Feature Selection and Extraction for Content-Based Image Retrieval

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***Abstract*— Content-Based Image Retrieval is a technique that utilizes the visual content of an image to search for similar images in large scale image databases. The visual content of an image represents the low-level features extracted from the image. These primarily constitute color, shape and texture features. The precision of image classification and image retrieval is mainly based on image feature extraction. More distinguished image features will yield better results in classification and retrieval process. Thus feature selection and feature extraction are the important tasks to be considered in image retrieval process. This paper aims to discuss about feature selection and an efficient method for feature extraction is proposed for image retrieval process.**

Keywords— **Content-Based Image Retrieval, Euclidean Distance Method, Relevance Feedback, Feature Vector**

I. INTRODUCTION

Image Processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Digital Image Processing is the use of computer algorithms to perform image processing on digital images. Interest in Digital Image Processing methods stems from two principal application areas: Improvement of pictorial information for human interpretation; and processing of image data for storage, transmission and representation for autonomous machine perception.

The influence of the digital images in the day-to-day life is tremendous and image processing has gained importance in science and technology. The process of Image Retrieval [3],[11],[12] has become an active research topic because of its application in many fields like Biometric systems, Image Search Engines, Digital Libraries, Medical Records etc., The rapid expansion of digital data content has led to the need for rich descriptions and efficient Retrieval Tool. To develop this, content based image Retrieval method has played an important role in the field of image retrieval.

Early techniques were not generally based on the visual information but based on textual annotation of the images. That is the images were first annotated with text and then searched based on the textual descriptions from the databases. This technique needs manual annotation of images. This task is a difficult and time-consuming process in case the size of the database is large. Also often the annotation process is incomplete and textual descriptions depend on the user. The annotation of images differs from one person to another. The other user may feel difficult to search for the images stored by another.

Another problem with textual annotation is the whole description of the images cannot be given. If the image contains geographical data then manual keyword description is not possible. It is also cultural language dependent and very difficult to describe every image in the database. The keyword matching process will not give most relevant images. The difficulties faced by textual annotation became more severe as the size of the image database has increased to a large scale.

These drawbacks were the driving force behind the emergence of Content-Based Image Retrieval. CBIR is a technique by which the images are retrieved from the database by extracting their low-level features. The image retrieval is only based on these extracted low-level features. In an effective image retrieval system, the user poses a query and the system should find the images which are somehow more relevant to the given query. When the query image is given, the processing algorithms extract the features from the image to represent the image content by numeric values. These values are called the feature vectors. These feature vectors are used in the image retrieval process.

The feature vector is very important since the images are retrieved based on this value. The feature selection and feature extraction plays a very important role in the image retrieval process. The performance and accuracy of the retrieval scheme depends on the precision of the feature extraction. Most distinguished features will yield better results. Thus the feature selection and feature extraction should be given importance in the image retrieval scheme.

The below shown activity diagram explains the basic steps in any of the CBIR systems:

