Performance and Accuracy related issues of Content-Based Image Retrieval

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Abstract

Due to the exponential growth of image data there is a compelling need for innovative tools which can easily manage, retrieve and visualize images from the large databases. The commonest approaches use the so-called Content-Based Image Retrieval (CBIR) systems. Content Based Image Retrieval is the popular image retrieval system by which the target image to be retrieved based on the useful features of the given image. Their goal is to support image retrieval based on content properties (e.g., shape, color, texture), usually encoded into feature vectors. One of the main advantages of the CBIR approach is the possibility of an automatic retrieval process, instead of the traditional keyword-based approach, which usually requires very laborious and time-consuming previous annotation of database images. The CBIR technology has been used in several applications such as fingerprint identification, biodiversity information systems, digital libraries, medicine and historical research among others. This paper aims to introduce the performance and accuracy related issues concerned with the creation of CBIR systems which is very important to be considered as the image database size grows.

Keywords – Content-Based Image Retrieval, Euclidean distance method, Support vector machine, Relevance feedback

1. INTRODUCTION

The influence and impact of digital images on modern society is tremendous and image processing is now a critical component in science and technology. Image Retrieval [11] is one of the active research area in information processing because of the rapidly growing need in many applications like medical records, biometric systems, geographical images, Digital libraries etc.,

In general, two different approaches have been applied to allow searching on image collections: one based on image textual metadata and another based on image content information.

The first retrieval approach is based on attaching textual metadata to each image and uses traditional database query techniques to retrieve them by keywords. However, these systems require a previous annotation of the database images, which is a very laborious and time-consuming task. Furthermore, the annotation process is usually inefficient because users, generally, do not make the annotation in a systematic way. In fact, different users

tend to use different words to describe a same image characteristic. The lack of systematization in the annotation process decreases the performance of the keyword-based image search.

These shortcomings have been addressed by the so-called Content-Based Image Retrieval (CBIR) systems. In these systems, image processing algorithms (usually automatic) are used to extract feature vectors that represent image properties such as color [8], [9], texture [2], [6], and shape [7], [13]. In this approach, it is possible to retrieve images similar to one chosen by the user (query-by-example).

One of the main advantages of this approach is the possibility of an automatic retrieval process, contrasting to the effort needed to annotate images. In large databases it is very difficult to annotate the images. The figure shows the architecture of the CBIR systems:
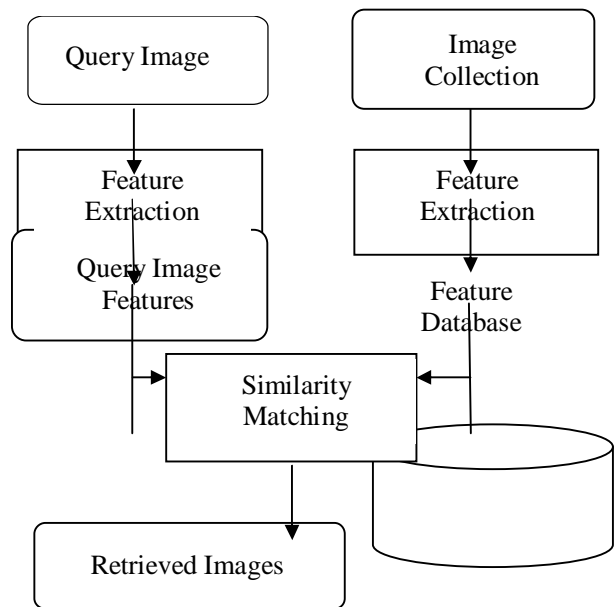

Figure 1 Architecture of CBIR System

2. RELATED WORK

Image Retrieval plays a pivotal role in many practical applications like medical imaging, Biometric systems and analysis of satellite images to be mentioned few. For image classifying, indexing and retrieval in manual method is very expensive one and time consuming because those images vary from one another. In this

section, some of the existing works related to image searching techniques in content-based image retrieval are reviewed. These searching techniques have used different image features for the retrieval process to map the query image with the database images.

The **Color Indexing** method [8] uses the color feature for the retrieval process. The color features are extracted using the color histogram technique. The different color distributions in the images are represented using color histograms. The color histograms of the database images and the query image are compared to retrieve the most relevant images to the given query image. This method fails incase two different images have same color distribution.

