Novel Color Feature Representation and Matching Technique for Content-based Image Retrieval

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Abstract: Color features of an image are the most widely used features in content-based image retrieval (CBIR) [1][6] systems. Specifically histogram-based algorithms are considered to be effective for color image indexing. Color histogram [2] describes the global distribution of pixels of an image which is insensitive to variations in scale and easy to calculate. However, the high dimensionality of feature vectors results in high computation cost and space cost. In this paper, we mainly focus on color features and propose a novel method named Color Frequency Sequence Difference (CFSD) to express color image, which only has one numerical value in one color channel. The CFSD is combined with information entropy to realize indexing. The novel approach is described in detail and compared with color histogram method presented in the literature. The experiment is finished and shows that the method proposed in this paper is effective and efficient.
Key words: Image Retrieval, Color Histogram, content-based image retrieval (CBIR), Information Entropy

INTRODUCTION

The rapid growth in the number of large-scale image repositories in many domains such as medical image management, multimedia libraries, document archives, art collections, geographical information systems, law enforcement agencies, and journalism has brought about the need for efficient content-based image retrieval (CBIR) mechanisms. There are several popular CBIR systems such as QBIC, Virage, Photobook, VisualSeek. In CBIR systems, the queries that are used to retrieve images can be broadly classified as primitive, logical, and abstract. A query is said to be a primitive one if it is based on features (such as color, shape, and texture) extracted from the images. A query is said to be logical if it employs the identities of the objects in the image. Sketch-based and linguistic queries, in which the user depicts or describes objects/regions in the desired spatial positions and ascribes attributes (such as class label, size, color, and shape properties) to them, can also be considered logical ones. Logical and abstract queries are sometimes known as semantic ones. There have been some attempts at using linguistic queries or semantic attributes [3][5] [6], [7], [8], [9]. However, this area has not received the attention it deserves.

Content-based image retrieval, uses the visual contents of an image such as color, shape, texture, and spatial layout to represent and index the image. But, the color features are absolutely necessary features in image retrieval. With the view to color features' importance, we just focus on color features to study.

In this paper, we propose a novel method based on color frequency and it's order difference to express color information which just has one numerical value in one channel. So it has higher advance in space cost and time cost. In order to testify our theory, the query system is finished. In the system, color images and gray images are all queried. The rest of the paper is organized as follows: In Section 2, we introduce the color space and color quantization. The disadvantage of traditional histogram is listed in section 3. As the emphasis of this chapter, we introduce the novel arithmetic which is preponderant in time cost and space cost in detail in Section 4. After that, Color entropy is used together to realize images retrieval. In Section 5, we present the experiment and the conclusions.

1. Color Space and Color Quantization

Obviously, of all image features, color and texture are fundamental characteristics of the content of all images. Color is also an intuitive feature and color features play more important role in image matching. The models of human perception of color differences are described in the form of color spaces [1], so the research on color image must be studied in a given color space. RGB, YIQ，YUV, HSV etc. are the most frequently used color spaces.

1.1. HSV Color Space

The representation of the colors in the RGB space is quite adapted for monitors, but for a human being, this is not a useful definition. To provide a user representation in the user interfaces, programmers prefer the HSL color space or HSV color space [5][8]. The acronym stands for Hue, Saturation, and Luminosity.

HSV color space is the often used one because of its accordance with human visual feature. HSV color space has two distinct characteristics: one is that lightness component is independent of color information of images; the other is that hue and saturation component is correlative with manner of human visual perception. Programmers would like to transform RGB color space to HSV(HIS) color space in image indexing. In this system, HSV color space is used[4].

1.2. Color Quantization

Color quantization is a process that reduces the number of distinct colors used in an image, usually with the intention that the new image should be as visually similar as possible to the original image.

In order to reduce the number of colors in images before color feature extraction, we should convert all our colors into a subset which is called quantization. In our system, color quantization is adopted, in order to avoid the lost of information. There are 256 colors in every color channel in 24 bit images. Due to high color dimensionality, the value of w(i) in formula 2 is very small. So some information will be lost if we don't quantize. In this system, every color channel is quantized into 16 bins.

