Sudan University of Science and Technology

College of Graduate Studies

College of Computer Science and Information Technology

Content Based Image Retrieval Method using Color, Texture and Shape Features based on Re-weighting Factor

طريقة إسترجاع الصور المستندة إلى المحتوي بإستخدام مميزات اللون و الملمس والشكل إعتمـاداً على عامل الترجيح

A Thesis Submitted to the College of Graduate Studies in Partial Fulfillment of the Requirement for the Degree of Master of Science in Computer Science

By

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2017

﴿ يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنْكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ (11)﴾

(سورة المجادلة: 11)

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Dedication

To the memory of my father, to my mother, to my brothers, to my sisters, to my teachers, to my friends.

Acknowledgement

First and foremost, I thank Allah for granting me the ability to complete this thesis.

I am heartily thankful to my supervisor Dr. Ali Alfaki, whose encouragement, guidance and support from the initial to the final stage enabled me to develop an understanding of the research.

I would also like to thank Dr. Fakher Eldeen Mohammed, for his comments and helpful tips.

I also thank the faculty members of the Department of Computer Science, Sudan University of Science and Technology for their great efforts.

Last but not the least, I am also grateful to my family, my friends and to all those who have supported and encouraged me.

Abstract

In recent years, the quantity of the digital image collection is growing rapidly due to the development of the internet and the availability of image capturing devices. The problem arises when retrieving these images from storage media. Thus, image retrieval system become efficient tools for managing large image databases. A content based image retrieval system allows the user to present a query image in order to retrieve images stored in the database according to their similarity to the query image. In this study, we have proposed a content based image retrieval method that uses a combination of color histogram, color moment, Gabor filter, and Canny's edge. The color histogram, and color moment are used for color features, Gabor filter is used for texture feature extraction, and for shape feature extraction we used Canny's edge. To improve the efficiency of the proposed system we assign different weights by multiplying the features vector by the weight factor generated with the precision process and calculate the similarity between the query image feature vectors and the feature vectors of the image in the database by using Euclidean distance. Experimental results show that the proposed method has higher retrieval accuracy than other conventional methods which combine these three features without the Re-weighting process mentioned above.

المستخلص

في السنوات الأخيرة، زادت كمية مجموعة الصور الرقمية بسبب تطور شبكة الإنترنت وتوفر أجهزة التقاط الصور. تنشأ المشكلة عند استرداد هذة الصور من وسائط التخزين. وعليه، اصبحت انظمة استرجاع الصور أدوات فعالة لإدارة قواعد بيانات الصور الكبيرة. نظام استرجاع الصور المستند إلى المحتوى يسمح للمستخدم بعرض صورة استعلام من أجل استرداد الصور المخزنة فى قاعدة البيانات وفقا لتشابهها مع صورة الاستعلام. في هذه الدراسة، اقترحنا طريقة استرجاع الصور على أساس المحتوى باستخدام مزيج من اللون، الملمس، الشكل. يتم استخدام (color histogram) و (color moment) لاستخراج ميزة اللون، يستخدم مرشح غابور لاستخراج ميزة الملمس، ولاستخراج ميزة الشكل استخدمنا حافة كاني. لتحسين كفاءة النظام المقترح قمنا بتعين أوزان مختلفة وذلك بضرب متجهة الميزات مع عوامل الاوزان الناتجه من عملية الدقة ومن ثم حساب التشابه بين متجه ميزة صورة الاستعلام و نواقل الميزة للصورة فى قاعدة البيانات باستخدام المسافة الإقليدية. أظهرت النتائج التجريبية أن الطريقة المقترحة لها دقة استرجاع أعلى من الطرق التقليدية الأخرى التى تجمع بين ثلاث سمات دون عملية إعادة الترجيح المذكورة أعلاه.

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List of Abbreviation

CBIR   Content Based Image Retrieval

CBVIR   Content Based Visual Information Retrieval

CCV   Color Coherence Vector

DBMS   Database Management Systems

FD   Fourier Descriptors

GCH   Global Color Histogram

GLCM   A Gray Level Co-occurrence Matrix

LCH   Local Color Histogram

QBIC   Query By Image Content

WT   Wavelet Transforms

CHAPTER ONE

INTRODUCTION

As background, this chapter begins with description of the subject. The motivation and contribution of this study to the relevant field is also stated. The problem statement, study objective, and scope of the work are then presented.. The chapter ends with the organization of this thesis.

1.1   Background

Today, with the development of the internet most people are interested to using digital information to display or stored, because of the advances of computing and multimedia technologies such as digital camera, image scanners. So the size of the image database is increasing rapidly. This increase in image database become the basis for many educational, entertainment and commercial applications. For this reason we need image retrieval system based on the content.

Content based image retrieval (CBIR), also known as query by image content (QBIC) and content based visual information retrieval (CBVIR) deals with the retrieval of relevant images from a large image database [1]. Retrieval depends on the basis of characteristics (Such as Color, Texture and Shape) that can be automatically extracted from the image themselves.

There is an increasing need for image retrieval technique for multiple different fields such as education, crime prevention, detect and recognize a human for security purposes (such as face recognition, DNS matching), remote sensing systems, and medical diagnosis.

Assuming the similarity is properly defined there are two types of queries that are of interest:

A. **Range Query:** Where we want to retrieve all elements that are closer than a given distance to the query content.

B. **Nearest Neighbor query:** where we want to retrieve a certain number of the elements most similar to the query.

In order for a practitioner to perform a search he must provide input to the CBIR. Unlike in traditional query systems text is not used. Several approaches have been explored [2]:

i. **Query by example:** in this type of query a user merely provides a sample image and, relying on its analysis, the engine will provide the user with a set of similar image (see figure1.1).

ii. **Query by region:** from an image, the user selects a region of interest comprising the characteristics he is interested in. It is then up to the CBIR engine to retrieve images that share those same characteristics.

iii. **Semantic query:** A type of keyword query. However, it is not based on existent metadata but instead relies on mappings between the low level features extracted from an image and high level concept. An example would be a search for micro calcifications in a fatty tissue breast. Due to its complexity (it is still an unsolved problem) this types of query are only present in research systems.

iv. **Query by sketch:** instead of using an image as source for a query, the user draws something a like what interests him. This methodology has been used to search for works of art in museums and image in the internet, but we know of no use case in clinical context.
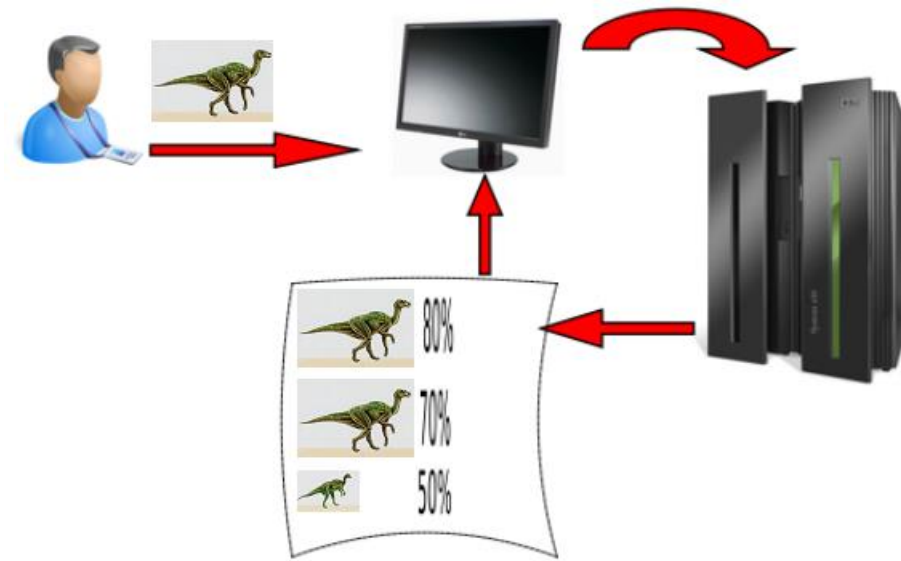
Figure.1.1 Diagram for Query by example

1.2 Motivation of the study

First: Most people are store and transfer digital image through internet. This process produces hundreds of digital image each day. We needs ease access to the huge database of digital image available on the internet.

Second: reduce the semantic gap between low level image features and human semantics.

1.3 Problem Statement

Retrieval process must be able to retrieve image based on the image's low-level visual features without the aid of keywords or textual description. Most of the current retrieval methods retrieves image based on single feature type either color, texture or shape, which is not a good solution for the accuracy and efficiency. This study combines image feature color, texture and shape, then Re-weighting factor are calculated and new features values are constructed, it is then use for final retrieval process.

1.4   Research Purpose and Objectives

The purpose of this thesis is to improving and develop a CBIR for large image database system by using color, texture and shape features.

The Objective of this study are:

i.   Extract different features from image using color, texture and shape.

ii.   Apply a feature re-weighting method to improve the effective of the information that will be retrieved.

iii.   To retrieve image based on the new features values after re-weighting and evaluated retrieve performance.

1.5   Research Scope

The focus of this research is to develop a CBIR system by using the WANG images database, and will apply the image retrieval techniques using color, texture, and shape features and finally improve result based on relevance feedback approach. The study focus on offline retrieval only. The research will address the following questions:

1.   What methods will be used to extract the features?

2.   How can calculate the similarity between images and query?

3.   How can evaluate the performance of the system?

4.   How can improve the efficiency of our system?

1.6   Thesis Organization

The thesis is divided into five major chapters. Chapter 1provides the short introduction of content based image retrieval. The motivation of the study, the problem statement, research purpose and objectives and research scope are also presented. Chapter 2 reviews the literature relevant to the study. More detail introduction of content based image retrieval and content based Medical image field is provided. Chapter 3 addresses the methodology of research and explains the dataset. The results and discussions are included in Chapter 4. Chapter 5 Concludes the work and provides some recommendations for future work.

CHAPTER TWO

LITERATURE REVIEW

This chapter explains the basic concept of CBIR system and visual features, the applications of CBIR.

2.1 Content Based Image Retrieval

Image retrieval has become a hot research area. Early work on image retrieval can trace back to the late 1970s. Images were first annotated with text and then use text based database management systems (DBMS) were used to perform image retrieval [3]. This approach relies on the textual descriptions of the images. Each and every image in the database is to be annotated with the textual keywords and the image search is based on these keywords. Text based image retrieval doesn't analyze the content, it depend on text description of the image and manual annotations of the images. It has lead two disadvantages; first one is that a considerable level of human labor is required for manual annotation. This process is time consuming to manually annotate each image in the database. The second is the annotation inaccuracy due to the subjectivity of human perception. The subjectivity of the perception and the impreciseness in the annotations may cause unrecoverable mismatches in retrieval processes [4]. To overcome the above disadvantages in text based image retrieval system, new approach of the image retrieval, Content based image retrieval (CBIR) was introduced in the early 1980s. In CBIR, images are indexed by their visual content, such as color, texture, and shapes that can be automatically extracted from the images themselves. The CBIR mainly consists of two steps, one step is the feature extraction and another step is the similarity matching [4]. There

are several CBIR systems developed in the early 1990s, some of these systems are commercial and most are academic such as : *Query by Image Content (QBIC)* is Commercial system developed in IBM's Almaden Research Center (USA) was the first by Flickner et al [5]. *The VisualSEEK* system (Smith et al, 1996) developed Columbia University Center for telecommunication Research [5]. *The Photobook* system developed in the MIT Media Laboratory by Pentland et al (1996) [5]. *The Netra* system developed at University of California, Santa Barbara (Ma & Manjunath 1997) [5].