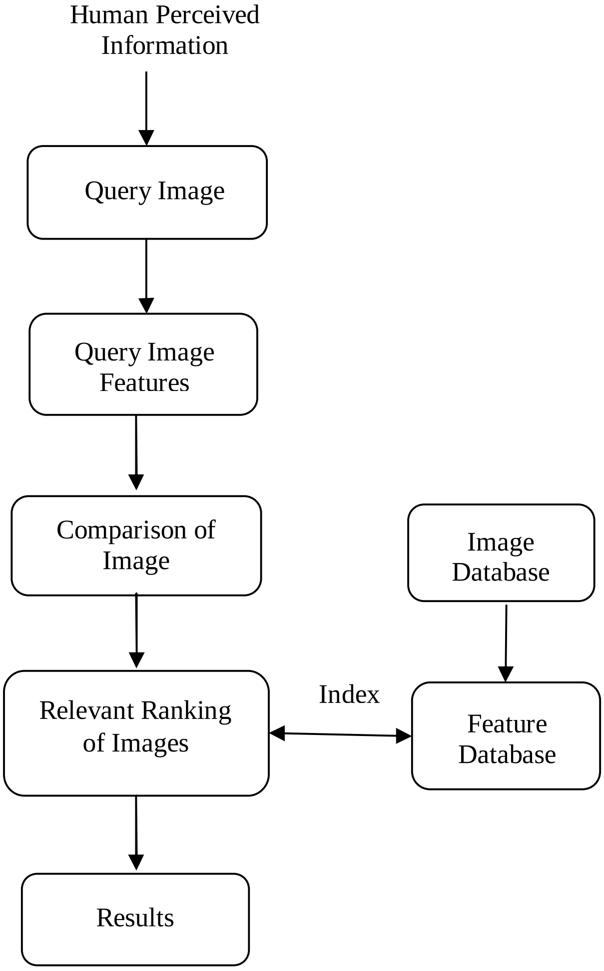

Fig. 1 Steps in CBIR Systems

II. RELATED WORK

The techniques discussed under this section have used different image features for retrieving the images to map the query with the database. The feature extraction methods have also been discussed.

Color Indexing [9] uses the color feature for the retrieval of images from the database. The features are extracted using the Color Histogram techniques. The color distributions in the images are represented using the Color Histograms. The histogram of the query image and the database images are compared for the retrieval. This method fails in case two different images have the same color distributions.

Comparing images using Color Coherence Vector [8] uses the histogram-based technique to compare the images based on spatial information. This method also uses the clor feature for retrieving the images from the database. Each pixel in the color bucket are classified as coherent or incoherent based on whether or not it is a part of a largely colored region. A color coherent vector stores the number of coherent versus incoherent pixels to compare with each other. The disadvantage of this method is the time-consumption for finding the coherence vector.

Biased Discriminative Euclidean Embedding [2], [13] method extracts color, shape and texture features using Tree structured and Pyramidal structured wavelet transforms. This method combines the feature vector values and compares the query image with the database images. Most often this method needs Relevance Feedback [4], [5], [10] for improving the performance of the retrieval scheme. A number of iterations can be performed until the user gets satisfied with the results. The iterations can be stopped when the expected results are obtained. This method has the drawback of number of iterations to be performed.

Texture Features for browsing and retrieval of image data [2], [6] utilizes the texture feature for retrieving of images. The textures features are extracted using Gabor Filters. The performance of this method depends on the filter selection algorithm and filter design strategy.

Modeling the shape of the scene [1], [7] is based on the spatial envelope properties. A set of dimensions like naturalness, openness, ruggedness etc., is proposed which represents the spatial properties. This method needs the evaluation of all spatial envelope properties.

Section III discusses about Feature Selection and Section IV about Feature Extraction Process. The Proposed algorithm for feature extraction is discussed in detail.

III. FEATURE SELECTION

Image features are important to be considered since the images are retrieved based on these features. The extraction of suitable features from the image is the basic step by which the query image and the database images can be compared. The commonest features in an image are color, shape and texture.

A. Color Feature

Color is one of the most widely used features for image retrieval. Color is invariant to complexity and very much sensitive to humans than the greyscale images. The color features are mostly extracted using the color histogram techniques, Color coherence vector etc.,

B. Texture Feature

Texture is the other feature of image used in image retrieval process. Texture feature can be extracted by many ways like Gabor Filters, co-occurrence matrix, Wavelet decomposition etc.,

C. Shape Feature

Shape is another major and powerful feature of an image. The shape can be extracted using Edge detection algorithm, Fourier Extraction etc.,

The combined features can produce better retrieved results than a single concise feature. Thus a method is proposed to extract two effective features of an image – the color and the shape. These combined features can yield better results. The color and shape features are extracted and combined into a single feature vector value. This feature vector value of the query image and the feature vector value of the database images can be compared to retrieve the relevant images.

IV. FEATURE EXTRACTION

After feature selection the next step is to develop the feature extraction process. The different image features and different techniques used for feature extraction were discussed under section II. The drawbacks of each method were also discussed. A method is proposed for feature extraction with HSV Color Model and Daubechies4 (db4) Wavelet transform. The color and shape features are extracted using these methods.

A. HSV Color Model

The three dimensions of color: hue, saturation and value represent the color model - HSV Color Model. Hue describes the color as like red, blue, purple etc. How light or dark a color is referred to either as a colors lightness or value. Saturation refers to the dominance of hue in the color. HSV Color model is the ideal tool for representing the image since it is more relevant to the human perception. The color carrying information can be differentiated from the intensity. This differentiation is not possible in RGB Color model which is the main drawback of this model.

