Automatic Color Reproduction Using Color Chart Position Estimation Method

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Abstract

In many fields such as telemedicine, electronic commerce, image archive of ruins and Internet mail order, color reproduction technique plays a key role in capturing an accurate image of target. The color of a target can be faithfully reproduced by presuming and recording the spectrum reflectance of the object which is not influenced by the lighting conditions using a multiple-spectrum camera. However, this technique has a disadvantage that a lot of money is required. Since it is cheaply realizable, a method of reducing the influence of the lighting conditions using a known color chart is used widely. Unfortunately, it is necessary to input the color chart position in the picture into a color reproduction system manually. In order to reduce this troublesome work, we proposed a method of estimating a color chart position in a picture. Traditionally, there is a technology that detects objects with SIFT (Scale-Invariant Feature Transform) that obtained features from local images in object detection. SIFT has robust features which are invariant to image scaling, and rotation, illumination changes. Using SIFT we can compute the similarity transformation between a template color chart picture and a target picture. We show the effectiveness of our method by experiments using real images under various lighting conditions.

Introduction

Practical research and development of the conventional color image processing and display system have mainly been turned to extension of screen resolution or color resolution. And rapid development of electron device technology gave the surprising performance to a display which we use every day. For example, also in the small display of a cheap portable electric device, we can view an image which has very high screen resolution and color resolution.

However, the color reproduction hardly performed until now has also come to be energetically studied at requests from many fields such as telemedicine, electronic commerce, image archive of ruins and Internet mail order. Color reproduction is reproducing the colors of target in a picture at the time of an inspection and use literally, and it can divide roughly into three kinds for the purpose.

1. The image itself is accepted as it is and it aims at displaying the colors faithfully.
2. It aims at presuming and recording the objective spectrum reflectance which is not influenced by the lighting conditions at the time of capturing an image.
3. It aims at rectifying the colors in an image in consideration of the lighting conditions at the time of capturing an image.

About the 1st of the above mentioned list, a color reproduction system of monitors is already put in practical use and it is widely used for people sensitive to colors such as a designer. About 2nd of the list, the research called "natural vision" [1] which used the multiple-spectrum camera and the multi-primary color display system is known. On a principle, although a very ideal result is obtained by using the system, it seems that spread still takes time since expensive apparatus is needed. The color reproduction technique dealt with in this paper is classified into the 3rd item. Although the method of reducing the influence of the lighting conditions at the time of capturing an image using a color chart is generally used, it is necessary to point the color chart position in a captured image to a system manually. When many colors are contained in a color chart to be used, it takes time and effort very much.

In this paper, we propose a method of estimating a color chart position in a picture using image recognition technology which progressed very much recently. Although mentioned later for details, it is necessary to learn the features of a color chart used first. Then, a color chart position is calculated by matching the features between the template picture and the target picture. By computing how each point in the color chart of the template picture is mapped in the target picture, the position of the central point of each color domain in the color chart of the target picture can be obtained for easily. Therefore, if the transformation parameters can be estimated accurately, it is possible to reproduce colors in a picture with the color chart automatically. Moreover, if the color chart currently used within the target picture can be judged automatically, it will become a more practical system.

Prior Learning

At first, we need a picture of which a color chart appears greatly in the center. Afterwards, we call the picture "template color chart picture". Features of the picture are computed using SIFT (Scale Invariant Feature Transform) [2]. Moreover, the coordinates of the vertices of the four corners of a color chart and the central point of each color domain are also recorded. SIFT uses only luminosity information of an image and following are the steps of computation used to generate features.

1. A color picture is changed into a gray scale picture.
2. Feature candidates are detected from the DoG (Difference of Gaussian) picture of various resolution.
3. Except for the point that the pixel value of the DoG pictures is small, and the point on edge, position of feature candidate points in sub-pixel order is estimated.
4. A slope histogram is created about the domain near each feature, and the direction of a slope is determined on the basis of frequency maximum.
5. Domain of the features is rotated so that the direction of a slope may come right above.
6. A domain is divided into the block of 4x4=16, and the slope histogram quantized in the eight directions within each block is computed.
7. Finally, the 16x8=128 dimension vectors at every feature points are obtained.

Figure 1 shows the template color chart picture used in prior learning. We use a color chart called "Macbeth Color Checker" containing 24 colors.