2.2 Concept of CBIR Systems

Content based retrieval system is divided into *Offline feature extraction* and *online image retrieval*. Figure 2.1 the process of a CBIR system. In *offline feature extraction*, the contents of the image in the database are extracted and described with a multidimensional feature vector, also called descriptor [6]. The feature vectors of the image constitute a feature dataset stored in the database. In Online image retrieval, the user can submit a query example to retrieval system in search of desired image. The system represents this query image with a feature vector. The distances/similarities between the feature vectors of the query example and those of the image stored in the database is then computed and ranked. The system ranks the whole dataset according to minimum distance criterion. Retrieval is performed using an indexing scheme to provide an efficient searching of the image database. User can provide relevance feedback to improve the retrieval result [6].
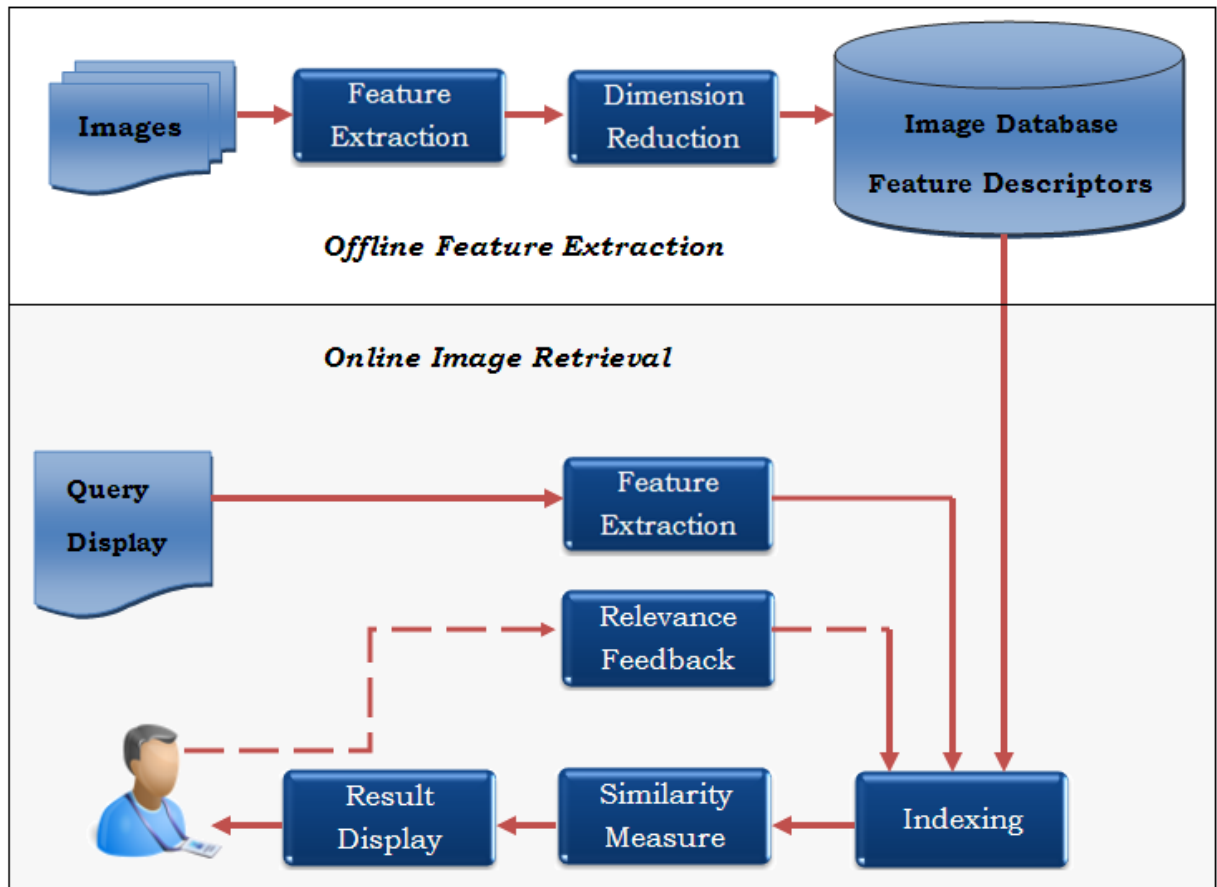
Figure 2.1: Framework for content based image retrieval [6]

So the basic components of the CBIR system are the feature extraction, storage of the image and the feature vectors and the similarity calculations between the images.

2.3 Feature Extraction

Feature extraction is one of most important role in the area of image retrieval. Any images have contained different features. These features are extracted from properties such as color, textual, and shape of query image and also from the various image in database. In this section describes three features: color, textual, and shape.

2.3.1 Color Feature

The color feature is one of the most important and widely used in image retrieval because of its invariance with respect to image scaling, translation, and rotation[7] The key issues in color feature extraction include the color space, color quantization, and the choice of similarity function [7]. Before extracting color feature, color space must determined first.

2.3.1.1 What is Color Space:

A color space is a mathematical representation of set of colors. All of the color space can be derived from the RGB information[8]. Each color in the color space is a single point represented in a coordinate system. One of the desirable characteristics of an appropriate color space for image retrieval is its uniformity. Uniformity means that two color pairs that are equal in similarity distance in a color space are perceived as equal by viewers[9]. The most frequently used technique is to convert color representations from the RGB color space to the HSV, CIEL*u*v or CIEL*a*b color space with perceptual uniformity. There are several color space exiting for a variety of reasons.

2.3.1.1.1 RGB Color Space

RGB space is a widely used system for representing color images. It is composed of three color components red, green, and blue. These components are called additive primaries since a color in RGB space is produced by adding them together. Major drawback of the RGB space is not suitable for CBIR because it is a perceptually not uniform and device dependent system[8].
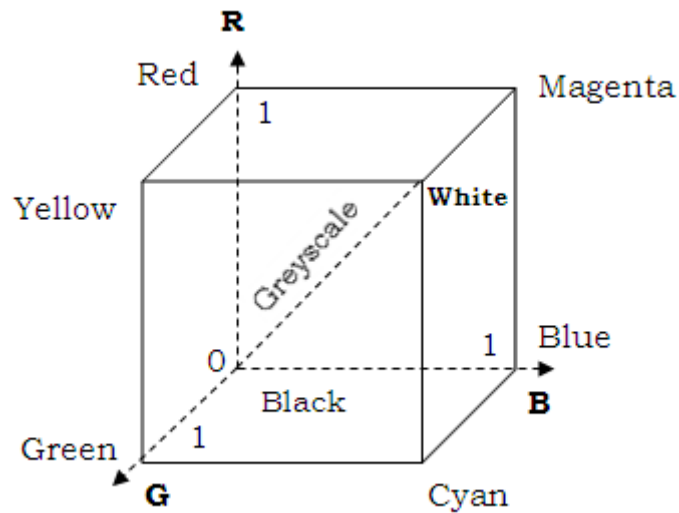
Figure 2.2: Color Cube for normalized RGB coordinates

2.3.1.1.2 CMY Color Space

CMP color space is used for color printing. Cyan, magenta, and yellow are the complements of red, green, and blue. They are called subtractive primaries because they are obtained by subtracting light from white. CMY color space has the same drawback of RGB[8].
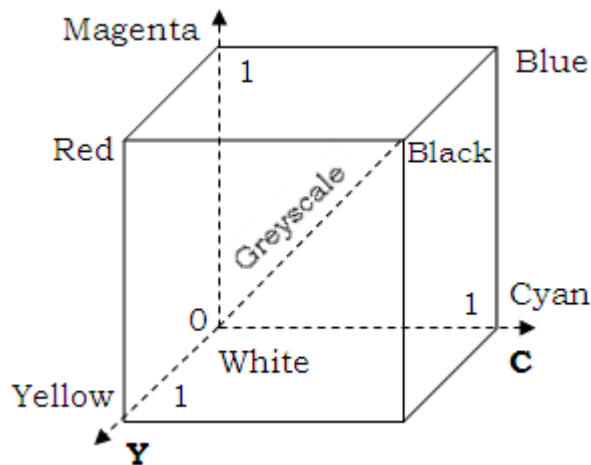
Figure 2.3: Color cube for normalized CMY coordinates

2.3.1.1.3 C.I.E.L*a*b and C.I.E.L*u*v Color Space

C.I.E.L*a*b and C.I.E.L*u*v Color space are device independent and considered to be perceptually uniform, which provide easy of similar metrics for comparing color. They consist of a luminance or Lightness component (L) and two chromatic components *a* and *b* or *u* and *v*. C.I.E.L*a*b is designed to deal with subtractive colorant mixtures, while C.I.E.L*u*v is designed to deal with additive colorant mixtures[9].

2.3.1.1.4 HSV Color Space

The HSV(hue, saturation, and value) and HSL(hue, saturation, lightness) color space is widely used in computer graphics and is a more intuitive way of describing color by its hue, saturation (lightness) and value (brightness). This color system is very useful in interactive color selection and manipulation. RGB coordinates can be easily translated to the HSV or HLS coordinates by a simple formula[9]. The HSV space can be visualized in three dimensions as a downward pointing hexacone. The line running down the center of the cone's vertical axis represents the intensity value V. Hue is represented as the angle relative to the red axis, which reside on the plane perpendicular to the intensity axis. Saturation refers to a point's perpendicular distance from the intensity axis (see Figure 2.4).
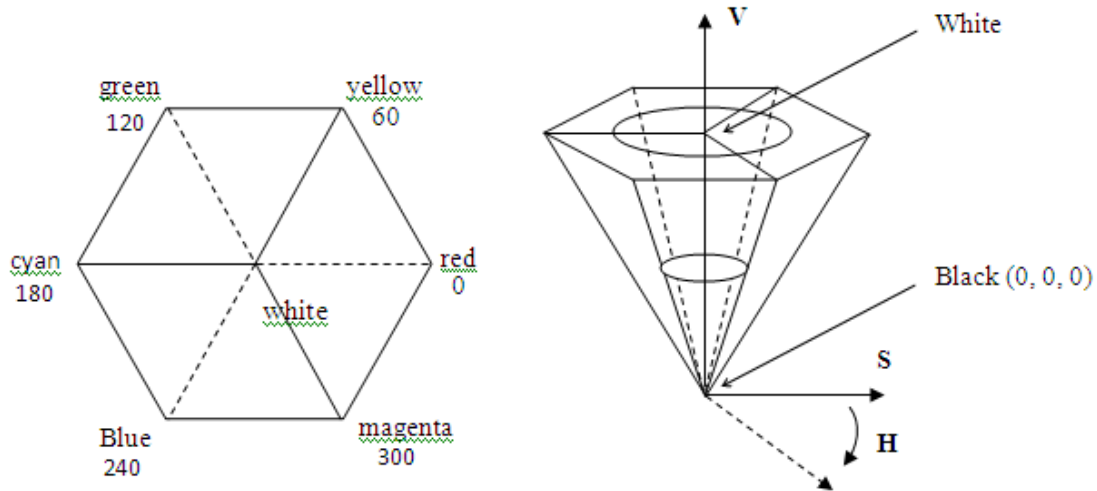
Figure 2.4: Color hexacone for HSV representation

So the hue represents the chromatic component in this model and it is definition of a color by the combination of the primary colors. Saturation refers to predominance of a particular hue in color. The value of a color refers to the intensity (the lightness or the darkness of the color). The HSV value of a pixel can a conversion from its RGB representation according to the following formula:

$$H = \cos^{-1} \frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}} \qquad 2.1$$

$$S = 1 - \frac{3[min(R,G,B)]}{R+G+B} \qquad 2.2$$

$$V = \left[\frac{R+G+B}{3}\right] \qquad 2.3$$

2.3.1.2 Color Quantization

In order to produce color histograms color quantization has to be applied. Color quantization is used to reduce the color resolution of an image. Using a quantized color map can considerable decrease the computational complexity during image retrieval[10]. In applying a standard

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quantization scheme on a color space each axis is divided into a number of part. When the axis are divided in k, l, and m parts the number of colors (n) used to represent an image will be n = k . l . m . A quantization of color space in n colors is often referred to as a n-bins quantization scheme[10].

