A Review on Feature Extraction Techniques Using Color, Texture and Shape Features

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Abstract—In numerous application domains such as education, crime prevention, commerce, and biomedicine, the amount of digital information is increasing rapidly. The problem seems when retrieving the data from the storage media. Content-based image retrieval systems aim to retrieve objects from massive image databases similar to the query image based on the similarity between image features. The paper gives the overview of color, texture and shape feature extraction techniques like color space, color histogram, color moments, color co-occurrence matrix and wavelet transform, Gabor wavelet transform, Gray level co-occurrence matrix respectively and also the comparative analysis of this techniques is shown in the paper.

Keywords— *CBIR; feature extraction; color space; color histogram; GLCM; Gabor wavelet transform; EHD.*

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I. INTRODUCTION

From the past and till now, images from different fields are stored in groups as image databases. For every field, thousands of images have some common features. If we want to search for a particular image, the primitive methods, like search by text or image description, aren't correct and time overwhelming. These images are utilized in all fields like medical, engineering, educational, sports, criminal, and many of them. For example, images in medical fields like X- rays are used for diagnoses and analysis purpose. For criminal field, face recognition is used for retrieving the suspicious people. To search for an image during a vast image database, it's not efficient to use text or image descriptors. To overcome this drawback, a replacement technique referred to as content based image retrieval is used to search and retrieve an image from the database [2][1]

Content Based Image Retrieval (CBIR) is the retrieval of images based on their visual features such as color, texture, and shape [3]. The first use of the concept content based image retrieval was by Kato[3] to describe his experiments for retrieving images from a database using color and shape features. Afterward this term (CBIR) has been used widely for the method of retrieving images from a large collection of images based on features (color, shape, and texture) that is the signature of the image.
The main advantage of using CBIR system is that the system uses image features instead of using the image itself. So, CBIR is cheap, fast and efficient over image search methods.

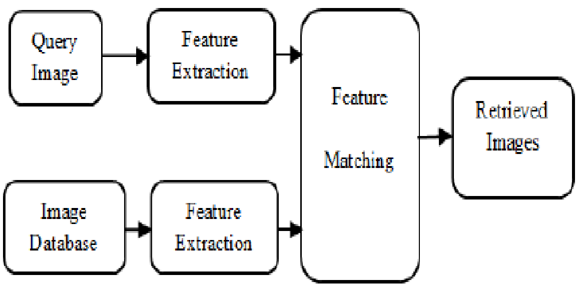

Fig.1. Block diagram of basic CBIR system [1]

Figure 1 shows the block diagram of basic CBIR system. The CBIR involves two phases: feature extraction and feature matching. The first phase involves extracting the image features while the second phase involves matching these features. Briefly, the features of each image stored in the database is extracted and compared to the features of the query image. If the distance between feature vectors of the query image and the image in the database is small enough, the corresponding image in the database is to be considered as a matched image to the query. The matched images are then ranked accordingly to a similarity index. Finally, the retrieved images are specified according to the highest similarity [1].

The organization of the paper is as follows. The section I give the introduction about the basic CBIR system. An overview of the color feature extraction techniques like color space, color histogram, color moments, color co-occurrence matrix, GLCM, Wavelet transform, Gabor wavelet transform, EHD are presented in section II. The section IV gives the comparative analysis of these different techniques and finally the conclusion is discussed in section V.

II. Related Work

The color, texture and shape feature extraction techniques used in CBIR are described. Feature extraction means obtaining useful information that may describe the image with its content. For instance, the image of a forest can be described by its green color and a few texture of trees. Objects in the image can be considered as shapes that can be a feature for the image. To describe an image, we've to consider its main features. Color, texture, and shape are some features considered for content image description. In this section, we will introduce the three main features:

A. Color Feature Extraction:

1) Color Space

A color space is a technique by which we can specify, create and visualize color. As humans, we may define a color by its attributes of brightness, hue and colorfulness. A color is therefore usually specified using 3 co-ordinates, or parameters. These parameters describe the position of the color inside the color space being used.

In most digital image processing, RGB (red, green, blue) color space is used in practice for color monitors. RGB stands for Red, Green, and Blue. RGB color space combines the 3 colors in numerous ratios to form alternative colors. The main disadvantage of the RGB color space is that it's perceptually non-uniform. To beat the disadvantage of the RGB color space, different color spaces are proposed.

The HSx color space is often utilized in digital image processing that converts the color space of the image from RGB color space to one of the HSx color spaces. HSx color space contains the HSI, HSV, HSB color areas. They're common to human color perception. HS stands for Hue and Saturation. I, V, and B represent Intensity, Value, and Brightness, severally.

