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Color-based Image Retrieval using Wavelet

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Abstract

There has been a great demand for efficient systems that can rapidly retrieve images of interest from a large quantity of images on the basis of the pictorial content such as color. Content-based image retrieval basically is to find a similar picture or pictures in the database when an image is given. In this paper we present a color-based image retrieval approach using a wavelet transform. The wavelet transform decompose the image into 4 subbands (LL, LH, HL, HH). Only the LL component is further decomposed until the desired depth is reached. Here we treat that the final LL component represents the original image. Color histogram is derived form the LL component and later histogram intersection is carried out for similarity process. We have shown in experimental work that using the LL component during color extraction give similar result when using the original image. Furthermore the processing task is faster on LL component when compare on the original image.

Keywords: *Content-based Image Retrieval, Wavelets, subband, color, RGB histogram.*

1. Introduction

In the past few years the demand for digital media storage has increased tremendously. The internet for example, is a distributed database system that contains several millions of digital data. Many people access these data frequently based on it's content-based such as color, texture and shape for various purposes. Some of the application in this field are multimedia information system, digital libraries, remote sensing and natural resources management, movie industry and video on demand. Most of the existing content-based image retrieval system such as QBIC, VisualSEEK and BlobWorld uses color, texture and shape in pixel domain to retrieve images. Recently the use of wavelet-based approach for content-based retrieval has become an interesting issue. The use of wavelet in compression has played an important role such as JPEG2000. The wavelet decomposition in wavelet technology has known to be an excellent localization property in spatial/time and in frequency domains and facilitates multiresolution analysis.

In this paper we present a color-based image retrieval approach using a wavelet transform. In our method the image first go through wavelet decompose in which image is decomposed into 4 subbands (LL, LH, HL, HH). Only the LL component is further decomposed until the desired depth is reached. Here we treat that the final LL component represents the original image. This is due to the fact that the statistic of the LL component resulted is almost the same as the statistic of the original image. Thus the color extraction is performed using the desired level of LL component rather than using the original image. During color extraction the color histogram is derived form the LL component and later histogram intersection is carried out for similarity process. We have shown in experimental work that extracting color directly from the LL component minimize the processing time and retrieving image is faster,

The organization of this paper is as follows. Section 2 explains the literature studies. Section 3 presents the system architecture. The system components include wavelet transform, color histogram and histogram intersection. Section 4 presents the experimental work and finding. Finally section 5 is the conclusion.

2. Related studies

There has been a great demand for efficient systems that can rapidly retrieve images of interest from large quantity of images on the basis of the pictorial content.

Image retrieval system is to find a similar picture in the database when an image is given [1, 6, 8, 10, 11, 12]. Thus content-based image retrieval is basically an object recognition problem. Several content-based image retrieval system has been proposed in the literature such as QBIC, Photobook and Virage[6, 11, 13]. These systems use low level image properties. Some of the potential applications of image retrieval are: multimedia information system, digital libraries, remote sensing and natural resources management, movie industry and video on demand [[6]. Recently wavelet transform [14] has played important roles in image compression such as JPEG2000 [2, 3, 4, 5, 15]and image retrieval . An application of wavelet transforms is the formation of classification features by using wavelet coefficients in high frequency bands. Subband and wavelet decomposition are well adapted in classification of color, texture and abnormal tissues in medical imagery. Color [7] i e of the most extensively used visual features in nt-based image retrieval. Color histogram [9][10] is a technique used to search color images in an image database. An image is actually made up of several components. As in the case of RGB image (*truecolor*), there are 3 components or *masks* that lay on top of each other to achieve the resulting image. Mandal et. Al. have proposed to compare the histogram of directional subband to find a match with the query image [16].

3. Color-based image retrieval system using wavelet

This image retrieval system consist of four components: wavelet transform component, color extraction component, RGB histogram component and histogram intersection as shown in figure 1. In off-line processing a collection of image are being processed on four components and stored the RGB histograms in the database. In on-line processing user's query is inputted through user interface to the system and system will produce the result immediately. Given an image, first the wavelet transform is carried out then color extraction and RGB histogram production. Histogram intersection component is the matching process between user inputted imaged to those images in database. During histogram intersection those most identical histograms are identified and respective images will be appeared on screen. Next section describes the component in detail.