2.3.1.3 Techniques Used For Extraction Color

To represent color features in CBIR system there are many techniques such as: the color histogram, color coherence vector, color Correlogram, and color moments.

2.3.1.3.1 Color Histogram

Color histogram is most popular techniques to describe the different colors distribution in an image[11]. The color histogram is easy to compute and effective in characterizing both the *global* and *local* distribution of colors in an image [9]. Color histogram is a method for describing the color content of image constructed by counting the number of pixels of each color. Color histogram uses two types of color space that are RGB, HSV. Color histogram is divided into Global color histogram (GCH) and Local Color Histogram (LCH). in ***local color histogram based*** CBIR, the image is divided into fixed block and then to obtains its color histogram for each block, where it enable compared the color distances between regions. ***Global color histogram based*** CBIR is the way of represent images with single histograms and it does not capture the content of an image. The global color histogram calculates frequency of color[12].

So, a color histogram represents the distribution of colors in an image through set a set of bins, where each histogram bin corresponds to a color

in the quantized color space. A color histogram for a given image is represented by a vector:

$$H = \{H[0], H[1], H[2], H[3], \cdots \cdots \cdots H[i], \cdots \cdots \cdots, H[n]\} \qquad 2.4$$

Where i is the color bin in the color histogram and H[i] represents the number of pixels of color i in the image, and n is the total number of bins used in color histogram[13].

Color histogram has two major drawbacks: they cannot fully accommodate the spatial information, and they are not unique[14] (not unique mean two different images with the same distribution of color histogram is very similar result).
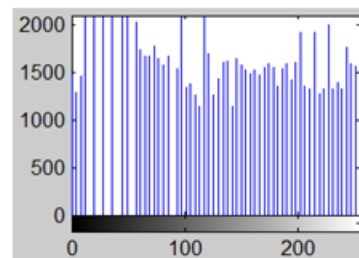
a) Sample image   b) Color quantization histogram

Figure 2.5: Sample Image and Its color quantization histogram

2.3.1.3.2 Color Moments

Color moments are the statistical moments of the probability distributions of colors and have been successfully used in many retrieval system, especially when the image contains just the object, it means color moment will work best when image has only object. Three parameters are calculated in this method mean , variance and Skewness. Color moments have been proved to be efficient and effective in representing color distributions of images and it suffer from the problem that they fail to

encode any of the spatial information surrounding the color within the image [15]. Mathematically, the first three moments are defined as [9]:

Mean:

$$\mu_i = \frac{1}{N}\sum_{j=1}^{N} f_{ij} \qquad\qquad 2.5$$

Standard Deviation:

$$\sigma_i = \left(\frac{1}{N}\sum_{j=1}^{N}(f_{ij} - \mu_i)^2\right)^{\frac{1}{2}} \qquad\qquad 2.6$$

Skewness:

$$s_i = \left(\frac{1}{N}\sum_{j=1}^{N}(f_{ij} - \mu_i)^3\right)^{\frac{1}{3}} \qquad\qquad 2.7$$

where f_{ij} is the value of the ith color component of the image j, and N is the number of pixels in the image.

2.3.1.3.3 Color Coherence Vector (CCV)

CCV incorporates spatial information into the basic color histogram. Each histogram bin is partitioned into two types: *Coherent* and *non-coherent* parts. The coherent component represents those pixels which are spatially connected and the non-coherent component includes those pixels that are isolated. As CCV captures spatial information; it usually performs better than color histogram[16].

2.3.2 Texture Feature

The textual feature is another commonly used to provide the better image description of visual content[13].

2.3.2.1 What is Texture?

Texture can be seen in many image from multi-spectral remote sensed data to microscopic photography. The term of *texture* is a somewhat misleading term in computer vision, which is not the normal meaning of the word. We recognize texture when we see it but it is very difficult to describe[17]. Despite its importance, there is no specific definition, however one can define texture is visual pattern that have properties of homogeneity that do not result from the presence of only single color intensity[10]. Some researchers describe texture such as:

* ❖ Faugeras and Pratt [10] : *The basic pattern and repetition frequency of texture sample could be perceptually invisible, although quantitatively present*.

* ❖ Bovik, Clarke, and Geisler [10]: *an image texture may be defined as a local arrangement of image irradiances projected from a surface patch of perceptually homogeneous irradiances*.

* ❖ Jain and Karu [5]: *Texture is characterized not only by the grey value at a given pixel, but also by the grey value pattern in a neighbourhood surrounding the pixel*.

* ❖ Haralick, Shanmugam, and Dinstein[10]: *texture has been extremely refractory to precise definition*.

there are two approaches to describe texture:

1. statistical approaches: analyze textural characteristics according to the statistical distribution of image intensity. Method used in statistical include Fourier power spectra, Co-occurrence matrices, Tamura feature, Wold decomposition, Markov random field,

Fractal model, and Multi-resolution filtering technique such as Gabor and wavelet transform[6].

2. Structural approaches: characterize texture by identifying a set of structural primitives and certain placement rules. Methods used in structural include morphological operator and adjacency graph. They tend to be most effective when applied to texture that are very regular[6].

Rao and lohase identify three features as being important in human texture perception[7]:

1. Repetition refer to periodic patterns and is often associated with regularity like a brick wall is repetitive patterns but picture of ocean water is non-repetitive (and has no structure).

2. orientation refers to the presence or absence of directional textures. directional textures have a flow like pattern as in a picture of wood grain or waves.

3. Complexity refers to the description complexity of the texture.

To make the texture representation meaningful to human visual perception, Tamura et al, developed computational approximation to the visual texture properties found to be important in psychology studies. The six visual texture properties were *coarseness*, *contrast*, *directionality*, *linelikeness*, *regularity*, and *roughness* [18].See Figure 2.6.

a) Simple Texture Images   b) Complex Texture Images

Regular   Irregular

Fine   Coarse

Directional   Non Directional

Figure 2.6 Example of simple and complex texture image

2.3.2.2 Techniques used for Extraction Texture

2.3.2.2.1 A Gray Level Co-occurrence Matrix

The GLCM which is a square matrix can reveal certain properties about the spatial distribution of the gray levels in the texture image. It was define by Haralick et al. in 1973 [19]. It show how often a pixel value known as the reference pixel with the intensity value (i) occurs in a specific relationship to a pixel value known as the neighbour pixel with the intensity value (j). each element (i,j) of the matrix is the number of occurrences of the pair of pixel with value(i) and a pixel with value (j) which are at a distance (d) relative to each other[19]. The spatial relationship between two neighboring pixels can be specified in many ways with different offsets and angles, the default on being between a pixel and its immediate neighbor to its right (see Figure 2.7).

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135^0 [-1 -1] 45^0 [-1 1]

0^0 [0 1]

Reference Pixel
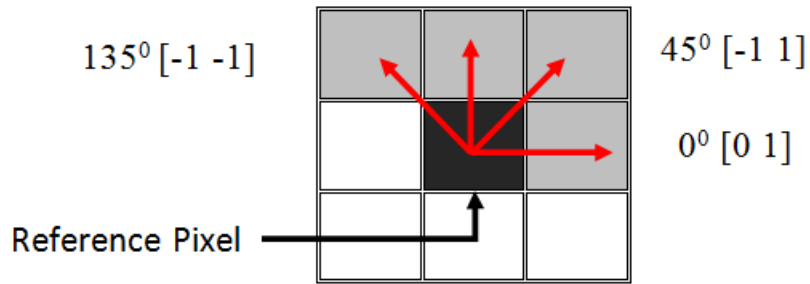
Figure 2.7 Co-occurrence matrix direction for extracting texture features

The four properties calculated are:

- ❖ Contrast: The contrast property returns a measure of the intensity contrast between a pixel and its neighbor over whole image [20].
- ❖ Correlation: Correlation measures the linear dependency of gray levels of neighboring pixels [20].
- ❖ Energy: Energy returns the sum of squared elements in the GLCM. This statistic is also called Uniformity or Angular second moment [20].
- ❖ Homogeneity: This statistic is also called as Inverse difference moment. In GLCM contrast and homogeneity are strongly, but inversely, correlated in terms of equivalent distribution in the pixel pair population [20].

Table 2.1: Popular formula

Feature	Formula
Energy	$\sum_i \sum_j P^2(i,j)$
Entropy	$\sum_i \sum_j P(i,j) \log P(i,j)$
Contrast	$\sum_i \sum_j (i-j)^2 \, P(i,j)$
Homogeneity	$\sum_i \sum_j \dfrac{P(i,j)}{1+|i-j|}$

2.3.2.2.2 Wavelet Transforms

Wavelet is a widely used multi-resolution tool in image processing. Wavelet transform (WT) have become one of the most important and powerful tool to represent both time and frequency content image. There are number of ways to separate the low and high frequency components [21]. The wavelet transform decompose a signal with a family of basic functions ψ_{mn} (x) Obtained through translation and dilation of a mother wavelet ψ(x) is expressed:

$$\Psi_{mn}(x) = 2^{-m/2}\, \Psi(2^{-m}x - n) \qquad 2.8$$

where m and are dilation and translation parameters. A signal f (x) can be represented as:

$$f(x) = \sum_{m,n} c_{mn}\, \Psi_{mn}(x) \qquad 2.9$$

The wavelet transform decomposes the image into low-high, high- low, and high-high spatial frequency bands at the coarsest scale. The L-L band contains the average image information whereas the other bands contain directional information due to spatial orientation [22]. Higher absolute values of wavelet coefficients in the high bands correspond to salient features such as edges or line[22]. Two major types of wavelet transforms used for texture analysis are the *pyramid structured wavelet transform* (PWT) and the *tree structured wavelet transform* (TWT) [9]. The PWT recursively decompose the LL band. However for some textures the most important information often appears in the middle frequency channels. To overcome this drawback the TWT decomposes other bands such as LH, HL or HH when needed [9].

