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# Color Scene Transform Between Images Using Rosenfeld-Kak Histogram Matching Method

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## ABSTRACT

*In digital color imaging, it is of interest to transform the color scene of an image to the other. Some attempts have been done in this case using, for example, lαβ color space, principal component analysis and recently histogram rescaling method. In this research, a novel method is proposed based on the Resenfeld and Kak histogram matching algorithm. It is suggested that to transform the color scene between two images, the histograms of the three R, G and B channels of the input image would be matched to the corresponding histograms of the destination one. The performance of the introduced method was investigated for several images. The obtained results indicated that this method is well capable of transforming the color scene between images. Prog. Color Colorants Coat. 6(2013), 17-24. © Institute for Color Science and Technology.*

## 1. Introduction

Considering the development of different color imaging devices such as displays, printers, etc, color imaging science and technology is promoted days to days [1-2]. One of the most important aspects of color image processing is to change the color of an image. It can be useful for color image enhancement, desirable color reproduction, color constancy, color gamut mapping and, etc [3-13]. Recently, some attempts have been reported on scene color transform between images. Some research applied lαβ color space, which is based on data-driven human perception research, to transform the color scene of one image to another [8-9]. It seems that this color space is not always match to the principal axes of color images. A set of works introduced to use principal component analysis for color transform [10-12]. The proposed model was presented in two forms, i.e. "Total" and "Segment", based on PC matching. It was claimed that Segment PC matching was well but automatic classification was hard. Another research proposed a method based on histogram rescaling between two color gamuts [13]. This method is based on adapting the lowest and highest source values of the first image to the

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corresponding values of the destination image. Figure 1 shows a schematic form of histogram rescaling.

In this way, the total shape of the histogram does not change, and the histogram is only snuggled or expanded. In addition, the image histogram is changed based on the lowest or the highest values even the image contains only a few pixels with those special values.

In the present study, a novel method is introduced for color transformation between images by applying histogram matching technique. This method is based on matching the histogram of the three R, G and B channels of the first image to the corresponding histograms of the destination image.

## 2. Experimental

The goal is the transformation of the color scene of an image to another. This paper introduces a method based on applying histogram matching or histogram specification algorithms. The fundamental reason of this idea is that by a histogram matching it is possible to transform both the type of colors and also the frequency of them between images. So, it is expected to have a similar color scene between color images by applying a suitable method based on a histogram matching algorithm. To this end, at first it is necessary to have a powerful algorithm for histogram specification. Image processing tools can give this opportunity.

### 2.1. Histogram matching or histogram specification [14-15]

Let us assume that I and J are two gray scale input and output images and r and z return to gray levels of them, also $p_r$ and $p_z$ denote their corresponding probability density functions. For more simplification, the procedure is considered in the case of discrete values. Let s be a random variable as follows:

$$S_k = T(r_k) = \sum_{j=0}^{k} P_r(r_j) = \sum_{j=0}^{k} \frac{n_j}{n}, \qquad k = 1,2,...,L-1 \qquad (1)$$

where n is the total number of pixels in the image, $n_j$ is the number of pixels with a gray level $r_j$, and L is the number of discrete gray levels.

So it is possible to define a random variable z with the property

$$v_k = G(z_k) = \sum_{j=0}^{k} P_z(z_j) = s_k \quad , k = 1,2,...,L-1 \qquad (2)$$

Follow from these two equations: G (z) = T(r), therefore

$$Z_k = G^{-1}[T(r_k)] \qquad k = 1,2,...,L-1 \qquad (3)$$

Or

$$Z_k = G^{-1}(s_k) \qquad k = 1,2,...,L-1 \qquad (4)$$

The transformation T(r) can be obtained from equation (1) which p(r) has been simply estimated from the input image.

