A Survey of Content Based Image Retrieval Using Color and Texture Features

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Abstract

Content based image retrieval (CBIR) system that works on the basis of low level image semantics cannot be directly related to the expressive semantics that is used by humans for deciding image similarities. The low-level semantic of the image consists of color, texture, and shape of the object inside an image. Nowadays, one type of feature extraction technique cannot provide complete result, so now a combination of different feature techniques like color, texture and shape features are being used. There is a generous increase in retrieval precision when combinations of these techniques are used in an effective way. In this paper, we propose a comparison of CBIR system using different feature extraction methods; three features based on color (i.e. HSV Histogram, Color Moment) and other two features computed by applying the texture feature using Gabor Wavelet and Wavelet Transform of the image. For similarity matching between the query image and database images, Manhattan distance or City Block or L1 distance is used. The experimental results on WANG database show higher retrieval efficiency in terms of precision when compared with existing methods using color and texture features.

Keywords: Content based image retrieval, HSV Histogram, Color Moment, Gabor wavelet and Wavelet Transform

I. INTRODUCTION

The recent incredible growth in computer technology [1], and the availability of image capturing devices such as digital camera, image scanners, the size of digital image collection is increasing rapidly. An efficient [2] image searching, browsing, and retrieval system is required by users from various domains like remote sensing, fashion, crime prevention, publishing, medicine, architecture etc. For this reason, many general purpose image retrieval systems have been developed. There are two categories for image retrieval: text based and content based. In text based image retrieval, the images are manually annotated by text descriptors, which can be used by database management system (DBMS). Then DBMS is used as image retrieval system. There are two disadvantages of this approach. The first is that manual annotation is laborious. The second is lack of accuracy in annotation because of subjective human perception. To overcome these disadvantages in text based image retrieval, content-based image retrieval (CBIR) was introduced in the early 1990s.

Content-based means searching images according to the content of image rather than metadata like keywords, tags, and description associated with the image. The term *content* here refer to colors, texture, shapes, and other information of image is derived from the image itself. CBIR system extracts images from large database of images using similarity between query image and database images. The similarity is measured on the basis of features like colors, textures, and shapes [3]. In the CBIR system, first the features of every image are obtained and then these are stored in a database. This database is called *feature database*. Similarly, features are obtained for query image, and then similarity matching process is performed. In this process, images similar to the query image are retrieved from the image database.

Technique like query by example (QBE) or query with specific content features can be further merged with *relevance feedback*. The relevance feedback is given by the user to improve the selection of relevant images by decreasing the irrelevant images in the retrieval process.

Features play an important role in a CBIR system. Early researches on CBIR system employed a single

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feature of image like color, texture, or shape which was not sufficient to extract the relevant images from the image database. So, various active researches in CBIR led to the combination of various feature extraction methods to solve this problem.

II. LITERATURE REVIEW

There are a number of previous works on CBIR. A few important ones are reviewed here.

Rui, Huang, Ortega, and Mehrotra [4] proposed an interactive retrieval approach based on relevance feedback mechanism, which considers the two issues in CBIR: (1) the difficulty of representing semantics using low level features; and (2) human visual perception of color. The proposed approach, implemented over more than 70000 images, shows that the overhead of composing the query is limited and user information is precisely captured using this approach.

Jalab [5] presented an image retrieval technique in which color layout descriptor is used as color feature, and Gabor wavelet coefficients are used as texture feature. He reported significant enhancement in retrieval performance. The experiment using the "wang.ist.psu" database reports the average precision-recall values as 56.16% and 56.25% respectively.

Fakheri, Amirani, and Sedghi [6] presented a method using texture and shape features of the image. The texture semantics is retrieved using Gabor wavelets. Similarity is matched using the principle of most similar highest priority (MSHP). The proposed approach implemented using the Corel dataset shows an accuracy of 60.7%.

Huang, Chan, Ng and Yeung [7] proposed an image retrieval technique based on combination of color moments of the HSV color space and Gabor texture descriptors with Euclidean distance used for distance measure. The proposed method implemented on the WANG database showed that the approach has accuracy of 63.6% with standard deviation of 0.286 which is comparatively higher than other methods based on color and texture feature extraction.

Rakhee, Govindan and Karun [8] proposed a CBIR technique based on combination of shape feature along with color-texture using Walsh Wavelet. The performance of the scheme is tested on a database containing 44 images and the results of the proposed scheme show that shape extraction with Sobel and Prewitt operators gives better efficiency than Canny and Robert operators.