2.3.2.2.3 Gabor Feature Extraction

Gabor filter (or Gabor wavelets) is most common method for texture feature is originally introduced by Dennis Gabor in 1946 [23]. They have been used widely in image texture feature extraction, especially in texture base image analysis (e.g., Classification, segmentation or edge detection) and more practically in face recognition. To be specific Gabor filter is designed to sample the entire frequency domain of an image by characterizing the center frequency and orientation parameters. The image is filtered with bank of Gabor filters of different preferred spatial frequencies and orientations. Each wavelet capturing energy at specific frequency and a specific direction. Expanding a signal using this basis provides localized frequency description, therefore capturing local features/energy of the signal. Texture features can then be extracted from this group of energy distributions. The scale (frequency) and orientation tunable property of Gabor filter make it especially useful for texture

analysis. Experimental evidence on human and mammalian vision supports the notion of spatial frequency (multi-scale) analysis that maximizes the simultaneous localization of energy in both spatial and frequency domains [24], are now used Gabor filter widely in various computer vision application. Gabor filter can be categorized into two components: a *real part as symmetric component* and *imaginary part as the asymmetric component.*

(a)   (b)
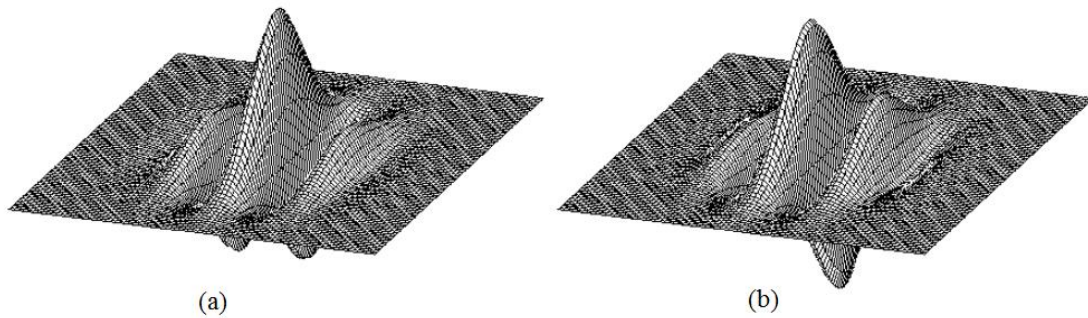
Figure 2.8 (a) The real part and (b) the imaginary part of a Gabor filter

2.3.2.2.3.1 Gabor function

The Gabor function is a complex exponential modulated by a Gaussian function. In its general form, the 2D Gabor function g(x,y) and its Fourier transform G(u, v) are defined as[25].

$$g(x, y) = \frac{1}{2\mu\sigma_x\sigma_y} \, exp\left[-\frac{1}{2}\left[\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2}\right]\right] exp(2\pi jWx) \qquad 2.10$$

where $j = \sqrt{-1}$, σ_x are the scaling parameters of the filter and σ_y define the Gaussian envelope along the x and y axes , and *W* is the frequency of the modulated sinusoid

$$G(u, v) = exp\left\{-\frac{1}{2}\left[\frac{(u-w)^2}{\sigma_u^2} + \frac{v^2}{\sigma_v^2}\right]\right\} \qquad 2.11$$

where $\sigma_u = 1/2\pi\sigma_x$, $\sigma_v = 1/2\pi\sigma_v$. Gabor functions form a complete but nonorthogonal basis set. Expanding a signal using this basis provides a localized frequency description. A class of self-similar functions, referred to as *Gabor wavelets*, is now considered. Let g (x, y) be the mother Gabor wavelet, then this self-similar filter dictionary can be obtained by appropriate dilations and rotations of g (x, y) through the generating function [26]:

$$g_{mn}(x,y) = a^{-m} g(x',y') \qquad\qquad 2.12$$

with x′ = a⁻ᵐ(x cos θ + y sin θ),

and y′ = a⁻ᵐ (-x sin θ + y con θ)

where a > 1, θ = nπ/K, n = 0,1, ..., K-1 and m = 0, 1, ..., S-1. K and S are the number of orientations and scales. The scale factor a⁻ᵐ is to ensure that energy is independent of m [26].

2.3.2.2.3.2 Gabor Filter Design

The nonorthogonal of the Gabor wavelet implies that there is redundant information in the filtered image, and the following strategy is used to reduce this redundancy. Let U_1 and u_h denote the lower and upper center frequencies of interest. Let K be the number of orientations and S be number of scales in multiresolution decomposition. Then the design strategy is to ensure that the half-peak magnitude support of the filter responses in the frequency spectrum touch each other as shown in fig2.9.This results in the following formulas for computing the filter parameters σ_u and σ_v(and thus σ_x and σ_y)[26].

$$a = \left(U_h / u_l \right)^{-1/(S-1)} \qquad\qquad 2.13$$

$$\sigma_u = \frac{(a-1)U_h}{(a+1)\sqrt{2\ln 2}} \qquad\qquad 2.14$$

$$\sigma_v = \tan\left(\frac{\pi}{2k}\right)\left[U_h - 2\ln\left[\frac{2\sigma_u^2}{U_h}\right]\right]\left[2\ln 2 - \frac{(2\ln 2)^2\sigma_u^2}{U_h^2}\right]^{-\frac{1}{2}} \qquad 2.15$$

where W = U_h and m = 0,1,...,S-1. In order to eliminate sensitivity of the filter response to absolute intensity value, the real (even) components of the 2D Gabor filters are biased by adding a constant to make them zero mean (This can also be done by setting G(0,0) in (2) to zero).
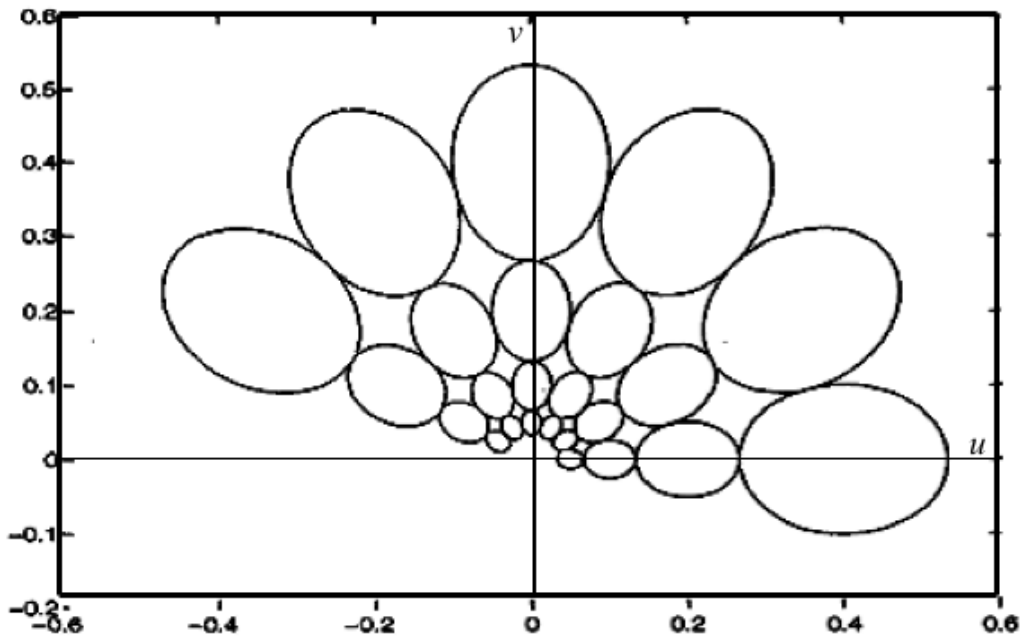
Figure 2.9 The elliptical contours indicate the half-peak magnitude of the filter response in the Gabor filter dictionary. The filter parameters used are U= 0.4, K=6, and S= 4.

2.3.2.2.3.3 Texture Representation

After applying Gabor filters on the image with different orientation at different scale, we obtain array of magnitudes:

$$E(m,n) = \sum_x \sum_y |G_{mn}(x,y)| \qquad\qquad 2.16$$

where $m = 1,2,\cdots,M-1; n = 0,1,\cdots,N-1$

These magnitudes represent the energy content at different scale and orientation of the image.

The main purpose of texture-based retrieval is to find images or regions with similar texture. It is assumed that we are interested in images or regions that have homogenous texture, therefore the following μ_{mn} and the standard deviation σ_{mn} of the magnitude of the transform coefficients are used to represent the homogenous texture feature of the region [24]:

$$\mu_{mn} = \frac{E(m,n)}{P \times Q} \qquad\qquad 2.17$$

$$\sigma_{mn} = \frac{\sqrt{\sum_x \sum_y (|G_{mn}(x,y)| - \mu_{mn})^2}}{P \times Q} \qquad\qquad 2.18$$

A feature vector can be constructed using μ_{mn} and σ_{mn} as feature components. With M scales and N orientations used in common implementation the feature vector is given[24]:

feature vector f = (μ_{00}, σ_{00}, μ_{01}, σ_{01}, ..., μ_{mn}, σ_{mn}).

2.3.3 Shape Feature

Shape is an important visual feature and it is one of the basic features used to describe image content.

2.3.3.1 What is Shape ?

Shape of an image describes more or less each and every object presented in an image [27]. Since the human perception and understanding of objects and visual forms relies heavily on their shape properties, shape

features play a very important role in CBIR. Shape is one of the most important image features of recognizing objects by human perception. Humans generally describe objects either by giving examples or by sketching the shape. In computer vision, shape is the most commonly used feature for characterizing objects in image retrieval. Queries for shapes are generally achieved by selecting an example image provided by the system or by having the user sketch a shape[28]. The Shape descriptors are categorized into two classes:
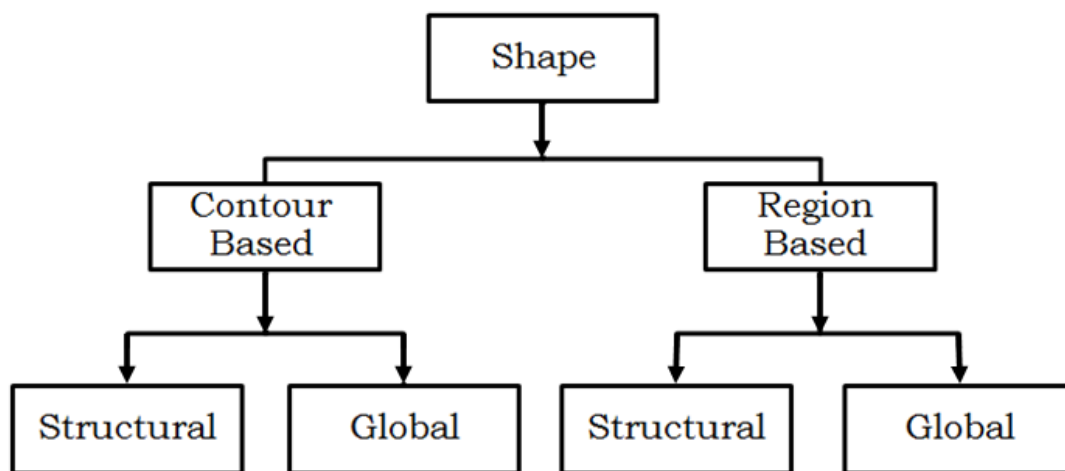
Figure.2.10 categorized of shape representation and description techniques

- ❖ **contour based descriptor** *(or called boundary based descriptor*s*)* representation uses only the outer boundary characteristics of the entities [29]. *Some global boundary based representative shape description techniques are* , Fourier descriptor (FD), wavelet descriptors, curvature scale space, Eccentricity. *Structure base techniques are* chain code or signature, centroid distance, cumulative angle, Shape Contexts(SC), polygonal approximation.

- ❖ **region based descriptor** **representation** uses the entire region[29]. The common *global region based methods are* Area, Euler Number, Eccentricity, Geometric moment, Invariant moment,

Zernike moments, Legendre moment, grid method, generic Fourier descriptor. *Structure based techniques are* Convex hull, media axis, and core

Shape features may also be local or global. A shape feature is structural (local) if it is derived from some proper subpart of an object, while it is global if it is derived from entire object[29]. A shape based representation of the image content in the form of point sets, contours, curves, regions, or surface should be available for computation of shape base features.

2.3.3.2 Techniques used for Extraction Shape

2.3.3.2.1 Simple Geometric Attributes

Description of the geometric properties of a region can be obtained measuring properties of points belonging to the region. those properties are for example[30]:

- ❖ Area: can be measured as the count of internal pixels.

- ❖ Bounding rectangle: is the minimum rectangle enclosing the object.

- ❖ Aspect ratio: is invariant to the scale of the object, since it is computed as the ratio of the width and length of rectangle.

- ❖ Roundness (also called circularity) is defined as :

$$Roundness = \frac{1}{Form\ Factor} = \frac{P^2}{4\pi a} \qquad\qquad 2.19$$

where P is the perimeter of a contour and A is the area of the enclose region.

