Appearance Reproduction of Photographic Prints by Display Monitor

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ABSTRACT

We examined a method for reproducing appearance of photographic prints under recommended viewing conditions by display monitors. We obtained an optimum conversion of color information based on measurement results of color patches on a photographic print and color patches displayed on a monitor. Then we reproduced the colors of the patches on the print as the patches on the display using the conversion. As a result, the appearance of the reproduced colors on the display was almost the same as on the print when both the background and surround were the same as the print.

1. INTRODUCTION

The SHADAI Gallery of Tokyo Polytechnic University has a collection that includes over 10,000 valuable photographic prints created by domestic and foreign famous photographers, and some of these works are open to the public at exhibitions that are held several times a year. However, the number of works displayed is limited due to given exhibition space. Therefore, digital exhibitions are expected as a new means of showing.

In this study, we examined a method for reproducing the appearance of photographic prints under a given viewing condition on a display screen.

2. DIGITAL EXHIBITION SYSTEM

2.1 System concept

In the present photo exhibition gallery, the work is hung on the wall, illumination light is applied there, and the viewer can freely appreciate the details of the work from the position he or she wishes to see. In the digital exhibition system as well, it is ideal to be able to appreciate the work reproduced on the screen of the display, in a manner that appreciates the work in the gallery. Such a digital exhibition system needs to have the following requirements.

(1) It should reproduce the color appearance of a photographic print that changes according to the light quality and color of the illumination light and the illumination angle.

(2) It should reproduce different texture according to the type of photographic print material and reproducing technique.

(3) It should reproduce the change of the appearance of the work that changes according to the observation position and angle of the viewer.

2.2 System configuration

In this study, as a first step, we develop a system that can realize (1) noted above. This system consists of the following devices.

a. Hyperspectral camera

This device acquires photographic prints as high-resolution digital images and color information of each pixel as spectral data.

b. Color signal processing engine

This engine calculates the spectral reflectance of each pixel from the two-dimensional spectral data obtained by the hyperspectral camera. From the spectral reflectance, the engine also calculates XYZ tristimulus values of colors under a given illumination light and converts the values into RGB values for displaying colors on the display.

c. High-resolution display system

This display system reproduce the appearance of photographic print as the image on a display monitor under an optimized observation environment.

Figure 1 shows the hyperspectral camera used in the study, HSC1804-CL2 (Hokkaido Satellite), which can acquire spectral images of all 141 bands at wavelength intervals of 5 nm from wavelengths of 350 nm to 1050 nm. When photographed from a distance of 50 cm, a subject of 330 mm (H) × 700 mm (V) is obtained as a digital image of 1920 pixels (H) × 4000 pixels (V).

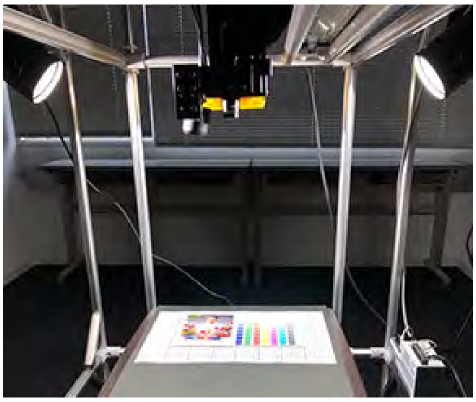

Fig. 1 Shooting with hyperspectral camera

3. REPRODUCTION OF COLOR APPEARANCE

3.1 Target color

Because photographic prints are sensitive to light, the intensity of exhibition lighting needs to be limited to some extent. Therefore, generally 50 lx or less is recommended as the illuminance at the exhibition [1]. In this study, we aimed to reproduce the color appearance of photographic prints with illuminance satisfying this condition. We used a test chart No. 5-1 of the Imaging Society of Japan, made with photographic paper, as a target sample (Figure 2).

