A New Method for Color Feature Representation of Color Image in Content-Based Image Retrieval Projection Maps

論 文
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Abstract

The most popular technique for image retrieval in a heterogeneous collection of color images is the comparison of images based on their color histogram. The color histogram describes the distribution of colors in the color space of a color image. In the most image retrieval systems, the color histogram is used to compute similarities between the query image and all the images in a database. But, small changes in the resolution, scaling, and illumination may cause important modifications of the color histogram, and so two color images may be considered to be very different from each other even though they have completely related semantics. A new method of color feature representation based on the 3-dimensional *RGB* color map is proposed to improve the defects of the color histogram. The proposed method is based on the three 2-dimensional projection map evaluated by projecting the *RGB* color space on the *RG*, *GB*, and *BR* surfaces. The experimental results reveal that the proposed is less sensitive to small changes in the scene and that achieve higher retrieval performances than the traditional color histogram.

Keywords : Color, Image, Feature, Representation, Content-based, 3D

I. INTRODUCTION

Color is a very important feature in extracting information from a color image, and color histogram comparison has recently become a popular technique for image or video retrieval [1]. The color histogram comparison is used as a preliminary step for database indexing in order to reduce the number of candidate images for next steps which could use other features (e. g. texture, shape) to compare database images with a given query image. In general, the *RGB* color space is inappropriate for image retrieval due to the fact that small changes in the resolution, scaling, and illumination may cause important modifications of the color histogram, and two color images may be considered to be very different from each other even though they have completely related semantics [2], and so other color spaces like HSI, YIQ, or LUV are often used for image retrieval [3-5].

Actually, the *RGB* color space is related to the color signal from the image capture devices like camera, video camera, or scanner, and so it is needed to use directly the *RGB* color space without a color space translation to other color spaces [1].

In this paper, 2 dimensional projection mapping are projected on the *RG*, *GB*, and *BR* surfaces from the *RGB* color space as a new color feature creation for image retrieval. When these proposed is used to compute the similarity distance between two images, these three 2-dimensional projection maps are connected and are transformed to a 1-dimensional projection vector.

This paper is organized as follows. The traditional color histogram method is described in Section 2, and the proposed 2-dimensional pro-

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jection map method is described in Section 3. Some experimental results and comparisons are shown in Section 4, and then some concluding remarks are then presented in Section 5.

II. Traditional color histograms

Usually, color histogram calls histogram from RGB color space. A color histogram denotes the joint probabilities of the intensities of the three color channels. The color histogram is defined as follows:

$$h_{R,G,B}[r,g,b] = N \cdot \mathrm{Prob}R = r, G = g, B = b \quad (1)$$

Where R, G, and B are the three color channels and N is the number of pixels in the image [6].

The color histogram is computed by counting the number of pixels of each color within the image. Since the number of colors is finite, it is usually more convenient to transform the three channel histogram into a single variable histogram. Given an RGB image, one transform is given by $m = r + N_r g + N_r N_g b$, where N_r, N_g, and N_b are the number of bins for colors red, blue and green, respectively. This gives the single variable histogram by. For example, fig. 1 shows color histogram of a sunset image with quantization rate of 5 bits.

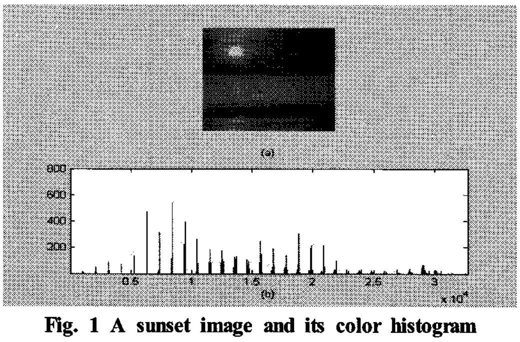


Fig. 1 A sunset image and its color histogram

This color histogram has a defect that a small change of color in the image may cause a great modification of the color histogram, and also color histogram may vary greatly by changes in lighting and large view angle. An effective way to retain light-independent color properties is to use only hue and saturation in HSI color space, and some kinds of improved methods to extract color features from the histogram of Hue component have studied [7-8]. But because an additional mathematical conversion processing from RGB space to HSI space is requested to use the Hue histogram, it is need to use directly the RGB color space without a color space translation to other color spaces for fast retrieval from the image database. The histogram of the hue component is defined as follows:

$$h_H[h] = N \cdot \mathrm{Prob}H = h \quad (2)$$

Where H is the hue component and N is the number of pixels in the image and Hue component has one value between 0 and 1. Fig. 2 shows the histogram of the hue component of the sunset image in fig. 1.