❖ Compactness: is very similar to roundness defined above. It is defined as the ratio of the perimeter of circle with an area equal to the area of the original object, i.e.

$$Comp = \frac{P_{circle}}{P} = \frac{2\sqrt{A\pi}}{P} \qquad 2.20$$

❖ Elongation: is defined as the ratio between the squared perimeter and area.

❖ Convexity: a convex hull is the minimal cover able to encase the object. It can be thought as an elastic ribbon stretched around the contour of an object. Convexity can be thus be defined as the ratio of perimeters of the convex hull and the original contour.

$$Conv = \frac{P_{covexhull}}{contour} \qquad 2.21$$

2.3.3.2.2 Moment Invariants

Moment Invariants is a statistical image feature which meets the translation, rotation and scale invariance, and has been widely used in image recognition. If the object R is represented as a binary image then the central moments of order: p + q for the shape of object R are defined as [9] :

$$\mu_{p,q} = \sum_{(x,y)\in R}(x - x_c)^p(y - y_c)^q \qquad 2.22$$

where (x_c, y_c) is the center of object. This central moment can be normalized to scale invariant:

$$\eta_{p,q} = \frac{\mu_{p,q}}{\mu_{0,0}}, \gamma = \frac{p+q+2}{2}, p + q = 2,3,\cdots \qquad 2.23$$

Based on these moments as set of moment invariants to translation, rotation, and scale can be derived:

$$\phi_1 = \mu_{2,0} + \mu_{0,2}$$

$$\phi_2 = (\mu_{2,0} - \mu_{0,2})^2 + 4\mu_{1,1}^2$$

$$\phi_3 = (\mu_{3,0} - 3\mu_{1,2})^2 + (\mu_{0,3} - 3\mu_{2,1})^2$$

$$\phi_4 = (\mu_{3,0} + \mu_{1,2})^2 + (\mu_{0,3} + \mu_{2,1})^2$$

$$\phi_5 = (\mu_{3,0} - 3\mu_{1,2})(\mu_{3,0} + \mu_{1,2})[(\mu_{3,0} + \mu_{1,2})^2 - 3(\mu_{0,3} + \mu_{2,1})^2]$$
$$+(\mu_{0,3} - 3\mu_{2,1})(\mu_{0,3} + \mu_{2,1})[(\mu_{0,3} + \mu_{2,1})^2 - 3(\mu_{3,0} + \mu_{1,2})^2]$$

$$\phi_6 = (\mu_{2,0} - \mu_{0,2})\left[(\mu_{3,0} + \mu_{1,2})^2 - (\mu_{0,3} + \mu_{2,1})^2\right]$$
$$+ 4\mu_{1,1}(\mu_{3,0} + \mu_{1,2})(\mu_{0,3} + \mu_{2,1})$$

$$\phi_7 = (3\mu_{2,1} - \mu_{0,3})(\mu_{3,0} + \mu_{1,2})\left[(\mu_{3,0} + \mu_{1,2})^2 - 3(\mu_{0,3} + \mu_{2,1})^2\right]$$

<div align="right">2.24</div>

2.3.3.2.3 Chain code

The chain code method was introduced in 1961 by Freeman. This method represents an object by a sequence of unit-size line segments with a given orientation i.e. an object is represented by a sequence of small vectors of unit length and a limited set possible directions, so this method is also known as the unit vector method. The choice of the first boundary pixel in the sequence should be independent. One method to choose the first boundary pixel is find the pixel in the border which results in the minimum integer number and that pixel is then used as the starting pixel i.e. first boundary pixel. But this chain code is not rotation, scale invariant. The chain code is sensitive to the noise[31].

2.3.3.2.4 Fourier Descriptors (FD)

The shape descriptor based on the object boundary can be formed in several ways. Fourier transform is considered as the most commonly used of all boundary object descriptors. They are obtained by applying Fourier transform on shape boundary, the Fourier transformed coefficients are called the Fourier descriptors (FD). For good shape description, an appropriate shape signature is essentially required to obtaining FD. The nice properties of FDs are its robustness and easy to derive. With Fourier descriptors, coarse shape features or global shape features are captured by lower order coefficients and the finer shape features are captured by higher order coefficients and noise is not a problem with Fourier descriptor. With Fast Fourier Transform (FFT) the computation is efficient[15].

2.3.3.2.5 Edge detection

Edge detection is the process to detect the important features of image because edge consist of meaningful features and significant information. Detection of edges in an image is a very important step towards understanding image features. Features mean the properties of image like discontinuities in physical and geometric characteristics of image or abrupt variation in the intensity of image. The quality of edges is affected by the presence of objects in similar illumination, noise and density of edges [32].The Goal of edge detection are produce a line drawing of scene from an image of that scene, important features can extracted from the edge of an image (e.g., corners, line, curves), and these feature are used by higher level computer vision algorithms(e.g., recognition)[33]. The most edge detection techniques are:

2.3.3.2.5.1 Sobel Edge Detection

The Sobel Edge Detection sometime called the Sobel operator or Sobel filter, is used in image processing and computer vision. The Sobel technique performs a 2-D spatial gradient measurement on an image and emphasizes regions of high spatial frequency that correspond to edges. Usually it is used to find the approximate absolute gradient magnitude of an input grayscale image at each point[34]. The Sobel edge detector consists of a pair of 3×3 convolution mask, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows). A convolution mask is generally much smaller than the real image. Accordingly, the mask is slid over the image, influencing a square of pixels at a time[33]. The Sobel masks can be defined as equations below:

$$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} \qquad\qquad 2.25$$

$$G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \qquad\qquad 2.26$$

Advantages:

❖ It is less susceptible to noise[34].

Disadvantages:

❖ It produces thicker edges. So edge localization is poor in case of images having fine details[34].

2.3.3.2.5.2 Robert Edge Detection

The Robert edge detector computes the 2-D spatial gradient measurement on an image. The Roberts gradient operators are used to detect edges applying a horizontal and vertical filter in sequence. Both filters applied to the image and then slope magnitude method could be applied to extract the connected edges in the image[33]. The operator consists of a pair of 2×2 convolution kernels. The two filters are basic convolution filters of the form given in equations blow:

$$G_X = \begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \qquad\qquad 2.27$$

$$G_y = \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix} \qquad\qquad 2.28$$

2.3.3.2.5.3 Prewitt Edge Detection

The Prewitt operator consists of a pair of 3×3 kernels which are convolved with the original image to work out approximations of the derivatives one for horizontal changes. Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge[33]. Prewitt masks can be defined as equations blow:

$$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} \qquad\qquad 2.29$$

$$G_y = \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \qquad\qquad 2.30$$

2.3.3.2.5.4 Canny Edge Detector

The Canny edge detection algorithm is known popularly as the optimal edge detector, developed by John F. Canny in 1986. There are multiple steps to implement the Canny Algorithm.

step 1: Smoothing:

It is inevitable that all images taken from a camera will contain some amount of noise. To prevent noise in first step of canny edge detection is to filter out any noise in the original image before trying to locate and detect any edges. The Gaussian filter is used to blur and remove unwanted detail and noise. By calculating a suitable 5×5 mask, the Gaussian smoothing can be performed using standard convolution method. A convolution mask is much smaller than the actual image. As a result, the mask is slid over the image calculating every square of pixels at a time[35].

Gaussian filter uses 2D distribution to perform convolution. The larger the width of the Gaussian mask, the lower is detector's sensitivity to noise. The weight of the matrix is concentrated at the centre, therefore any noise appearing in the outside columns and rows will be eliminated, as the weight decreases outward from the centre value. The localization error in the detected edges also increases slightly as the Gaussian width is increased. The increasing of standard deviation reduce or blurs the intensity of the noise. Convolution of raw I(i ,j) is carried out with Gaussian filter G. Assuming the 2-D Gaussian function as[36]:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$
2.31

Where σ is indicates the standard variance of Gaussian function, and it determine the width of Gaussian filter and outcome of smoothing [36].

Mathematically, the smooth resultant image is given by:

$$F(i,j) = G * I(i,j) \qquad\qquad 2.32$$

Step2: Sobel Operator

After smoothing the image and eliminating the noise, the next step is to find the edge strength by taking the gradient of the image. The Sobel operator performs a 2-D spatial gradient measurement on an image. Then, the approximate absolute gradient magnitude (edge strength) at each point can be found. The Sobel operator uses a pair of 3×3 convolution masks, one estimating the gradient in the x direction(columns) and the other estimating the gradient in the y direction (rows). they are shown below [35]:

$$G_x = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} \qquad\qquad 2.33$$

$$G_y = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} \qquad\qquad 2.34$$

The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2} \qquad\qquad 2.33$$

The magnitude or edge strength of the gradient is then approximated using the formula [35]:

$$|G| = |G_x| + |G_y| \qquad\qquad 2.34$$

Where G_x and G_y are the gradients in the x and y directions respectively.

Step3: Finding Gradient angle

Finding the edge direction is trivial once the gradient in the x and y directions are known. However you will generate an error whenever sum of Gx is equal to zero i.e. Gx value in denominator meaning calculating arc tan of infinity. So the edge direction will equal to 90 or 0 degrees depend on Gx value and 0 degrees depend on Gy value [35].

formula for finding the edge direction:

$$\theta = arctan\left(\frac{G_y}{G_x}\right)$$

2.35

Step4: Tracing the edge in the image using theta(angle)

Once the edge direction is known the next step is to related the edge direction to a direction that can be traced in an image. So if the pixels of a 5×5 image are aligned as follows [35]:

```
X   X   X   X   X
X   X   X   X   X
X   X   a   X   X
X   X   X   X   X
X   X   X   X   X
```

Then it can be seen by looking at pixel "a", there are only four possible direction when describing the surrounding pixels 0 degrees (in the horizontal direction), 45 degrees (along the positive diagonal), 90 degrees (in the vertical direction), or 135 degrees (along the negative diagonal), 180 degrees region is just an mirror region of 0 degrees region. Therefore any edge direction calculated will be up to the closest angle [35].
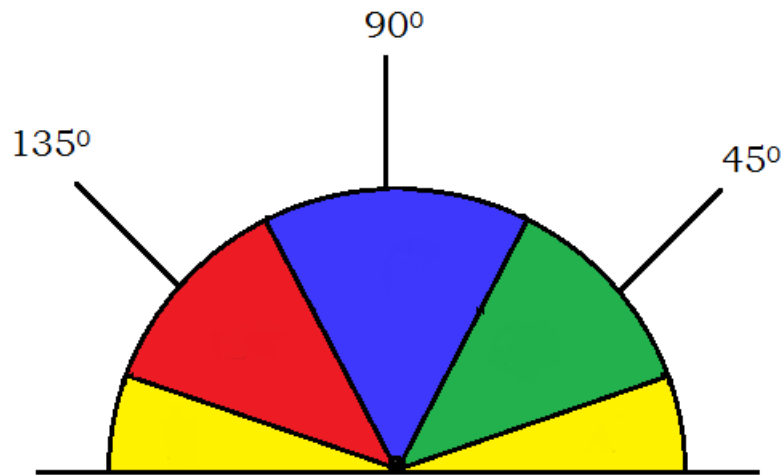
Figure.2.11 Illustrates Tracing the edge in the image using angle

Therefore, any edge direction falling within the yellow range (0 to 22.5 & 157.5 to 180 degrees) is set to 0 degrees. any edge direction falling in the green range (22.5 to 67.5 degrees) is set to 45 degrees. Any edge direction falling in the blue range (67. to 112.5 degrees) is set to 90 degrees. And finally, any edge direction falling within the red range (112.5 to 157.5 degrees) is set to 135 degrees [35].