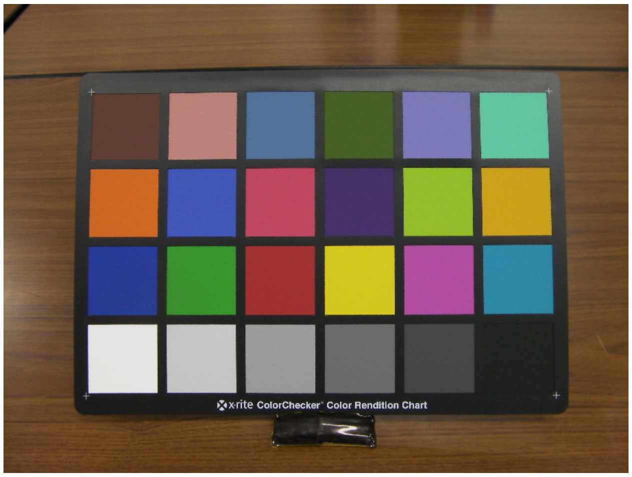

***Figure 1**. Template Color Chart Picture*

The result of prior learning is shown in Figure 2. The size of arrows overwritten on the picture shows the scale of SIFT features detected inside the color chart. The root of an arrow represents position of a feature point. Naturally, direction of an arrow points out the direction of a slope.

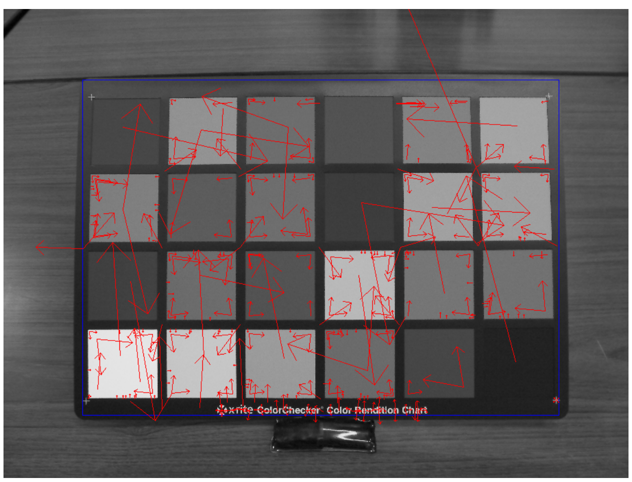

***Figure 2**.Result of Prior Learning*

Color Chart Position Estimation Method

Position of a color chart in a picture in which a photographic subject is taken together with the chart can be estimated in the following procedures.

1. The picture is converted into a gray scale picture, and SIFT features are computed.
2. The SIFT features learned in advance and above mentioned features are matched.
3. The affine transformation [3] of a point in the template color chart picture to a target image point is estimated by at least 3 matches.
4. The positions of vertices of the four corners of the color chart in the template color chart picture can be converted into those in the target picture.
5. The positions of central point of each color domain are similarly estimated.

Generally for the 3rd item in the above lists, the statistical technique of RANSAC (Random Sample Consensus) [4] robust over outliers is used. Figure 3 shows the flow of RANSAC.

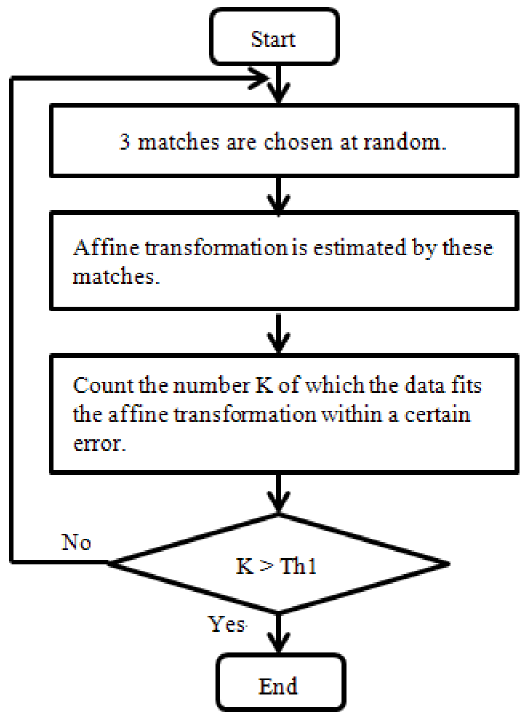

***Figure 3**.Flow of RANSAC*

However, since the color chart is very featureless, we modify RANSAC method. Figure 4 shows the flow of modified RANSAC. The steps where the mark of an asterisk is attached are newly added in modified RANSAC.