2. Color Histogram

Color is usually represented by the color histogram, color correlogram, color coherence vector, and color moment under a certain color space. The color histogram serves as an effective representation of the color content of an image if the color pattern is unique compared with the rest of the data set. The color histogram is easy to compute and effective in characterizing both the global and local distribution of colors in an image. In addition, it is robust to translation and rotation about the view axis and changes only slowly with the scale, occlusion and viewing angle. So Color histograms are widely used for the Content-Based Image Retrieval (CBIR).

There are several difficulties with histogram based retrieval. The first of these is the high dimensionality of the color histograms. Even with drastic quantization of the color space, the image histogram feature spaces can occupy over some dozens of dimensions in real valued space. This high dimensionality ensures that methods of feature reduction, pre-filtering and hierarchical indexing must be implemented. Second, distance of color histogram is not consistent with the vision of human. The novel feature representation is proposed to solve the two problems.

2.1. Shortcoming of existing color histogram

In this section, we discuss the shortcoming of the most frequently used similarity measures on the color histogram: The L1-metric [9] and the distance of histogram intersection [9].

Without loss of generality we may assume that all images contain N pixels and hence: The L1-distance of two color histograms H and Q is defined as :

$$D_{L1}(H,Q)=\sum_{i=1}^{n}\left|h(i)-q(i)\right| \tag{1}$$

In the definition, h(i) is the color histograms of image H, and q(i) is the color histograms of image Q.

The distance of histogram intersection [9]in two color histogram H and Q is defined as

$$D_{LJ}(H,Q)=1-\sum_{i=1}^{n}\min(h(i),q(i)) \tag{2}$$

Let us have a look at Figure 1, and we can draw the conclusion that the distance between the histograms H1 and H2 should certainly be smaller than the one between H1 and H3 from human's vision. But the distances are different using the above two formula.

$$D_{L1}(H1,H2)=2$$

$$D_{L1}(H1,H3)=D_{L1}(H2,H3)=1.33$$

From the result, we can conclude that image H1 is more similar to H3 than H2, which is different with the vision of human.

$$D_{LJ}(H1,H2)=1$$

$$D_{LJ}(H1,H3)=D_{LJ}(H2,H3)=0.33$$

From the result, we can also conclude that image H1 is more similar to H3 than H2, which is different with the vision of human.

This happens because perceptual similar color histograms maybe a large L1 distance apart from each other. And the distance of histogram intersection also doesn't consider this situation.

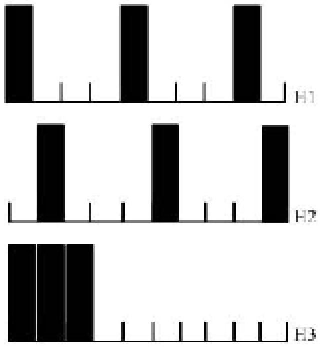

Figure 1: three color histograms

In our system, we can solve the problem by color frequency sequence difference which will be discussed below.

3. Color Frequence Sequence Difference

We use a numerical value to express color feature of a picture.

In images,

$$sfd = \sum_{i=1}^{N} w(i)h(i) \quad (3)$$

$$w(i) = 1/(\left|i - i'\right| + 1) \quad (4)$$

In the above equation, $h(i)$ is the frequency color i. N is the number of initial colors. The value of $\left|i - i'\right|$ means the distance of $h(i)$ moving which is greater, it contributes to sfd much less. The value of $h(i)$ is much greater it contribute to sfd more much. i is the new subscript and i' is old subscript, that's to say i is the subscript in ordered histogram and i' is the subscript of color i in out-of-order histogram's.

In formula 4, we add 1 for fear denominator is zero.

There are three color channels, so we calculate three sfds. That is to say, every color channel has one sfd. The color feature values are decrease, therefore, the arithmetic consumes less time and space. The final distance of two images is the average of the difference of three sfds.

Now we give the results by the method proposed in this paper.

First we order the color frequency by descending. In the above example, Histogram H1 and H2 are same to H3 after ordering.