Step5: Non maximum Suppression

After the edge directions are known, non maximum suppression now has to be applied. Non maximum suppression is used to trace along the edge direction and suppress any pixel value (set it equal to 0) that is not considered to be an edge. This will give a thin line in the output image [35].

Step6: Hysteresis Thresholding

The output of non maxima suppression still contains the local maxima created by noise. Instead choosing a single threshold, for avoiding the problem of streaking two threshold t_{high} and t_{low} are used. for a pixel

M(x, y) having gradient magnitude G following conditions exists to detect pixel as edge[36]:

❖ if G < t_{low} than discard the edge.

❖ if G >= t_{high} keep the edge.

❖ if t_{low} < G < t_{high} and any of its neighbors in a 3×3 region around it have gradient magnitudes greater than t_{high} , keep the edge.

❖ if none of pixel (x, y) neighbors have high gradient magnitudes but at least one falls between t_{low} and t_{high} search the 5×5 region to see if any these pixels have magnitude greater than thigh. if so, keep the edge.

❖ else discard the edge.

2.4 Content Based Image Retrieval System

2.4.1 Query By Image Content (QBIC)

Query by image [37] content is the first commercial content based image retrieval developed in IBM by Flickner et al.(1995). It Provide framework and techniques basis for many image retrieval systems. QBIC supports queries based on example images, user-constructed sketches and drawing, and select color and texture patterns, etc. The color feature used in QBIC are the average (R,G,B), (Y,I,Q), (L,A,B), and mathematical transform to munsell (MTM) coordinates, and a k-element color histogram. In its new system, text-based key word search can combined with content based similarity search. its texture feature is an improved version of the Tamure texture representation such as combinations of coarseness, contrast, and directionality. Its shape feature consists of shape area, eccentricity, major axis orientation, and a set of algebraic moment invariants. QBIC is one of

the few systems which take into account the high dimensional feature indexing. Indexing, clustering, and filtering methods must be designed into the matching methods to maintain performance.

2.4.2 Virage

Virage [37] is a content based image search engine developed at Virage Inc. Similar to QBIC, Virage supports visual queries based on color, composition (color layout), texture, and structure (object boundary information). But Virage one step further than QBIC. It's also supports arbitrary combinations of the above four atomic queries. The users can adjust the weights associated with the atomic features according to their own emphasis.

2.4.3 RetrievalWare

RetrievalWare [37] is a content based image retrieval engine developed by Excalibur Technologies Corp (1993). From one publications we can see that its emphasis was in neural nets to image retrieval. Its recent search engine uses color, shape, texture, brightness, color layout, and aspect ratio of the image as the query features. It also supports the combinations of these features and allows the users to adjust the weights associated with each feature.

2.4.4 Photobook

Photobook [37] is a set of interactive tools for browsing and searching images developed at the MIT Media Lab by Pentland et al (1996). Photobook consists of three sub-book from which shape, texture, and face features are extracted, respectively. Users can then query based on the corresponding features in each of the three sub-books. This application supports a variety of matching algorithms such as Euclidean or

Mahalanobis distance, divergence, vector space angle. The latest version of photobook also supports matching algorithms via dynamic code loading [38]. Photobook includes FourEyes an interactive tool for image segmentation and annotation. The user selects some image regions and gives them labels and FourEyes extrapolates the labels to other regions on the image and in the database [38].

2.4.5 VisualSEEK

VisualSeek [38] is Developed at the Columbia University Center for Telecommunication Research by Smith et al (1996). It integrates feature based image indexing by color with region based spatial query methods. This enables queries with multiple color regions in the sketch image. Queries may be conducted by sketching a layout of color regions by providing the URL of a seed image or by using instances of prior matches.

2.4.6 Netra

Netra [37] is a prototype image retrieval system developed at the University of California Sants Barbara. Netra uses color, texture, shape, and spatial location information in the segmented image regions to search and retrieve similar regions from the database.

2.5 Related Work

In 2012, *Amanbir Sandhu et al.*[39] proposed a content based image retrieval compare the several feature extraction techniques for color, texture, and shape feature extraction. For color extraction Histogram, texture GLCM, and different shape features like area, eccentricity, euler number, and filled area. The experiments shown the similarity between these features and also that the output obtained using this combination of

color, texture, and shape is better as obtaining output with a single feature.

In 2013, *Poorani M et al*.[40] this work proposes the use of three features for retrieving the images, which are color, shape, and texture. These feature are extracted by different techniques. Color feature is extracted by color histogram and color descriptor. Shape feature is extracted by Hu moment and edge detection method. Texture feature is extracted by gray level co-occurrence matrix and texture descriptor. This paper was compared three features analyze which is the most suitable features for image retrieval. The robust feature vector set is a combination of three features lead to best results.

In 2014, *C.S.Gode et al*.[41] proposed was present a framework for combining all the three feature color, texture, and shape information and achieve higher retrieval efficiency. Color feature is extracted by color histogram.Co-occurrence matrix calculate the feature vector for texture. Canny algorithm is use for edge detection to calculate the feature vector for shape. Invariant moments are then used to record the shape features. The combination of color, shape, and texture features between image and its complement in conjunction with the shape feature provide a robust feature set for image retrieval. the experimental results demonstrate the efficacy of the method.

In 2014, *Aruna Verma et al*.[32] proposed was present a novel framework for combining all three feature color, texture, and shape information and achieve higher retrieval. In this work an efficient CBIR the author proposes exploit the wavelets, which represent the visual feature. It use Haar wavelet to decompose color images into multilevel scale and wavelet coefficients, with which we perform image feature extraction and

similarity match. The features that are extracted usually fall in three general Categories color, shape, and texture.

In 2015, *Nupur Kandalkar et al*.[20] in this work the different color, shape, and texture feature extraction techniques have been studied and implemented in order to obtain the desired results. The results also prove that only color, shape or texure features are insufficient to describe the entire image, and thus a combination of two or more feature extraction techniques is required to obtain best results.

In 2016, *R.Bulli Babu et al*.[42] in this work, authors have proposed a technique for the result images are not only based on the color, texture, and shape but also the underlying points of the image. At first the pictures are recovered based on the color, then took after by texture and finally tracing the underlying graphical structure. The proposed system is efficient in recovering images based on the content of the image presented as query. Retrieving images based on underlying graphical structure will help in removal of many irrelevant images and makes the system efficient.

Table 2.2 Summarization of Related Work

No	Author	Year	Proposed Method	Evaluation Parameter	Performance Results
1	Amanbir Sandhu, Aarti Kochhar	2012	Compare the several feature, and integrate different feature: GLCM, Histogram, Area, Eccentricity, EulerNumber, FilledArea **Measures like:** Euclidean Distance	Precision, Recall, Accuracy	Combination features: Precision= 30% Recall = 70% Accuracy = 50%
2	Poorani M, Prathiba T, Ravindran G	2013	Compare the several feature, and combination different feature: RGB histogram, HSV histogram, color moment, GLCM, Hu mement, Edge detection **Measures like:** Euclidean Distance	Accuracy	
3	C.s.Gode, A.N.Ganar	2014	integrate three feature: histogram, Co-occurrence matrix, Canny edge detection **Measures like:** Euclidean Distanc		
4	Aruna Verma, Deepti Sharma	2014	integrate three feature: Haar wavelet to decompose color histogram, GLCM, Edge **Measures like:** Euclidean Distance	Recall	

5	Nupur Kandalkar, Arvind Mani, Garima Pandey, Jignesh Soni	2015	integrate three feature: Color histogram, color Moment, GLCM, Gabor, region properties Measures like: Euclidean Distance	Precision, Recall	Precision = 50% Recall = 40%
6	R.Bulli Babu, V.Vanitha, K.Sai Anish	2016	integrate three feature and trace the underlying points of image (Active Re-ranking): Color histogram HSV, Wavelet Transform, Mass, Centroid, Dispersion	Precision, Recall	

2.6 Relevance Feedback

Relevance feedback is a powerful approach used to reduce the semantic gap between the low level features and high level feature. Relevance feedback was originally developed for improving the effectiveness of information retrieval systems [6]. The main idea of relevance feedback is for the retrieval system to understand the user's information needs. For a given query the retrieval system returns initial results based on pre-defined similarity metrics. Then the user is required to identify the positive examples by labeling those that are relevant to the query [6]. The system subsequently analyzes the user's feedback using a learning algorithm and returns refined results. A typical relevance feedback mechanism contains a learning component and a dispensing component. The learning component uses the feedback data to estimate the target of the user [6].

There are many techniques used in relevance feedback such as:

- ❖ **_Query Point Movement (QPM):_** Query shifting mechanisms seems to be more useful when the first retrieval contain few relevant images. in this case the user may have queried the database using an image sample located near the boundary of the relevant region in feature space. More relevant images can then be retrieved by moving the away from the region of non-relevant images towards the region of relevant images [43].

- ❖ **_Query Re-weighting:_** When the query is able to retrieve large number of relevant images then it is more effective to refine the result by some feature re-weighting mechanism than moving the query point. Feature relevance weighting techniques are based on a weighted similarity metric where relevance feedback by user is used to update the weights associated with each feature in order to refine results [43].

- ❖ **_query expansion:_** The query expansion tries to find the ideal query point from which the best possible and the highest set of relevant samples can be achieved. In QPM one simply finds the centroid of relevant samples which in turn acts as a new query point. In query expansion on the other hand instead of assuming a unimodal distribution the system assumes many smaller unimodal distributions to construct multiple centriods using QPM on individual clusters of relevant samples and then the multiple centroids are taken as multip-point query and images are retrieved from iso-similarity regions based on these points.

2.7 Similarity Measure

After low level visual feature extraction, similarity measure are conducted to compare the query image with each image in the database and the most image are ranked according to their similarity value and returned to the user. Some of the most commonly used similarity measure used in CBIR is Euclidean distance, Minkowski-form distance, Kullback Leibler divergence distance, Mahalanobis distance, and Earth mover's distance.

2.8 Performance Evaluation

Evaluation of retrieval performance is a crucial problem in CBIR. Many different methods for measuring the performance of a system have been created such as average precision, average recall, average retrieval. The *precision* of the retrieval is defined as the fraction of the retrieved image that are indeed relevant for the query:

$$Precision = \frac{Number\ of\ relevant\ images\ retrieved}{Total\ Number\ of\ images\ retrieved} \qquad 2.36$$

The *recall* measure the ability of the system to retrieve all the models that are relevant:

$$Recall = \frac{Number\ of\ relevant\ images\ retrieved}{Number\ of\ relevant\ images\ in\ the\ database} \qquad 2.37$$

A good retrieval system should have high values for precision and recall.

