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Spectral Reconstruction of Chinese painting based on Pseudo-inverse method in Graphic Communication

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Abstract

In this paper, the multi-channel spectral reconstruction system was built by using the digital camera with filter, which could help the digital camera to get the CCD response value that could be conversed into spectral reflectance. As result, the relative color information of the Chinese painting could be acquired and the process of spectral reconstruction could be accomplished. About research process, firstly, the Chinese painting color cards were made by using the Mali Chinese painting pigment coated on xuan paper, and part of these card were chose as the training samples, and the other part was as for experimental samples. Secondly, the color information of Chinese painting card could be gotten by using the EOS 5D canon digital camera to take photos with these cards. At the same time the spectral reflectance of these card could be tested by spectrophotometer. Finally, the relative spectral reconstruction algorithm was used to reconstruct spectral reflectance for experimental samples. The result showed that based on Pseudo-inverse method to reconstruct spectral reflectance of Chinese painting card could have higher accuracy and the color information of the Chinese painting could be accurately reproduced.

Introduction

Recent years, With rapidly development and application of color reproduction technology and digital imaging devices, the more efficient of color transmission and reproduction will be demanded[1-2]. However, the traditional color reproduction could only achieve the goal that the chromaticity is correctly reproduced, which is difficult to ensure the original color appearance[7]. This is because that the different conditions of lighting and observation sometimes could lead to huge difference of color rendering. What is more, the phenomena of metamerism is existed in the XYZ space, which could be described that spectrum of visually identical colors (the XYZ tristimulus values are exactly the same) may be completely different. But if the conditions of lighting is changed, the original two identical colors and XYZ values will become different [3-4].

Thus, spectral color reproduction technology will be a breakthrough in application of color science. And during using multi-spectral imaging technology, the efficient reconstruction of spectral (mainly the color spectral reflectance) plays an irreplaceable role. This is because that it could not only ensure color consistency without depending on standard light source and observer, but also achieve visual consistency of the tone layer and deal with phenomena of metamerism[5-6].

Chinese painting samples production

The simulation samples were made according to the method of making the Chinese painting artwork, which was the basis for making color control color samples for Chinese paintings. Thus, this part researched the type of pigment and paper when Chinese painting samples were made. Through analyzing, the pigment of traditional Chinese painting generally are divided into two major categories:one is mineral pigment, and the other is plant pigment. However, on the market, most of the Chinese painting uses Mali Chinese painting pigment for creation. So, this paper also chose this pigment coated on xuan paper to make Chinese painting samples[8].

Process of making Chinese painting card

The Mali Chinese painting pigment has many different base colors. This paper chose 24 colors as the base colors and used tow different colors that were added water to combined. Firstly, according to the ration of water to pigment was 1:2 to

combined. And then two different pigment were combined with ratio 1:1. Finally, the 276 color card were made and numbered. The sample production process is shown in Fig1.1.

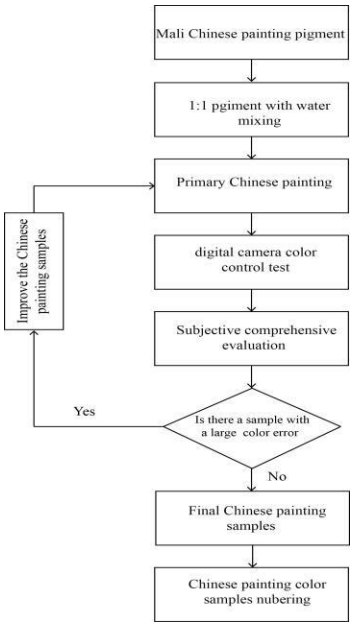

Fig.1.1 the process of making Chinese samples

Chosen for Chinese painting samples

Finally, 81 color samples were chosen as the training samples, and the rest 81 color samples were as for experimental samples, as shown in Fig.1.2

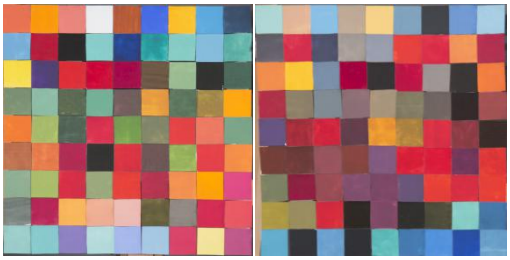

Fig.1.2 Chinese painting samples(left is training samples, right is experimental samples)

Spectral Reconstruction Algorithm based on Pseudo-inverse method

Assume that the digital camera's noise is negligible and the sensor response vector C corresponds to the spectral reflectance vector R, then for the matrices C and R composed of k vectors, there is an m*n matrix A, making the value of $[R - AC]$ the smallest, assuming this time[7]:

$$R = AC \tag{1}$$

Therefore, it can be seen from Equation (1) that the intermediate transformation matrix A can be calculated by measuring the sensor response value vector C' and the spectral reflectance vector R' of the training sample with a digital camera[9-10].

