Dynamic Range Images at HDR-level

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Figure 1: The first two images are pictures of material samples. The first one is the original material image, and the second is the color corrected material image. The rest three images are BRDF rendering results from the material HDRI. The third image uses the color corrected HDRI at LDR-level by using the ICC profile, the fourth one uses the HDRI without color correction and the last one uses the color corrected HDRI at HDR-level.

Keywords: color correction, HDRI

1 Introduction

In recent research in representing realistic appearance of materials, HDR (High Dynamic Range) images constructed from LDR (Low Dynamic Range) images taken with different exposure time using a digital camera are used to measure radiance of materials like BRDF. However, in order to reproduce the original color of the materials, they require color correction of the HDR images. Before constructing an HDR image, the color of each LDR image is corrected by using the ICC profile or other method. Then they make a color corrected HDR image from the color corrected LDR images [Goesele et al. 2001]. We call this method the LDR-level color correction. However, each pixel value of LDR images represents not only color but also intensity. Since the pixel values of the LDR images are modified for color correction before making an HDR image, the intensity of each pixel is also changed. In this paper, we propose a color correction method at HDR-level, where the correction is made after the HDR image is constructed. This gives a much better reproduction of the original color of a given material in our experiment.

2 HDR-level color correction

To directly correct the color of an HDR image, we create a transformation matrix between the HDR image of a color checker and the color checker’s reference values in the CIEXYZ space. To perform this, we have to consider the following issues:

1. Normalization: Since the pixel values of an HDR image represent intensity, unlike RGB, the maximum pixel value is not bounded. However, for comparison with the color checker, the pixel values of the HDR image should be normalized. We construct an HDR image of a light source itself which is used in measurement, and the maximum pixel value is chosen as the maximum intensity level in that measurement. Then, the HDR image is normalized by the maximum intensity.

2. Tone-balancing: Even though the HDR image is normalized from 0 to 1.0, the normalized maximum pixel value (1.0, 1.0, 1.0) does not match with the white color. Therefore, for accurate comparison with the color checker, it is needed to balance a tone. We calculate the ratio of the color checker’s HDR image to the reference data for a white patch and apply the ratio to the reference data creating a tone-balanced color checker. Then, by using polynomial regression, we find a transformation matrix between the tone-balanced color checker and the HDR image. Finally we can obtain the color corrected HDR image, while keeping the original tone. To measure the error of the color corrected HDR image, we calculate the average color difference $\Delta E$ between the color-corrected color checker’s HDR image and the reference data of the checker. In this computation, we apply the ratio to the HDR image, unlike the method used in the tone-balancing step.

3 Conclusion

We correct the color of the HDR image by applying the proposed HDR-level color correction method. Figure 2 shows the color difference of each color patch in CIELAB space. The average $\Delta E$ for the HDR-level color correction, 10.2698, is much smaller than that for the LDR-level color correction, 22.8561.

References


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