CHAPTER THREE

METHODOLOGY

3.1 Datasets Description

The data used in this research are images of Wang database. The images are developed by James G.Wang .et al at University of Pennsylvania state University. The Wang database is a subset of the Corel database. It consist of 1000 natural images in JPEG format in different sizes shown in Figure.3.1.
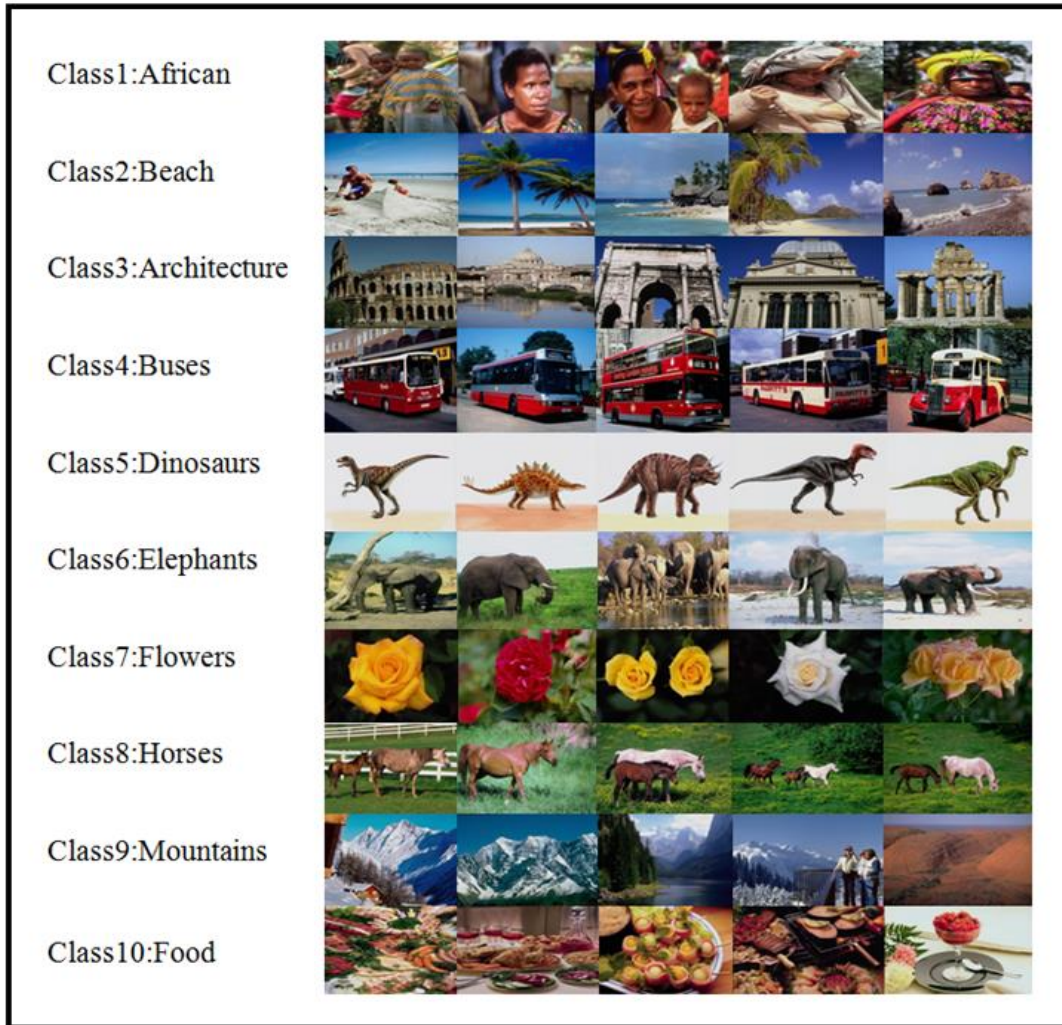

Figure 3.1 Sample of Wang Image Database

3.1.2 Image File Formats

Image file formats provide a standardized way to store the information describing an image in a computer file. A variety of image file formats are available at present, Like JPEG, GIF, BMP, TIFF.

- ❖ **JPEG**: Is short for Joint Photographic Experts Group. It has '.jpg', '.jpeg' as the allowed extensions. It is the most common format for storing and transmitting photographic images on the World Wide Web and is a commonly used method of compression for photographic image.

3.1.3 Images Types

The image types includes: binary, gray scale, color image, multispectral. In this research we used gray scale.

- ❖ **Color Images:** can be modeled as three-band monochrome image data where each band of data corresponds to a different color. The actual information stored in the digital image data is the gray-level information in each spectral band. Typical color image are represented as red, green, and blue (RGB). corresponding color image would have 24 bit/pixel (8 bit for each of three color).

- ❖ **Gray-scale images:** Gray-scale image are referred to as monochrome (one color) images. They contain gray-level information, no color information. The number of bits used for each pixel determines the number of different gray levels available. The typical gray-scale image contains 8 bit/pixel data, which allows us to have 256 different gray levels.

3.2 Framework Description Proposed CBIR System

In this section, the methods used for developing CBIR method includes the integration of different components given in Figure.3.2.
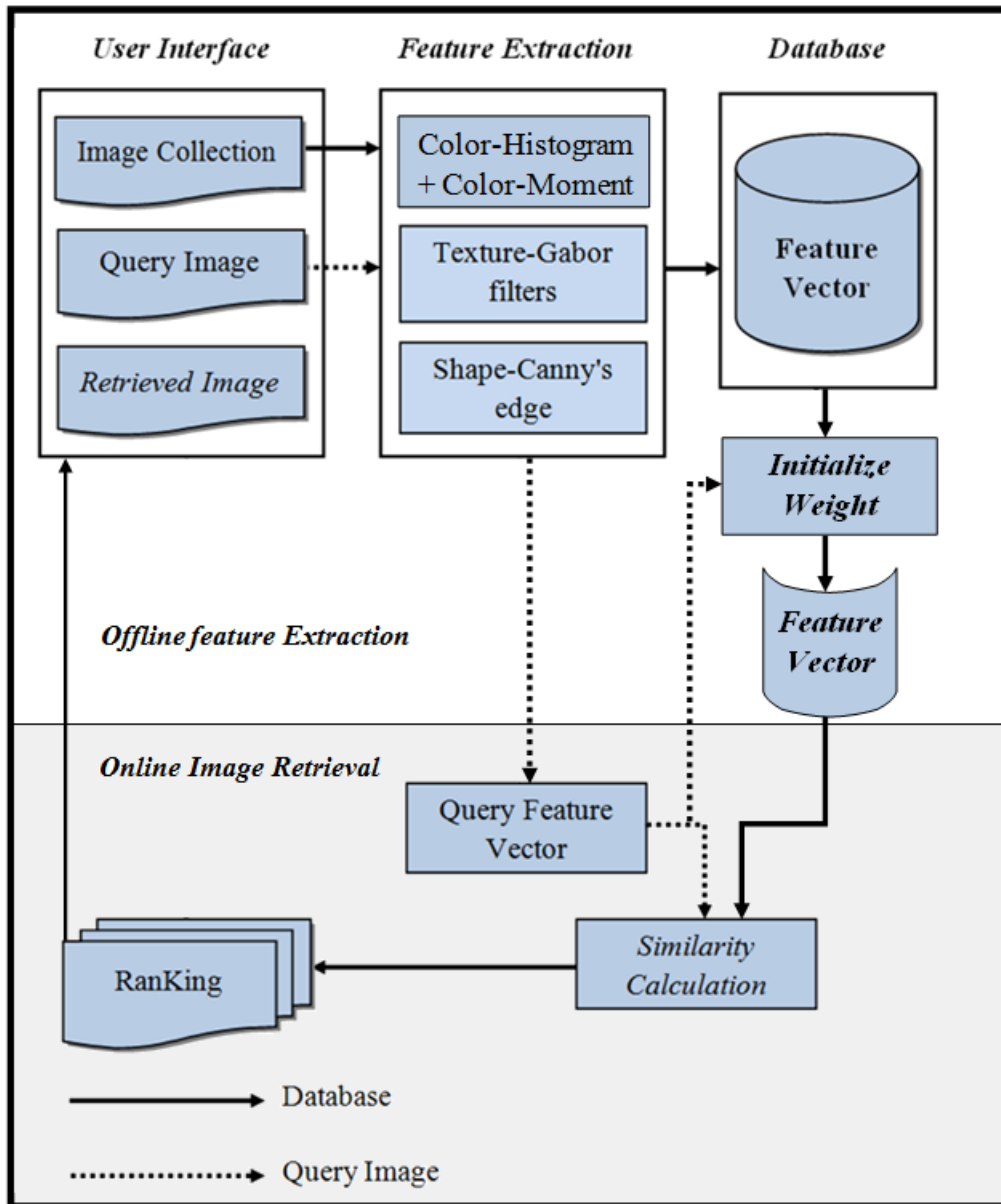

Figure.3.2 framework of methodology

As illustrated in Figure 3.2, the framework consists of several sequential stages or phases.

Phase 1: Offline Feature Extraction

In the *first stage* is collecting images and then extract the information from these image by one of the ways mentioned in chapter (2), and the information is stored in the database in the form of feature vectors. The sample images are input in the *second stage*, then the images feature will extract and go to the *third stage* where initialize weight are obtained by calculating the similarity between the query image and images stored in the database using predefined distance measure, the results are then ranked and the weight feature vector saved. *Finally*, we assign weights to each feature respectively. This process generates and stores a new feature vector.

Phase 2: Online Image Retrieval

This phase describes the retrieval process. The retrieval process is initiated when a user query the system using an example image. The query image is converted into the representation of feature vector using the same feature extraction that was used for building the feature database. The similarity measure is a calculate the distance between the feature vectors of query image and new feature vectors database. Finally, the ranks the search results and then returns the images that are most similar to query examples.

3.2.1 Apply Algorithm For Feature Extraction

Image feature selection plays an important role because it can represented content of the image efficiency and higher accuracy. There are many methods to extract these features, in this study uses three feature extraction methods i.e. color histogram, color moment, Gabor filter and Canny's edge detection.

3.2.1.1 Histogram Feature Extraction

In this study used the histogram approach because its extracts both local and global features of color, fast computation and simple.

Proposed algorithm to find the histogram of an image is following:

Step1: Read the image.

Step2: Convert the images from RGB color space into HSV color space.

Step3: Split image into h, s and v planes.

Step4: Compute histogram.

Step5: Store the value in a database.

3.2.1.2 Color Moment Feature Extraction

In this study used the moment approach because its compact feature of color and sensitive to spatial information.

Proposed algorithm to find the moment of an image is following:

Step1: Read the image.

Step2: Split image into R, G and B planes.

Step3: Compute mean value for each channel.

Step4: Compute standard Deviation for each channel.

Step5: Construct feature vector and store in a database.

3.2.1.3 Gabor filters feature extraction

There are different approaches of texture feature extraction, in this study used Gabor filters because its detect different frequency and orientation.

Our proposed algorithm to find the Gabor filters of image is following:

Step1: Read the image.

Step2: Convert the RGB images into gray level.

Step3: Construct bank of 24 Gabor filters using the Gabor function with 4

scales and 6 orientations.

Step4: Apply Gabor filters on the gray level of the image by convolution.

Step5: Get the energy distribution of each of the 24 filters responses.

Step6: Compute the mean μ and the standard deviation σ of each energy

distribution.

Step7: Construct feature vector and store in a database.

3.2.1.4 Canny's Edge Detection

In this study used Canny's edge detection approach because its better detection especially in noise conditions, improving signal to noise ratio, localization and response.

Our proposed algorithm to find the Canny's edge of images is as follows:

Step1: Read the image.

Step2: Convert the color images into a grey scale.

Step3: Apply Canny's edge detection technique to detect the edges and

store it into a 2D matrix.

Step4: The maximum value of each column is taken from the generated

matrix.

Step5: Store the value in a database.

3.2.2 Proposed CBIR Algorithm

The proposed system workflow is illustrated as follows as it explained in Figure.3.3

Step1: Input the query image.

Step2: Extract features vector for query image by using above algorithms

that use to extract feature vector of images database.

Step3: Match query image with the image database feature, get class

precision, and then provides re-weighting factor.

Step4: Generated the new feature vector by multiply the above

re-weighting factor by each features vector.

Step5: Save new features vector in the image database.

Step6: Similarities are calculated between query image feature and new

image feature database.

