A Research on the Methods of Image Retrieval Based on Color Features with Equal Intervals

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Abstract

Color has been broadly applied in the Content Based Image Retrieval, as it has a strong robustness for resizing, rotating and translating images. When doing feature extraction, global color histogram and the traditional blocking color histogram cannot give a sufficient description of the spatial information of images, thus the retrieval effect is not very good. Concerning this problem, the article employs rectangular frames with equal interval to extract color features for retrieval. First, this method segments images by way of equal interval; second, color accumulation histogram is used to extract the color features of each block; and then the article calculates the similarity distance between the retrieval images submitted by users and the images from image library. To highlight the central area of the image, the article divides the original image into small blocks from inside to outside and gives each a reductive weight in turn. And then accumulate the weights of the similarity distance and figure out the total similarity distance. Thus conduct the image retrieval and export the retrieval results; after applying this method to experiment and making an analysis, it shows that the retrieval of this algorithm is superior to the property of global color histogram and the common blocking histogram.

Keywords

Image Retrieval; Color Histogram; Rectangular Frames with Equal Intervals.

1. Introduction

With the fast development of the Internet, a large number of image data continually emerge. It is urgent to deal with the problem of how to effectively retrieve attractive images from those countless ones. The traditional image retrieval manually annotates images and then searches the images by way of text retrieval. But there are also many defects [1] : manually annotating images needs much work, which inevitably results in subjectivity and uncertainty. And also users' demands cannot be well met. Therefore, it will be more desirable to retrieve images from the contents of the images themselves.

The main idea of content-based image retrieval attempts to retrieve the images that can meet the need of users on the basis of understanding the contents of images by using the low-level features of images [2], such as color, shape, vein, spatial relation, etc. And color is the lowest and most notable among the low-level features. The classic image retrieval algorithm employs the color features of images, that is, global color histogram [3]. This method is simple in calculation, and at the same time insensitive to the translation and rotation of images. But it cannot show the spatial relation between color compositions. For example, the color histogram of green leaves may be the same as that of green lawn, but they are two different images. And this may cause retrieval mistakes. Later, based on the global color histogram, this article makes an optimization and puts forward such methods as accumulation histogram and blocking histogram. The accumulation histogram [4] accumulates each component of the color histogram step by step and then generates a new histogram, which can help to avoid the situation of zero value resulted from the fact that global histogram cannot extract all the color characteristics value. Blocking histogram [5] is a way to divide the image into certain equal blocks and calculate blocks respectively. Although these methods reflect the spatial information of color, they destroy global histogram algorithm's invariability of translation, rotation and resizing, and do not make a higher improvement of the retrieval efficiency.

As to the problems above, the article puts forward the method of accumulation color histogram based on equal interval block. This method not only keeps the rotation and translation of color features invariable, but also adds image spatial information, distributes different weights to each block and improves the efficiency of image retrieval.

2. The Selection and Quantization of Color Space

There are many color models, such as RGB space, HSL space, HSV space, etc. Each space has its own advantages. Thus it is of vital importance to select a suitable space. This article adopts the HSV color space, as HSV space is most suitable for naked eyes to distinguish. Although other color spaces are also transformed from RGB color space when dealing with images, RGB space is not directly perceived, hence it is difficult to judge the color represented by the weight among the RGB ones[6].

The HSV color space uses hue (H), saturation (S) and value (V) to describe colors. This model can be denoted by a six-sided pyramid. As shown in Figure 1, the long axis is brightness, the angle of the revolving axis is hue and the distance to the long axis is saturation. The hue (H) is differentiated by colors. For example, the red, yellow and green can be measured by the angles between 0° and 360°. Saturation (S) shows the degree of color intensity and is measured by percentage with the lowest degree as 0% and the complete saturation as 100%. Value (V) reflects the degree of shade and is also measured by percentage. Here 0% shows black, the darkest color and 100% shows white, the brightest color.

