COMPARATIVE ANALYSIS BETWEEN VARIOUS TECHNIQUES USED IN CBIR

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Abstract: The rapid advancement and the development in the multimedia technology have made possible of increased usage of large image databases. For managing and retrieving the digital images, Content-Based Image Retrieval (CBIR) is an efficient technique. This paper is an analytical survey that focuses on the advantage of adopting the content-based image retrieval system. In comparison to the traditional system that uses a single extracting feature, this paper shows much interest on the methods that combines features like color, texture and shape for image retrieval. This paper also shows the performance comparisons between various commonly adopted algorithms for image matching.

Index Terms **- CBIR, Feature Extraction, Color, Texture, Shape, HSV, Color Histogram, Canny Edge Detection**

I. INTRODUCTION

Image retrieval is the process in which searching and retrieving of images from large databases is carried out. As the images grow complex and diverse, retrieving the appropriate images becomes a difficult task.

Content-based image retrieval is a technique from which we can search similar images from large scale image databases (i.e., huge datasets) as per the user's requirements. It is an active and fast emerging research area from last two decades. Previous techniques of retrieving the images were not based on visual features but that were on the basis of textual annotation of images. This refers that images were first annotated with the help of text and then searched by using a traditional text-based approach from traditional database management systems [1]. Since, the performance of retrieving images by traditional approach is very much sensitive to the keywords that users use and the system. So, content-based image retrieval (CBIR) is now more focused towards multimedia area that deals with the image contents like color, texture, etc. in place of annotated text. [2]

The main concept here is to analyze information of the images by their low level features, such as

- Color
- Texture
- Shape
- Color layout, etc.

And to create images feature vectors as its index. These features are kept for future use in an image feature database [2]. When user provides a query image, the above mentioned features of the query image are extracted so as to match with the features in the feature database by a pre-determined algorithm/s. Thus, a bunch of relevant images for the query image can be retrieved directly [3].

One of the most widely used aspects is color. It is a low-level visual feature and is invariant to orientation and size of image. Color histogram is invariant to orientation and scale, making it powerful in classifying the images.

Another most commonly used aspect is texture. It is again a low-level visual feature that makes possible to innate surface properties of an object and their relationship/s with the surrounding environment [4].

For retrieving images, object shape features can also be taken into consideration. It provides powerful information, as we know that humans can recognize objects solely from their shapes. Since, semantic information of an object is stored in its shape. Thus, differentiating it from other elementary visual features like Color or Texture features

In the past time, many researchers make use of single feature for retrieval of images but the results were not upto-the-mark since an image consists of various visual characteristics [1][3]. Thus, in order to obtain good results, it is best to select appropriate features.

In this paper, we will discuss various feature extraction methodologies used in content-based image retrieval systems along with their comparisons.

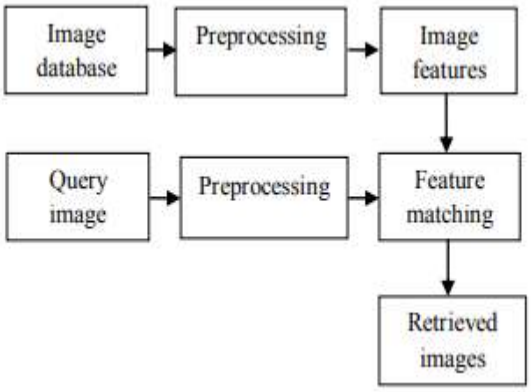

Figure 1: Block diagram of CBIR system

A. ***Color Feature Extraction***

Color is one of the most important visual feature of an image as human eyes are color sensitive. So the color is one of the main characteristic features of the content of images. By using this feature, we the humans can recognize most of the images or the objects included in an image.There are numerous techniques based on color similarity that have been proposed so far for retrieving images and most of them are using the same basic idea. All those images that are stored in the database are analyzed to compute their features. The two old approaches followed are:

- GCH
- LCH

Global Color Histogram (GCH) is mainly used to represent images by their histograms and the similarity that is in between the two images is evaluated by the distance between their color histogram. This approach is sensitive towards color distortions, intensity variations, and cropping.

Local Color Histogram (LCH) involves the divisioning of images into blocks and then obtaining the histogram individually for each of the block. So, these histograms thus represent an image. Each block of one image can be used to compare with the block of the second image in the same location in order to compare between the two images. This traditional approach represents the images more deeply [8].

One of the most commonly used color system for retrieving images is the RGB color system. Unfortunately, for describing colors in terms that are practical for human interpretation, this color system is not well suitable. Whereas, an ideal tool that we can use for developing image processing algorithms which are based on color descriptions that are natural and intuitive to humans is the HSV (hue, saturation, value) model [5].