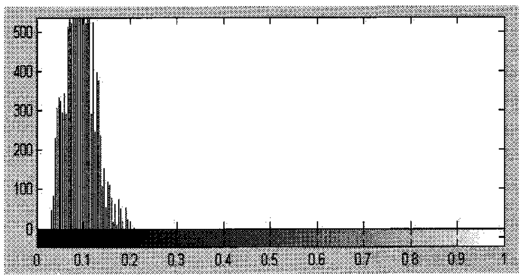


Fig. 2 Histogram of hue component of the sunset image

Because these traditional color histograms have relation of frequency of pixels that have equal color, changing color histogram changes image contents slightly. if there is identical color continuously, feature of color may not change. In this study, we propose a new color feature representation method have emphasis on existence of such color.

III. 2-Dimension PROJECTION MAPS

A new method that is proposed to represent color features of a color image efficiently is changing 3-dimensional RGB color space map to 2-dimensional projection maps. Fig. 3 shows

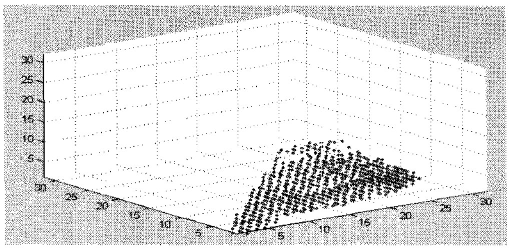


Fig. 3 3-dimensional RGB color space map of the sunset image in Fig. 1

3-dimensional *RGB* color space map representing the three brightness values in *R*, *G*, and *B* channels of the sunset image.

Projecting the 3-dimensional color space map to 2-dimensional *RG*, *GB*, and *BR* surfaces make three 2-dimensional projection maps. First, to generate the projection map to *RG* surface, correspond the integer value of the R channel brightness to the x coordinate bin and the integer value of the *G* channel brightness to the y coordinate bin by one to one for one pixel in the image, then the position (x, y) in the 2-dimensional map has value of 1, and then the same procedure for the all pixels can make a 2-dimensional projection map. Through equal process, other projection maps to *GB* surface and *BR* surface, P_{RG}, P_{GB}, and P_{BR} are formed as follows:

$$P_{RG}(x,y) = \begin{cases} 1, at\ x = v(r),\ y = v(g) \\ 0, at\ other\ bins \end{cases} \quad (1)$$
$$P_{GB}(x,y) = \begin{cases} 1, at\ x = v(g),\ y = v(b) \\ 0, at\ other\ bins \end{cases}$$
$$P_{BR}(x,y) = \begin{cases} 1, at\ x = v(b),\ y = v(r) \\ 0, at\ other\ bins \end{cases}$$

Where, $v(r)$, $v(g)$, and $v(b)$ are brightness values of one pixel in the image. Three 2-dimensional projection map of the sunset image are presented in Fig. 4.

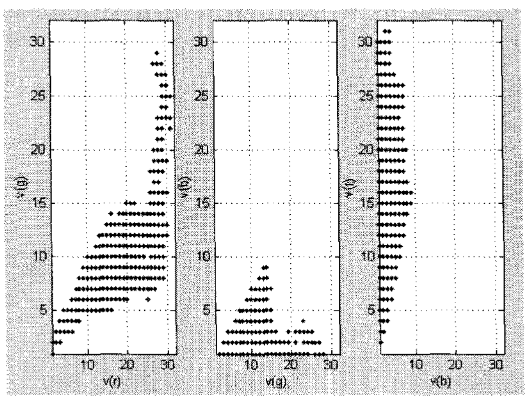


Fig. 4 Three 2-dimensional projection maps

In the content-based image retrieval, in order to measure similarities between the query image and the object images in the database, these three 2-dimensional projection maps are connected and transformed to a 1-dimensional projection vector as follows:

$$I= [P_{RG}(1,1), \cdots, P_{RG}(2^q, 2^q), \quad (4)$$
$$P_{GB}(1,1), \cdots, P_{GB}(2^q, 2^q),$$
$$P_{BR}(1,1), \cdots, P_{BR}(2^q, 2^q),$$