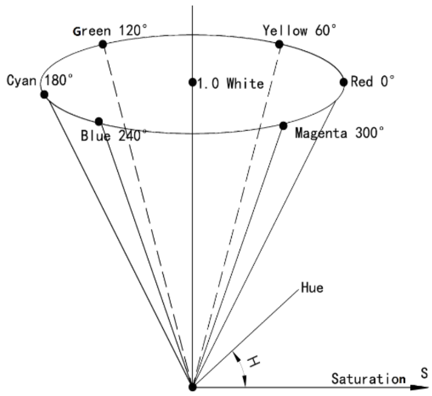


Figure.1 HSV Color Model

2.1 The Transformation from RGB to HSV

Assume that the RGB color values are given as (r, g, b), and r, g, b∈[0, 1, …, 255]. Suppose the values that RGB colors transform into HSV space are h, s, v, then the transformation is as follows:

Assume $v^{'}$ = max (r, g, b), $v^{''}$ = min(r, g, b), define $r^{'}$, $g^{'}$, $b^{'}$ as:

$$r^{'}=\frac{v^{'}-r}{v^{'}-v^{''}} \qquad g^{'}=\frac{v^{'}-g}{v^{'}-v^{''}} \qquad b^{'}=\frac{v^{'}-b}{v^{'}-v^{''}}$$

Then:

$$h^{'}=\begin{cases}5+b^{'} & r=v^{'}\ and\ g=v^{''}\\ 1-g^{'} & r=v^{'}\ and\ g\neq v^{''}\\ 1+r^{'} & g=v^{'}\ and\ b=v^{''}\\ 3-b^{'} & g=v^{'}\ and\ b\neq v^{''}\\ 3+g^{'} & b=v^{'}\ and\ r=v^{''}\\ 5-r^{'} & others\end{cases} \tag{1}$$

$$h = 60 \times h' \qquad h \in [0,360] \tag{2}$$

$$v = v'/255 \quad \text{v} \in [0\ ,\ 1] \tag{3}$$

$$s = \begin{cases} \dfrac{v' - v''}{v'} & v' \neq v'' \\ 0 & v' = v'' \end{cases} \qquad s \in [0,1] \tag{4}$$

2.2 The Quantization of Color Space

As the distinguishing ability of human beings' visual system is limited, pure eyes cannot differentiate too many changes in color. Besides, if there are too many colors in an image, the quantization of histogram will be quite a lot. And the increase of quantization will occupy more storage space and also the calculation will be larger. Therefore, it is necessary to quantize color space to reduce color dimensions. There are mainly two ways of quantizing color space: equal interval quantization and non-equal interval quantization. The former may centralize the information on a small number of colors. In addition, it also makes it possible that the same color can contain different information. So this article employs the non-equal interval quantization [7]. According to the distinguishing ability of naked eyes, this article divides hue (h) into eight parts, saturation into 3 parts and brightness (v) into 3 parts, and the values after quantizing are H, S, and V correspondingly. Based on different color ranges, the quantization is as follows:

$$H = \begin{cases} 0 & h \in [316,20] \\ 1 & h \in [21,40] \\ 2 & h \in [41,75] \\ 3 & h \in [76,155] \\ 4 & h \in [156,190] \\ 5 & h \in [191,270] \\ 6 & h \in [271,295] \\ 7 & h \in [296,315] \end{cases} \tag{5}$$

$$S = \begin{cases} 0 & s \in [0,0.2] \\ 1 & s \in [0.2,0.7] \\ 2 & s \in [0,7,1] \end{cases} \tag{6}$$

$$V = \begin{cases} 0 & v \in [0,0.2] \\ 1 & v \in [0.2,0.7] \\ 2 & v \in [0,7,1] \end{cases} \tag{7}$$

According to this quantization level, compose the 3 color components into the feature vector of one dimension:

$$L = HQ_sQ_v + SQ_v + V \tag{8}$$

Among which, Q_s and Q_v are quantization series of S and V respectively. In this article, given that $Q_s = 3$, $Q_v = 3$, then the formula above can be transformed into:

$$L = 9H + 3S + V \tag{9}$$

Thus, H, S and V are distributed on the one-dimension vector. According to Formula (9), the value range of L is [0, 1, 2,…,71]. The HSV color space after quantization is divided into 72 colors, which can effectively compress color features and are quite favorable for the visual perception of the eyes.

