An image retrieval algorithm based on improved color histogram

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Abstract. Nowadays, with the rise of the Internet, digital images have been developing quickly. The demand of multimedia based on digital image is more and more urgent. Image retrieval algorithms are an effective and accurate algorithm, which search images in large image database. It is widely used in Internet platform and image database. However, most of the proposed methods are based on text content, which can not accurately retrieve the target image according to the visual features and the needs of users. So we proposed an image retrieval algorithm based on improved color histogram, which extracts features based on HSV non-uniform quantized color. Our approach divided the image into several blocks, and calculate the color features of these regions respectively with different weights to search images with each block of color histogram. Our method makes full use of the advantages of image segmentation and HSV inhomogeneity to extract color features for image retrieval. Compared with existing methods, our approach can achieve a higher accuracy.

1. Introduction

With the rise of multimedia technology, image, video and other applications are more and more widely used in all fields of life [1]. The storage and management of image data become more and more important [2]. Image management mainly include image classification and image retrieval. Accurate and effective image retrieval method can provide powerful support to image database system and meet users' demand for images [3]. At present, image retrieval algorithms mainly include text-based methods and content-based methods.

The text-based image retrieval methods use the form of text to describe the image features, mainly depending on the image labels [4]. In the process of image retrieval, the target image is obtained by matching the label information and search information of the image. However, with the growth of massive image data, the cost of labels of these images are very high, and it cannot satisfy people's needs.

Content-based methods mainly use feature extraction for image retrieval [5]. The content mainly includes visual features and semantic features, while visual features are mainly colors, shapes, textures and so on. At present, content-based image retrieval methods are widely used. Among these features, color feature is an important visual feature information [6]. It is easier to extract than other features. More importantly, color features are less dependent on the transformation of the image such as scaling, rotation, vision and other deformation, and show strong robustness. So far, many scholars put forward a lot of the methods of using color features for image retrieval. They are Color histogram method, Color Moment method and Color Coherence Vectors method and so on [6]. Among these methods, color histogram is the most widely used [7].
2. Background and Related work

2.1 RGB color space

The RGB color space is widely used in image processing [8]. Currently, the color information collected by the image processing in the first is the RGB value, which is the original color of the image. In other words, other color features are based on the conversion of the RGB color value. RGB color space is the original color space, which is not intuitive enough to conform to the rule of human visual recognition. Therefore, we generally transform the RGB color space to more intuitive space.

2.2 HSV color space

HSV color space is oriented to visual perception [8], which is converted by RGB. HSV color space includes three basic elements: hue, saturation and brightness. Hue (H) is the color of light, saturation (S) is the depth of color, and brightness (V) is the brightness of color that can be distinguished by human vision. HSV color space can be represented by a three-dimensional diagram, as shown in figure1:

![Figure1 Space gram of HSV](image)

3. Method

3.1 RGB to HSV

To extract image features, we need to convert the RGB color space to HSV. The formula is as follows:

\[
V = \frac{1}{\sqrt{3}} (R+G+B) \\
S = 1 - \sqrt{3} \frac{\min(R,G,B)}{V} \\
H = \begin{cases} 
\theta, & G \geq B \\
2\pi - \theta, & G < B 
\end{cases} \\
\theta = \arccos \left[ \frac{\frac{1}{2} (R-G)+(R-B)}{\sqrt{(R-G)^2+(R-B)(R+B)}} \right]
\]

The transformation from RGB color space to HSV can also use such a method to calculate. The formula is as following:

\[
V = \max(R,G,B) \\
S = \frac{V - \min(R,G,B)}{V}
\]
\[ r' = \frac{V - R}{V - \min(R,G,B)} \]
\[ g' = \frac{V - G}{V - \min(R,G,B)} \]
\[ b' = \frac{V - B}{V - \min(R,G,B)} \] (7)

\[ g' = \frac{V - G}{V - \min(R,G,B)} \]
\[ b' = \frac{V - B}{V - \min(R,G,B)} \] (8)

\[ b' = \frac{V - B}{V - \min(R,G,B)} \] (9)

So the H, S, V can be computed as:

\[
H' = \begin{cases} 
5 + b' R = \max(R,G,B) \text{ and } G = \min(R,G,B) \\
1 - g' R = \max(R,G,B) \text{ and } G \neq \min(R,G,B) \\
1 + r' R = \max(R,G,B) \text{ and } B = \min(R,G,B) \\
3 + g' R = \max(R,G,B) \text{ and } R = \min(R,G,B) \\
5 - r' \text{ other} 
\end{cases} \] (10)

\[ H = 60 \times H' \] (11)

Where, \( H \in [0,360] \), \( S \in [0,1] \), \( V \in [0,1] \)