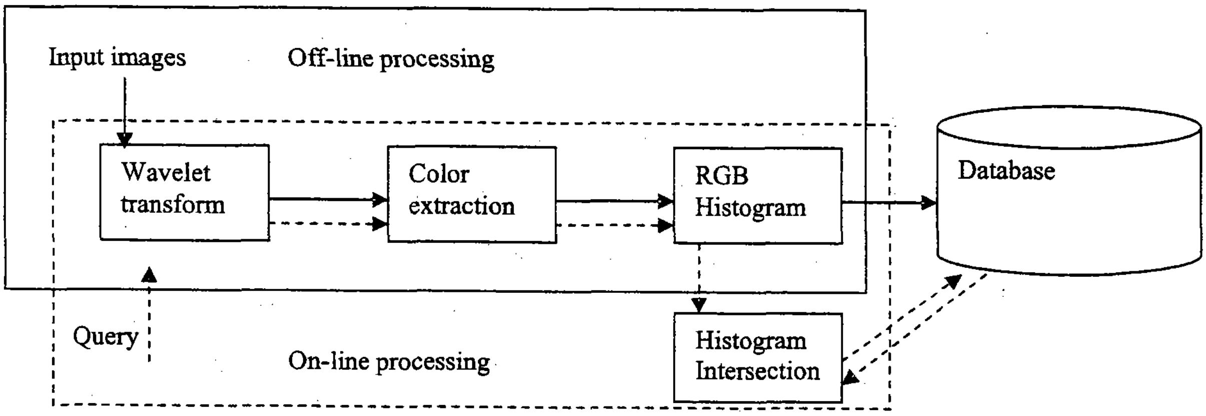


Figure 1: System architecture

3.1 Wavelet transform

Wavelets have long been used to assist researchers and mathematician in handling and manipulating signals [2]. The Wavelet Transform (WT) is a mathematical tool for analyzing signals. Basically the WT decomposes a given function f on different scales or frequency bands [14]. This is done by convolving f with the translated and dilated wavelet ψ:

$$L_{\psi}f(a,b) = \frac{1}{\sqrt{a}} \int f(t)\, \psi\left(\frac{t-b}{a}\right) dt$$

The parameter b allows investigating different parts of the signal f separately. The size of a detail is related to a specific range of frequencies, hence often called the frequency parameter. Wavelet decomposition is produced by an analysis filter bank and followed by downsampling [14]. This process can be iterated as many stages as desired. Figure 2 shows a 2D WT applied on an image.

Digital images are actually two dimensional, $f(x,y)$. A 2D WT of an image can be easily computed by taking WT along each dimension [5]. In figure 2, $\downarrow 2$ denotes downsampling by a factor of 2. Downsampling is done by dropping every even position. *H* denotes a highpass filter and *L* denotes a lowpass filter. The resulting image will yield 4 bands:

1) horizontally and vertically lowpass (*LL*)
2) horizontally lowpass and vertically highpass (*LH*)
3) horizontally highpass and vertically lowpass (*HL*)
4) horizontally and vertically highpass (*HH*)

Usually, Wavelet decomposition is applied recursively on the digital image. This means the decomposition is done a finite number of times until a desired result is achieved. The process is done depending on the level of compression rate desired, the size of the original image, and the length of the filters [2]. The higher the desired compression ratio, the more times the decomposition is done.

A *(n-1)*-level wavelet decomposition is associated with n resolution levels (Figure 3(a)), numbered from *0* to *n-1*, with 0 and n-1 corresponding to the coarsest and finest resolutions, respectively [3]. The LL_0 component is the most nearest image that resembles the original image compared to other subband signals. Color information in the LL_0 signal component will be extracted directly and stored into RGB histogram for image retrieval.

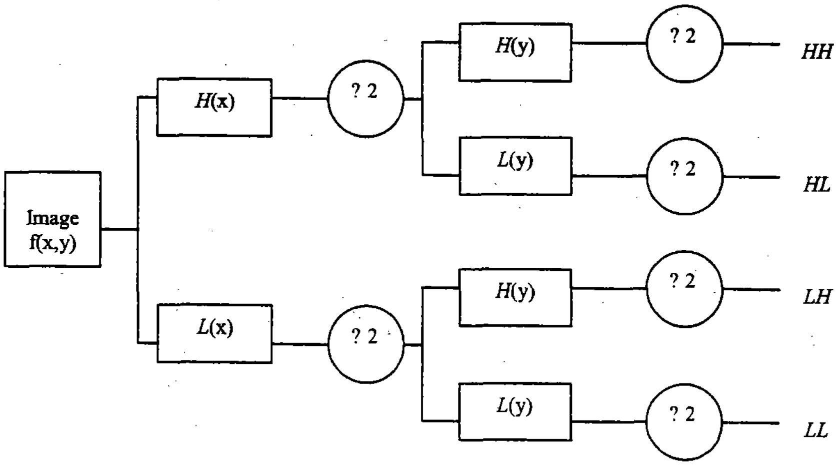
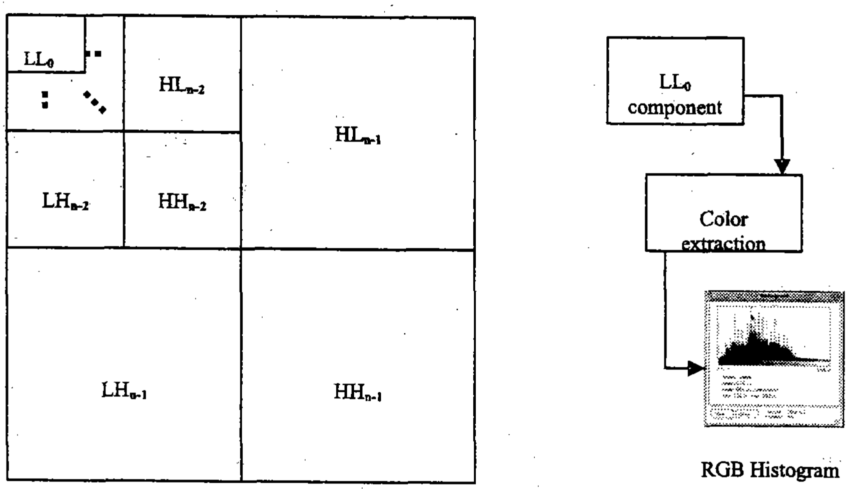


Figure 2: 2D WT producing 4 subbands HH, HL, LH, and LL.