Where, I is 1-dimensional projection vector, q is the number of quantization bits per pixel and q is 5 here.

Therefore, length of the 1-dimensional projection vector is $2^q \times 2^q \times 3$. Because length of the color histogram is $2^q \times 2^q \times 2^q$, length rate between color histogram and 2-dimension projection map is $\frac{2^q}{3}$ and in case of $q = 5$, the length rate is about 10. 7. Therefore, we can find that the processing speed reduces greatly and will appear for the performance through follow experiments.

IV. Experiments and results

The proposed method of color feature representation was compared with the traditional color histograms. Their performance to retrieve similar images from a heterogeneous collection of images has been used as comparison criterions. For the color histograms, because values that compose the color histogram are analogous, the Euclidean distance method is used to measure similarities between a query image and candidate images.

For the *RGB* color histogram and the histogram of Hue component, when the feature vector of the query image is C_p and one of the candidate image is C_c, the distance between these two images, ED_{histo}, is computed as follows.

$$C_p = \{C_p(1), \cdots, C_p(n)\} \quad (5)$$
$$C_c = \{C_c(1), \cdots, C_c(n)\}$$
$$ED_{histo} = \sqrt{\sum_{i=1}^{2^q \times 2^q \times 2^q} (C_p(i) - C_c(i))^2}$$

Where, n is length of histogram and is $2^q \times 2^q \times 2^q$.

For the 2-dimensional projection map, because its 1-dimensional projection vector is a bit pattern of binary value, the Hamming distance was used to measure similarities between a query image and candidate images., when the feature vector of the query image is I_p and one of the candidate image is I_c, the distance between these two images, HD_{2d}, is as follows.

$$I_p = \{I_p(1), \cdots, I_p(n)\} \quad (6)$$
$$I_c = \{I_c(1), \cdots, I_c(n)\}$$
$$HD_{2d} = \sum_{i=1}^{2^q \times 2^q \times 3} abs(I_q(i) - I_c(i))$$

Where, n is length of 1-dimensional projection vector and is $2^q \times 2^q \times 3$.

To estimate their performance, 5 images that the color contents are similar is selected from database that stores 100 sunset images and 5 images selected for querying are represented in fig. 5.

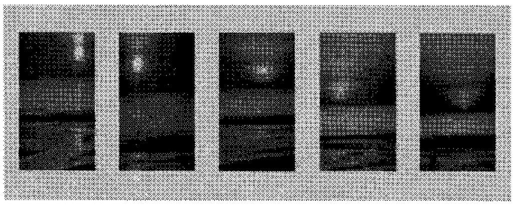
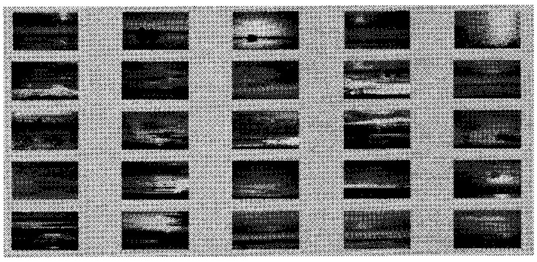


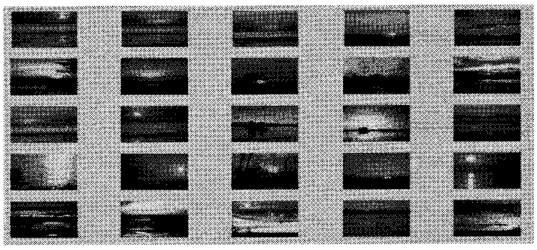
Fig. 5 Query images with similar colors

When these similar images was used as query images in turn, the experimental results were compared each other. First, when the first image of the selected sunset images was presented as a query image, fig. 6 shows the results of, (a) the color histogram, (b) the Hue histogram, and (c) the proposed 2-dimensional projection maps.

