CONTENT BASED IMAGE RETRIEVAL USING COLOUR AND TEXTURE

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ABSTRACT:

Invention of digital technology has lead to increase in the number of images that can be stored in digital format. So searching and retrieving images in large image databases has become more challenging.Against the traditional system where the images are retrieved based on the keyword search, CBIR system retrieves the images based on the visual content. The increased need of content based image retrieval technique can be found in a number of different domains such as Data Mining, Education, Medical Imaging and Crime Prevention. This paper presents the content based image retrieval, using features like colour and texture. The colour and texture features are extracted through HSV based colour histogram and wavelet transformation respectively. In this paper the performance of HSV colour space and wavelet based colour histogram is evaluated on the basis of accuracy, precision and Recall. This system has demonstrated a promising and faster retrieval method on a WANG image database containing 100 general-purpose colour images. Thus, HSV based colour space and wavelet based colour histogram image retrieval methods are presented based on the colour distribution of the images.

Index terms: Content-Based Image Retrieval**,** HSV.

I. Introduction:

Content-based image retrieval, a technique which uses visual contents to search images from large scale image databases according to user's interests, has been an active and fast advancing research area over the last few years. However, this has exacerbated the problem of locating a desired image in a large and varied collection. This has led to the rise of a new research and development is Content-Based Image Retrieval (CBIR), the retrieval of images on the basis of features automatically extracted from the images themselves. In CBIR the image databases are indexed with descriptors derived from the visual content of the images.[1]

The Internet is one of the best places to find different types of data such as images, text documents etc. But due to nuances of natural language, it is very difficult to get relevant information. For example, if the user is looking for sunset images, he may get different types of images. Only a few of them satisfy the user's interest because the existing software retrieve images on the basis of string match and many of these are completely irrelevant to the user. To handle such types of ambiguities, feedback based techniques are developed for customized content-based image retrieval.

CBIR or Content Based Image Retrieval is the retrieval of images based on visual features such as color, texture and shape. Reasons for its development are that in many large image databases, traditional methods of image indexing have proven to be insufficient, laborious, and extremely time consuming. These old methods of image indexing, ranging from storing an image in the database and associating it with a keyword or number, to associating it with a categorized description, have become obsolete. This is not CBIR. In CBIR, each image that is stored in the database has its features extracted and compared to the features of the query image. It involves two steps:

1. **Feature Extraction**: The first step in the process is extracting image features to a distinguishable extent.
2. **Matching**: The second step involves matching these features to yield a result that is visually similar.

In the CBIR features of the image (color, texture and shape) are the most important content for indexing and retrieval of the image. The features extracted are then form a vector and this vector will be used for indexing of particular image.[2]

1.1COLOUR

1.1.1 Definition

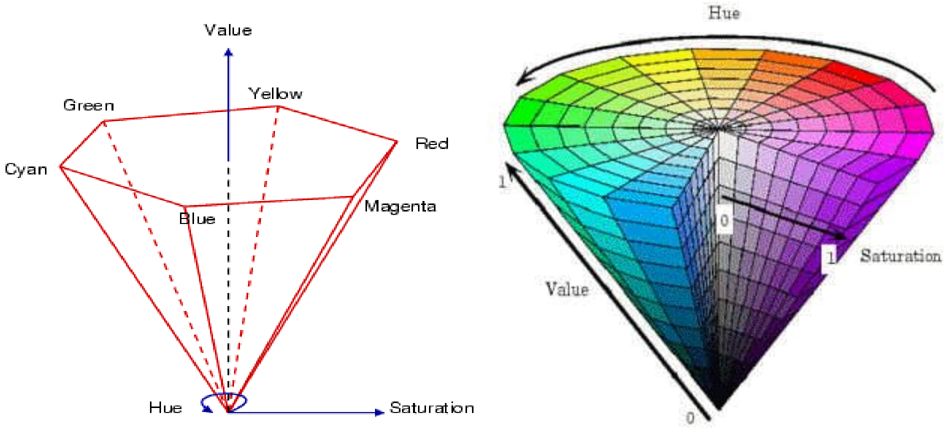
Color is a property that depends on the reflection of light to the eye and the processing of that information in the brain. Usually colors are defined in three dimensional color spaces. These could either be RGB (Red, Green and Blue), HSV (Hue, Saturation and Value) or HSB (Hue, Saturation and Brightness). The last two are dependent on the human perception of hue, saturation and brightness. Most image formats such as JPEG, BMP, GIF, use the RGB color space to store information.

1.1.2 Color Space

For a certain combination of a colour model plus a mapping function colour space is a more specific term. Colour space is used to identify colour models. The purpose of a colour space is to facilitate the specification of colours.