Table 1: Some common color feature extraction methods

Low Level Feature	Methods
Color	Color Histogram
	Fuzzy Color Histogram
	Average RGB
	Color Correlogram
	Geometric moments
	Color Coherence Vector

B. ***Texture Feature Extraction***

Texture is also an important feature used to identify the contents of images. Examples include identifying crop fields, mountains from aerial image domain, etc. In addition to this, texture can also be used to describe contents of images, such as hair, clouds, etc. Thus, both identifying and describing characteristics of images are supportive when texture is integrated with color. One main difference between color and texture features is that color is a pixel property whereas texture is a local-neighbourhood property. Since the power of texture feature is accelerated when it is combined with color feature, the content-based retrieval system thus provides the techniques for querying with respect to texture and color in an integrated manner [6]. The main approaches to the task of texture feature extraction that exists in image processing literature are as follows:

- Spectral Approach
- Structural/Syntactic Approach
- Statistical Approach

The Spectral Approach refers to the frequency domain where features are related to statistics of filter responses. Examples are Laplacian and Laplacian of Gaussian filters (these are usually good edge detectors).

Structural approaches tries to derive the geometrical representations based on the concept that texture might be viewed as a spatial organisation of texture elements. For example, Fourier spectrum, etc.

In Statistical approach, commonly applied statistics include 1-D histograms, moments, grey-level co-occurrence matrices, and etc. These collect image signal statistics from the spatial domain as feature descriptors.

Table 2: Some common texture feature extraction methods

Low Level Feature	Methods
Texture	Discrete Fourier Transform
	Gabor Filter
	Gabor Wavelet Transform
	Discrete Wavelet Transform
	Laplacian Pyramid
	Gaussian Pyramid

C. *Shape Feature Extraction*

Shape of a face is also one of the most important visual features and this basic feature is helpful in describing the image contents. But representing and describing the shape feature is one of the difficult task because whenever a 3-D real world object is projected over a 2-D image plane, object information in one of the dimension is lost which results in that, the partially extracted shape from the image represents the projected object.

Shape is more often washed with noise, arbitrary distortion, defects and occlusion thus making the problem even more complex. Not only this, it is still not known about what is more important in shape. Current approaches for shape extraction have both positive and negative attributes. Usually, we can extract shape features from an image by using following two kinds of methods:

- Contour
- Regions

In order to extract the boundary features of an object shape, we can use the Contour-based methods. Such method completely ignores some of the important features that are inside the boundaries.

In Region-based methods, image is first divided into different segments (regions) by applying segmentation, by setting up the threshold values as per the desirable outputs and image boundary can be obtained by using any edge detection method to an image [7].

Shape matching is one of the large research areas in itself. Some of the Shape representation methods are Fourier descriptors, invariant moments, deformable templates, curvature scale space (CSS), etc. [8]. Fourier descriptor is one of the important methods that have proven to be more efficient and robust in comparison to the curvature scale space (CSS) for shape representation and description techniques [9]. However, in partial shape matching, Fourier descriptor method is not much suitable. B. Ramamurthy [1][10] proposed a novel approach in which two different algorithms are mentioned for better matching of user query image with the stored database images. The Canny edge detection algorithm is said to perform better in comparison to some other algorithms under almost all conditions even under noisy conditions. Canny edge detection algorithm is observed to be computationally more expensive in compare to LoG (Laplacian of Gaussian) [11].

Table 3: Some common shape feature extraction methods

Low Level Feature	Methods
Shape	Fourier Descriptors
	Invariant Moments
	CSS Descriptors
	Deformable Templates

II. EXISTING APPROACHES

Visual feature extraction is the basis of any content-based image retrieval technique. The most widely used features are color, texture, shape and spatial relationships. Because of the subjectivity of perception and the complex composition of visual data, a single best representation for any given visual feature doesn't exist.

There are multiple approaches which have been introduced for each of these visual features and each one of the Characterizes the feature from a different perspective.

A. COMMON TECHNIQUES USED FOR EXTRACTION

1. *Relevance Feedback (Human Interaction)*

The Relevance Feedback technique was originally developed for information retrieving. This technique is a supervised learning technique used for improving the effectiveness of information retrieval systems. In order to improve the system's performance, the main idea in Relevance Feedback technique is to use the positive and negative examples provided by the user. Here, according to predefined similarity metrics, the system first retrieves a list of ranked images for a given query, and then a set of positive and/or negative examples are selected by the user from the retrieved images and the system subsequently refines the query and retrieves a new list of images. In this technique, retrieving the relevant images involves the user's interaction.

2. *Iterative/Machine Learning*

Machine Learning techniques are more useful for retrieving Content Based Images. Applications of iterative techniques are becoming more common in CBIR in addition to machine learning. This technique is most suitable technique for complex semantics but the only problem here is that it is difficult to implement.

There are two types viz:-

i. Supervised Learning
ii. Unsupervised Learning

Both of these are associated with low level features. There are number of transform based techniques which are useful in retrieving the texture based feature extraction.