Thakkar and Kale [9] proposed a CBIR system in order to get higher efficiency based on color moment, Ranklet transform and Hough Transform, and showed that the retrieval results are more precise than when using the feature individually. Wang database was used to evaluate the proposed approach.

Recently, Arun and Govindan [10] proposed an image retrieval technique based on inferring visual dictionaries. This is an unsupervised visual dictionary learning scheme which provides low error in encoding image patches. Good precision performance is reported for retrieval.

Giri and Meena [11] focused on color and texture based techniques for achieving efficient and effective retrieval of images. Color feature extraction is done by color histogram and color moment. This texture feature extraction is acquired by wavelet and Gabor transform. For this classification of extracted features they used support vector machine. Euclidian distances are calculated of every feature for similarity measures.

The literature survey shows that the CBIR as of today is still an active topic of research. Despite the fact that numerous attempts are made to develop a highly efficient system, most of the CBIR systems lag behind in terms of efficiency due to lack of semantic information available from image features. It is concluded that using only one type of feature extraction is insufficient to retrieve images efficiently. There is substantial improvement in retrieval accuracy when combinations of these techniques are used. Hence, there is a need for further work in CBIR for achieving better efficiency in terms of precision, recall, and time complexity.

III. METHOD

This paper suggests a comparison approach to image retrieval in which color feature extraction and texture feature extraction methods are used. In this approach collection of images is stored in the database. The approach is basically divided into two major phases. The first phase applies the feature extraction techniques to all database images and then extracts the feature vectors, and stores them in feature database (feature dataset). In this paper feature extraction method is a combination of color and texture feature techniques that are HSV histogram, color moment, Gabor wavelet, and Wavelet transform techniques. In the second phase, the same process is done for query image and feature vector of query image is obtained. At last, the similarities of the query image feature vector with the database feature vectors are computed to retrieve images based on some distance metric. The whole process is shown in the fig. 1. This technique has been used in many CBIR systems. In this approach, HSV histogram and Color moment are employed for the extraction of color features.

IV. FEATURE EXTRACTION

Feature extraction is a necessary step in retrieving the images from the database. It is the process of extracting the most relevant information from the image which is used to define relevant images. These features are further converted into vectors called feature vectors. There are various methods for extracting features from images. Color feature and texture feature are used in this paper. An important attribute of an image is color which is invariant to any change in size and direction of the image. Hence, this feature has been used in many CBIR systems. In this approach HSV histogram and color moment are employed for the extraction of color features.

A. HSV Histogram

The histogram of colors is an important feature to represent components of color that are present in the image [3][14]. In this approach, the image is quantized in HSV color space into 8x2x2 equal bins. The HSV corresponds to Hue, Saturation, and Value which provides human visual perception of color. After the quantization phase, a histogram is created which is further converted into feature vector. The rotation, translation and scale invariance of color histogram enable it as an efficient feature for representing images in CBIR systems.

B. Color Moment

The base concept of the Color moment [12] is the distribution of the color in an image, which can also be indicated as a probability distribution. To overcome the quantization effects of the color histogram, the color moment as a feature vector for image retrieval is used [13]. Most of the color distribution information is