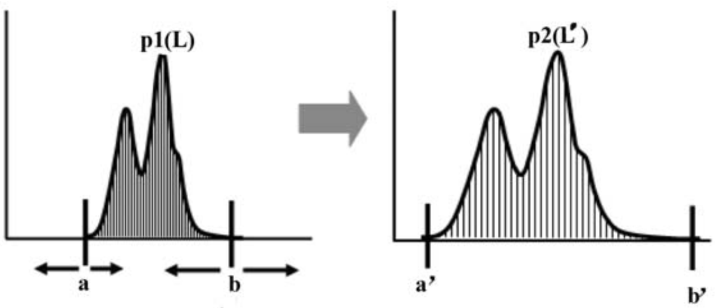


**Figure 1:** Histogram rescaling [13].

Since the real values of z's do not exist, some simplification should be done. From equation 2 the z's which are looking for must satisfy the equation $G(z_k)=s_k$, or $(G(z_k)-s_k)=0$. Thus the closest answer which can be gotten to satisfy this equation is to let $z_k=\hat{z}$ for each value of k, which $\hat{z}$ is the smallest integer in the interval [0, L-1] such that

$$(G(z_k)-s_k))\geq 0 \qquad k=1,2,...,L-1 \tag{5}$$

The total procedure of histogram specification can be summarized as follows:

- Obtaining the histogram of the input and output images
- Computing $s_k$ for each gray value $r_k$ using equation 1
- Obtaining the transformation function G using equation 2
- Applying equation (5) to compute $z_k$ for each $s_k$

Each pixel with $r_k$ value in the input image is mapped to the corresponding $s_k$ level and then $s_k$ is mapped to the final $z_k$ value.

Resenfeld & Kak got it more practical and simpler [8]. Based on their proposed method, if it is assumed that $r_0, r_1, r_2, ..., r_{L-1}$ are the gray levels of input image, and $z_0, z_1, z_2, ..., z_{L-1}$ are the gray values of the output image, then

Computing the histogram of input and output images ($p_r$ and $p_z$, respectively)

For a specific $k_0$ value which satisfies the following equation:

$$\sum_{i=0}^{k_0} p_r(i)\leq p_z(z_0)\leq \sum_{i=0}^{k_0+1} p_r(i) \tag{6}$$

All the pixels with gray values of $r_0, r_1, r_2, ..., r_{k_0}$ must get $z_0$ gray level. If the equality is not confirmed, some pixels with gray values of $k_0$+1 should be gotten $z_0$ value in order to reach the total number of $P_z(z_0)$.

In the same procedure, for $k_1$:

$$\sum_{i=0}^{k_1} p_r(i)\leq p_z(z_0)+p_z(z_1)\leq \sum_{i=0}^{k_1+1} p_r(i) \tag{7}$$

All the maintained pixels with $k_0$+1 value and may be some pixels with $k_1$+1 gray value should be gotten $z_1$ value.

This procedure is continued until L-1 gray level. By implementing this algorithm, the histogram of the input image would be much the same as the histogram of the output image.

The above procedure was defined for gray scale images. However, for a color image, which is also the case of this research, the procedure should be accommodated. A digital color image consists of three R, G and B channels. So a color image has a 3 dimensional histogram.

In this research, we are not going to compute a 3D histogram. It is suggested that the above procedure is applied for each channel of a color image separately. In the other way, the histogram of each R, G and B channels of the input image should be matched to the corresponding histograms of the output image. Therefore, each of the three R, G and B channels can be considered as a gray scale image and the above procedure of histogram matching would be feasibly applied.

## 3. Results and discussion

As described above, the proposed method is based on matching the histogram of the initial image to the destination one for the three R, G and B channels. To show the capability of this method, several standard test images were analyzed. The sources of the test images are available [16-17].

Figure 2 shows two standard images named here as "Houses" and "Parrots", the histogram of their three channels and the results of applying the proposed method to transform the color scene of Parrots image to Houses image. By applying this method, the histograms of the three R, G and B channels of the Houses are matched to the histograms of the corresponding channels of Parrots image. As indicated, the color scene of the Parrots image is interestingly and precisely transformed to the Houses. It also demonstrates that in some cases, this method can be applied to increase the image quality and the image enhancement.

Figure 3 shows two images, called here as "Sunset" and "Red Sunset" with their three histograms of the R, G and B channels. In addition, the result of histogram matching of the three channels of Sunset image with the Red Sunset is shown. As indicated, the proposed method is competent to change the color scene of an image based on the destination one.