The difference between them is their transformation methodology from the RGB color space. Hue describes the actual wavelength of the color. Saturation is the measure of the purity of the color. As an example, red is 100 percent saturated color, however pink isn't 100 percent saturated color because it contains an quantity of white. Intensity describes the lightness of the color. HSV color space is the most widely used when converting the color space from RGB color space [4].

Several color spaces, such as RGB, HSV, CIE L*a*b, and CIE L*u*v, have been developed for different purposes [5]. Although there is no agreement on which color space is the best for CBIR, an appropriate color system is required to ensure perceptual uniformity.

2) Color Histogram

The most commonly used method to represent color feature of an image is the color histogram. Many CBIR systems use color histograms as a color feature to represent the image. A color histogram is a type of bar graph, where the height of each bar represents an amount of particular color of the color space being used in the image [5].

Traditionally, two known methods are used to calculate color histograms. they are the global color histogram (GCH) and the local color histogram (LCH).

GCH method, the most widespread method, takes the histogram of all the image and therefore the distance between two images are determined by the distance between their color histograms. the disadvantage of this technique is that it doesn't embody information regarding all image regions. This makes the gap between images cannot show the real difference. Moreover, it's possible to create two completely different images to be similar using their GCH (short distance between their color histograms).

In the contrary, an LCH divides an image into fixed blocks or regions, and takes the color histogram of each of those blocks individually. The image will be represented by these color histograms. To compare two images, using their histograms, we calculate the distance between a block from one image and another block from the second image in the same location. This method improves the efficiency of retrieving images more than using GCH.

Although LCH contains more information about an image, but when comparing images, it is computationally expensive and it does not work well when images are translated or rotated.

3) Color moments

Color moments are measures that can be used differentiate images based on their features of color. Once calculated, these moments provide a measurement for color similarity between images. There are many central moments of an image's color distribution. The most important of them are *Mean*, *Standard deviation* and *Skewness*. Mean can be understood as the average color value in the image.The standard deviation is the square root of the variance of the distribution. Skewness can be understood as a measure of the degree of asymmetry in the distribution.

4) *Color Co-occurrence Matrix*

The color co-occurrence matrix (CCM) is a common method used for capturing color variations in the image which gives the color feature. It is used to calculate the probability of the occurrence of same pixel color between each pixel and its adjacent pixel [5]. Each pixel in image correspond to the four adjacent pixels so each image can be represented by four images motifs of scan pattern, which can be further constructed into four two dimensional matrices. From these four matrices, the motifs of scan pattern are generated to capture the color variation in image.

B. Texture Feature Extraction:

Textures are referred as the visible patterns which have likeness properties that do not possible from existence of only a single color or intensity. Texture includes valuable information regarding the structural arrangement with surfaces and their relationship to the surrounding environment. The various texture properties are recognized by the human eye like, regularity, directionality, smoothness, and coarseness.

1) Wavelet Transform

The wavelet transform includes texture analysis and classification using multi-resolution approach. In wavelet Transform, an image is decomposed according to the shifted and dilated wavelet functions. A 2-D discrete wavelet transform is obtained efficiently by applying the filter bank to each column of the image and also applying the filter bank to each row of the resultant coefficient [6][8].

2) Gabor Wavelet Transform

Gabor wavelet Transform (GWT) is most widely used technique for texture analysis feature extraction. It uses the multi-orientation and multi-resolution approach for texture analysis.

The features of the image are computed by applying the filter at different orientation and scale, the array of magnitudes are obtained. By calculating the mean and standard deviation of the magnitudes of transformed coefficients are used to represent the similar texture of the image [7][8][10]. The following mean and standard deviation of the transformed coefficients gives the similar texture feature of the region.

$$\mu_{mn} = \sum_{x}\sum_{y} G_{mn}(x, y)$$

$$\sigma_{mn} = \sqrt{\sum_{x}\sum_{y}(|G_{mn}(x, y)| - \mu_{mn})^2}$$

3) *Gray level Co-Occurrence Matrix*

GLCM is composed of the probability value, Its level is determined by the image gray-level. [8]

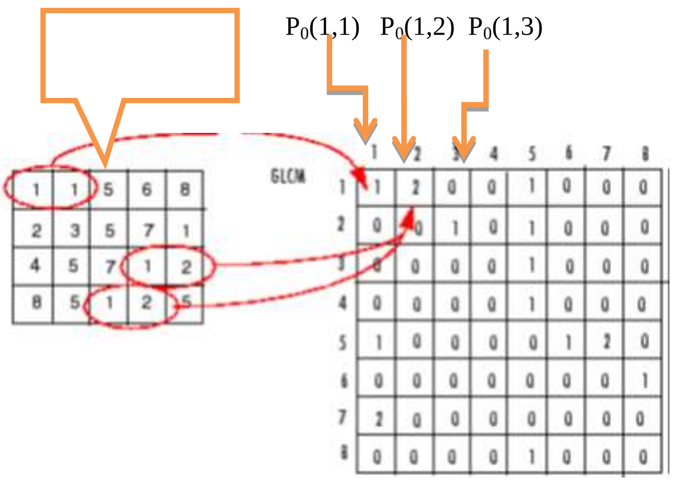

Fig.2. How to create GLCM.

