An Improved Image Retrieval Algorithm Based on Color Histogram

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Abstract. Color is a basic element of image content and is one of the main sensing features for recognizing images. Color histogram is widely used to retrieve images and the processing mostly concerns the choice and quantization of color space, the definition of color histogram and the distance of two images in color histogram space. In this paper, three key questions on how to make use of the characteristic of color are discussed, that is, expression of color, obtain of the characteristic of color and measurement of similarity. HSV color space can describe characteristic of color well, generalized histogram and block dominant color matrix can express the color distribution well. Experiment results show that the new algorithm proposed in this paper is more efficient and can significantly improve the precision rate.

Introduction

Content-based image retrieval (CBIR) means query an image according to the feature of object or region in the image, the feature may be color, shape, texture and other feature, or the combination of these features. CBIR has three characteristics:

1) The various quantization features used to query can describe the image content and also are saved with the image together.
2) The query is a kind of approximate query based on similarity measure.
3) Most of the CBIR system use query method of Query by Example(QBE)

Structure of a typical content-based retrieval system is shown in Fig.1:

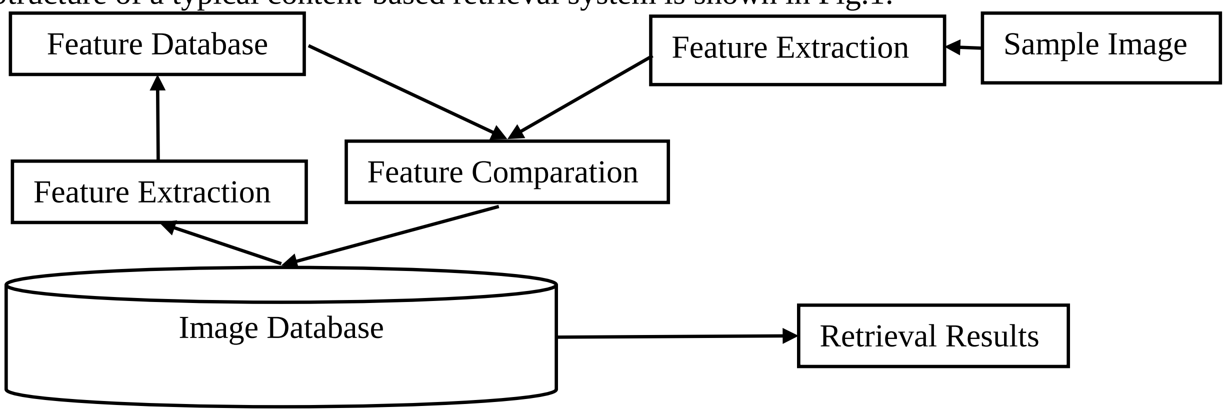

Fig.1. Typical Structure of CBIR

Images have various features such as shape, color, texture, etc., in which the color feature is the most significant, reliable and stable visual feature. With respect to the geometric characteristics, color features are not sensitive to the changes of size and direction of the sub-objects in the image, and thus have very strong robustness.

In addition to having the characteristic of simple to compute, the color global histogram is also insensitive to translation and rotation. However, the global histogram can describe neither the spatial relationship of the objects in the image, nor the color distribution of the image. In this paper, an improved query algorithm based on color histogram is proposed, that is, the combination of generalized histogram and dominant color matrix is used to describe the spacial location information of the image, and then is used as query feature.

RGB Color Space and HSV Color Space

Various color models have been proposed till now, during which RGB color model is the most practical one. Digital images are generally represented by RGB color space, which have three channels: red (R), green (G) and blue (B), respectively indicates the color brightness values on a channel. RGB color space has many advantages such as facilitate to display on CRT device, convenient to exchange images, suitable for image processing and etc.. However, the disadvantage of RGB color space is that if a color is modified, its three channels should all be modified, which means RGB color space is not a uniform visual color space and the distance between the color space can not describe the visual color similarity of human eyes.

Compared with RGB color space, HSV color space can benefit users more, which corresponds directly to the three elements of human eye color vision characteristics, namely hue (H), Saturation (S) and Value (V). H represents the color of light, such as red, green, blue, orange, etc. S is the degree of color depth or shading, which reflects the extent of a certain color be diluted by white. If the white component is zero, the saturation is 100%, only white, the saturation is zero. V is the degree of brightness and shade of light, and the greater the energy of light waves, the greater the brightness. Hue and saturation of colors illustrates the depth of color, collectively known as chroma.