3. *Statistical Moments, Euclidean Distance*

Statistical Moments are also used to extract the features like color, shape, etc. It makes use of Euclidean distance, Cosine correlations, Absolute distance, etc.

Euclidean Distance measures the similarity between the two different vectors of image. This distance metric is commonly used for similarity measurement in image retrieval because of its effectiveness and efficiency. The formula for Euclidean Distance is:

$$\text{Euclidean Distance} = \sqrt{\sum_{i=1}^{n}[Qi - Di]^2}$$

Where, Q and D are feature vectors of the Query image and database image.

4. *K-means Clustering, Independent Component Analysis*

K-means Clustering is a method in which final required number of clusters is equal to the initial number of components of the population taken. Each component in the population is next examined and is assigned to one of its clusters depending on the minimum distance. Each time, when a component is added to the cluster, recalculation of centroid position is carried out. This process continues till all the components are grouped into the final required number of clusters.

The K-means algorithm is a very simple algorithm. It can be easily implemented in solving many practical problems.

Independent Component Analysis (ICA) initially makes use of the existence of independent factors (latent variables) in the multivariate data and then decomposes an input data set into the statistically independent components.

5. *Fuzzy Logic and Ripplet Transform*

The Fuzzy c-means (FCM) clustering is one of the most widely used clustering algorithms so far. This algorithm is based on an iterative optimization of a fuzzy objective function. The data item to a cluster has degree of membership in between [0, 1]. Its output is the membership value of the image with each of the K classes for a provided input/query image. The input image is the image that belongs to the class for which the membership value is high.

RT is a higher dimensional generalization of the Curvelet Transform (CVT). It is capable of representing images or 2D signals at different scales. It is also capable of representing images in different directions. In order to achieve anisotropic directionality, CVT makes use of parabolic scaling law. For images with discontinuities along CD curves, RT provides a new tight frame with sparse representations.

6. *BPNN & LDA*

The recognition of a particular individual can be made on the basis of BPNN with LDA and MDA. Steps to be followed are:

Step 1: To identify an individual, capture the video.
Step 2: To remove the unwanted information, Background Subtraction is performed on the input video.
Step 3: Now Detection and Tracking is performed. Also, the subject location is obtained.
Step 4: Various parameters are now calculated for extracting features. For example, parameters like distance between the head and the feet (the height of the individual), distance between both the hands, etc. are calculated.
Step 5: Now the gait recognition is carried out.
Step 6: The matching is done on the basis of Content Based Image Retrieval.
Step 7: Finally recognition is made using Neural Network Techniques.

7. Spacial Principal Component Analysis

This algorithm is used for classification. It provides more accurate image classifier system than any other technique.

PCA algorithm is used for extracting the important features of an image. Such important features of an image are integrated in the predefined class (or a single module). It has been analysed that, the techniques which are based on PCA provides better classification and most accurate results in the area of computer vision like weather forecasting, face recognition, medical diagnostics, remote sensing images, data mining, etc.

Table 4:- Summarized comparison between techniques.

S.NO.	TECHNIQUES LIST	MERITS	DEMERITS	PERFORMANCE PARAMETERS
1	Relevance Feedback [12][13]	In boosting the accuracy of image retrieval, this technique is quite efficient.	Requires more than four iterations to achieve high performance.	Precision = 85.50
2	Machine learning [13]	This technique is suitable for complex semantics.	The learning speed is quite low.	Average precision with number of iterations = 0.9
3	Average precision with number of iterations = 0.9 Statistical moments, Euclidean distance [14]	This technique is helpful as it decreases the size of the vector based features and computational complexities.	The length that needs to be traversed so as to gather all the images is very difficult.	Min, Max and Average longest precision in terms of precision and recall.
4	K-means clustering, Independent Component Analysis [15]	This technique is helpful as matching the relevant images with query image are quite high. This technique reduces the time complexity.	Extracting the features of an image is quite difficult in contrast to other techniques.	Number of false positives using DCT.
5	Fuzzy logic and Ripplet transform [16]	It is able to progress the accuracy of retrieval and to reduce the computational.	The designing is very difficult to implement.	Average Precision =0.55
6	BPNN & LDA [17]	This technique is helpful in terms of handling large number of inputs. Error probability is very less.	Lot of computations is needed in this technique as the set feature vector is heavy.	Cumulative matching score using the BPNN + MDA.
7	Spacial Principal Component Analysis [18]	This technique is used to acquire the high precision. For this, learning method is used and region wise comparison is done (i.e., region to region comparison is made).	Weights are not changed self-adaptively.	Recall, Accuracy and Precision.

III. CONCLUSION

Content Based Image Retrieval System is a way of finding the relevant images in large image database.

In this paper, we have done an analytical study of various image extraction features such as Color, Texture, Shape, etc. and the methods used to bring out such extractions from the digital images. Our overall survey shows that there is considerable performance variability among the various feature extraction methods.

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