Content Based Image Indexing and Retrieval using Color Descriptor in Wavelet Domain

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Abstract

*This project presents an approach to index and retrieve images using a compact color descriptor in two color spaces namely HSV,and CIE L*u*v*. A compact color descriptor adopted in the proposed content-based image retrieval system is 127-bit binary Haar color histogram, which is used as an index of the images in the database. The color histogram is obtained for an image using a suitable color space. Here, HSV color space, and CIE L*u*v*color space are chosen for comparison. A compact color descriptor is obtained from Haar transform coefficient of the color histogram. Each coefficient is quantized to a binary number, resulting in a 127-bit color descriptor. The descriptors of the images in the database are compared to the descriptor of the query image. The most similar images are retrieved and ordered according to their distances to the query. The proposed retrieval system can effectively retrieve the most similar images in CIE L*u*v* color space.*

Keywords – Compact color descriptor, color spaces, image retrieval.

1. Introduction

Content-Based Image Retrieval, a technique which uses visual contents to search images from large scale image databases has been an active and fast advancing research area. In Content-Based Image Retrieval, images in database are represented using low level image features such as color, texture, and shape. Among these low level features, color features are the most widely used features for image retrieval because color is the most intuitive feature and can be extracted from images conveniently [2]. Due to their little semantic meaning and its compact representation, color features tend to be more domain independent compared to other features. In color indexing, given a query image, the goal is to retrieve all the images whose color compositions are similar to the color composition of the query image. Typically, the color content is characterized by color histograms, which are compared using the histogram distance measure. Color Histogram [3] is the most commonly used descriptor in image retrieval.

Database images having similar features to the query image given by user is retrieved using a compact color descriptor obtained from Haar transform coefficient of the color histogram [4]. Each coefficient is quantized to a binary number. This results in a 127-bit binary Haar descriptor. The binary nature of the descriptor allows simple matching metric based on hamming distance. The descriptors of the images in database are used as an index of each image. Then, the descriptors of the database images are compared to the descriptor of the query. The most similar database images are retrieved and ordered according to their distances to the query [1]. The procedure for obtaining compact color descriptor and similarity distance measure

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is adopted for the two color spaces (HSV, and CIE L*u*v*) and the results are analyzed. The objective is to identify which color space is suitable for retrieval process. The existing method has obtained the color histogram in HSV color space and has adopted a 63-bit color histogram. Finally, a prototype system is developed to compare the accuracies in two color spaces. The 127-bit color descriptor has better retrieval performance than 63-bit color descriptor.

The organization of this paper is as follows. Section 2 describes the color features identified for obtaining the color histogram. Section 3 presents a process to generate a 127-bit binary Haar color descriptor. Section 4 explains the retrieval system followed by the experimental results in Section5. Finally a conclusion and future work is presented in Section 6.

2. Color Features

The first step to extract color feature is to select an appropriate color space. Several color spaces are available, such as RGB, CMYK, HSV, CIE L*u*v*, and CIE L*a*b*. However, RGB color space is not perceptually uniform, which implies that two colors with larger distance can be perceptually more similar than another two colors with smaller distance, or simply put, the color distance in RGB space does not represent perceptual color distance[2]. In view of this drawback, perceptually uniform color spaces like HSV, and CIE L*u*v are chosen for a comparative analysis. Gonzales and Woods [5] use the following equations for RGB to HSV conversion:

$$\mathrm{H} = \cos^{-1}\left\{\frac{\frac{1}{2}\left[(R-G)+(R-B)\right]}{\sqrt{\left[\left(R-G^{2}\right)+(R-B)(G-B)\right]}}\right\} \tag{1}$$

$$\mathrm{S} = 1-\frac{3}{R+G+B}\left[\min(R,G,B)\right] \tag{2}$$

$$\mathrm{V} = \frac{1}{3}(R+G+B) \tag{3}$$

In order to use L*u*v* space, the color values are first converted from RGB space into CIEXYZ space with a linear transform and then from CIEXYZ space into L*u*v* color space using the following transform [2]:

$$l = \begin{cases} 116\sqrt[3]{y'_n}-16 & \text{if} \quad y'_n > 0.008856 \\ 903.3y'_n & \text{otherwise} \end{cases} \tag{4}$$

$$\begin{aligned} u &= 13l(u'-u'_n) \\ v &= 13l(v'-v'_n) \end{aligned} \tag{5}$$

$$\text{where } y'_n = Y/Yn;$$

$$u' = \frac{4X}{X+15Y+3Z}; \qquad u'_n = \frac{4X_n}{X_n+15Y_n+3Z_n};$$
$$v' = \frac{9Y}{X+15Y+3Z}; \qquad v'_n = \frac{9Y_n}{X_n+15Y_n+3Z_n}; \tag{6}$$

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.607 & 0.174 & 0.200 \\ 0.299 & 0.587 & 0.114 \\ 0.000 & 0.006 & 1.116 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{7}$$

A very important attribute of the CIEXYZ color space is that it is device independent. Every color space has a transformation from the CIE *XYZ* color space. A 128-bin color histogram is obtained from the 256 histogram frequency values. This color histogram is obtained using a suitable color space. In this paper, two color spaces namely HSV, and CIE L*u*v* are used and experimentally compared for all the database images.