1.1.3 HSV Colour Space

To describe a specific colour the HSV colour space uses Hue (H), Saturation (S) and brightness values (V). In interactive colour selection and manipulation this colour system is very useful. It is easier to think about a colour in terms of hue and saturation than in terms of additive or subtractive colour components. HSV is a transformation of an RGB colour space. It has been reported that the HSV colour space gives the finest colour histogram feature, among the different colour spaces. Its components are relative to the RGB colour space from which it derives. For human perceive HSV space is more suitable.



(a) **(b)**

Figure 1. (a) HSV coordinates system (b) HSV colour model

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}(R-G)+(R-B)}{\sqrt{(R-G)^2+(R-G)+(R-B)}}\right\} \quad \text{... (1)}$$

$$S = 1-\frac{3}{R+G+B}\,[\min(R,G,B)] \quad \text{... (2)}$$

$$V = \frac{1}{3}(R+G+B) \quad \text{... (3)}$$

II Feature Extraction

2.1 Colour Feature Extraction

The colour histogram is one of the most commonly used colour feature representation in image retrieval. The power to recognize an object using colour is much larger than that of a gray scale.

2.1.1 Colour Space Selection and Colour Quantization

The colour of an image is represented, through any of the popular colour spaces like RGB, XYZ, YIQ, L*a*b*, U*V*W*, YUV and HSV[5]. It has been reported that the HSV colour space gives the finest colour histogram feature, among the different colour spaces. In HSV colour space the colour is presented in terms of three components: Hue (H), Saturation (S) and Value (V) and the HSV colour space is based on cylinder coordinates.[6&7] Colour quantization is a process that optimizes the use of distinct colours in an image without affecting the visual properties of an image. For a true colour image, the distinct number of colours is up to 2^{24} = 16777216 and the direct extraction of colour feature from the true colour will bring about a large computation. In order to lessen the computation, the colour quantization can be used to represent the image, without a major reduction in image quality, thereby reducing the storage space and enhancing the process speed.[8]

2.1.2 Colour Histogram

A colour histogram signifies the distribution of colours in an image, through a set of bins, where each histogram bin corresponds to a colour in the quantized colour space. A colour histogram for a given image is represented by a vector:

H = {H[0],H[1],H[2],H[3] … … … … H[i], … … … ,H[n] }

Where 'i' is the colour bin in the colour histogram and H[i] represents the number of pixels of colour i in the image, and n is the total number of bins used in colour histogram. Typically, each pixel in an image will be assigned to a bin of a colour histogram. Accordingly in the colour histogram of an image, the value of each bin gives the number of pixels that has the same corresponding colour. In order to compare images of different sizes, colour histograms should be normalized. The normalized colour histogram H` is given as:

H' = {H[0],H'[1],H'[2], … … ,H'[i] , … . ,H'[n]} H'[i]=H[i]/ p,

Where 'p' is the total number of pixels of an image[9]

An example of a colour histogram in the HSV colour space can be seen with the following image:

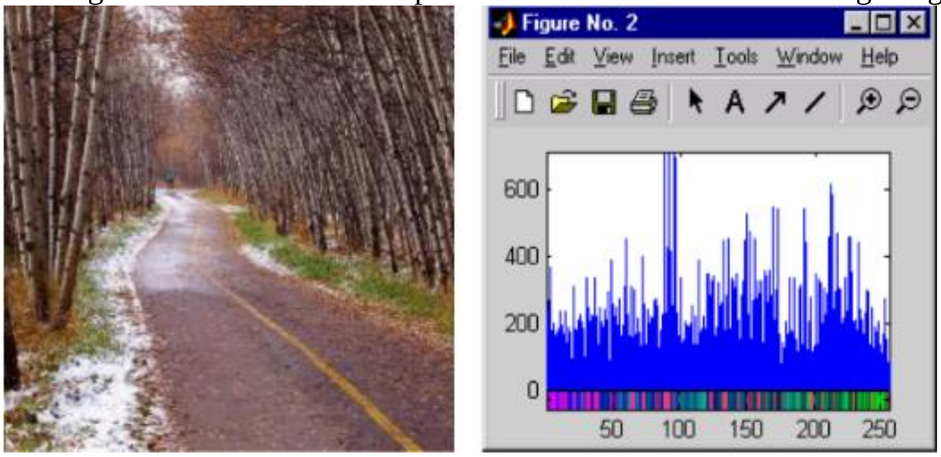


Figure 2. Sample Image and its Corresponding Histogram

2.2 Texture Feature Extraction

Like color, the texture is a potent low-level feature for image search and retrieval applications. Texture is an attribute representing the spatial arrangement of the grey levels of the pixels in a region or image[10]. The common known texture descriptors are Wavelet Transform[11], Gabor-filter[12], co-occurrence matrices[13] and Tamura features[14]. Wavelet Transform is preferred as it putrefies an image into orthogonal components, because of its better localization and computationally inexpensive properties.[3 & 4]