By measuring the data of the training sample Fig.1.2, and according to Equation 1 can be obtained:

$$A = R'C'^{+} \tag{2}$$

C'^{+} is the pseudo inverse matrix of C', so that the spectral reflectance R of the experimental sample in Fig.1.2 can be obtained by multiplying the conversion matrix A by the response value C of the experimental sample measured by a digital camera:

$$R = AC = (R'C'^{+})C \tag{3}$$

Experiment

Experimental steps

Firstly, the photograph conditions were determined, and the Multi-channel spectral reconstruction system was built by using the EOS 5D canon digital camera with 3 different bands of red, green and blue filters, and the spectral reflectance could be obtained by using the Eye-one spectrophotometer. About the experiment of this paper, the focus setting of this digital camera was manual mode, and the aperture size was f5.6, the exposure time was 06s and ISO was 50. the process could be seen in Fig.1.3

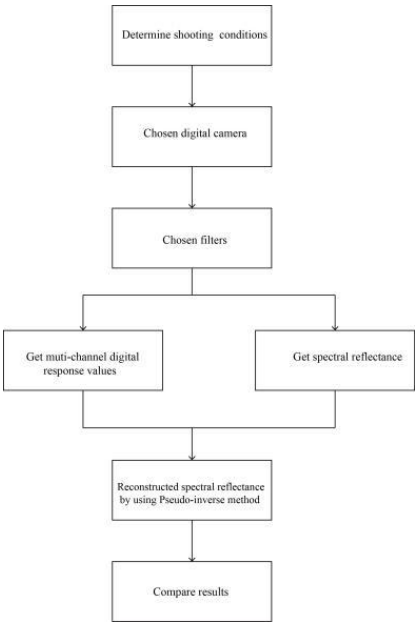

Fig.1.3 Experimental process

Meanwhile, the data of these filters could be seen from Fig.1.4, and the green filter was chosen in this experiment. Then, after the CCD response value of these card were gotten by using the digital camera, the intermediate transformation matrix A was calculated by using the equation 2, and finally the spectral reflectance of the experimental samples could be obtained by using the Pseudo-inverse method.

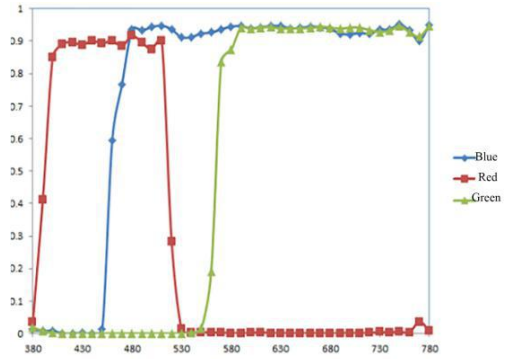

Fig.1.4 RGB filters data

Experimental Result

Pseudo-inverse method, which showed that mean ΔE was 5.0305 and mean RMSE was 0.00211, and the data were as shown in table.1

table.1 Pseudo-inverse spectral reconstruction data results

RMSE	ΔE
Mean	Mean
0.0213	5.5782
0.0222	5.5335
0.0211	5.6087
0.0219	5.6034
0.0201	5.6024
0.0209	5.6072
0.0214	5.5866
0.0212	5.5775
0.0205	5.6041
0.0211	5.6062

And the 2 experimental samples were chosen to compare the spectral curve, the experimental samples without filter could be seen in Fig.1.5, with green filter could be seen in Fig1.6.

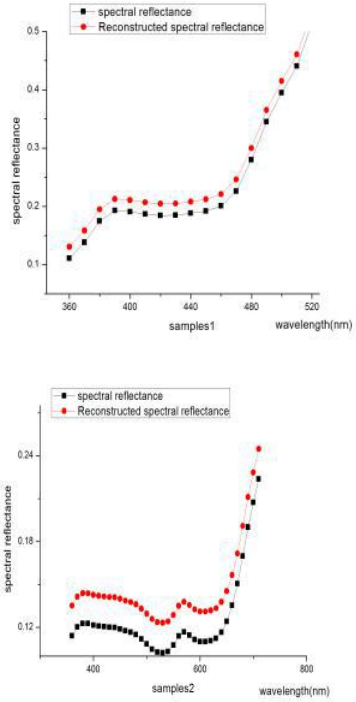

Fig.1.5 the raw spectral reflectance and the reconstructed spectral reflectance without filter

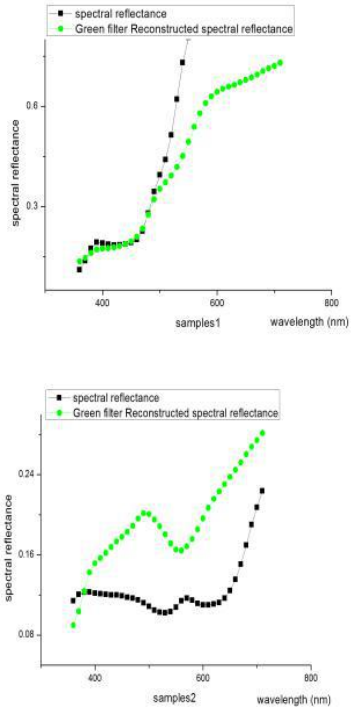

Fig.1.6 the raw spectral reflectance and the reconstructed spectral reflectance with green filter

Conclusion

By using the Multi-channel spectral reconstruction

system with digital camera and using the RGB filters to build multi-channel , the color information could be accurately reproduced, which could promote the development of reproducing colors of culture heritage liking Chinese painting. And in this paper, the homemade Chinese color card were chosen as the samples, which could effectively reduce the color error and more accurately reflect color information of Chinese painting. Finally, the Pseudo-inverse method was used to reconstruct spectral reflectance, which could reduce the calculating time and more accurately reproduce colors.

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Biography

Meiqi Lin obtained her graduate degree in Printing Engineering in Qilu University of Technology. She will finish the postgraduate degree within the group of Prof. Lin (Qilu University of Technology) with the focus on the preparation of the color science.