Colour and Texture Features for Content Based Image Retrieval

Lenina Birgale, Manesh Kokare and Dharmpal Doye
Department of Electronics and Telecommunication Engineering,
Shri Guru Gobind Singhij Institute of Engineering and Technology, Vishnupuri, Nanded 431606,INDIA
Lenina2003_2003@yahoo.com, mbkokare@sggs.ac.in, dddoye@sggs.ac.in

Abstract

The novel approach combines colour and texture features for content based image retrieval. Features like colour and texture are obtained by computing the measure of standard deviation in combination with energy on each colour band of image and sub band of wavelet. Wavelet transform is used for decomposing the image into 2x2 sub-bands. Feature database in content-based image retrieval of 640 Visual texture (VisTex) color images is constructed. It is observed that proposed method outperforms the other conventional histograms and standard wavelet decomposition techniques.

1. Introduction

Application of world wide web (www) and the internet is increasing exponentially, and with it the amount of digital image data accessible to the users. A huge amount of Image databases are added every minute and so is the need for effective and efficient image retrieval systems. There are many features of content-based image retrieval but four of them are considered to be the main features. They are colour, texture, shape, and spatial properties. Spatial properties, however, are implicitly taken into account so the main features to investigate are colour, texture and shape. Though there are many techniques of search this paper will focus on colour and texture features for CBIR. The main motivation of the present work is to use the decomposition scheme based on colour planes in combination with histograms, which yield improved retrieval performance. Advantage of three-colour plane wavelet decomposition is that it yields a large number of sub bands, which improves the retrieval accuracy. Through combination of standard wavelet decomposition on colour planes and histograms we can increase the number of features, which in turn improves the retrieval accuracy. To support the efficient and fast retrieval of similar images from image databases feature extraction plays an important role in content-based image retrieval. A fundamental ingredient for content based image retrieval is the technique used for comparing images.

2. Colour

Colour not only adds beauty to objects but also more information [1], which is used as powerful tool in content-based image retrieval. In color indexing, given a query image, the goal is to retrieve all the images whose color and texture compositions are similar to those of query image. In color image retrieval there are various methods, but here we will discuss some prominent methods.

Typical characterization of color composition is done by color histograms. In 1991 Swain and Ballard [2] proposed the method, called color indexing, which identifies the object using color histogram indexing. Color histograms are way to represent the distribution of colors in images where each histogram bin represents a color in a suitable color space (RGB etc) [3]. A distance between query image histogram and a data image histogram can be used to define similarity match between the two distributions. To overcome problem with histogram in 1995 Mehtre et al [4] proposed two new color-matching methods as “Distance Method” and “Reference Color Table Method”, for image retrieval. They used a coarse comparison of the color histograms of the query and model images in the Distance method they proposed.

Most colour histograms are very sparse and thus sensitive to noise. In 1995 Stricker and Orengo [5] proposed cumulated color histogram. Their results are better than color histogram approach. Observing the fact that the color histograms lack information about how color is spatially distributed, in 1997 Rui and Huang [6], introduced a new color feature for image retrieval called color correlogram. This feature characterized how the spatial correlation of pairs of colour changes with distance in an image. Usually, because the size of color correlogram is quite large, the color autocorrlogram is often used instead. This feature only captures spatial correlation between identical colors.

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The main contributions of this paper are as follows. Here we have proposed a wavelet-based approach for content-based image retrieval. Also histograms are used for color feature extraction for CBIR, and these color and texture features are combined to improve the retrieval efficiency.

The main title (on the first page) should begin 1-3/8 inches (3.49 cm) from the top edge of the page, centered, and in Times 14-point, boldface type. Capitalize the first letter of nouns, pronouns, verbs, adjectives, and adverbs; do not capitalize articles, coordinate conjunctions, or prepositions (unless the title begins with such a word). Leave two 12-point blank lines after the title.

3. Standard wavelet

The STFT represents a sort of compromise between the time- and frequency-based views of a signal. It provides some information about both when and at what frequencies a signal event occurs. However, one can only obtain this information with limited precision, and that precision is determined by the size of the window. But many signals require a more flexible approach where we can vary the window size to determine more accurately either time or frequency. Wavelet analysis is such an approach in which window with variable-sized regions is used. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high-frequency information. However it is a time-frequency region, but rather a time scale.

3.1. The Discrete Wavelet Transform

Calculating wavelet coefficients at every possible scale is a fair amount of work, and it generates an awful lot of data. That is why we choose only a subset of scales and positions at which to make our calculations. It turns out, rather remarkably, that if we choose scales and positions based on powers of two so-called dyadic scales and positions then our analysis will be much more efficient and just as accurate. We obtain such an analysis from the discrete wavelet transform (DWT) given by equation 1.

$$DWT = \sum_{k=1}^{\infty} \sum_{l=-\infty}^{\infty} q(k,l)\psi(2^{-k}t-l) \qquad 1$$

An efficient way to implement this scheme using filters was developed in 1988. This algorithm is in fact a classical scheme known in the signal processing community as a two-channel sub band coder. This very practical filtering algorithm yields a fast wavelet transform a box into which a signal passes, and out of which wavelet coefficients quickly emerge. Let's examine this in more depth.