2.2.1 Haar Discrete Wavelet Transforms:

Discrete wavelet transformation (DWT)[15] is exercised to transform an image from spatial domain into frequency domain. The wavelet transform represents a function as a superposition of a family of basis functions called wavelets. Wavelet transforms dig up information from signal at different scales by passing the signal through low pass and high pass filters. Wavelets supply multi-resolution capability and good energy compaction. Wavelets are robust with respect to colour intensity shifts and can incarcerate both texture and shape information efficiently. The wavelet transforms can be computed linearly with time and thus allowing for very fast algorithms. DWT decomposes a signal into a set of Basis Functions and Wavelet Functions. The wavelet transform computation of a two-dimensional image is also a multi-resolution approach, which relates recursive filtering and sub-sampling. At each level (scale), the image is decomposed into four frequency sub-bands, LL, LH, HL, and HH where L denotes low frequencyand H denotes high frequency as shown in Fig

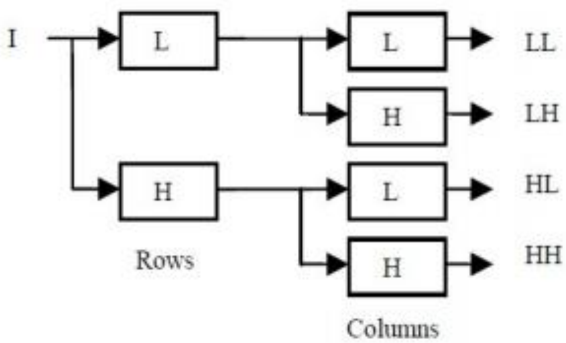


Figure 3. Discrete Wavelet Sub-band Decomposition

2.3 DISTANCE METRICS:

In image analysis, the distance transform measures the distance of each object point from the nearest boundary and is an important tool in computer vision, image processing and pattern recognition. In the distance transform, binary image specifies the distance from each pixel to the nearest non-zero pixel. The Euclidean distance is the straight-line distance between two pixels and is evaluated using the Euclidean norm. The city block distance metric measures the path between the pixels based on a four connected neighbourhood and pixels whose edges touch are one unit apart and pixels diagonally touching are two units apart. The distance transform provides a metric or measure of the separation of points in the image.

2.3.1 Euclidean distance algorithm:

Euclidean distance algorithm computes the minimum distance between a column vector ‘q’ and a collection of column vectors in the code book matrix (cb). The algorithm computes the minimum distance to ‘q’ and finds the column vector in cb that is closest to ‘q’. Figure shows Euclidean distance algorithm.

$$d(a,b) = |p - q|$$

$$\sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_n - q_n)^2}$$

$$= \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2}$$

2.3.2 Histogram Euclidean distance:

Let ***h*** and ***g*** represent two color histograms. The Euclidean distance between the color histograms ***h*** and ***g*** can be computed as:

$$d^2(h,g) = \sum_A \sum_B \sum_C (h(a,b,c) - g(a,b,c))^2$$

In this distance formula, there is only comparison between the identical bins in the respective histograms. Two different bins may represent perceptually similar colors but are not compared crosswise. All bins contribute equally to the distance.