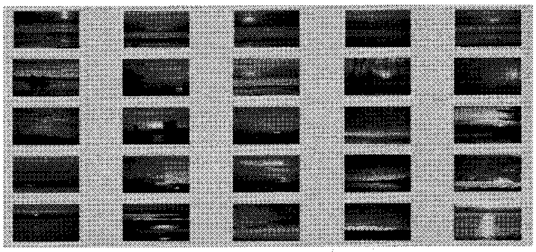
To compare their retrieval performance, for each color representation method from result of fig. 1, the number of query images that appear in priority order 1 to 5 was counted. Then,



(a) the color histogram



(b) the Hue histogram



(c) the proposed

Fig. 6 Results of retrieval for first sunset image as a query

equal process was done for other query images and number of other query images that appear in priority order 5 was counted. The result was compared in table 1.

From table 1, average ratios of retrieval performance about each method are as following: 36% for color histogram, 56% for Hue histogram, and 76% for 2-Dimension projection map.

Table 1. Comparison of retrieval results for each color representation methods (in priority order 5)

Query	Methods	Representation Number (N)	Efficiencies $\frac{N}{5} \times 100(\%)$
q1	Color histogram	2	40
	Hue histogram	3	60
	The proposed	4	80
q2	Color histogram	2	40
	Hue histogram	2	40
	The proposed	4	80

Query	Methods	Representation Number (N)	Efficiencies $\frac{N}{5}\times 100(\%)$
q3	Color histogram	2	40
	Hue histogram	3	60
	The proposed	3	60
q4	Color histogram	1	20
	Hue histogram	2	40
	The proposed	4	80
q5	Color histogram	2	40
	Hue histogram	4	80
	The proposed	4	80

Then equal process was done for other query images and number of other query images that appear in priority order 10 was counted. The result was compared in table 2.

For the number of other query images that appear in priority order 10, average ratios are as following: 44% for color histogram, 64% for Hue histogram, and 96% for 2-Dimension projection map.

Table 2. Comparison of retrieval results for each color representation methods (in priority order 10).

Query	Methods	Representation Number (N)	Efficiencies $\frac{N}{5}\times 100(\%)$
q1	Color histogram	3	60
	Hue histogram	3	60
	The proposed	5	100
q2	Color histogram	2	40
	Hue histogram	3	60
	The proposed	4	80
q3	Color histogram	2	40
	Hue histogram	3	60
	The proposed	5	100

Query	Methods	Representation Number (N)	Efficiencies $\frac{N}{5}\times 100(\%)$
q4	Color histogram	2	40
	Hue histogram	2	40
	The proposed	5	100
q5	Color histogram	2	40
	Hue histogram	5	100
	The proposed	5	100

Therefore, from the results of above experiments, when the 2-Dimension projection map that was proposed for representing color features of a color image was used in image retrieval, we found that the proposed has better performances than other two methods. We also compared their retrieval performances for flower, animal, nature, and plane images and same result was obtained. In fig. 7, fig. 8, fig. 9, and fig.10, we could know that the proposed 2-Dimension projection map could express better color characteristic of image.

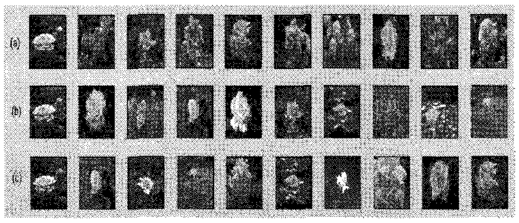


Fig. 7 Results of retrieval by (a) the color histogram, (b) the Hue histogram, and (c) the 2-dimensional projection maps for flower images.