Figure 2 shows an example of how to construct the gray-level co-occurrence matrix. Image I is a gray scale image of size 4 x 5. To create the gray-level co-occurrence matrix, we have to create a square matrix and its dimension is equal to the largest pixel value in the image. In the GLCM, element (1, 1) contains the value 1 because there is only one instance in the image where two, horizontally adjacent pixels have the values 1 and 1. Element (1, 2) contains the value 2 because there are two instances in the image where two, horizontally adjacent pixels have the values 1 and 2. We repeat this for every two adjacent pixels and count the number of times this pair of values are appeared in the image.

4) Steerable Pyramid

The steerable pyramid model is used as texture recognition system. It divides an image into a set of oriented sub-bands and low-pass residual. The image is decomposed into a set of undecimated directional sub-bands and one decimated lowpass sub-bands [10]. The texture features are calculated from the output of the oriented filters.

C. Shape Feature Extraction:

Shape is known to play an important role in human recognition and perception and object shape features provide a powerful clue to object identity. Edge is a local shape feature and it captures the general shape information in the image [9]

Edge Histogram Descriptor

Edges in images represent a vital feature to represent their content. Human eyes are sensitive to edge features for image perception. A method of representing such a vital edge feature is to use a histogram. An edge histogram within the image space represents the frequency and the directionality of the brightness changes in the image. We adopt the edge histogram descriptor (EHD)[9][13] to describe edge distribution with a histogram based on local edge distribution in an image. The extraction method of EHD consists of the following stages:

1) An image split into four ×four subimages.
2) Every subimage is further partitioned into non overlapping image block with a small size.
3) The perimeters in every image block square measure categorized into 5 types: vertical, horizontal, 45° diagonal, 135° diagonal and nondirectional edges.
4) Thus, the histogram for every subimage represents the relative frequency of occurrence of the five kinds of edges in the corresponding subimage
5) Once examining all image blocks in the subimage, the five-bin values are normalized by the whole range of blocks in the subimage. Finally, the normalized bin values are quantized for the binary representation. These normalized and quantized bins represent the EHD.

IV. Comparative Analysis

A comparative analysis of the color, texture and shape feature extraction techniques with their advantage and Disadvantages are shown in table I, table II and table III respectively.

TABLE I: A COMPARATIVE ANALYSIS OF COLOR FEATURE EXTRACTION TECHNIQUES

Methods	Advantage	Disadvantage

Color Space	*Simple to use and fast computation*	*No specific disadvantage*
Color Histogram	*Simple to use and fast computation*	*Lost spatial information and no color similarity*
Color moments	*Provides effective representation of colors*	*No specific disadvantage*
Color Co-occurrence Matrix	*It captures the color variations in image*	*No specific disadvantage*

TABLE II: A COMPARATIVE ANALYSIS OF TEXTURE FEATURE EXTRACTION TECHNIQUES

Methods	Advantage	Disadvantage
Wavelet Transform	*Less retrieval time*	*Poor performance compared to the Gabor wavelet transform*
Gabor Wavelet Transform	*Achieves highest retrieval results*	*Computationally intensive*
Gray level Co-Occurence Matrix	*Achieves highest retrieval results*	*No specific disadvantage*
Steerable pyramid	*Rotation invariant*	*More computation and storage*

TABLE III: A COMPARATIVE ANALYSIS OF SHAPE FEATURE EXTRACTION TECHNIQUES

Methods	Advantage	Disadvantage
Edge histogram Descriptor	*Easy to implement, present high retrieval performance*	*No specific disadvantage*

V.CONCLUSION

This paper discusses about various techniques for extracting color, texture and shape features. It gives the details about various methods also presents the comparison of all this feature extraction methods. From the comparison of these methods, The methods are well used for color, texture and shape feature extraction in CBIR.

Acknowledgment

I would wish to express my gratitude to my guide Prof.Arun kulkarni and my co-guide Prof.Sunil Yadav for his instructive comments and valuable guidance. I am also grateful to all faculties of computer Engineering department, my colleagues and family for their encouragement and constant support.

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