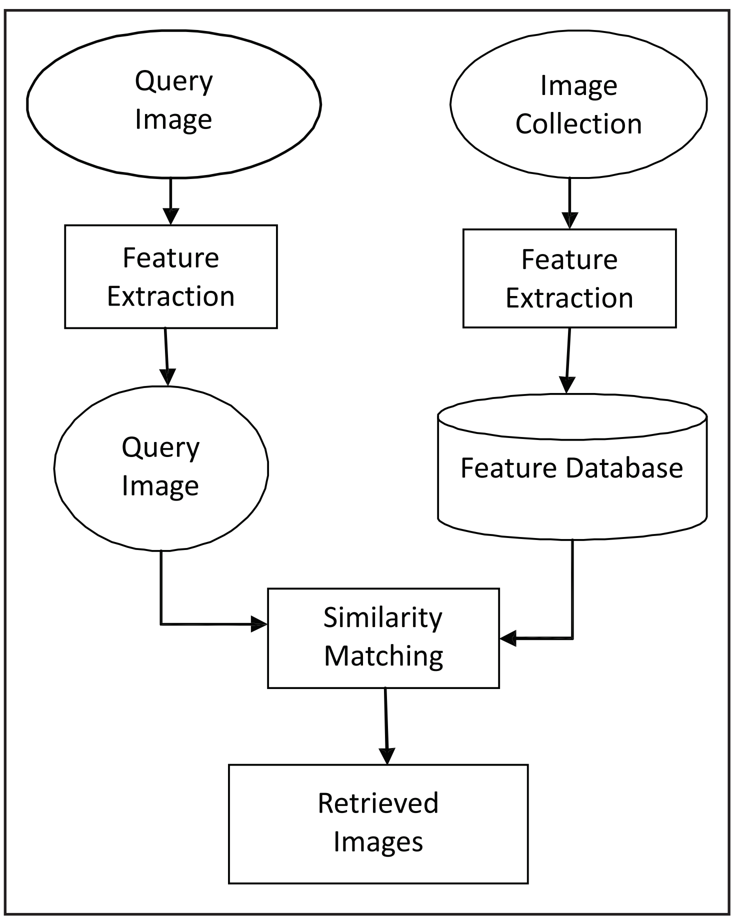

Fig. 1. Block Diagram of CBIR System

captured by two low order moments [11].

The mean color is captured by first-order moment (μ_c) in (1)

$$\mu_c = \frac{1}{MN} \Sigma^M_{t=1} \Sigma^N_{j=1} P^c_{ij} \quad (1)$$

Where, P^c_{ij} is the value of the c^{th} colour component of the color pixel in the i^{th} row and j^{th} coulmn of the image.

The standard deviation is captured by the second-order moment or variance (σ_c) in (2)

$$\sigma_c = [\frac{1}{MN} \Sigma^M_{t=1} \Sigma^N_{j=1} (P^c_{ij} - \mu_c)^2]^{1/2} \quad (2)$$

Where, P^c_{ij} is the value of the c^{th} color component of the color pixel in the i^{th} row and j^{th} column of the image.

C. Gabor Wavelet

Gabor wavelet is one of the leading approaches in texture feature extraction [3][15]. Basically, these are the group of wavelets which capture energy information at a particular frequency in a particular direction. This wavelet is implemented in a different manner and is well suited for texture extraction.

The equation for the Gabor wavelet transform of image I(a,b) with size P X Q is given by convolution:

$$G_{m,n} = \Sigma u \Sigma v I(a - \underline{u}, b - v) \varphi^*_{m,n}(u,v) \quad (3)$$

where,

m is the scale value and n is the direction value;

u and v represent the size of filtermask;

$\varphi^*_{m,n}$ denotes the complex conjugate of $\varphi_{m,n}$.

This self-similar function $\varphi^*_{m,n}$ is derived from the mother wavelet Ψ. In this purposed approach, the numbers of scale m and orientation n are 6 and 8 respectively.

After putting on the Gabor wavelet transform, we obtain the energy information (at different orientation and scale) which is denoted in (4).

$$E(m,n) = \Sigma a \Sigma b |G_{m,n}(a,b)| \quad (4)$$

From this energy information, the feature vector is obtained by computing mean using (5) and standard deviation as shown in (6).

$$\mu_{m,n} = \frac{E(m,n)}{P \times Q} \quad (5)$$

$$\sigma_{m,n} = \frac{\sqrt{\Sigma a \Sigma b (|G(a,b)| - \mu_{m,n})^2}}{P \times Q} \quad (6)$$

D. Wavelet Transform

Wavelet transform is a multi-resolution approach [11][16]. Image processing wavelet transforms have been used in many waves. Most of wavelet-based tools and ideas have been proposed and studied for image compression, noise removal from images, image retrieval, and image reconstruction etc. To retrieve images for texture features the multi resolution wavelet transform has been employed. The wavelet features achieve only low level of retrieval accuracy. To increase effectiveness in CBIR wavelet, features computed from discrete wavelet coefficients are assigned weights. In our approach, first the image is changed into gray color space, and then resized to 256x256 [3]. Then, two-dimensional DCT is put on the image, and the mean and standard deviations are calculated to construct the feature vector.

V. ALGORITHM

The algorithm for image retrieval from storage is:

Step 1: Load stored values from dataset.

Step 2: Load query image.

Step 3: Extract a query image (As given in feature extraction algorithm).