In Histogram H1, W(1)=1, which denotes color 1 is not moved in order. w(5)=1/4, which denotes color 5 is moved 3 scale in order. W(9)=7, which denotes color 5 is moved 6 scale in order. Others are zero.

$$sfd_h = \sum_{i=1}^{N} w(i)h(i) = 0.46427$$

In Histogram H2, w(2)=1/2, w(6)=1/5, w(10)=1/8, others are zero. sfd_q =0.275

In Histogram H3, w(1)= w(2)= w(3)=1, others are zero.

sfd_p =1

$$D_{sfd}(H,Q) = |sfd_h - sfd_q| = 0.18927$$

$$D_{sfd}(H,P) = |sfd_h - sfd_p| = 0.53573$$

$$D_{sfd}(H,P) > D_{sfd}(H,Q)$$

so H is more similar to Q than P which is similar to human vision. But when the every color frequency in color histogram is ordered, the asd is 1. There will be an error in the situation. To reduce error, Information entropy is used in this system[2].

$$E(H) = -\sum_{i=1}^{n} h(i)\log_2 h(i) \quad (5)$$

$$D_{Le}(P,Q) = |E(P) - E(Q)| \quad （6）$$

Clearly, the more bins a color histogram contains, the more discrimination power it has. However, a histogram with a large number of bins will not only increase the computational cost, but will also be inappropriate for building efficient indexes for image databases. In this system, the number of bins won't increase any computation cost because all color frequencies is calculated to one number in a color channel.

$$D(P,Q) = w1 \times D_{sfd} + w2 \times D_{Le} \quad (7)$$

In formula 7, w1+w2=1. if the histogram of image H and P

are ordered, $sfd_h = sfd_p = 1$, then $D_{sfd}(H,P) = 0$

which won't mean the two images are very similar. That's means every image has an exclusive sfd, but one sfd is not corresponding to exclusive image. Every image has an exclusive value of entropy, but a value of entropy is not corresponding to one image. In order to reduce error, the two properties are used together. Experiments prove it's great.

4. Experiments and Results

In this paper, our purpose is to describe a novel approach for replacing color histogram, so we just focus on color histogram.

We have developed the system using Matlab 7.3.

There are about 1000 images whose sizes are from 140×105,640×480 to 1024×768 in the experiment. There are two group experiments in this system. The first one adopts the conditional color histogram. Second one adopts the new method proposed in the paper. Figure 1 and figure3 adopts the conditional color histogram, and figure 2 and figures 4 adopts the new method. In Figure 1 and Figure 2, the first image is the original one, the second is the rotation image of the original. The third is narrowed one. From the results, it proves that the new method is robust to translation and rotation, and is more excellent in based on originality, significance, quality and clarity. Certainly, to meet users' different need, we should consider feedback and which will be our further research issues.

As we known, traditional color histogram has high dimensionality of color feature vectors which results in high computation cost and space cost, so we mainly focus on the cost matter to propose a novel method named Color Frequency Sequence Difference (CFSD) to replace the old one. The indexing results just show the two methods' precision and recall is same nearly.

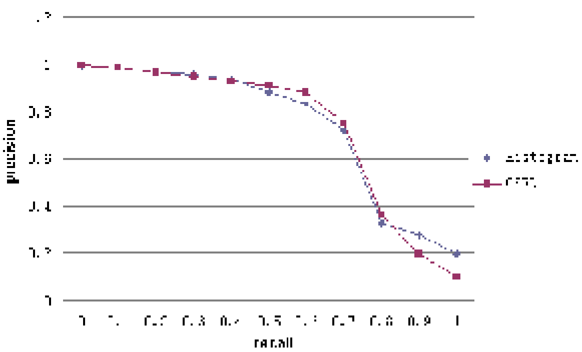

Table 1, precision and recall

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Science Foundation of China ' [Grant Nos. 60873147 and 60573182].

REFERENCES

[1]Datta Ritendrata, LiJ ia, Wang James Z. Content-based image retrieval-Approaches

and trends of the new age[A]. In Proceedings of the 7th International Workshop on

Multimedia Information Retrieval, in Conjunction with ACM International Conference

on Multimedia[C]，Singapore, 2005:253-262.

[2]John ZM. An information theoretic approach to content based image retrieval[D].

Louisiana State University and Agricultural and Mechanical College, Phd. Thesis,

2000:pp45-62.