B. Wavelet Transform

A wavelet is a little piece of a wave. The wavelet transform was borne out of the need for further development from the Fourier transform. The wavelet transforms signals in the time domain to a joint time-frequency domain. The wavelet transform is used for information location in time - frequency, basically has the capacity of be moved of a scale to other, therefore it is adapted for signs analysis not stationary. The wavelet transform consists of a set of base functions that represent the sign in different frequency bands, each one with corresponding different resolutions in each scale.

C. Daubechies4 Wavelet Transform

Daubechies4 wavelet transform is a second order member of the Daubechies family. This wavelet transform consists of four scaling and four wavelet coefficients. All these scaling and wavelet coefficients are applied to images to extract the features from the images.

The Scaling coefficients are as follows:

$$h0 = \frac{1+\sqrt{3}}{4\sqrt{2}} \quad (1)$$

$$h1 = \frac{3+\sqrt{3}}{4\sqrt{2}} \quad (2)$$

$$h2 = \frac{3-\sqrt{3}}{4\sqrt{2}} \quad (3)$$

$$h3 = \frac{1-\sqrt{3}}{4\sqrt{2}} \quad (4)$$

Each step of the wavelet transform applies the scaling function to the data input. If the original data set has N values, the scaling function will be applied in the wavelet transform step to calculate N/2 smoothed values. In the ordered wavelet transform the smoothed values are stored in the lower half of the N element input vector.

The Wavelet coefficients are as follows:

$$g0 = h3 \quad (5)$$

$$g1 = -h2 \quad (6)$$

$$g2 = h1 \quad (7)$$

$$g3 = -h0 \quad (8)$$

Each step of the wavelet transform applies the wavelet function to the input data. If the original data set has

N values, the wavelet function will be applied to calculate N/2 differences. In the ordered wavelet transform the wavelet values are stored in the upper half of the N element input vector.

The scaling and wavelet functions are calculated by taking the inner product of the coefficients and four data values. Each iteration in the wavelet transform step calculates a scaling function value and a wavelet function value. The index i is incremented by two with each iteration, and new scaling and wavelet function values are calculated.

The analysis of an image by Daubechies4 wavelet transform can be as shown in Fig. 2. The image is analysed in layers and at different resolutions. The color and shape features are analysed during this transformation. Each band analyses the image in a different fashion. The color and shape features are extracted using this transformation.

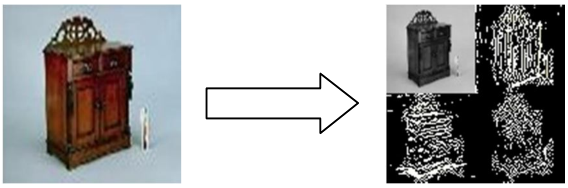

Fig.2 An Example for Daubechies4 Wavelet Transform

The output of this transformation will be a feature vector value. This value is used for comparison of images. When the user provides the query image, the system extracts the features of the query image. The feature vector value of the query image and the database images are compared to find the similarities between them. Most relevant images will be selected for display. The comparison can be done using different methods like Euclidean Distance method, Chessboard method etc. Euclidean Distance method is the most popular method to find the similarity between images. After comparison, the relevant images will be selected for display to the users.

The performance of the algorithm can be evaluated by calculating the precision value. Precision is defined as the ratio of relevant images in the set of all images returned by a query. The ideal value for Precision and Recall is 1. Generally there is an inverse relationship between precision and recall where it is possible to increase one at the cost of reducing the other yielding a trade-off between them.

$$\text{Precision} = \frac{\text{Number of relevant items retrieved}}{\text{Number of items retrieved}} \qquad (9)$$

V. Conclusions and Discussions

The color and shape features were selected for the image retrieval. The feature selection is an important task to be performed. Hence the feature selection is given importance in this paper. The features were extracted by using the proposed method Daubechies4 wavelet transform. The output of the algorithm can be estimated with the precision value. The effectiveness of the algorithm can be analyzed with Corel Image Gallery[14]. The Corel image gallery consists of about 10,800 images divided into different concept groups.

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