Step 4: Match the feature values stored in dataset.

Step 5: Retrieve the images which show maximum relevance.

VI. SIMILARITY MEASURE

The query image features are obtained to get the desired feature vectors. The image is retrieved based on the match between query feature vector and the database feature vectors to get the least distance by calculating the Manhattan (City Block) [3] distance is given in (7).

$$d = \Sigma^n_{i=1} |X_i - Y_i| \quad (7)$$

where, X_i and Y_i are the feature vectors of query images and database image respectively.

VII. EXPERIMENT RESULT

The implementation is done using MATLAB. The experimental database used is the WANG database of

500 images [17]. It consists of Corel Photo database grouped into ten classes but this paper contains only five classes. For similarity measure, generally Manhattan distance is used and it always gives better results. So, in this paper City Block or Manhattan or L1 distance metric is used. A comparison of conventional CBIR methods and the suggested method is also performed. The accuracy of the CBIR system proposed is measured using the precision performance measure. Precision represents the ratio of the relevant images out of the total images retrieved to the total images retrieved [3]; it is defined as follows:

$$Precision = \frac{Total\ relevant\ images\ retrieved\ from\ database}{Total\ image\ retrieved\ from\ database}$$

The results are shown in above table I as reported in [3], [5-7]. These results are used for comparison among methods. The results clearly show that for majority of image classes in the database, the suggested approach gives enhanced precision values. Over all of the 5 classes it is much better in [3]than those reported in [5-7](Table I).

Line graph (fig. 2) shows the best result for method in [3] amongst all reported methods in [5], [6] and [7] . In fig. 2. 0 to 1 represent the precision value and African people, beach, building, buses, and dinosaur represent the different classes of images stored in the database.

TABLE I.
COMPARISON OF METHODS

Image Classes	Method: Color layout descriptor +Gabor Filters [5]	Gabor wavelets +GVF Function [6]	Color Moment +Gabor Texture[7]	RGB average +HSV histogram +Gabor wavelet+ discrete cosine transform[3]
African People	0.32	0.55	0.54	0.6
Beach	0.61	0.4	0.42	0.72
Building	0.39	0.4	0.16	0.64
Buses	0.39	0.68	0.67	0.88
Dinosaurs	0.99	0.96	0.99	1
Average precision	0.54	0.6	0.56	0.76

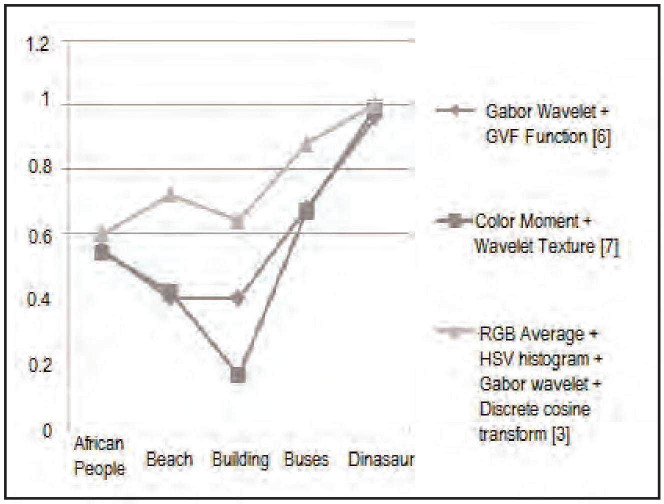

Fig. 2. Comparison between precision value and image classes for Gabor wavelets +GVF Function[6], Color Moment + Gabor Texture [7], RGB average +HSV histogram +Gabor wavelet+ discrete cosine transform[3].

VIII. CONCLUSION AND FUTURE WORK

The approach in this paper makes use of HSV color histogram, Color Moment, Gabor Wavelet, and Wavelet Transform. Experimental results show that the method in [3] provides better accuracy than existing CBIR systems in retrieving images. The approach provides better precision for all of the image classes in the database when compared with four of the other works in literature.

There are a number of areas for the improvement of the CBIR systems. An efficient CBIR system should provide maximal support to introduce the meaning (semantic) of the content in the images. In the literature various techniques are available for improvement of CBIR systems. Combinations of these techniques can be used for achieving better efficiency. However, the growth of scheme with the shape features can further increase the retrieval efficiency and time performance of the CBIR systems, which can be the scope for future work.

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