The **Support Vector Machine learning for Image retrieval** [3], [11] presents a novel method of relevance feedback based on support vector machine in CBIR system. A SVM classifier can be learned from training data of relevance images and irrelevance images marked by users. Using the classifier the system can retrieve more images relevant to the query in the database efficiently. Consequently the performance of this method depends on interactive learning.

Comparing images using color coherence vector [9] is a histogram-based method for comparing images that incorporates spatial information. Each pixel in a given color bucket can be classified as either coherent or incoherent, based on whether or not it is part of a large similarly-colored region. A color coherence vector (CCV) stores the number of coherent versus incoherent pixels with each other. By separating coherent pixels from incoherent pixels, CCV's provide finer distinctions than color histograms. This method has the disadvantage of increased time consumption for the calculation of CCV. This time complexity matters as the size of the database grows.

Texture features for browsing and retrieval of image data [2], [6] uses texture information for browsing and retrieval of large image data. This method proposes the use of Gabor wavelet features for texture analysis and provides a comprehensive experimental evaluation. The performance of this method depends on the filter selection algorithm and the filter design strategy.

Modeling the shape of the scene [7] proposes a computational model based on a very low dimensional representation of the scene termed as spatial envelope. A set of perceptual dimensions like naturalness, openness, roughness, expansion and ruggedness are proposed that represents the dominant spatial structure of a scene. The method needs the evaluation of all these spatial envelope properties.

SIMPLIcity: Semantics-sensitive Integrated Matching for Picture Libraries [12] uses semantics classification method, a wavelet-based approach for feature extraction and Integrated region matching (IRM) based upon image segmentation. The system classifies images into semantic categories, such as textured-nontextured, graph-photograph. A measure for the overall similarity between images is developed using a region-matching scheme that integrates properties of all regions in the images. The drawback is that like other CBIR systems, SIMPLIcity assumes that images with similar semantics share some similar features. This assumption may not always hold. The other one is that the shape matching is not ideal. When an object is segmented into many regions, the IRM distance should be computed after merging the matched regions.

All of these methods have their own advantages and disadvantages in their retrieval performance. In Image retrieval process, set of image features have been used for image retrieval. The following section describes different features set used by different authors in their image retrieval applications.

Image features: Image features play an important role in image retrieval processing. In order to perform image retrieval process, the extraction of suitable features from the images are very important and by which, both the query image and database images are compared to retrieval of very similar images to query image from the database. There are three level of feature extraction global, local and pixel. The simplest visual image features are directly based on the pixel values of the image. Images are scaled to a common size and compared using Euclidean distance and image distortion model. Local features are extracted from small subimages from the original image. The global feature can be extracted to describe the whole image in an average fashion. The low-level features extracted from images and their local patches are color, texture, and shape.

Color features: The color feature is one of the most widely used visual features in image retrieval. Because the human vision system is more sensitive to color information than grey values of images. Generally color features are extracted using the color histogram technique [8]. The color histogram describes the different colors distribution in an image in a simple and computationally efficient manner. Other color feature extraction techniques are region histogram, color coherence vector [9], correlation histogram etc.

Texture features: The texture feature is usually extracted by using filters method. The Gabor filter [6] is frequently used filter method in texture extraction. A variety of Gabor filters in different degree and their relative positions captures value at that specific frequency and direction. Texture can be extracted from this group of value distributions**.** Other texture feature extraction methods are co-occurrence matrix, wavelet decomposition, Fourier filters, etc.

Shape features: Shape [7], [13] is an important and most powerful feature used for image classification, indexing and retrievals. Shape information extracted using histogram of edge detection. Other techniques for shape feature extraction are elementary descriptor, Fourier descriptor, template matching, Quantized descriptors etc.

3. PROPOSED METHOD

In this system, the input query image is given at runtime to get the features of the image. The processing of database images consist of main stages namely image feature extraction, image classification and Image retrieval

that have been used in order to retrieve the similar images from the database. For retrieval process, Euclidean distance finding method has been used. The following processing steps have been applied in order to perform the retrieval of similar images from the database.

1. The images are given as input to the system.
2. For given input images, color and shape features are extracted using Hue Saturation Value (HSV) color model and applying Daubechies4 wavelet transformation[13].
3. Based on the extracted color and shape features, image classification process has been performed using Fuzzy k-means clustering algorithm.
4. The images are organized and stored.
5. Finally, Searching and Retrieval process has been performed using similarity measures such as Euclidean Distance method.
6. The top most relevant images to the given query images are retrieved. These images are ranked and displayed as results to the user.