[3] Chan, T., and Chen, L. H.: Fast Mapping Algorithm for Histogram to Binary Set

Conversion: Pattern Recognition Letter, Vo1.21(2000), 899-906

[4]Zhen-hua Zhang, Yong Quan, Wen-hui Li, A New Content-Based Image Retrieval ,

proceedings of 2006 international conference on Machine Learning and

Cybernetics,pp4013-4018,2006.8

[5] Brunelli,R.,and Mich,O., Histograms Analysis for Image Retrieval, Pattern

Recognition, Vol.34, (2001) 1625-1637

[6] Lu, W., Tan, Y. P., A Color Histogram-Based People Tracking System, The IEEE

International Symposium on Circuits and Systems, Vo1.2(2001), pp. 137-140

[7] Hong Anxiang, Some Thesis Research on Content-based Image Retrieval, A

Dissertation Presented to graduate School of Zhejiang University, pp.10-11,2003.3

[8] WANG Tao, HU Shi-min, SUN Jia-guang, Image Retrieval Based on

Color-Spatial Feature , Journal of Software, Vol.13, No.10 ,2002

[9] Rao A,Srihari R, Zhang Z. Spatial color histogram for content-based retrieval[a]. In

11th IEEE International Conference on Tools with AI[C]. 1999,pp183-186

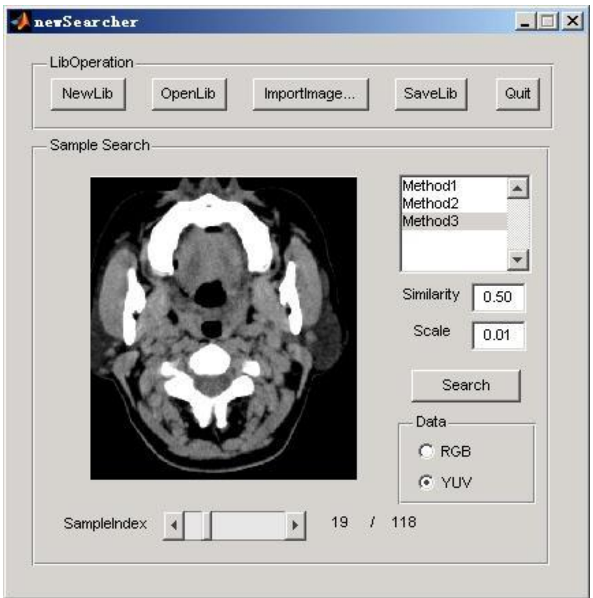

Figure 2, Main retrieval interface

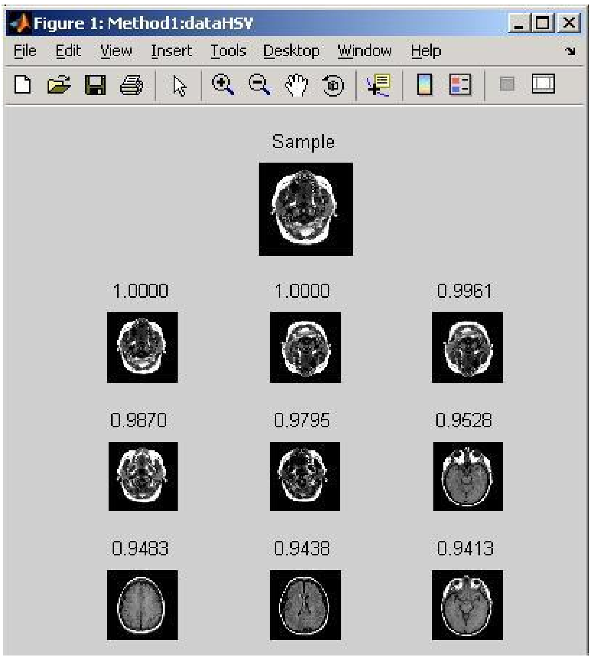

Figure 3, the gray images retrieving result of traditional color histogram

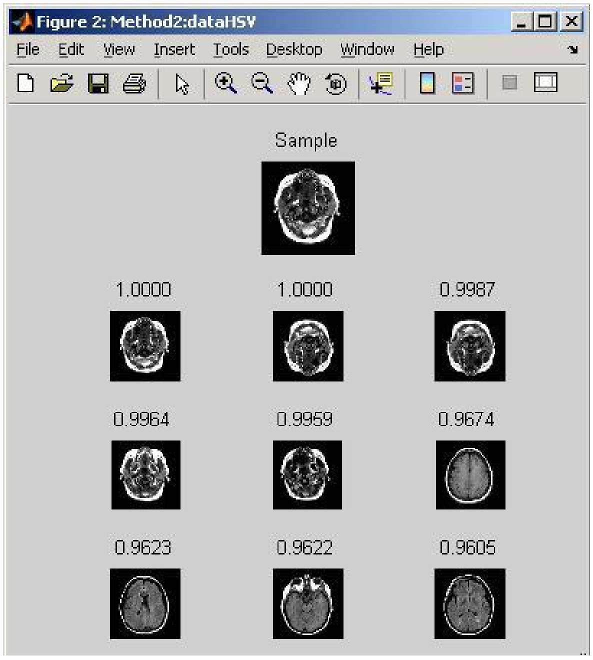

Figure 4, the gray images retrieving result of the new method

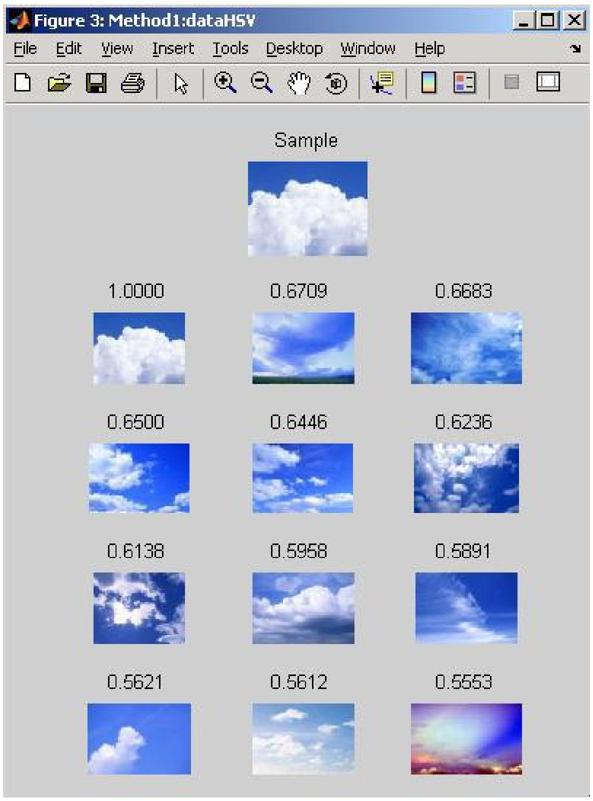

Figure5, the color images retrieving result of traditional color histogram

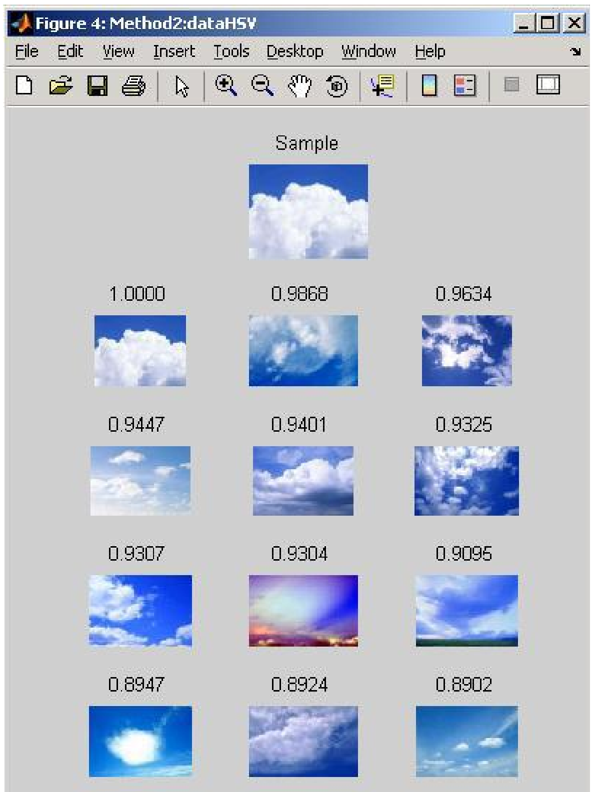

Figure6, the color images retrieving result of he new method