Let ,

$$\varnothing(x) = \sum_n h_{\varnothing}(n)\sqrt{2}\varnothing(2x-n) \qquad 2$$

$$\psi(x) = \sum_n h_{\psi}(n)\sqrt{2}\psi(2x-n) \qquad 3$$

Both $\varnothing(x)$ and $\psi(x)$ can be expressed as linear combinations of double-resolution copies of themselves. Here $h_{\varnothing}$ in equation 2 and h_{ψ} in equation 3 the expansion coefficients are called scaling and wavelet vectors, respectively. They are the filter coefficients of fast wavelet transform (FWT),

$W_{\phi}(j,m,n)$ Approximate coefficients

$W_{\psi}^{H}(j,m,n)$ Horizontal coefficients

$W_{\psi}^{V}(j,m,n)$ Vertical coefficients

$W_{\psi}^{D}(j,m,n)$ Diagonal coefficients

Here $W_{\phi}(j,m,n)$ is the original image whose DWT is to be computed.

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4. Proposed method

The novel method which gives better retrieval performance is discussed below.

4.1. Image database

The database used in the experimentation consists of 40 different color textures from VisTex image database. Size of each color database is 512 x 512 x 3. Each 512 x 512 x 3 images is divided into sixteen 128 x 128 x 3 non-overlaping sub images, thus creating a database of 640 patterns in the database.

4.2. Feature database creation

The database of 640 color texture images was analyzed using standard wavelet, histograms and combination of both. We have extracted texture features using Standard Wavelets. As every colour has its own importance in an image we have used the features extracted from all the three-colour planes (that is RGB planes) of an image. We have used three level decomposition of each plane. To calculate the feature vector we have first level energy (given by equation 4) and computed standard deviation (given by equation 5) of each sub-band. Thus the coloured texture feature vector size of database is of 640 x 72 and for query image is 1 x 72. First level energy is computed by the equation 4.

$$Energy = \int_{-\infty}^{\infty} |x(t)| dt \qquad 4$$

where $x(t)$ is a function whose energy is to be computed.

Similarly standard deviation is given by 5.

$$S.D = \sqrt{\frac{\sum_{n=1}^{N} \left(x_n - \bar{x}\right)}{N}} \qquad 5$$

Where $\bar{x}$ is arithmetic mean

N is total number of elements in the array.

4.3. Similarity measure

A query pattern is any one of 640 patterns from image database. This pattern is processed to compute features with standard wavelet and histograms on color bands. Then Euclidean distance metric given by equation 6 is used to compute the similarity or match value for given pair of images.

$$D_{(x,y)}^{Eucl} = \sqrt{\sum_{i=0}^{n} \left(x_i - y_i\right)^2} \qquad 6$$

5. Experimental results

Comparison of average retrieval accuracy for 640 different colored textures using histograms, conventional Standard wavelet and their combination is provided in figure1. When Tile 10.bmp is given as query and retrieved using three different methods of retrieval used, in this paper following results were obtained. The results obtained by both the texture features and colour features consideration the retrieval efficiency is 82% that is fourteen images retrieved from the database are of same texture and colour contents. Red, Green and blue curves in figure 1 indicates the average retrieval efficiency using only colour, only texture and colour and texture combined respectively . The images retrieved are shown in figure 2.

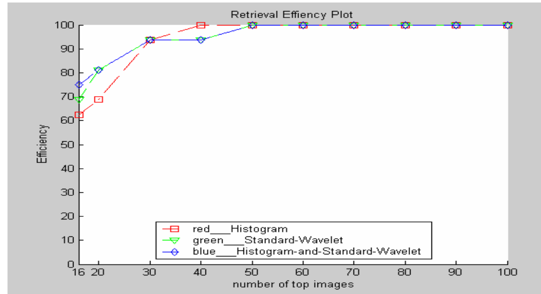

Figure 1: Curved graphs giving the average retrieval efficiency

6. Conclusions

After the absolute analysis of the results obtained by each method following conclusions can be drawn. When only colour is considered as retrieval parameter in CBIR gives only 62.5% of average retrieval efficiency. Similarly when only texture features are considered as retrieval parameter there is not much improvement in the retrieval efficiency. The average retrieval efficiency obtained by this method is only 68.75%. Which shows that only texture features or only colour features are not sufficient to describe an image. But there is considerable increase in retrieval efficiency when both colour and texture features are combined for CBIR. The average percent retrieval efficiency has increased up to 75%. Thus it is rightly said in [1] that only colour or only texture cannot differentiate a cheetah and a tiger.

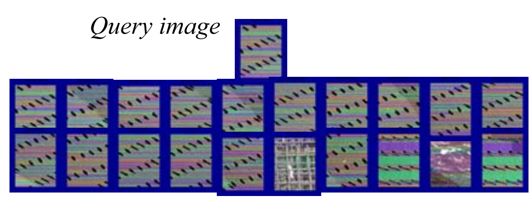

Figure 2: Retrieval Example using Standard Wavelet and Histograms

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