A. Feature Extraction

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. In this work, the features are extracted using Daubechies4 wavelet transform [13]. Shape representations can be either edge or region based. Shape provides numerical information of an image, which do not change even when the position, size and direction of the objects are changed. HSV color model is used for representing the color space. HSV color model decouples the intensity component from the color carrying information in a color image. As a result, HSV color model is an ideal tool for developing image processing algorithms based on color descriptions that are natural and intuitive to humans. Daubechies4 (db4) wavelet transform is applied to extract the features. It is named after the Inventor Daubechies and it is a second order transform of Daubechies family. The transformation consists of four scaling and four wavelet functions and hence the name Daubechies4 transform. Two or more different features are extracted resulting in two or more feature descriptors at each image point. A common practice is to organize the information provided by all these descriptors as the elements of one single vector commonly referred to as feature vector.

B. Image Classification

Image classification is one of the important steps in image retrieval process because it saves more time while searching the images from huge volume of database. Clustering is a pixel-based technique that is used for image segmentation. Clustering or cluster analysis is the task of assigning set of objects into groups called clusters so that the objects in the same cluster are more similar to each other in some sense than those in other clusters. Clustering is the common technique for statistical data analysis used in many fields including machine learning, pattern recognition, image analysis, information retrieval and bio-

informatics. Many different clustering algorithms are in existence today. Among these k-means and fuzzy k-means [12] are widely in use. The output of this algorithm is n-clusters. The value of n can be user-defined.

C. Image Retrieval

As the feature extraction and image classification are over the next step is to present the query image to the system. The query image features are extracted in the same way and these features are used for comparing with the database image features. There are various image retrieval methods that have been applied in various applications. One among which is Euclidean distance method [13] for image similarity measurement. In this work, Euclidean distance method is used for the retrieval of similar images from the database. When query image is given, the color and shape feature of that image is identified and which is compared with clusters one by one by using Euclidean distance method. The mapping depends upon the query image's feature vector values. By comparing query image feature vector with database images feature vector values, the distance between images will be found and shortest distance will be considered as best matching image in that matching process. Similarly, one after one best matching images will be found by measuring the one after one shortest distance in order to retrieve the similar images from the database. The distance d between two image feature vectors is calculated as follows:

$$= \overline{\Sigma \ (\ (\ ) - \ (\ ))} \qquad (1)$$

Where,
$fq(i)$ is the ith feature vector of the query image
$fd(i)$ is the ith feature vector of the database image

The shortest distance will be considered as the best matching images. The same process is repeated until the query image is compared with all the images in the database. Finally the most relevant images are ranked based on the distance between them and the topmost relevant images are displayed as results to the user.

4. CONCLUSIONS AND DISCUSSIONS

In this work, both color and shape features are extracted for the retrieval process. Color is one of the effective features which can express visual information as well as invariant on the complexity. By the use of color features images can be grouped together very easily. Shape feature is another major component of Image Processing. Hence a method is proposed in which both color and shape features are used for efficient retrieval. Because when both features are used for retrieval process then the results obtained through the retrieval process are more efficient. The corel image database is used for the retrieval process.

- **Accuracy:** The retrieval scheme must be accurate, i.e. the retrieved images must resemble the query image. We classify a retrieval as accurate if for a given query image the perceptually (to a human) most similar

image in the database is retrieved by the system as the topmost retrieval.

- **Performance:** It is desirable to have an efficient retrieval scheme. Since image databases typically have thousands of images, the retrieval scheme must be "realtime". The total time taken for retrieval on the entire database should be analyzed.

Due to the rapid expansion of image database, unfortunately, the scalability of the image database is also increased in day to day activities. When the scalability of the image database is increased, then the performance of the retrieval process is decreased. Hence the performance of the retrieval process is needed to be increased more along with the large scalability of the database.

To overcome this issue, Daubechies4 wavelet transform and Fuzzy k-means clustering are used. This will give retrieval accuracy and performance in retrieving the most relevant images from the large databases. By clustering the total time needed for searching the entire database is reduced. By using Daubechies4 wavelet transform will yield more distinguished image features. Thus more distinguished image features will yield better and accurate images during the retrieval process.

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