3. Retrieval Algorithm of Accumulation Color Histogram with Equal Interval

3.1 Image Block

The traditional way of using color histogram for image retrieval only considers the color statistics of the whole image but neglects the spatial distribution of color in images, which inevitably causes very large retrieval errors. To improve this situation, it is necessary to segment images before conducting the statistics of color histogram. Usually this method divides images into certain blocks, makes statistics of the histogram of each block and then compares the similarity between the blocks corresponding to the two images. The commonly used blocking method is to divide the images into equal m*n blocks, as shown in Figure 2. This blocking method has certain defects: 1) this blocking strategy is not qualified with the invariability of rotation and scale, 2) the main content of the images is principally located in the middle part of the images and this blocking neglects the attention of human eyes on the central area. To highlight the importance of different areas of the images and overcome the defects such as the sensitiveness of traditional blocking algorithm to the transformation of rotation and scale, this article puts forward to segment images based on the rectangular frames with equal interval.

The dividing way based on the rectangular frames with equal interval: take the diagonal intersection M as the center, and then divide the rectangular frames with this center. Assume to divide images into S rectangular frames and given that the distance between frames are equal, as shown in Figure 3. Then the side length of the rectangular frame is:

$$\begin{cases} a' = ka/S \\ b' = kb/S \end{cases} \quad (k = 1, 2, 3, \dots, S) \tag{10}$$

In the formula, a and b are the size of the whole image.

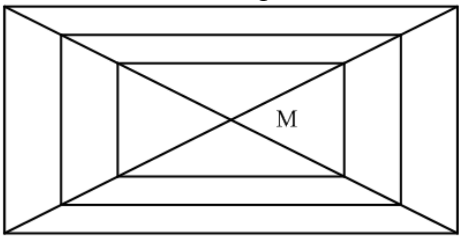


Figure.3 Block Division with Equal Interval

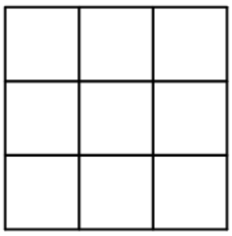


Figure. 2 Illustration of Image Blocking

3.2 Weight Distribution

In general, when checking an image, we often focus on the middle area of the image but neglect the fringe. Besides, when dealing with an image, usually we put important information in the middle of the image. Then the information of the central area appears relatively more important. Therefore, to highlight the center of images, this article gives each rectangular frame a different weight wk and each weight reduces successively from the inside of the rectangular frame to the outside[8]. The feature of the weight of each block is as follows:

$$\sum_{k=1}^{N} w_k = 1 \tag{11}$$

3.3 Feature Matching

When extracting the color features of images, if traditional histogram cannot extract all the values, then the situation of zero value may arise after working out the color histogram. These zeros have a great influence on similarity measurement and also on the retrieval results. Accumulation color histogram generates a new histogram by accumulating every component of the histogram. This method makes a great improvement of the zero situation in statistical histogram. And this method is shown as follows:

$$I(k) = \sum_{i=0}^{k} \frac{n_i}{N} \quad k = 0,1,2,\ldots,L \tag{12}$$

In the formula, k is the value of the color features of images, L is the number of feature values, ni is the number of feature values as k and N is the total number of the image picture element.

The similarity matching of color features adopts the method of Euclidean Distance. First calculate the similarity distance of each corresponding block; second multiply weight to the similarity distance of each block; and then work out the total distance. Suppose that Q and P are two images and that the color histograms of each sub-block are hi and si, then the distance between each sub-block is:

$$D(j) = \sum_{i=1}^{L} \left| h_i - s_i \right|^{1/2} \tag{13}$$

In the formula, L is the dimension of color quantization. Finally work out the actual similarity distance of the two images according to the weight wj of each rectangular frame. The statistical formula is as follows:

$$D(P,Q) = \sum_{j=1}^{n} w_j D(j) \tag{14}$$

n is the number of blocks.

3.4 Algorithm Flow

This algorithm employs the searching method based on examples. Users submit the querying image P and image data base D. The images in D extract features by adopting the following steps, and the flow is as follows:

1) Through carrying out experiments and result analysis on the quantity of different parts, it reaches a conclusion that the retrieval precision is the highest when divided into 7 parts. Therefore, divide the image into 1 rectangular and 6 rectangular frames with a total of 7 parts according to equal interval method.