3.2 Color quantization

\[ H = \begin{cases} 
0, & H \in [0^\circ, 60^\circ) \\
1, & H \in [60^\circ, 120^\circ) \\
2, & H \in [120^\circ, 180^\circ) \\
3, & H \in [180^\circ, 240^\circ) \\
4, & H \in [240^\circ, 300^\circ) \\
5, & H \in [300^\circ, 360^\circ) 
\end{cases} \] (12)

\[ S = \begin{cases} 
0, & S \in [0,0.25] \\
1, & S \in [0.25, 1] \\
0, & V \in [0,0.3] \\
1, & V \in [0.3, 0.8] \\
2, & V \in [0.8, 1] 
\end{cases} \] (13)

Then, we constructed the eigenvector for the color. According to the previous quantization level, we synthesize the components of colors into color feature vectors.

\[ G = HQ_SQ_V + SQ_V + V \] (15)

where, \( Q_S \) and \( Q_V \) are quantitative levels of the color components \( S \) and \( V \) respectively.

3.3 Color histogram method

The global color histogram method can implement simple calculation [9], but it is not sensitive to the translation and rotation operation of images, and it cannot obtain the spatial relation of color composition. However, in image retrieval, the spatial distribution of color greatly affects people's judgment of image similarity, and the spatial relationship of color is more consistent with people's visual perception of color. We proposed an image method based on segmentation [10]. First, we divide the image into several sub-blocks. Then we extracts the features of each sub-block of the image to obtain the local features. We assign different weights to different sub-blocks according to people's visual perception of different regions of the image.

We use Euclidean distance to calculate the similarity of the image [11]. We let \( \tilde{q} = \{q_0, q_1, ..., q_l\} \) represent the feature vector of the histogram of sample images[12]. And the \( \tilde{s} = \{s_0, s_1, ..., s_l\} \) represents the feature vector of the histogram. Therefore, the Euclidean distance algorithm of image histogram carries out the calculation formula of image similarity measurement as follows:

\[ D(Q,S) = \left( \sum_{i=0}^{L} (q_i - s_i)^2 \right)^{1/2} \] (16)

Where, \( q_i \in [0,1] \), \( s_i \in [0,1] \), and they all have been normalized. We let \( L \) represent the dimension of the histogram vector.

We calculated the similarity of images as following:
\[
\text{sim}(Q, S) = \frac{1}{L} \sum_{l=0}^{L-1} \left[ 1 - \frac{|q_l - s_l|}{\max(q_l, s_l)} \right]
\] 

(17)

4. Experiment

In this section, we used several sets of data sets and different evaluation metrics to evaluate the performance.

4.1 Data sets

In the experiment, 1000 images with different colors in the coral image library were selected as the test set, and we use HSV non-uniform quantitative method (HSVM) was adopted. We randomly selected a number of images in several groups for image retrieval, and calculated their accuracy rate and recall rate respectively [13].

4.2 Evaluation metrics

We use the precision and recall rates to measure the performance of image retrieval. TP represents the number of retrieved relevant images, FN represents the number of all retrieved images, and FP represents the number of retrieved images.

\[
\text{Precision} = \frac{TP}{FN}
\]

\[
\text{Recall} = \frac{TP}{FP}
\]

4.3 Baseline methods

1. Global color histogram method (GCHM): This method is aimed at the composition distribution of colors in the image, we calculate the probability of various colors appearing. Features are extracted from various colors and their probability of occurrence [14].

2. Cumulative color histogram method (CCHM): In a cumulative histogram, adjacent colors are related in frequency. It eliminates the effect of zero value in image when extract features [15].

3. Main color histogram method (HCHM): By computing the probability of various colors appearing in the image, it selects the most frequent colors as the primary colors. Then the feature extraction is carried out according to the main color [16].

4.4 Experimental results and Analysis

We used several groups of data sets with images ranging from 1 to 20 to test the performance of our method. We obtained the accuracy and recall rate of our method and baselines respectively from different data sets. The experimental results are as follows:

![Figure2](image-url) The precision of data set
As can be seen from figure1 and figure2, compared with baseline methods, the precision and recall rate of our method have achieved better results. At the beginning, with the increase of the images, the precision and recall rate both showed a descending tendency. And the precision, recall rate begin to rise and gradually stabilize as the number of images reach to 10.

The results of Image retrieval are shown as figure4:

![Image Retrieval Results](image.png)

**Figure3** The recall of data set

**Figure4** The result of image retrieval

5. **Conclusion**

We proposed an image retrieval algorithm based on improved color histogram in this paper. We used HSV non-uniform quantized to extract color features of images. Our method first uses Gaussian filtering to preprocess the images. The images are segmented into several pieces and different weights are set for different areas according to human visual perception. Finally, the color values of each region quantitatively represented to extract color features, and implement the image retrieval. Compared with the existing algorithms, our method use the non-uniform features of HSV and can achieve more efficient for image retrieval. In the future, we will further optimize the algorithm to improve the accuracy and the speed of retrieval.
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