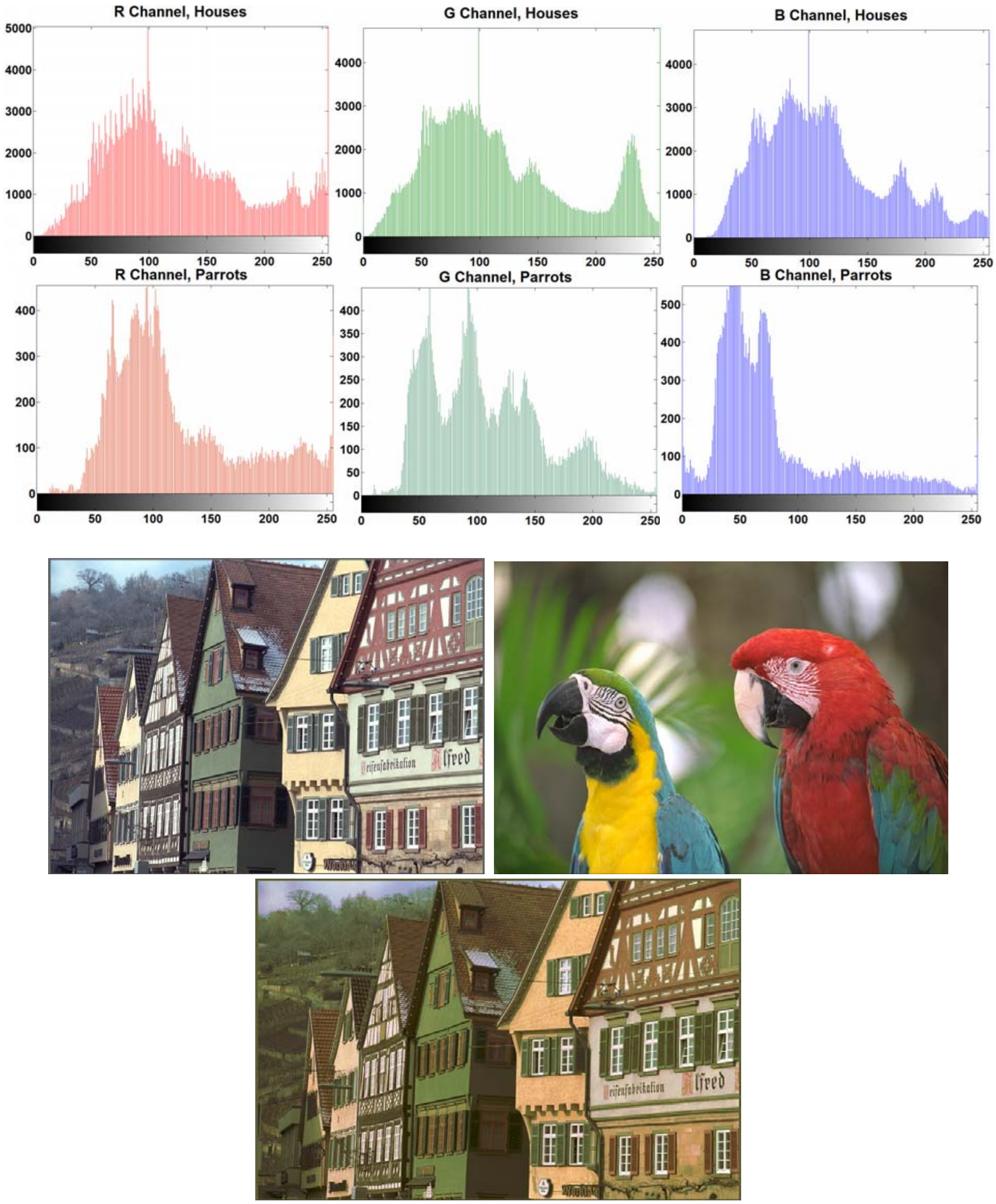


**Figure 2:** The original images of houses and parrots, the histogram of each of the three R, G and B channels of two images (above) and the image of houses (below) after matching its histogram channels with parrots image.