3. Color Descriptor

The Haar transform coefficients of the 128-bin color histogram are obtained using Haar wavelet function. Since the Haar wavelet function contains only values of +1 or _1. Therefore, the computation does not involve any multiplication.

$$\Psi(x) = \begin{cases} 1 & 0<=x<0.5 \\ -1 & 0.5<=x<1 \\ 0 & \text{Elsewhere} \end{cases} \tag{8}$$

The wavelet function $\Psi(x)$ together with its integer translates and binary scaling, spans the difference between any two adjacent scaling subspaces [7]. The Haar transform coefficients are obtained by taking the inner product of the basis functions with the given histogram. Each of the Haar transform coefficients is quantized to binary. The Haar transform coefficients are hierarchically computed. The first level, the 128 bins of histogram is divided into two halves. If the sum of the histogram values in the left half is greater than the sum of the histogram values in the right half then the first bit of descriptor is '1' else it is '0'. This is repeated recursively at second, third, forth, fifth, sixth, and seventh levels resulting in 4,8,16, 32 and 64 coefficients. Therefore, the 127(1+2+4+8+16+32+64) bits binary Haar descriptor is obtained. After calculating the binary Haar histogram, this descriptor will be used as an index of each image [1]. The color descriptors for database images in HSV, and CIE L*u*v color spaces are obtained and stored.

4. Image Retrieval

When an image is selected as the query image, its 128-bin color histogram is calculated. The histogram of query image is transformed to the binary Haar descriptor. Similarly, the color descriptors for the database images are obtained and stored. The descriptor of the query image is compared to the descriptor of the candidate images using the hamming distance. The retrieval results are ordered according to the rank and presented to the user. The retrieval performance for the two color spaces is analyzed. Moreover, the proposed image retrieval system can efficiently retrieve the most similar images from the database in CIELUV color space than the existing system which has 63-bit color descriptor.

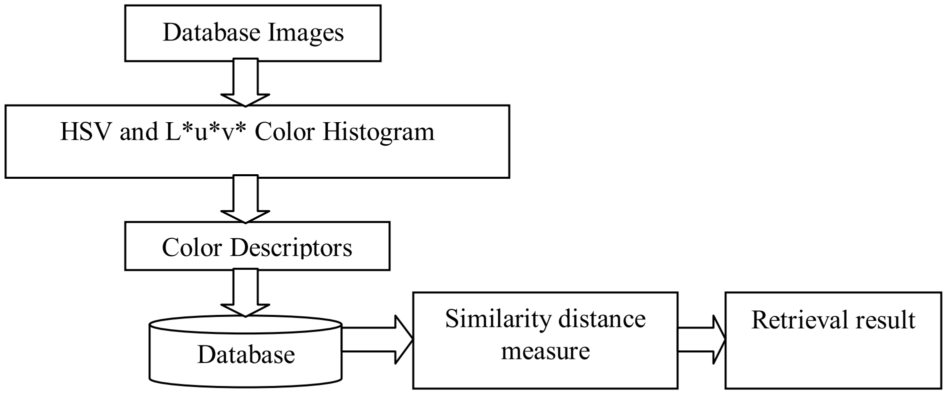

Figure 1. Architecture for retrieval of images from database

5. Experimental Results

Database images of 100 numbers are subjected to analysis. Averaged Normalized Modified Retrieval Rate (ANMRR) is an overall performance calculated by averaging the result from each query [1]. The average rank AVR(q) for query q is computed as follows:

$$AVR(q) = \sum_{k=1}^{NG(q)} \frac{Rank(k)}{NG(q)} \tag{9}$$

where NG(q) is the size of the ground truth set for a query image q, Rank(k) is the ranking of the ground truth images retrieved by the retrieval algorithm. The modified retrieval rank is computed as follows:

$$MRR(q) = AVR(q) - 0.5 - \frac{NG(q)}{2} \tag{10}$$

Normalized Modified Retrieval Rate (NMRR) is used to measure the performance of each query. NMRR is defined by

$$NMRR(q) = \frac{MRR(q)}{K(q) + 0.5 - 0.5 * NG(q)} \tag{11}$$

The NMRR is in the range of [0, 1] and smaller values represent a better retrieval performance. ANMRR is defined as the average NMRR over a range of queries, which is given by

$$ANMRR = \frac{1}{NQ} \sum_{q=1}^{NQ} NMRR(q) \tag{12}$$

where NQ is number of query images.

Table 1. Retrieval performance based on ANMRR

Retrieval Performance	ANMRR	
	HSV	LUV
Existing Method	0.13	0.02
Proposed Method	0.047	0.02

Table 2. Retrieval performance based on AVR,MRR&NMRR

Sample Query Images	HSV			LUV		
	AVR	MRR	NMRR	AVR	MRR	NMRR
Query Image 1	3.67	0.17	0.018	2.5	-1	-0.11
Query Image 2	3.84	0.34	0.036	4.17	0.67	0.071
Query Image 3	4.6	1.6	0.16	3.4	0.4	0.04

Figure 2. Sample Query Images

The results in table 1.show that the proposed retrieval system can efficiently retrieve the most similar images from the database in CIELUV color space than HSV color space. The parameters value in table 2. show the detailed test results of the proposed retrieval system.

6. Conclusion and Future Work

In this paper, a compact 127-bit binary Haar descriptor is adopted to retrieve the similar images with that of the query using hamming distance. The results show that the proposed retrieval system can efficiently retrieve the most similar images from the database in CIELUV color space than HSV color space. However, image retrieval using color features may give disappointing results [6], because in many cases, images with similar color do not have similar content. To have a better retrieval performance, both the color and texture features can be combined.

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