Fig. 2 Test chart No. 5-1 of the Imaging Society of Japan (color patches surrounded by red frames were measured)

This chart was stuck on a gray board paper which was regarded as an exhibition wall, placed vertically on a desk, and illuminated with a halogen light source (color temperature 3300 K, illuminance 50 lx). Then, among the color patch series (B, G, R, Y, M, C, K) on the right side of the chart, the 22 colors of the color patches in the thinnest color, dark color, intermediate color, and paper white were measured with spectrophotometer SR3 (TOPCON). Then XYZ tristimulus values of the 22 colors were obtained and these values were taken as the target colors.

3.2 Reproduction of target color by display

In this study, liquid crystal display EIZO - CG248 - 4K (23.8 inch, wide color gamut, number of display pixels 3840 × 2160) was used as display monitor. This display was adopted from the viewpoint of resolution and stability of color reproduction [2]. In order to make the white luminance and color of the display as close as possible to the paper white of the illuminated photographic print, the display was calibrated. Calibration was carried out with ColorNavigator 6 so that the reference white of the display had a color temperature of 4000 K, a luminance of 30 cd / m ^{2}, and a gamma value of 1.0.

Under these conditions, XYZ tristimulus values of RGB three primary colors and white and black were measured, and then a following conversion matrix from given XYZ tristimulus values to RGB data for display was obtained based on additive color mixing principle.

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = 255 \cdot \begin{pmatrix} 0.511 & -0.139 & -0.089 \\ -0.514 & 1.147 & 0.030 \\ 0.003 & -0.008 & 0.059 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} \cdot \cdot \cdot \quad (1)$$

Using this equation, RGB values for display were calculated from XYZ values of 22 color patches including white of the target color, displayed as color patches on the display screen, and XYZ tristimulus values of the patches were measured with SR 3.

4. RESULTS & DISCUSSIONS

L * a * b * values were calculated from the XYZ values of the color patches for both of print and display, with the paper white of the photographic print and the white of the display being the respective reference white. The results of comparing the values of both on the a * b * plane are shown in Figure 3. Except for a few color charts, most of the color charts had the same value.

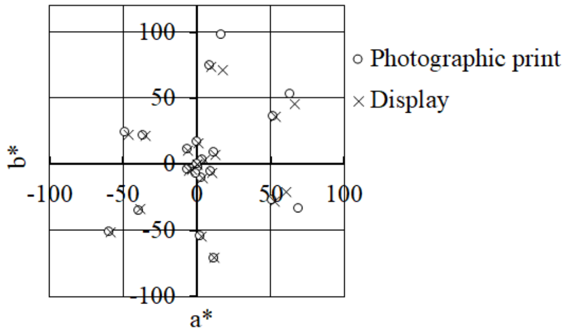

Fig. 3 Comparison of color patches reproduced on display and color patches of photographic print

In the result of displaying the RGB digital image read using the scanner ES-10000G (EPSON), the color difference in the L * a * b * space was 21.3 in the average color difference and 52.3 in the maximum color difference. In contrast, in the result after color correction, the average color difference was 3.5 and the maximum color difference was 26.4. The large color difference was Y, M, and R dark color in order. In addition, when comparing the colors of the displayed patches and the print patches visually, it was confirmed that they are almost the same color.

In the high-density Y and R color patches in which the color difference of the reproduced color patches was large, inverse conversion of the conversion of Expression (1) was performed, and a large color difference was observed without returning to the original state. For these colors, it is thought that the conversion error due to the Expression (1) derived based on the color reproduction model appeared largely.

5. SUMMARY

With the color correction by a 3 × 3, matrix conversion, the color appearance of the photographic print patches could be reproduced on the display with good accuracy. If the hyperspectral camera is used, colors viewed under arbitrary illumination light can be reproduced.

6. REFERENCES

[1] T. Fujiwara, “Handbook of exhibition illumination for curator”, pp. 12-13, Kodansha (2014).

[2] Y. Azuma, T. Tamura, M. Inui, and K. Uchikawa, “A basic research on realistic texture reproduction of photographic print by display monitor”, Proc. of ACA2018, pp.603-607 (2018).