(a) (b)

Figure 3: Subband structure

3.2 Color extraction and RGB histogram

Color histogram is a very popular method for characterizing images in image retrieval systems using color feature [8][11][12]. A color histogram is constructed by counting the numbers of pixels for each bin. RGB Histograms uses RGB color space to analyze images. RGB color space is widely used in most of the existing content-based image retrieval systems [7]. It contains three color components which are red, green and blue. Each color is represented by different wavelength. Each of this histogram uses the same concept as gray scale. A histogram is composed of multiple bins and each bin corresponds to a certain range of values [1]. During the construction of the histogram, every pixel in the image is analyzed to get the intensity level of color components based on the RGB space. These pixels will then be stored into bins corresponding to specific intensity levels and col mponent (red, green blue). Then, the number of pixel in each bins are calculated and stored. The number of pixels and the intensity level are used to plot the histogram for each color component.

In our system system, color information will be extracted from the LL component right after the wavelet transform. RGB histograms can be quantized into 3 dimensions with each color dimensions containing 20 bins each. Color images are spited into 3 color channels, red, green and blue. Then, a histogram is plotted for each color channel. Therefore a color image will have three individual histograms. The compressed image and its corresponding RGB histogram will then be stored into the database.

3.3 Histogram Intersection

We use histogram intersection technique as the matching technique to retrieve images from the database. Co istogram intersection technique was used in [7] and [8]. Histogram Intersection is used to compare two histograms based on one interested color at the same time. It is used to measure the similarity between histogram of the reference image and the model image. The intersection between histogram h and g are given by:

$$d_I(h,g) = \frac{\sum_{m=0}^{M-1} \min(h[m], g[m])}{\min\left(\sum_{m_0=0}^{M-1} h[m_0], \sum_{m_1=0}^{M-1} g[m_1]\right)}$$

When the reference image is inserted into the system, the RGB Histogram is plotted for that image. The search engine will first choose a single interested color histogram then search for possible histogram that matches that histogram. The histogram of the model image and the reference image is then overlapped on top of each other and the intersection area is observed. A larger intersected area shows more similarity between the reference images while smaller intersection shows otherwise.

4. Experimental Results

We have built a small prototype with 100 images on SQL 7.0 server as the database. After the retrieval, only the top ten best matches are shown for each query image as shown in figure 4. These matches are ordered according to the best match (image with the highest similarity score, calculated by the system using histogram intersection) in the upper left. The second best match would be on the right and so on.

5. Conclusion

In this paper we present a color-based image retrieval approach using a wavelet transform. The wavelet LL component and later histogram intersection is carried out for similarity process. We have shown in preliminary experimental work that using the LL component during color extraction give similar result when using the original image. Furthermore the processing task is faster on LL component when compare on the original image. The number of bins also has also been reduced. Future work will focus on color and texture using wavelet and subband segmentation.

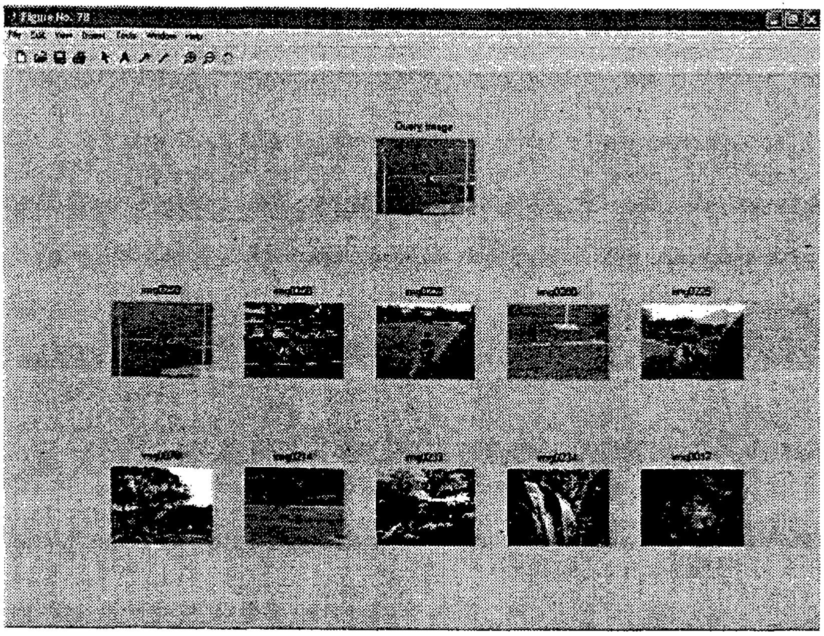


Figure 4: Image retrieval results

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