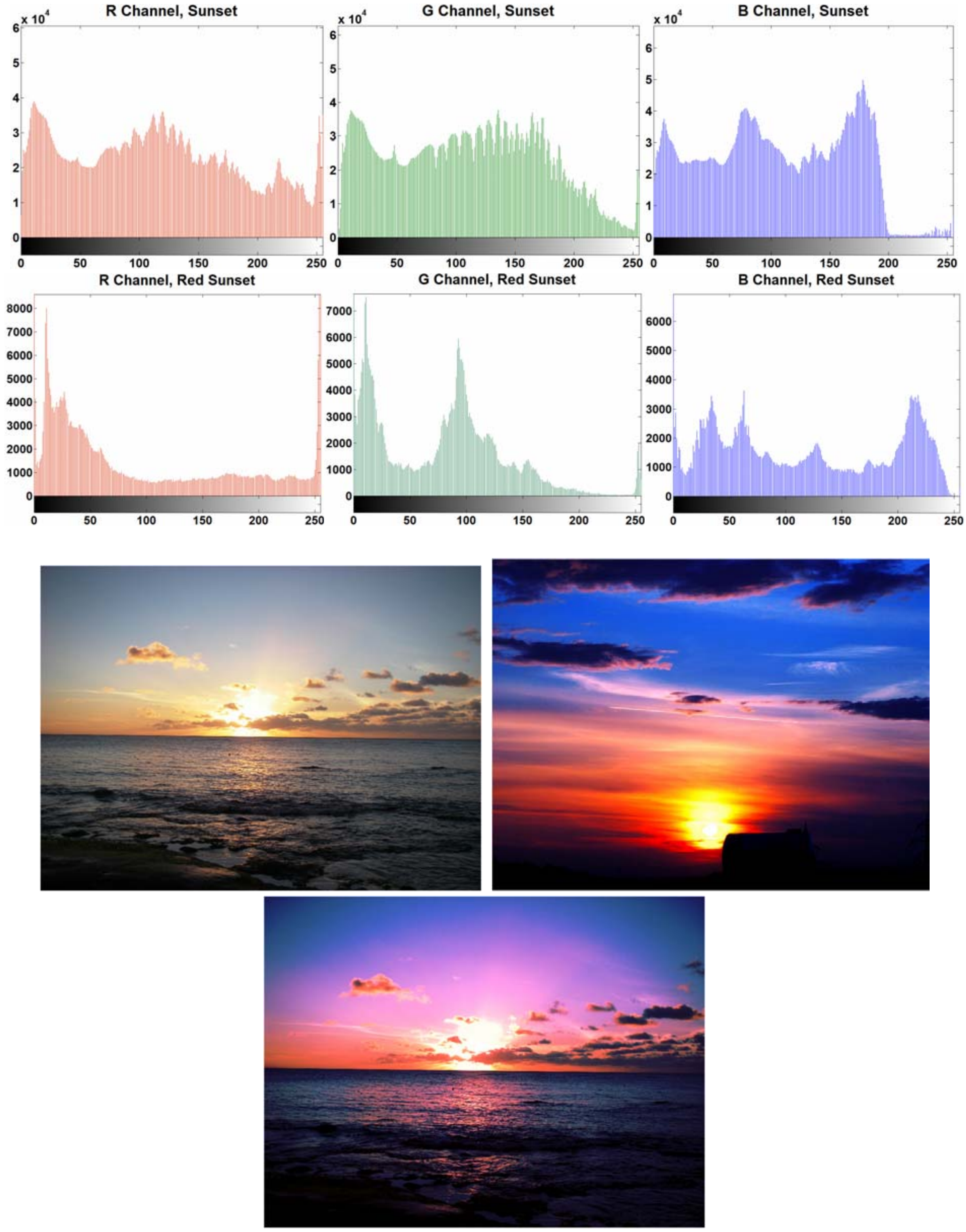


**Figure 3:** The original images of sunset and red sunset, the histogram of each of the three R, G and B channels of each two images (above) and the image of red sunset (below) after matching its histogram channels with red sunset.

