A Study of Order-based Block Color Feature Image Retrieval Compared with Cumulative Color Histogram Method

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Abstract**—***Color is one of the most important features in image retrieval. Color histograms have proved to be stable representations of an image, but they might be similar in different kinds of images because they describe the global intensity distribution of images. A new color image representation method is proposed in this paper. At first, each color channel (R, G, B) of an image is divided into 48 blocks (6 rows X 8 columns). Secondly, statistical features are computed to characterize the block's color feature. Finally, all block features are combined to form an image's color feature. The experimental results show that the retrieval effectiveness of the proposed technique is better than color histogram-based method.*

Keywords-order-based block feature; cumulative histograms; image retrieval

I. INTRODUCTION

The widely use and ever increasing amount of image data require effective indexing and retrieval systems. Traditional methods of image retrieval are based on the idea of storing text keywords to retrieve image data, or Text-based Image Retrieval (TBIR) [1]. But textual annotation is extremely time-consuming with large scale image databases; moreover, summarizing image data with a few keywords is considerably more difficult since it is dependent on the subjective description of the annotator. In many current applications with large image databases, TBIR proved to be insufficient. A different idea of images retrieval is Content-based Image Retrieval (CBIR) [2][3][4][5][6][7]. CBIR aims at indexing and retrieving images by automatic description on their objective visual contents, it searches an image database for images by image example, where the retrieved images are similar to the query image in visual contents. The term 'content' might be color, shape, texture, or any other feature that can be automatically extracted from the image itself.

CBIR involves how to extract characteristic features (color, texture, shape) from images [8]. The color features are often found the most effective and simplest ones [9]. The distribution of colors of an image (Color histograms) is one of the most important features in image retrieval, it proved to be stable representation of an image [10], and cumulative color histogram is a more robust version of it [11]. However, Color histogram might be similar to different kinds of images because it describes the global color intensity distribution of images. Moreover, similar images of different lighting conditions produce dissimilar color histograms. A new color image representation method called order-based color block color feature is proposed in this paper, the method takes image classification behavior in human into consideration. From the Experimental results, it is concluded that a retrieval based on the proposed technique provides better results than the color histogram-based method.

The paper is organized as follows. First, the Order-based block color feature technique is proposed in Section II. Section III introduces the cumulative color histograms. Section IV presents the experimental results comparison between the two methods. Finally, in Section V, we present our conclusion and discussion.

II. ORDER-BASED BLOCK COLOR FEATURE

A. Characteristics of Image Classification Behavior

When thinking generally about how human classify a picture, we get the following two characteristics. The one is when given a photograph, people can categorize it as landscape or portrait at a glance, without examining the scene in detail. The other one is that when given a photograph including objects such as hills, rivers, trees and so on, people recognize it as a landscape image. If the location of each object is changed to form another photograph, people recognize it as a landscape picture too; the latter is not that different from the former in terms of picture category.

B. Order-based Block Color Feature Extraction

Based on the above two facts, we put forward a color feature extraction method called Order-based Block Color Feature method, it simulates the image classification behavior, in other words, it has bionic traits.

A digital image undergoes the following process to extract Order-based Block Color Features. First, images were reduced to a comparatively small resolution according to the first trait mentioned above. Next, based on the second trait, each color channel (R, G, B) of an image is divided into several rows and columns (blocks). For a special color channel, statistical value such as the minimum value, the maximum value and the mean value of each block is computed respectively. These values characterize a block's statistical features. After that, for a special statistical feature

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(e.g. minimum value), values of the same row are sort in ascending order representing a row's order-based block features, simulating the independence of object location in the second trait. And all order-based block features are linked to form the special feature of the channel. Finally, all of the three color channels' features are combined to form an image's order-based block color features.

III. Color Histograms and Cumulative Color Histograms

Given a discrete color space, a color histogram count how many of each color occurs in the image. The color histogram H(P) of image P is defined as follows：

$$H(P) = \{h_{x,y,z}\} \quad (1)$$
$$where \quad x, y, z \in \{1,2,...,M\}$$

$$h_{x,y,z} = \frac{count(P \mid r = x, g = y, b = z)}{N} \quad (2)$$

Where x, y, z is R, G, B value respectively, count(P | r=x, g=y, b=z) is the total number of pixels with color value (x, y, z) in P, N is the total pixel number.

The cumulative color histogram C(P) of image P is then

$$C(P) = \{c_{x,y,z}\} \quad (3)$$

$$c_{x,y,z} = \sum_{i}^{x}\sum_{j}^{y}\sum_{k}^{z} h_{i,j,k} \quad (4)$$

Colors are analogous. In a color space, the image colors that are transformed to a common discrete color are thought of as being in the same 3D histogram bin centered at that color [6]. For example, in a 24bit true color 3D RGB space, the R, G, and B axes are each divided into 28=256 sections, for a total of 28x28 x28=16777216 bins of colors. To reduce the total number of the colors, one way is to reduce the sections of axes.

Color Histograms describe the global color intensity distribution of an image. However, Order-based Block Color Feature takes advantage of local color statistical information.

IV. Experiments

In this section, Experiments were performed to compare Order-based Block Color Feature (OBCF) with Cumulative Color Histogram.

A. Feature Extraction and Similarity Measurement

In OBCF method, each color channel of an image was divided into 48 blocks (6 rows X 8 columns), so each row had a feature of total 3(max, min, mean)*8column=24 values. Thus a color channel had 6*24=144 feature values, and an image had a feature vector of 3*144=432 values. In other words, an image's OBCF was a 432 dimensional vector.

In CCH method, as is discussed in section III, a common digit image space has a total number of 16777216 colors. To reduce the total color number, the R, G and B axes were each divided into 8 sections, for a total of 512 colors. Thus, an image's CCH was a 512 dimensional vector.

To measure the similarity between a database image I and the query image Q, we used L2 norm (Euclidean distance), which is given by

$$D(I,Q) = \sqrt{\sum (I_i - Q_i)^2} \quad (5)$$

B. Precision and Recall

Precision and Recall are two widely used measures for evaluating the quality of results in image Retrieval. They are given by the following formulas:

Precision = (number of relevant images retrieved by a search) / (total number of images retrieved by a search)

Recall = (number of relevant images retrieved by a search) / (total number of existing relevant images)

Precision can be seen as a measure of exactness, whereas Recall is a measure of completeness.

C. Experimental Results

An experimental test of OBCF shows that the method is efficient in image retrieval. A small image database consisting of 36 images of 12 categories was used in the experiment. Each category has 3 images. All the 36 images in the database were also used as query images. Each of the images had different resolution and was resized to 120x160 in resolution before feature extraction. Fig. 1 is a show of the database.

Figure 1. A small image database used in the experiments. Each of the thirty-six images shown here is resized to 120x160 in resolution before feature extraction.

For the 36-image database shown in Fig. 1, in OBCF method, the top one match is one of the correct images 31 of 36 times, the rest four cases are images No.3, No.16, No.20, No.23 and No.24. In CCH method, the top one match is one of the correct images 28 of 36 times, the rest eight cases are images No.3, No.5, No.16, No.17, No.18, No.20, No.23, No.24. The results show that OBCF has a higher Precision rate (31/36) than CCH (28/36). Moreover, to the four mismatch images in OBCF method, they were mismatched too in CCH method, since (3 16 20 23 24) is a subset of (3 5

16 17 18 20 23 24). These results demonstrate that OBCF is more efficient than CCH.

The images No.31, No.32 and No.33, were studied further to show the bionic traits in OBCF. The three images belong to the same category. Fig. 2 shows top four images retrieved by CCH method, in which, the first image in each row is a query image, the rest four ones are images retrieved. Fig. 3 shows the results of OBCF method.

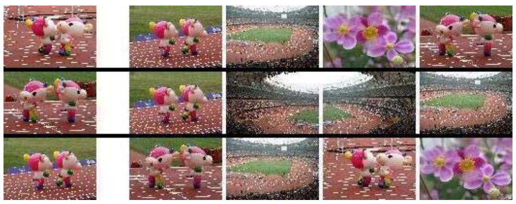

Figure 2. Query images and the top four matches by CCH method.

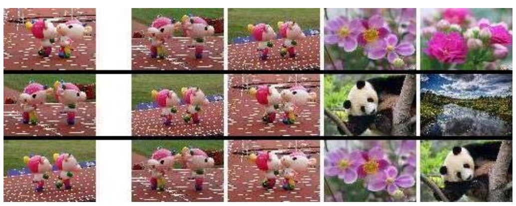

Figure 3. Query images and the top four matches by OBCF method.

Color histograms describe the global color intensity distribution which is also a statistical feature of color; they might be similar to different kinds of images, as is showed in Fig. 2. Each of the three images retrieved an image in a different category as the second match.

OBCF considers not only statistical features of color, but also independence of object location of image classification behavior. Fig. 3 shows that all of the three images have 100% recall rate.

Another experiment is performed to evaluate how successful OBCF is, using a larger image database. In the database, there are 140 images in 40 categories, including all images in the former database. Each category in the database has images number varying from two to eight.

Fig. 4 shows the performance of OBCF-based and CCH-based method in terms of recall.

From Fig. 4, we can see that in both methods, as the number of retrieved images increases so the average recall rate increases. Under the same total number of images retrieved, OBCF-based method has a higher recall rate than CCH-based method. Since the maximum number of images in a category is 8, considered the recall on number 10 of images retrieved (horizontal axis), OBCF is 0.76 of recall, and CCH is 0.675.

Fig. 5 shows the performance of OBCF-based and CCH-based method in terms of precision.

From Fig. 5, we can see that in all methods, as the number of retrieved images increases, the average precision rate decreases. Under the same total number of images retrieved, OBCF-based method has a higher precision rate than CCH-based method. As the average number of images in a category is 3.5 (140/40), considered the precision on number 2 of images retrieved (horizontal axis), OBCF is 0.83 of precision, and CCH is 0.76.

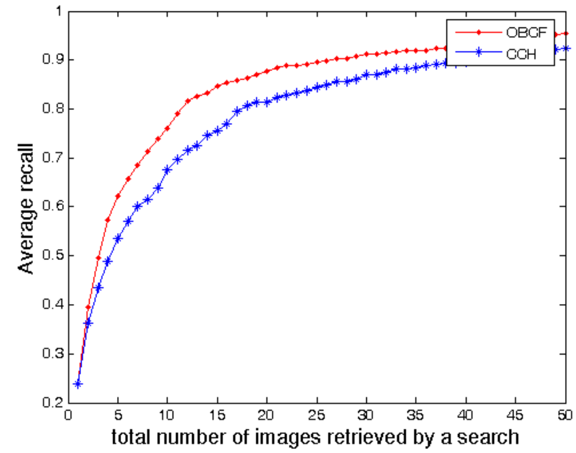

Figure 4. Performance comparison of OBCF and CCH in terms of recall.

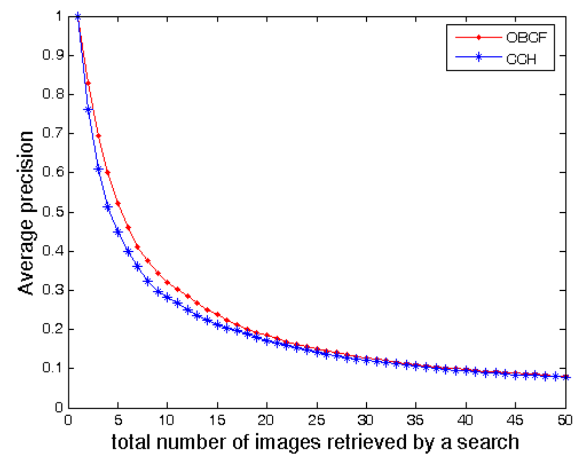

Figure 5. Performance comparison of OBCF and CCH in terms of precision.

V. Conclusion and Discussion

OBCF takes advantage of the local color statistical information besides its bionic traits. A study of OBCF is presented in this paper compared with CCH. Experiments showed that OBCF presented promising results. OBCF is one type of image's color features, and color is one of the most important features in image retrieval. This is not to say that color alone suffices for CBIR. As future work, a deep analysis will be made combining OBCF with other features such as shape, texture, and so on.

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