3.1 Colour Histogram System

The block diagram of the colour histogram proposed method is shown in Fig

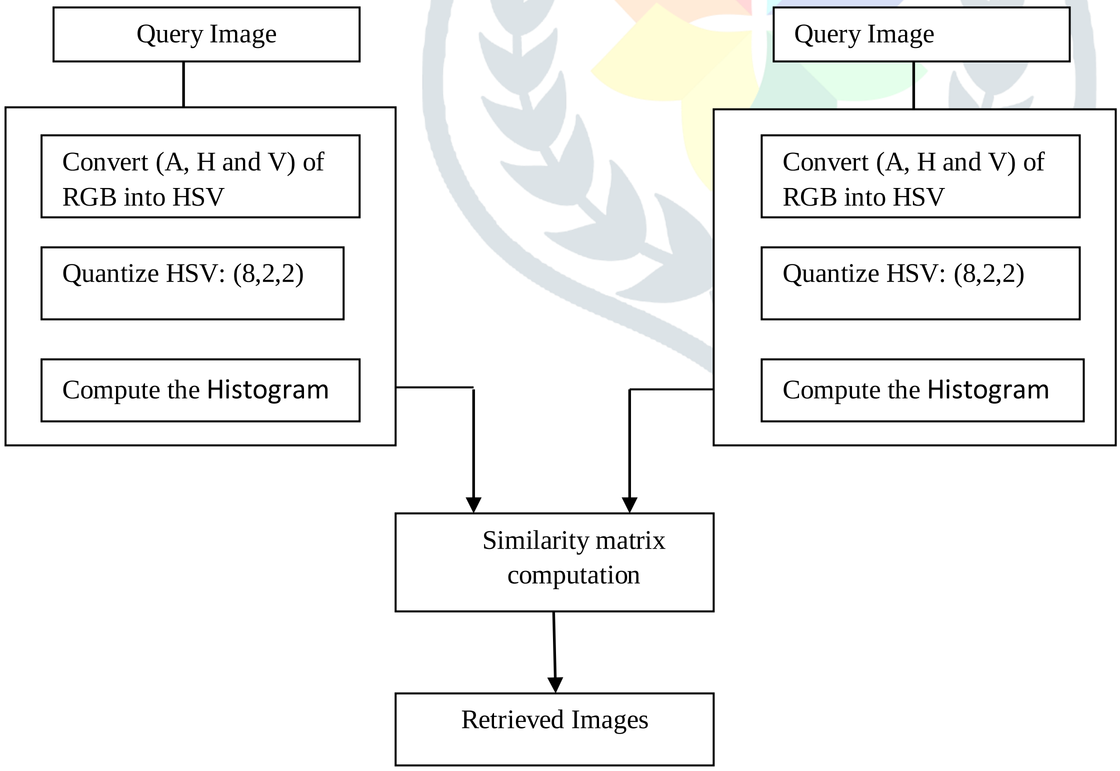


Fig.4. Block Diagram of Proposed System

3.1.1 Method

1) Extract the Red, Green, and Blue Components from an image
2) Translate the R, G,B components into HSV plane.
3) Colour quantization is carried out using colour histogram by assigning 8 level each to hue, Saturation and value to give a quantized HSV space with 8x8x8=512 histogram bins.
4) The normalized histogram is obtained by dividing with the total number of pixels.

5) Repeat step1 to step 4 on an image in the database.
6) Compute the similarity matrix of query image and the image present in the database.
7) Repeat the steps from 6 to 7 for all the images in the database.
8) Retrieve the images.

3.1.2 Performance Evaluation

The performance of retrieval of the system can be determined in terms of its recall and precision. Recall measures the capacity of the system to retrieve all the models that are relevant, while precision measures the ability of the system to retrieve only the models that are relevant. It has been accounted that the histogram gives the finest performance through recall and precision value[35,44]. They are defined as:

$$Precision = \frac{Number\ of\ Relievant\ images\ retrived}{Total\ Number\ of\ images\ retrieved} = \frac{A}{A+B}$$

$$Recall = \frac{Number\ of\ relievant\ images\ retrieved}{Total\ number\ of\ relevant\ images} = \frac{A}{A+C}$$

Where A represent the number of relevant images that are retrieved, B, the number of irrelevant items and the C, number of relevant items those were not retrieved. The number of relevant items retrieved is the number of the returned images that are similar to the query image in this case. The total number of items retrieved is the number of images that are returned by the search engine.

Table 1: Accuracy of CBIR using HSV Colour Model

Images	**No.of images in database**	**No.of images retrieved**	**No.of relevant images retrieved**	**Precision**	**Recall**	**Accuracy**
Africans	10	5	4	0.8	0.4	0.6
mountains	10	5	4	0.8	0.4	0.6
buses	10	5	1	0.2	0.1	0.15
dinosaurs	10	5	4	0.8	0.4	0.6
elephants	10	5	5	1	0.5	0.75
roses	10	5	4	0.8	0.4	0.6
monuments	10	5	4	0.8	0.4	0.6
horses	10	5	4	0.8	0.4	0.6
food	10	5	5	1	0.5	0.75

Average precision = 0.778

RESULTS AND DISCUSSION

Table2 : Comparison of CH & WBCH

Image Fields	**Accuracy Of Colour Histogram**	**Accuracy Of Wavelet Based Colour Histogram**
Africans	0.6	0.63
Mountains	0.6	0.63
Buses	0.6	0.7
Dinosaurs	0.63	0.66
Elephants	0.48	0.66
Roses	0.69	0.69
Monuments	0.69	0.65
Horses	0.66	0.68
Food items	0.6	0.63

Here an approach for Content Based Image Retrieval is presented by combining the colour and texture features called Wavelet-Based Colour Histogram Image Retrieval (WBCHIR). Similarity between the images is ascertained by means of a distance function. The experimental result shows that the wavelet based colour histogram method outperforms the CBIR retrieval method using HSV Colour model in terms of Average Precision. The area of content-based image retrieval is a hybrid research area that requires knowledge of both computer vision and of database systems.

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