As another example, Figure 4 shows the image of "Peppers1" and "Peppers2", the histogram plots of the three R, G and B channels of two images and the results of applying the proposed method to transform the color scene of Peppers 2 to Peppers 1. It can be clearly seen that the color scene of the second image is feasibly transformed to the first one.

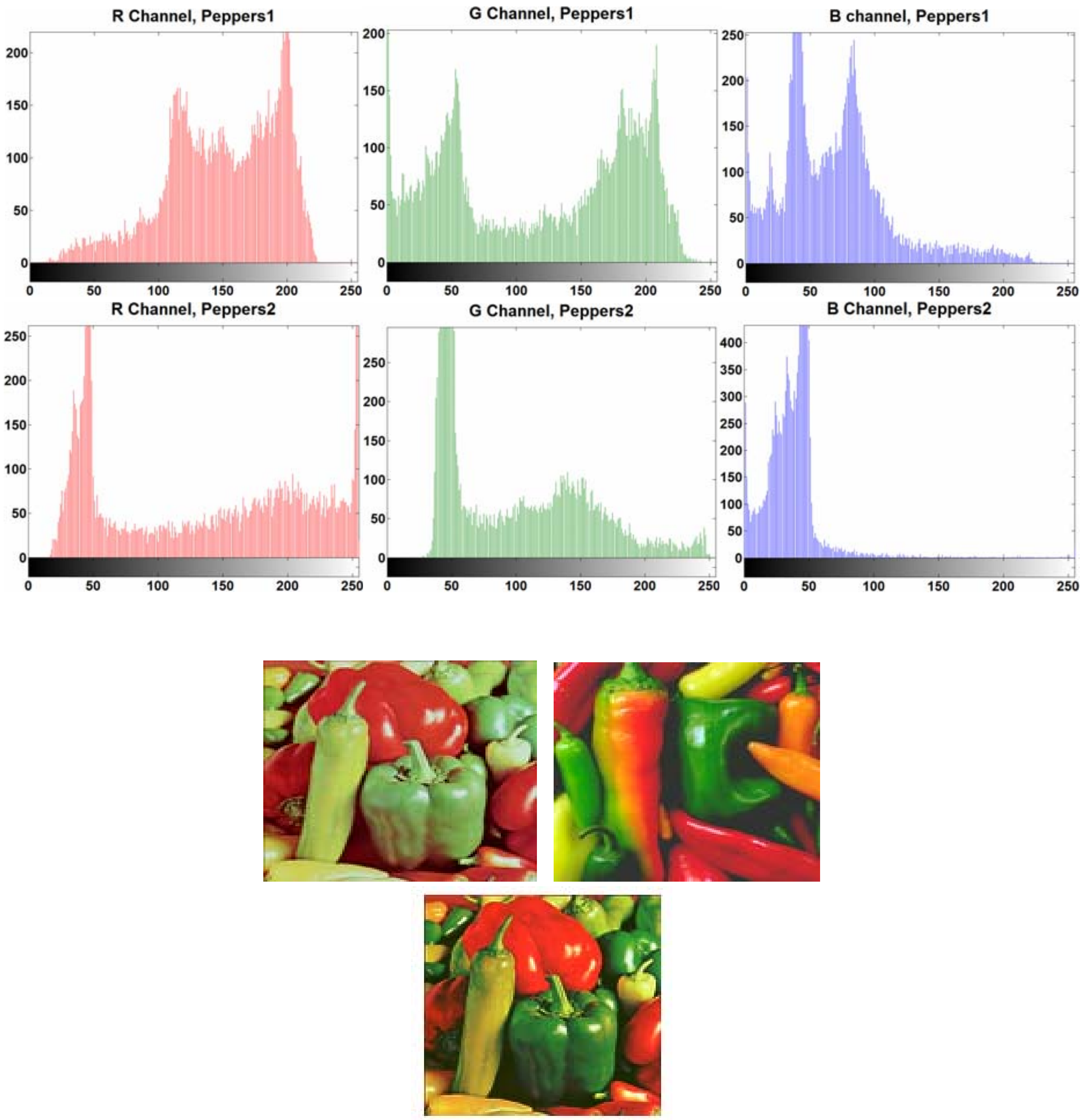


**Figure 4:** The original images of peppers1 and peppers2, the histogram of each of the three R, G and B channels of two images (above) and the image of peppers1 (below) after matching its histogram channels with peppers2.