HSV color space is widely used in computer graphics, scientific visualization, and other fields, which is a uniform color space and its conversion is a nonlinear transformation. The quantization result of HSV space can generate color space consistent with the visual characteristics with smaller dimension, which can greatly help query.

The conversion from RGB to HSV color space is shown as follows:

Suppose $v' = \max(r, g, b)$, then

$$v = v'/255 \tag{1}$$

$$s = \frac{v' - \min(r, g, b)}{v'} \tag{2}$$

Command

$$r' = \frac{v' - r}{v' - \min(r, g, b)},\ g' = \frac{v' - g}{v' - \min(r, g, b)},\ b' = \frac{v' - b}{v' - \min(r, g, b)} \tag{3}$$

Then

$$60h = \begin{cases} 5 + b' & if \quad r = \max(r, g, b) and g = \min(r, g, b) \\ 1 - g' & if \quad r = \max(r, g, b) and g \neq \min(r, g, b) \\ 1 + r' & \text{if} \quad \mathrm{g} = \max(r, g, b) and b = \min(r, g, b) \\ 3 - b' & \text{if} \quad \mathrm{g} = \max(r, g, b) and b \neq \min(r, g, b) \\ 3 + g' & if \quad r = \max(r, g, b) and \mathrm{b} = \min(r, g, b) \\ 5 - r' & else \end{cases} \tag{4}$$

where $r, g, b \in [0,255]$,after conversion, $h \in [0,360]$, $s, v \in [0,1]$

Generalized Image and Generalized Histogram

The traditional color histogram is the statistic, analysis, and comparation to the color of pixels the image contains, which doesn't take into account the correlation between adjacent pixels, and the space distribution of color as well. Thus, for images close to the color component while have different spatial distribution, the conventional histogram can not accurately distinguish. To overcome the disadvantage mentioned above, generalized histogram is incorporated, that is, combine two corresponding pixels(one pixel from original image and the other from smoothed image) to form a binary vector, the collection of the binary vector is called generalized image. Suppose a color image $X = \{x_{mn}\}$ with size of $M \times N$, smooth it using 3×3 or 5×5 template to get image Y whose size is also $M \times N$. X and Y constitute a binary tuple $(X,Y) = \{x_{mn}, y_{mn}\}_{M \times N}$, which is called generalized image of image X.

The histogram of generalized image is generalized histogram, which contains the color distribution information of original image. For two images close to the color component while have different spatial distribution, their spacial distance of generalized histogram will be widened compared to conventional histogram, so that they can distinguished better.

Image Retrieval Based on Dominant Color Matrix

Structure of experimental system is shown in Fig.2:

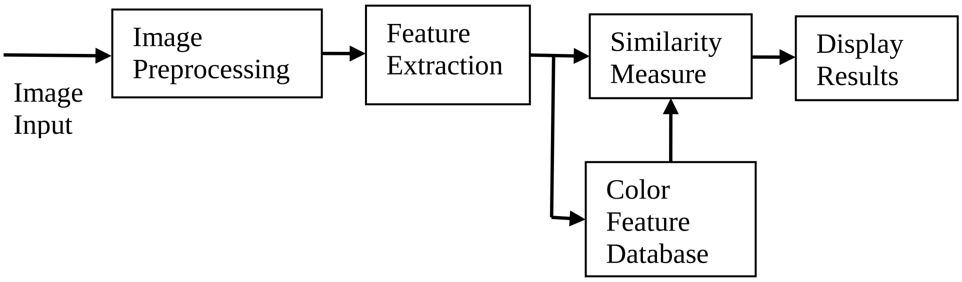

Fig.2. Structure of Experimental System

1.Calculate dominant color matrix

To contain the color distribution information of the image, we could divide an image into 4×4, 6×6, 8×8 blocks or other resolution. Before the image be blocked, both the accuracy of spacial description and the complexity of computation should be considered. Although more blocks can describe color distribution information more accurately, they increase the amount of calculation and reduce the retrieval efficiency. According to the test, 4×4 block scheme is used. Dominant color matrix is get as follows:

1) Calculate the generalized histogram of 16 block of ;
2) Identify the color appear most frequently in each block, that is the main color of each sub-block;
3) Find out the location the main color appear in generalized histogram of each block, which would be used to replace main color, thus the 4×4 main color matrix is obtained, which can act as the color feature of an image.