2) Calculate the accumulation histogram of each sub-block.

3) The distribution of weight, the weight of each block reduces in turn from the center of the image to the outside and each is set as 7/28, 6/28,…, 1/28.

4) Based on Formula (14), successively calculate the actual distance between Image P and the image needed to be retrieved in the feature library. Then give the feedback of distance from small to large to users.

4. Experiment Analysis

This retrieval method conducts the simulation with MATLAB software as the experiment platform. During the experiment, 500 images, showing food, flowers, architectures, horses and cars are selected from the Corel Image Library as the feature image library for simulation experiment. Each type is chosen with 100 images. To verify the effectiveness of the algorithm, this article makes and compares the retrieval method based on the global color histogram and that of the traditional image with homogeneous block, as well as the text method. Figure 4 gives export example for the 3 methods above.

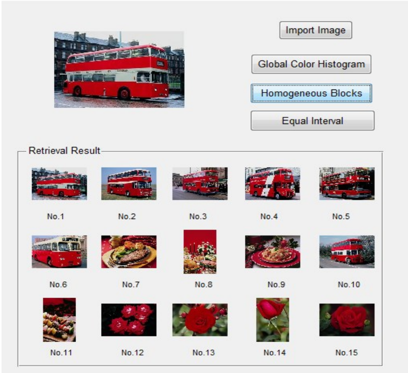
The content-based image retrieval employs precision ratio and recall ratio as the evaluation standard for retrieval [9]. Precision ratio is the proportion of relevant images to the whole images retrieved. Recall ratio is the proportion of all images retrieved to the relevant images, that is:

$$\Pr ecision\ ratio = \frac{Number\ of\ relevant\ images\ among\ images\ retrieved}{Number\ of\ images\ retrieved}$$

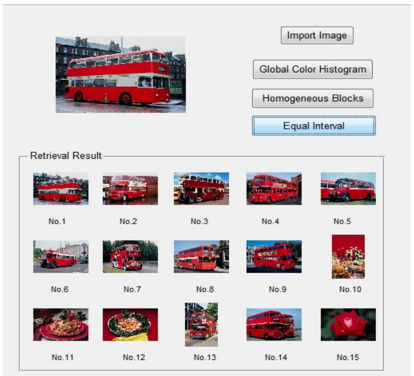
$$\text{Re} call\ ratio = \frac{Number\ of\ relevant\ images\ among\ images\ retrieved}{Number\ of\ all\ the\ relevant\ images}$$

(a) Import Image

(b) Global Color Histogram



(c) 3×3 Homogeneous Blocks



(d) Text Method

Figure.4 Example of Exporting Results

During the experiment, the algorithm described in this article selects 15 images that are most similar as the results of retrieved images. If we set the number of relevant image among images retrieved as n, and the precision ratio as n/15, then we can select the precision ration as the performance index of this article, as the two are in proportion. To lower the experiment error, the article randomly draws 10 different images from each type as the importing image. Thus the average precision ratio can be worked out, as is shown in Table 1.

Table 1 Performance Comparison of Image Retrieval Methods

Images	Average Precision Ratio		
	Global Color Histogram	Homogeneous Blocks	Text Method
Cars	48.7	57.3	74.6
Flowers	53.4	65.5	80.7
Horses	43.6	57.1	71.4
Architectures	45.8	57.4	66.3
Food	38.7	46.6	52.3

It can be shown from the analysis of the experiment results that the method used in this article has a clearer improvement than the algorithm of global color histogram. But the retrieval effect of architectures and food images is not very obvious, which reflects certain limitation of using color for retrieval.

5. Conclusion

The distribution information of color space may lose when using global color histogram for retrieval, while the common blocking is devoid of rotation invariability. This article puts forward the color-based equal interval image partitioning algorithm. This method employs the way of rectangular frames to divide images, and to some extent, solves the problem that global histogram loses spatial information. It can be drawn from the experiment analysis that the retrieval effect is not desirable by using single color features for retrieving certain images. In addition to color features, image also possesses such features as vein, shape. What need to be perfected is to integrate color, vein, shape, etc. for retrieval.

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