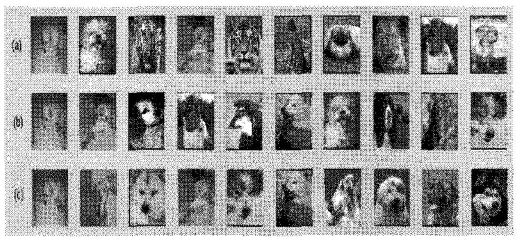


Fig. 8 Results of retrieval by (a) the color histogram, (b) the Hue histogram, and (c) the 2-dimensional projection maps for animal images.

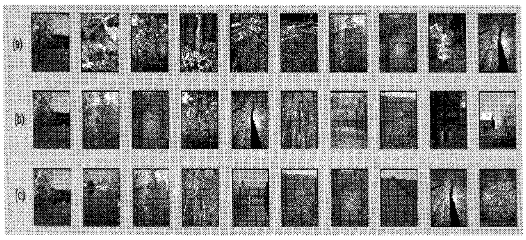


Fig. 9 Results of retrieval by (a) the color histogram, (b) the Hue histogram, and (c) the 2-dimensional projection maps for nature images.

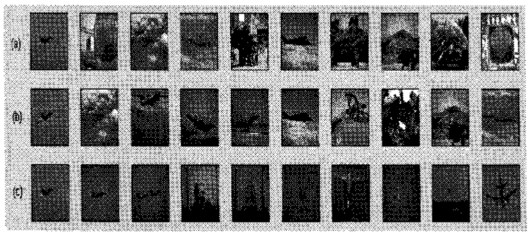


Fig. 10 Results of retrieval by (a) the color histogram, (b) the Hue histogram, and (c) the 2-dimensional projection maps for plane images.

V. Conclusions and future work

To improve color image retrieval performance using color feature, the 2-dimensional projection mapping method has been proposed. For the given heterogeneous image collections, some experimental results show that the proposed method has better performance than the color histogram and the Hue histogram in image retrieval.

The proposed 2-dimensional projection maps are projections of *RGB* color space to three RG, GB, and BR surfaces, and they have more precise color information than the color histogram or Hue histogram.

Hereafter, a study for comparison between the proposed method and the traditional color feature creation methods would be done in image classification fields.

[References]

[1] A. D. Bimbo, *Visual information retrieval*, Morgan Kaufmann Publishers, Inc. pp. 81-116, 1999.

[2] S. Sablak and T. E. Boult, "Multilevel color histogram representation of color images by peaks for omni camera," in *Proceedings of the IASTED International Conference Signal and Image Processing*, pp. 18-21, Oct. 1999.

[3] A. Vellaikal and C. C. J. Kuo, "Content based image retrieval using multiresolution histogram representation," in *Proceeding of SPIE Digital Image Storage and Archiving Systems*, vol. 2606, pp. 312- 323, 1995.

[4] H. J. Zhang, Y. Gong, C. Y. Low, and S. W. Smoliar, "Image retrieval based on color feature: an evaluation study," in *Proceedings of SPIE Digital Image Storage and Archiving Systems*, vol. 2606, pp. 212- 220, 1995.

[5] X. Wan and C. C. J. Kuo, "Pruned octree feature for interactive retrieval," *SPIE Multimedia Storage and Archiving Systems II*, vol. 3229, pp. 182-193, 1997.

[6] J. R. Smith and S. F. Chang, "Tools and techniques for color image retrieval," in *Proceedings storage & retrieval for image and video databases*, vol. 2670, http://www.ctr.columbia.edu/~jrsmith/html/pubs/tatfcir/color.html, Mar. 2004.

[7] S. Sural, Gang Qian, and S. Pramanik, "Segmentation and histogram generation using the HSV color space for image retrieval," *Proceedings of 2002 International Conference on Image Processing*, Vol. 2, pp. 589-592, Sep. 2006.

[8] Y. Tao and W. I. Grosky, "Spatial color indexing: a novel approach for content-based image retrieval," in *IEEE international conference on multimedia computing and systems*, vol. 1, pp. 530-535, jun. 2007.

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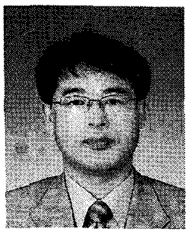

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