An interesting example is shown in Figure 5; a standard image named "Goldhill" with its histogram of its three channels. Furthermore, the result of transforming the color scene of Peppers2 image to the Goldhill image is shown in this figure. As illustrated, the proposed method can well interchange the color scene of the image. It can be also used to give the scene of sunset to the image, so using different transforming image it is possible to mimic daylight hours.

## 4. Conclusions

One of the most important tasks in color imaging science is to color change and color transform of an image. It can be so useful for color image enhancement, color scene interchanging, color gamut mapping, and desirable color reproduction, etc. In the present study, a new method is proposed for the color scene transform between images by applying histogram matching or histogram specification algorithms. It is suggested that to transform the color scene between two images, the histogram of the three R, G and B channels of the first image would be matched to the corresponding histograms of the destination image. Histogram matching can be carried out using Rosenfeld and Kak method. The performance of the proposed method is investigated for several standard images. The obtained results show that this method can be feasibly and accurately applied for the color scene transform between color images.

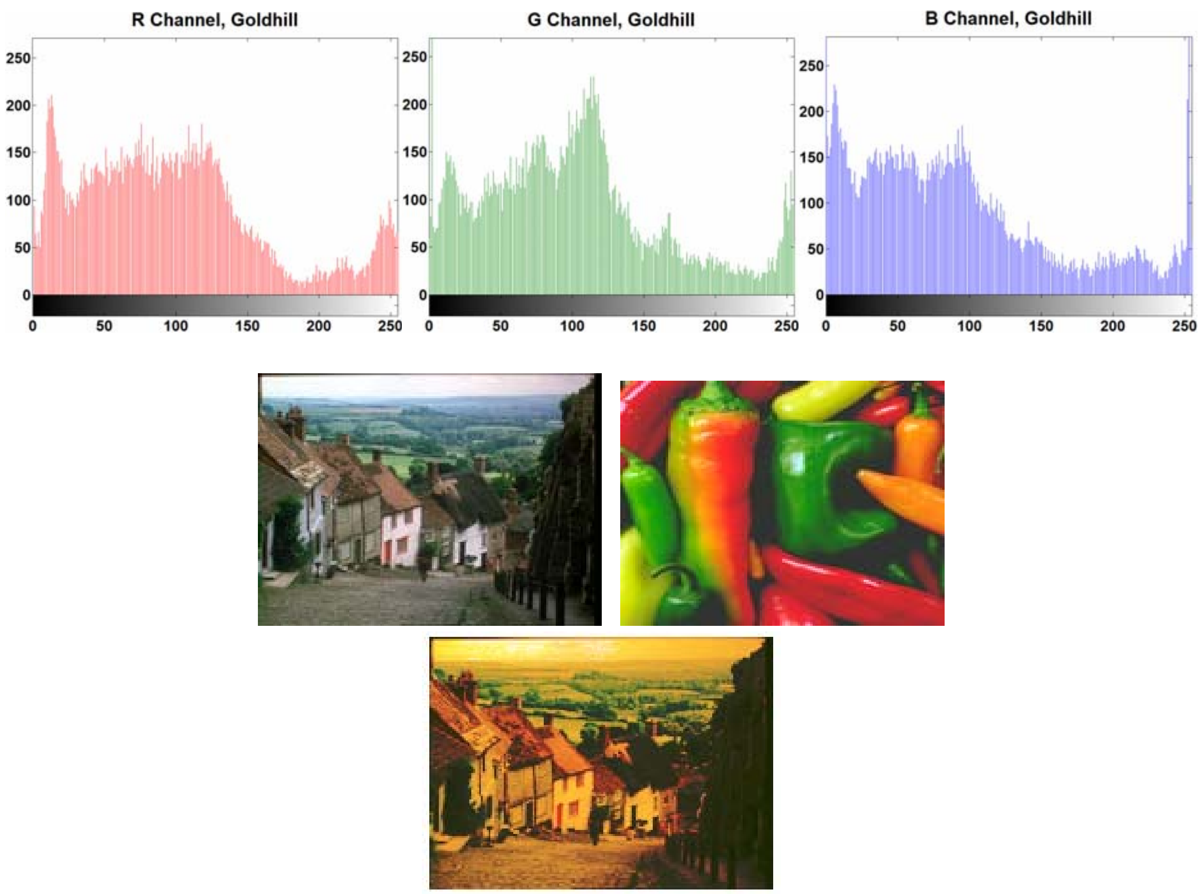


**Figure 5:** The original images of goldhill and peppers2, the histogram of each of the three R, G and B channels of goldhill images (above) and the image of goldhill (below) after matching its histogram channels with peppers2.

## 5. References

1. H-Ch Lee, Introduction to Color Imaging Science, Cambridge University Press, New York, 2005.
2. L. W. MacDonald and M. R. Luo, Colour imaging: vision and technology, John Wiley & Sons, Chichester England, 1999.
3. R. Saito and H. Kotera, Extraction of image gamut surface and calculation of its volume, Proc. IS&T's NIP16: International Conference on Digital Printing Technologies, Vancouver, Canada, (2000), 566-569.