Furthermore, different weight coefficients are given to each block due to the different degree of importance in the image retrieval process. The setting of the weight coefficients is shown in Tab.1:

Tab.1. The Weight Value of Each Sub-block

0.02	0.04	0.04	0.02
0.04	0.15	0.15	0.04
0.04	0.15	0.15	0.04
0.02	0.04	0.04	0.02

2.Similarity measure

The geometric distance is often used to measure the similarity of the two images. In this paper, we use blocks distance, as shown in Equation 5:

$$Dist(Q,P)=\sum_{i=1}^{N}\left|Q_i-P_i\right| \tag{5}$$

where, $Q=\{Q_1,Q_2,...,Q_N\}$ and $P=\{P_1,P_2,...,P_N\}$ are feature vectors of query image and target image, N is the number of sub-blocks. The smaller the value of $Dist(Q,P)$, the more similar the two images, if the value of $Dist(Q,P)$ is 0, it shows that the two images are most similar.

3. Retrieval based on block dominant color matrix;

1) Calculate for each query image generalized block color histogram, the dominant color matrix;
2) Calculate the dominant color matrix of each image(target image) in database;
3) Calculate the distances between query image and each target image according to Equation 6;
4) Sort the distances from small to large;
5) Set a threshold value, select images with distance less than the threshold value as the query result.

In this paper, the block scheme is 4×4, value of N is 16, Q_i and P_i are the correspond pixel's value of dominant color matrix of query image and target image. Considering the weight coefficient of each block w_i, get distance calculation equation of two image Q and P, as follows:

$$Dist(Q,P)=\sum_{i=1}^{16}\left(w_i\times\left|Q_i-P_i\right|\right) \tag{6}$$

Conclusion

Select 4 images from database with 500 images as query image, named Q1, Q2, Q3, Q4. Record the recall rate and precision rate based on two algorithms: traditional HSV color histogram(absolute distance) and improved block dominant color matrix. The result is shown as follow:

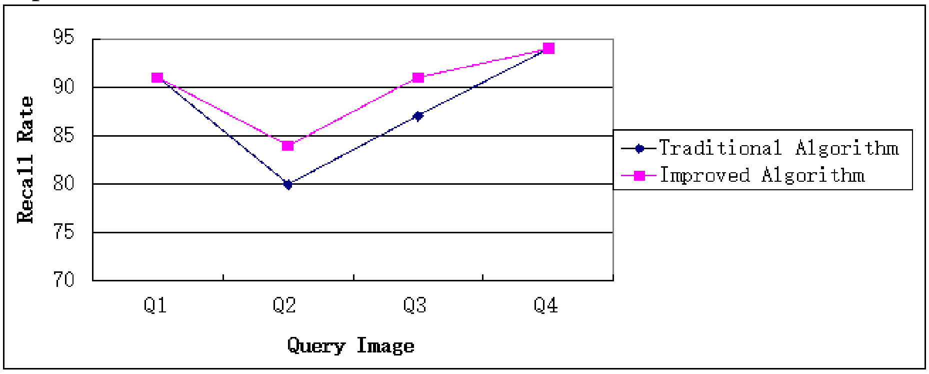

Fig.3. Recall Rate

The retrieval results shown in Fig.3 and Fig.4 illustrate that the effect is significantly improved when the improved algorithm is used, for example, the recall rate can be 94% and the precision rate can be 69%. The experiment done in the retrieval system proved that color is the most powerful search feature of CBIR, and image feature composed of block dominant color matrix can achieve better query results.

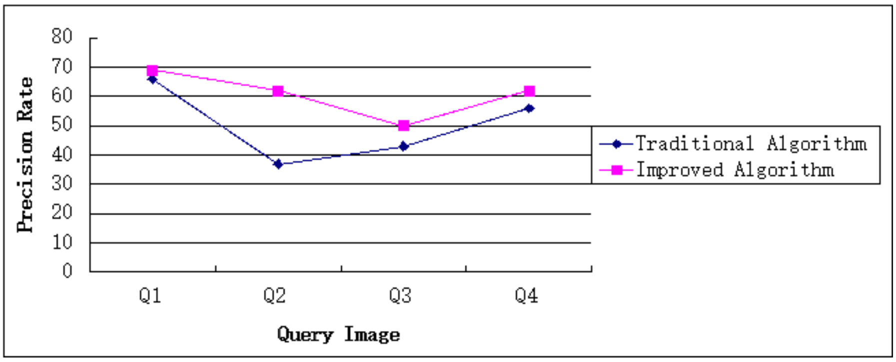

Fig.4. Precision Rate

Acknowledgments

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