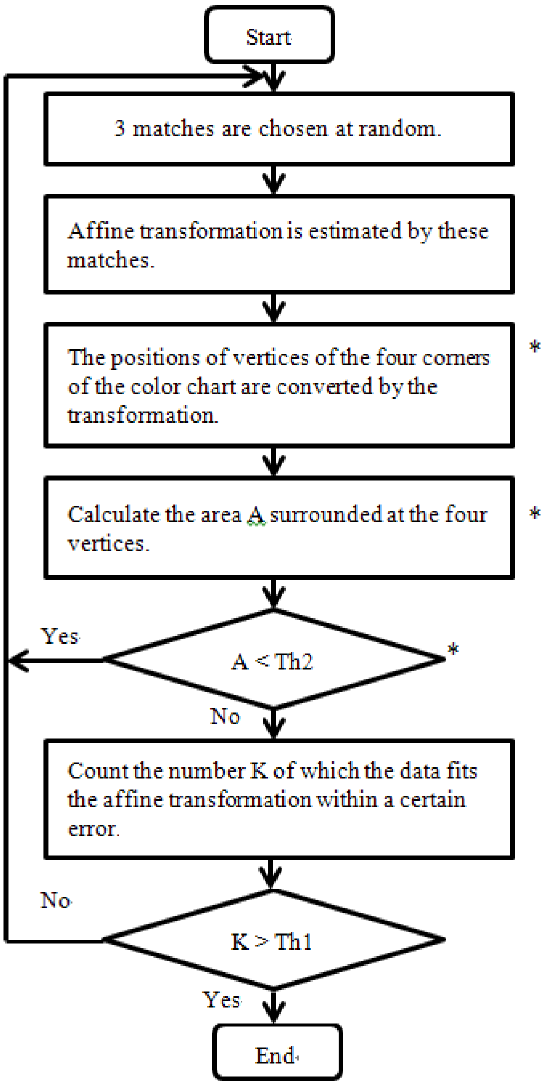

Figure 4*.Flow of modified RANSAC*

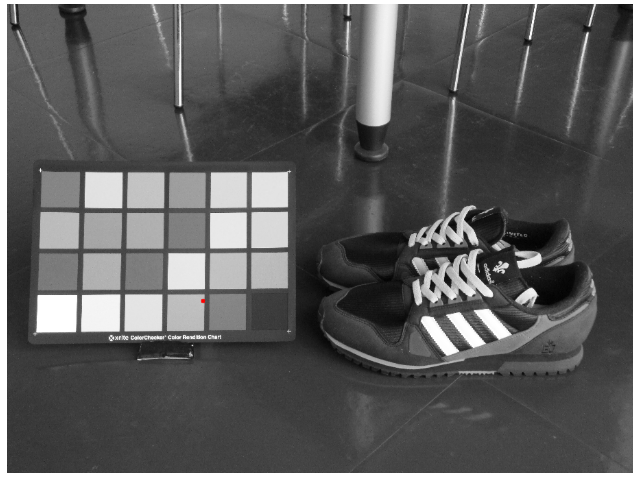

Figure 5*.Result of Prior Learning*

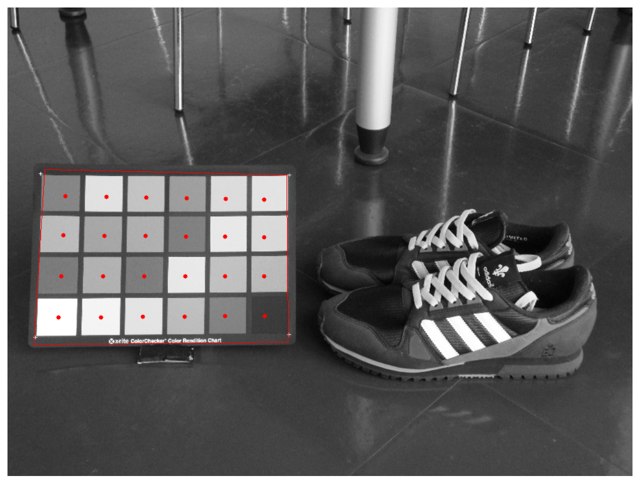

Figure 6*.Result of Prior Learning*

Experiments

20 photographs were taken with a digital camera under various lighting conditions so that a colorful sneaker and a color chart might be settled in frame. In order to confirm our proposed method, we tried to estimate the position of a color chart and the central point of each color domain from these pictures. In 17 pictures, the position of a color chart and the central point of each color domain were able to be estimated among all 20 pictures by proposed method. By comparison, accurate estimate values could be obtained in only 14 pictures using conventional method. An example which could not be estimated by conventional method is shown in Figure 5. Figure 6 shows that the position of a color chart and the central point of each color domain in the picture were estimated by proposed method.

Conclusion

A color chart position estimation method was examined for the purpose of automatic color reproduction. Although the almost exact position was estimated in 85% of pictures in the proposal technique, for utilization, improvement in the further estimation accuracy is required. There was a tendency few computed amounts of the SIFT features to be in the picture which failed in estimating the position of a color chart. This observation has suggested that increasing the amount of the SIFT features computed enables the position estimation.

References

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Author Biography

Tosiaki Yamanouchi is an assistant professor of Kanagawa Institute of Technology, Japan. He gained BE and ME degrees from Waseda University in 1990 and 1992 respectively. He worked at the University as a research associate for three year, and he moved to Kanagawa Institute of Technology in 1997. His main research field is Image Processing.