4. R.Saito and H.Kotera, Gamut Mapping Adapted to Image Contents, Proc. Congress of the International Colour Association (AIC 05), Granada, Spain, (2005), 661–664.
5. T. Horiuchi, F. Nohara and S. Tominaga, Accurate Reversible Color-to-Gray Mapping Algorithm without Distortion Conditions, *Pattern Recognit. Lett.*, 31(2010), 2405-2414.
6. A. Ibrahim, T. Horiuchi and S. Tominaga, Illumination-Invariant Representation for Natural Color Images and Its Application, Proc. IEEE Southwest Symposium on Image Analysis and Interpretation (SSIAI2012), Santa Fe, New Mexico, USA, (2012), 157-160.
7. X. Xiao, L. Ma, Color Transfer in Correlated Color Space, In VRCIA '06: Proceedings of the 2006 ACM international conference on Virtual reality continuum and its applications, (2006), 305-309.
8. E. Reinhard, M. Ashikhmin, B. Gooch, and P. Shirley, Color transfer between images, *IEEE Comput. Graphics Appl.*, 21(2001), 34-41.
9. M. Zhang and N.D. Georganas, Fast color correction using principal regions mapping different color spaces, *Real-Time Imaging*, 10(2004), 23–30.
10. H. Kotera, Y. Matsusaki, T. Horiuchi, R.Saito, Automatic **Color** Interchange between Images, Proc. Congress of the International Color Association (AIC 05), Granada, Spain, (2005), 1019 -1022.
11. Y. Matsusaki and H. Kotera, and R. Saito, A Region-based Automatic Scene Color Interchange, Proc. IS&T's International Conference on Digital Printing Technologies (NIP21), Baltimore, Maryland, (2005), 399-402.
12. R. Saito, T. Horiuchi, and H. Kotera, Scene Color Interchange using Histogram Rescaling, Proc. IS&T's International Conference on Digital Printing Technologies (NIP22), Denver, Colorado, (2006), 378-381.
13. R. Saito, H. Okuda, T. Horiuchi and S. Tominaga, "Scene-to-Scene Color Transfer Model Based on Histogram Rescaling", Proc. Midterm Meeting of the International Color Association (AIC 07), Hangzhou, China, (2007), 122-125.
14. R.C. Gonzalez, and R.E. Woods, Digital Image Processing, Prentice-Hall, New Jersey, 2rd edition, 2002.
15. A. Rosenfeld, A.C. Kak, Digital Picture Processing, Academic Press, New York, 2rd edition, 1982.
16. http://www.r0k.us/graphics/kodak/
17. http://sipi.usc.edu/database/database.php?volume=misc.