Reproduction of Artwork on Display using Hyperspectral Imaging and Monitor Calibration

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Abstract. Reproducing physical artwork in a display screen is difficult due to many limitations in space and equipment. In this paper, we propose a method to make real artwork and monitor artwork the same using hyperspectral imaging and monitor calibration. The spectral reflectance obtained using RGB image with hyperspectral imaging is excellent in color reproduction and can also be used in re-illumination. By using the lighting characteristics of the space where the artwork is located and the color matching function, we can obtain XYZ images from the spectral reflectance. Monitor calibration is a method to obtain the RGB values for outputting XYZ color components, and we can obtain the RGB image of the obtained artwork through monitor calibration. By displaying the obtained RGB image on the monitor, we can confirm that it is similar to the real artwork.

Keywords: Hyperspectral Imaging, Color Correction, Monitor Calibration

1 Introduction

The importance of digitalization of physical artworks is increasing as the number of digital artworks and exhibitions grows. However, reproducing the same color as the physical artwork on a monitor through a simple image capture is not easy, as many conditions such as lighting and color conversion conditions in the location of the image capture are necessary, and those conditions may still limit the situation.

In this paper, we use hyperspectral imaging to obtain the spectral reflectance, and then use monitor calibration to reproduce the color. Hyperspectral imaging is used to obtain the spectral reflectance of the artwork using a conventional RGB camera and color chart. The spectral reflectance is re-illuminated in XYZ color and then converted into RGB color through monitor calibration.

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2 Color reproduction of artwork on the monitor

The reproduction of a artwork through a monitor is carried out through the process shown in Figure 1. Reflectance spectra is obtained from images obtained from multiple illuminations and then re-illuminated into XYZ colors. Then, the artwork in XYZ colors is converted into an RGB image through monitor calibration.

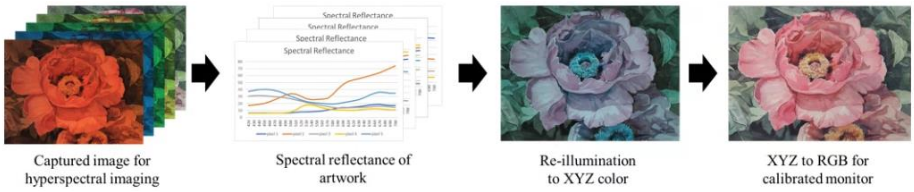

Fig 1. Pipeline of art reproduction methods

2.1 Hyperspectral Imaging

The hyperspectral imaging method for obtaining spectral reflectance using RGB camera and multiple lighting sources can be obtained by using a linear camera model and the PCA basis functions of the spectral reflectance, Parkkinen basis functions. The linear camera model can be expressed as a camera model where the intensity of light is proportional to the RGB values, as shown in equation 1.

$$I = \int p(\lambda)s(\lambda)r(\lambda)d\lambda \tag{1}$$

Here, $p(\lambda)$, $s(\lambda)$, $r(\lambda)$, and I represent the power spectrum of the light source, the camera sensitivity, the object's spectral reflectance, and the RGB values, respectively. spectral reflectance can be expressed as a function of wavelength using the basis functions $b(\lambda)$ and coefficients σ, as shown in equation 2, and can be combined into a single matrix by expressing the function as a wavelength, as shown in equation 3.

$$r(\lambda) = \sum \sigma b(\lambda) \tag{2}$$
$$I = \sigma F \tag{3}$$

By using equation 3, the RGB value and spectral reflectance of an object whose spectral reflectance is known can be obtained by obtaining the function F, and the same lighting can be used to obtain the reflectance coefficient σ. To determine the lighting and camera characteristics, five different lights must be used as shown in Figure 2, and color charts and artwork images are required. By obtaining the lighting conditions and camera characteristics from the color charts with known spectral reflectance, and the same conditions to obtain the artwork image, the spectral reflectance of the artwork can be obtained. This acquired image is relit into XYZ color using the linear camera model, the XYZ color matching function, and the lighting spectrum.

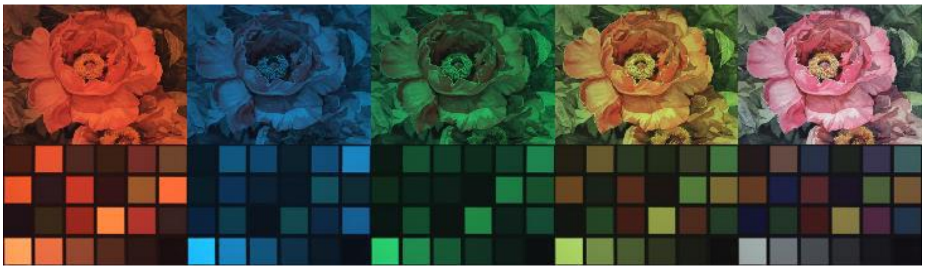

Fig 2. Artworks and color checkers obtained from 5 different lights

Fig 3. The artwork that is re-illuminated into an XYZ image.

2.2 Monitor Calibration

Monitor calibration is the process of determining the relationship between XYZ and RGB colors. Most video data is based on RGB, but in this paper, by generating XYZ images, the effect of lighting can be seen more greatly through direct use of monitor calibration. Monitor calibration is obtained by using a spectroradiometer to acquire the RGBW spectrum of the monitor and then determining the XYZ values through a color matching function. The acquired RGBW XYZ values can be used to create a matrix that transforms from XYZ to RGB.


Fig 4. Reproduced artwork

3 Conclusion

In this paper, we propose a method for reproducing artwork by obtaining the spectral reflectance of the artwork and using XYZ color to re-illuminate it, and using monitor calibration to convert the XYZ image to RGB. This method allows us to reproduce the artwork on a monitor in a way that is similar to the actual object. This was confirmed by confirming that the artwork was reproduced on the monitor in a similar way to the actual object.

References

1. Sim, K.D., Park, J.I., Hayashi, M., and Kuwahara, M.: Artwork Reproduction Through Display Based on Hyperspectral Imaging. In: Proceedings of the International Conference on Human-Computer Interaction, pp. 332-342. Springer, Heidelberg (2022).
2. Park, J.I., Lee, M.H., Grossberg, M.D., and Nayar, S.K.: Multispectral imaging using multiplexed illumination. In: Proceedings of the International Conference on Computer Vision, pp. 1-8. Springer, Heidelberg (2007).

3. Parkkinen, J.P., and Jaaskelainen, T.: Characteristic spectra of Munsell colors. Journal of the Optical Society of America A, vol. 6, no. 2, pp. 318-322 (1989).