Step7: Retrieve images that are more similar to the query image. and
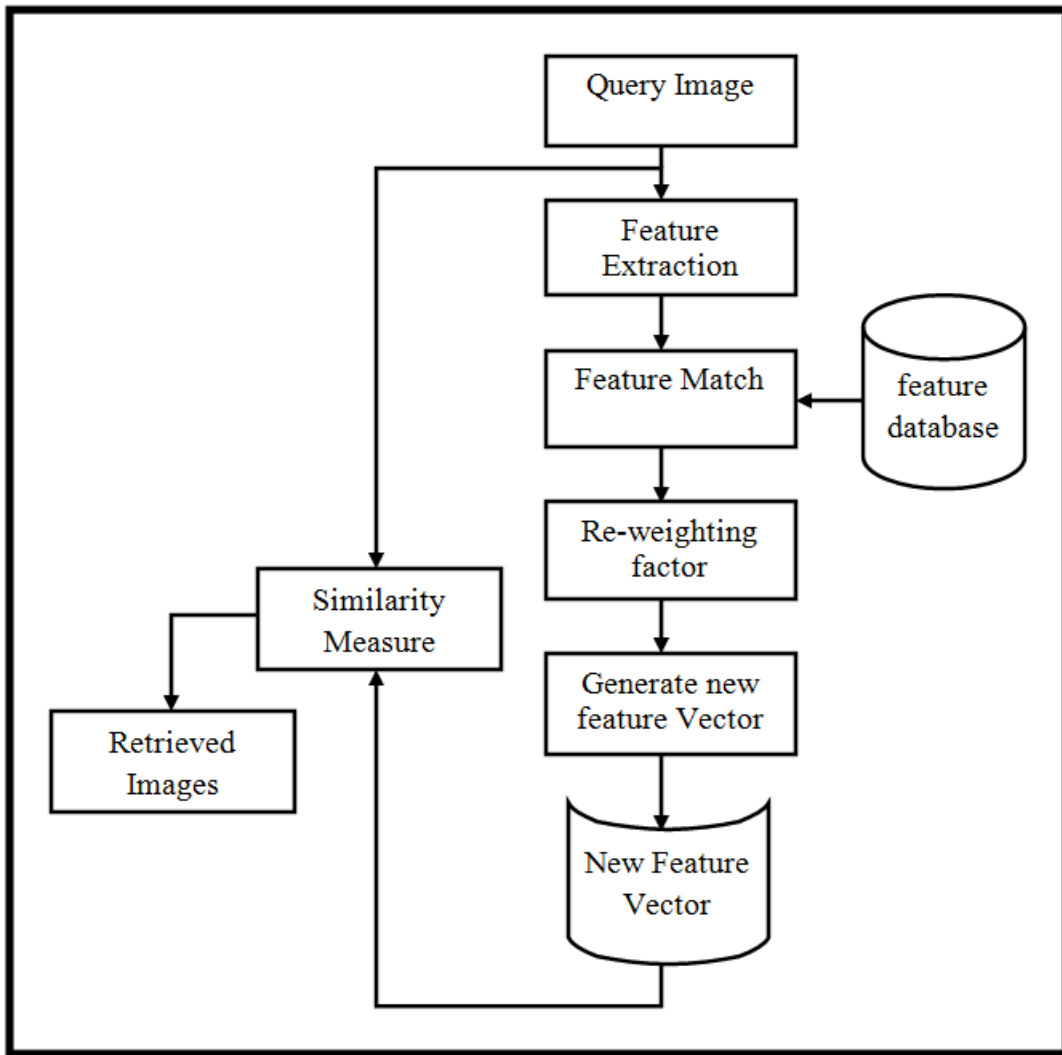
calculate the final precision.

Figure.3.3 Architecture of Proposed System

Table 3.1 Pseudo Code for Proposed Method

Pseudo Code for Proposed Method
1: w ← xlsread(file directory); {read the weight feature vector}
2: f ← xlsread(file directory); {read the feature vector}
3: nf ← zeros(row, column); {Initializes the new feature}
4: x ← 1; y ← 100; { Initializes value x , y }
5: For i = 1: 10
6:   For j = i : y
7:    nf(x:y,:) ← f(x:y,:) * w(i);{Multiply weight vector w by each feature f}
8:    IF(j == y) & (j < 1000)
9:      y ← y + 100 ;
10:     x ← j + 1;
11: ElseIF (j > 1000)
12:    break;
13: end IF
14: end For
15: end For
16: xlswrite(file directory);

3.3 Similarity Comparison

There are various techniques to computed similarity between the query image feature vectors and the feature vectors of the image in the database. This study used the Euclidean distance because of its higher accuracy.

The similarity between the feature vector of query image and feature vectors of the images in the database is calculated by the formula [4]:

$$Ed(QI, DBI) = \sqrt{\sum_{i=1}^{n}(QI_i - DB_i)^2}$$

QI : query image feature.

DBI: Database image feature.

n: number of image in the database.

CHAPTER FOUR

EXPERIMENT RESULTS AND DISCUSSION

In this chapter, we present the evaluation of our proposed system that was introduced in the previous chapter. We compare our system results with other CBIR systems that use three feature or same image database.

4.1 Implementation Environment

The proposed CBIR is implemented using MATLAB (R2013a) version 8.1.0.604 with image processing toolbox on Intel Core 2.60 GHz processor with 8 GB of RAM and also using Wang database, which consist of 10 classes and each class containing 100 images mentioned in Chapter 3.

4.2 Performance Evaluation Metrics for CBIR System

For experimental results it is significant a suitable metric for performance evaluation. We have used average precision and it is defined as follows:

$$\text{Precision} = \frac{Number\ of\ relevant\ images\ retrieved}{Total\ Number\ of\ images\ retrieved}$$

4.3 Experimental Results

In this section, we present the experimental result of our work. For each experiment, we select the some query images randomly from different classes. Each query returns the top 10 images from the database. In particular, a retrieved image is considered a match if and only if it is in the same class as the query image. Present the six experimental results from our work.

4.3.1 Experiment (1): African People Class

Selected the query image from the African People class randomly and retrieve the most top 10 images that are similar to the query image. output is shown in Figure 4.1.
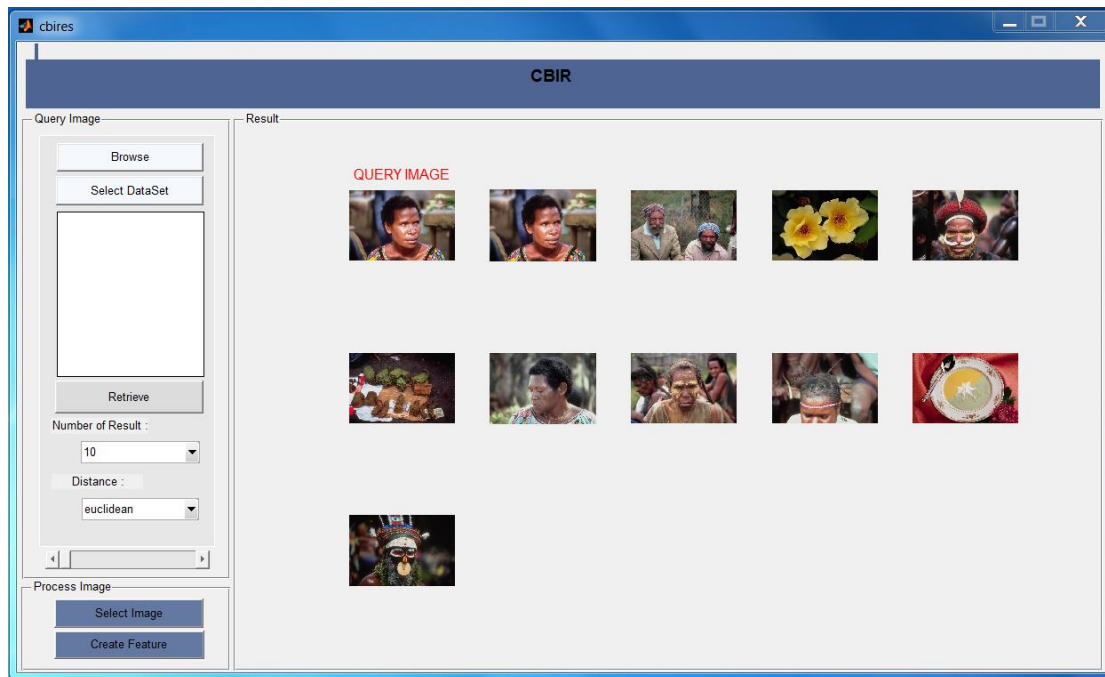

Figure 4.1 African People Query result

The result by the system are not relevant to query image. The retrieved images are belonging to other class of the query image, like Flowers, Food. So the system retrieves only a few correctly. Because number of relevant for the top 10 images retrieved is 8 relevant images and 2 irrelevant images for query image as African People.

4.3.2 Experiment (2): Building Class

Selected the query image from the Building class randomly and retrieve the most top 10 images that are similar to the query image. output is shown in Figure 4.2.
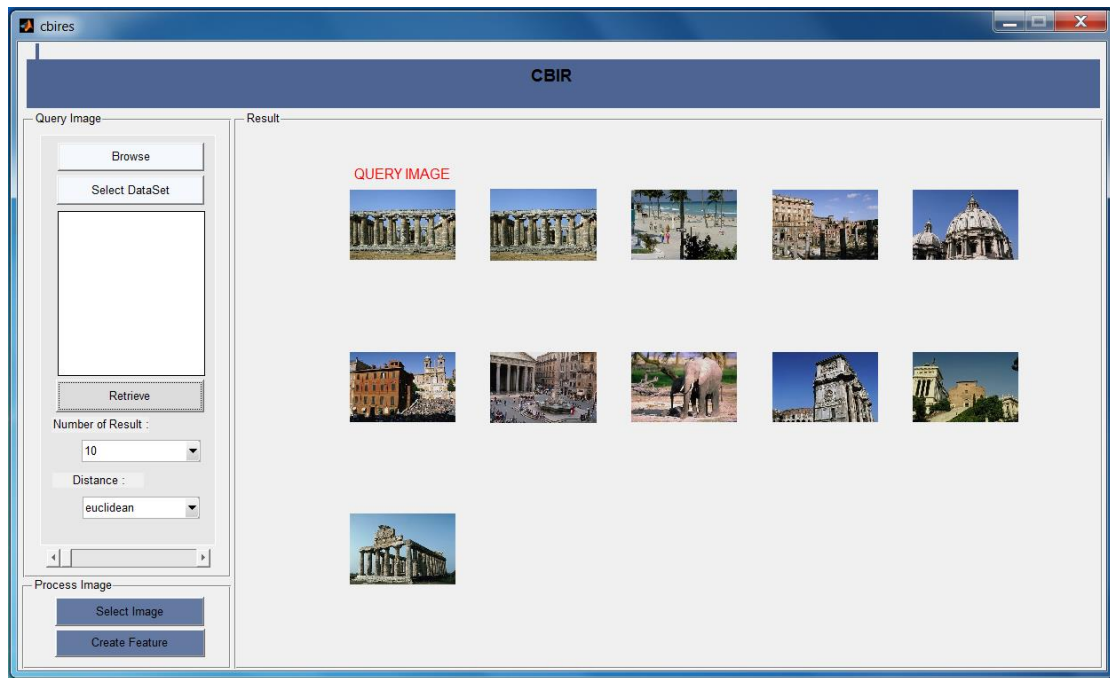
Figure 4.2 Building Query result

The result by the system are not relevant to query image. The retrieved images are belonging to other class of the query image, like Beach, Elephants. So the system retrieves only a few correctly. Because number of relevant for the top 10 images retrieved is 8 relevant images and 2 irrelevant images for query image as Building.

4.3.3 Experiment (3): