Adaptive-Binning Color Histogram for Image Information Retrieval

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Abstract

From the 90's, the image information retrieval methods have been on progress. As good examples of the methods, Conventional histogram method and merged-color histogram method were introduced. They could get good result in image retrieval. However, Conventional histogram method has disadvantages if the histogram is shifted as a result of intensity change. Merged-color histogram, also, causes more process so, it needs more time to retrieve images. In this paper, we propose an improved new method using Adaptive Color Histogram (ACH) in image retrieval. The proposed method has been tested and verified through a number of simulations using hundreds of images in a database. The simulation results have quickly yielded the highly accurate candidate images in comparison to other retrieval methods. We show that ACH's can give superior results to color histograms for image retrieval.

Keyword: *QVIC, CBIR, ACH*

1. Introduction

The recent development of multimedia information era makes it possible to use images in various applications. As image databases are becoming larger and more widespread, there is a growing need for effective and efficient content-based image retrieval (CBIR) systems. With the advent of large-scale image database and multimedia techniques, the content-based image retrieval has received extensive attention and became a new research focus. In the large-scale image database, there are tens or hundreds of thousands of images. It is very difficult to catalogue images by hand. We need to retrieve images that are similar to a given image or user-creating imaging representation as quickly as we can. In QBIC (Query by Image Content) system, color, texture and shape are used to build an index for the images [1].

In general, a color is the most straightforward information which can be easily retrieved from digital images with simple and compact description. Its feature vectors can be calculated efficiently because of its invariance to the rotation and translation of the image content. In the beginnings of 90's, Swain and Ballard had firstly proposed that the color of image was represented through color histogram [2]. Then they performed similar retrieval by evaluating the histogram intersection between sample and database images. After that, many researchers proposed to use different kinds of color histograms as the features vectors to be stored in the index.

The characteristics of histogram are as follows.

·It is robust, since the color histogram is invariant to rotation of the image on the view axis, and changes in small steps when rotated otherwise or scaled [3].

·It is simple to implement

·It is fast

·It has low storage requirements. The color histogram size is much smaller than the size of the image itself

·No spatial information is included: thus two completely different images may have similar histograms

·Lighting conditions may alter the histogram of an image

In conventional color image retrieval system, the most straight forward approach is using CHM (Conventional Histogram Method). Histograms of each color, for example, images of 256 colors, will be generated. Similarities between such images are then performed and measured by Histogram Intersection Method (HIM). This is the basic approach and can give simple and efficient representation of color distribution. Indexes of histograms can represent many types of features such as colors in different color space, coefficients in transformed domain or spatial-related information. There are also many variations in comparing histograms.

However, although the conventional color histogram method can describe the global color distribution of image quite straightforwardly, it only provides a very coarse characterization of an image. There is no spatial information included in color histogram. Thus, two completely different images may have very similar histograms. Also, the lighting conditions will alter the histogram of an image. Even the two pictures which only have little difference in lighting conditions can not be easily matched.

A merged-color histogram (MCH) method is proposed for histogram-based image retrieval based on dominant colors in images [4], [5]. In the MCH method, colors from images and between images are merged to form their dominant color set, instead of color components. Images of similar color can be selected and ranked.

But this method requires more processing to generate feature vectors. For a large scale image database, this method will take long times for feature vectors. And after intra-palette merging and inter-palette merging, although the extra storage is getting smaller than the conventional histogram method, some important information of the image will be ignored.

In our paper, a new method using histogram is proposed. We call this method ACH (Adaptive Color Histogram). It could facilitate the matching between images with shifted-histogram.

2. Histogram

2.1 Introduction of histogram

The image histogram is a simply bar graph of pixel intensities. The pixel intensities are plotted along the x-axis and the number of occurrences for each intensity represents the y-axis.

A histogram is a method used to describe the frequency distribution of a digital signal. Histograms are composed of multiple bins, with each bin corresponding to a range of values. The value of each bin is obtained by summing the occurrences of digital signal samples whose values fall in the domain of that corresponding bin. We assume that all the images are scaled as a discrete color space which contains the same pixels of n. The histograms are the feature vectors to be stored as the index of the image database.

Let I be an image quantized to m colors C_1, C_2, $\cdots$ C_m. For a pixel $p = (x, y) \in I$, we denote $I(p)$ as its color and $I_C = \{p | \ I(P) = c\}$. And n is the total number of pixels in an image[6]. Then color histogram defined by (1).

$$Hc_i(I) = n * \underset{p \in M}{pr}[p \in Ic_i] \qquad (1)$$

For any pixel in the image, normalized histogram Hc_i gives the probability that the color of the pixel is c_i. Hc_i is defined by (2).

$$Hc_i(I) = \frac{hc_i(I)}{n} \qquad (2)$$

Possible problems in Conventional Histogram

Images with same visual information but with shifted light intensity may degrade the similarity level significantly if conventional histogram method is used.

Histogram is very sensitive to lighting conditions due to the nature of color space. Perceptually, similar colors are interpreted as completely different thus giving non-appealing results. In Fig.1., (a) is original image, and (b) is intensity shifted image that have brightness condition. Fig.2. is Original histogram and Intensity histograms of images with intensity shift.

In Fig. 1. and Fig. 2., the similar histograms in different brightness conditions of the two pepper images are shown. The intersection of the two histograms holds a result of smaller value, although the two images are highly visually similar.

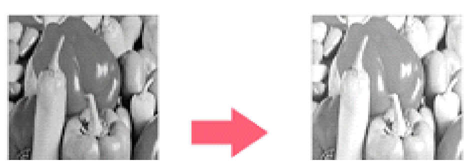

Fig. 1. The original image (a) and Intensity shifted image (b)

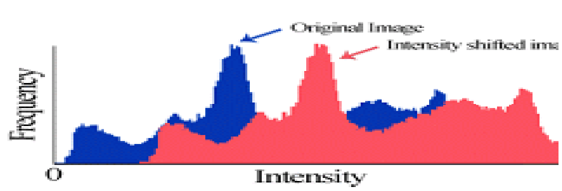

Fig. 2. Original histogram and Intensity histograms of images with intensity shift

3. Adaptive color histogram

The method proposed in our paper is divided into three steps. The first is histogram bins calculating, the second is to find start point of histogram, and the third is to measure the intersection area between query image and model images from the database. In the proposed ACH method, we consider the adaptive histogram for comparing.

3.1 Start point of histogram

To divide the histogram more accurately, we should find the start point of the histogram first. As in Fig. 3., the start point of h(a) is Sa. In Fig. 4., the start point of h(b) is Sb.

In Fig. 1. and Fig. 2., we can find that even there is shift between h(a) and h(b), the global figure of the histogram doesn't change so much. For that, we consider the bins of histogram instead of the whole histogram.

3.2 Histogram bins

After find start point, we can divide the histogram easily. In order to prove the veracity of the similarity matching, the width of the bins must be the same. Here, we set a constant l, and the value of l can set to 1 pixel, 2 pixels, 3 pixels … n pixels. In Fig. 3., for $h(a)$, from the start point S_a, each 20 pixels will be divided to an bin. Thus, we can get 8 bins as a result. In Fig. 4., from the start point S_b, we can also get 8 bins at last. So the histograms can be divided into bins as shown in Fig. 3. and Fig. 4.

So the $H(M_a)$ can be described by (3).

$$H(M_a) = h(n_{a1}) + h(n_{a2}) + h(n_{a3}) + \cdots + h(n_{a8}) \quad (3)$$

And $H(M_b)$ can be described by (4).

$$H(M_b) = h(n_{b1}) + h(n_{b2}) + h(n_{b3}) + \cdots + h(n_{b8}) \quad (4)$$

If after dividing, the two picture's histograms have different bin numbers, we just consider the minimum one. For example, as in Fig. 5., the histogram is only divided into 6 bins with each bin 20 pixels width. So if we compare it with the original image (a), only 6 bins will be calculated. The other bins in h(a) are not compared.

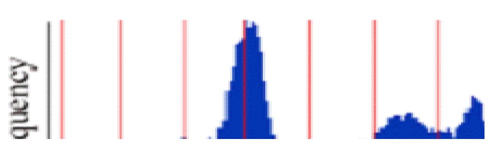

Fig. 3. The histogram of original image after dividing into bins

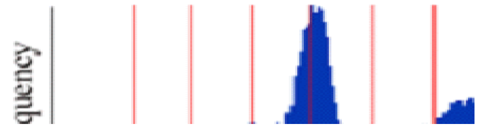

Fig. 4. The histogram of different image after dividing into bins

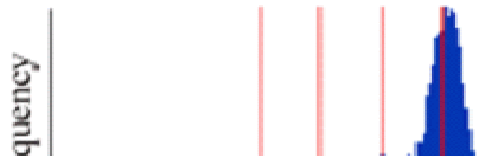

Fig. 5. The histogram of different image after dividing into bins

3.3 Matching method

We now compare the query image and the database images by histogram intersection. Histogram intersection was proposed for color image retrieval. The intersection of histogram
$h = H(M)$ and $g = H(I)$ is given by (5)

$$d(h,g) = \frac{\sum_{m=0}^{M-1} \min(h[m]:g[m])}{\min(\sum_{m_0=0}^{M-1} h[m_0]:\sum_{m_i=0}^{M-1} g[m_1]} \quad (5)$$

Colors no presented in the user's query image do not contribute to the intersection. This formulation differs from that proposed by Swain and Ballard in order to make it a true distance metric. The intersection formula is not symmetric in h and g and therefore is not a distance metric [7].

In some cases, the bins number M of h and g is not the same. For example, in Fig. 3., the bin number is 8, and in Fig. 5., the bin number is 6. In this case, we choose the minimum one of the two numbers. So if we calculate the intersection of Fig. 3. and Fig. 5., the value of M will be 6.

4. Experiments

In our simulations, a database of N = 1,000 JPEG images [8] is divided into 10 classes of different scenes (e.g. buses, horses, Africa life, etc). There are 100 images in each class.

Using our method, we can get the results as shown in Fig. 6., Fig. 7., and Fig. 8. The left block in the first row is sample image; other blocks are the retrieval image series.

Fig. 6. Query image and retrieval images list(1)

Fig. 7. Query image and retrieval images list(2)

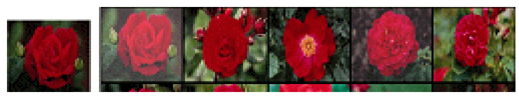

Fig. 8. Query image and retrieval images list(3)

The performance of the retrieval results is measured by Precision, Recall[9] and AVRR(Average Rank of Relevant images):

$$precision = \frac{No.of\ \ \mathrm{R}\ \ images\ \ retrieved}{Total\ no.of\ \ \mathrm{R}\ \ images\ \ retrieved} \quad \textbf{(6)}$$

$$recall = \frac{No.of\ \ \mathrm{R}\ \ images\ \ retrieved}{Total\ no.of\ \ \mathrm{R}\ \ images\ \ in\ \ database} \quad \textbf{(7)}$$

$$AVRR = \frac{1}{n}\sum_{i=1}^{n} R_i \quad \textbf{(8)}$$

n : **the number of retrived images.**

R_i : **the rank at which i-th relevant image retrieved**

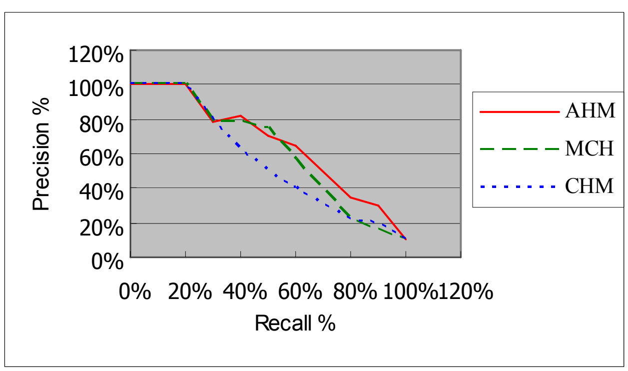

Fig. 9. Performance between our method, MCH and CHM using query images of class "cars

Relevant images are referred to images in the same class. Equation (6) gives the precision which measures the hit-rate that the class of the retrieved images is the same as that of input reference image from the whole database. Equation (7) gives the recall which measures the capability of finding images with the same class from the whole class of images in the database. And AVRR presented in Equation (8) means the average rank of relevant images. R_i means the rank of relevant image. The number of image is presented by n.

Fig. 9. shows the Precision and Recall results using "cars" shown in Fig. 7. From Fig. 9., we can see that our method usually outperforms the MCH and CHM with higher precision when recall rate is bigger than 54%.

In table 1, the performance of ACH, MCH and CHM is com-pared by their precision, recall and AVRR.

·MCH : Merged Color Histogram
·CHM : Conventional histogram method

Table 1. The result of three method using Fig. 6.

Method	Recall	Precision	AVRR
ACH	0.78	0.67	4.2
MCH	0.59	0.61	4.0
CHM	0.47	0.51	3.5

With these results, we can see that our method is efficiently and present a good performance in image retrieval using adaptive histogram.

5. Conclusions

In this paper, a new method for representing and retrieving images using adaptive histogram is proposed.

Traditional histograms have disadvantages when the histogram is shifting caused by intensity change. A small shift may therefore change a large amount of bin assignments simultaneously and thus make the comparison more difficulty. There are measures that alleviate exist, but they can not really eliminate it and are furthermore much more complex.

Comparing with other methods, our method is simpler. It doesn't have special requirement or extra restriction for images. The experiment results demonstrate that it has high performance and can improve the retrieval precision. As for the intensity changed, good results can be achieved. As the future work, further tests with large-scale image database are expected. We also want to improve the dividing strategy of the histogram to make the retrieval more efficient.

6. References

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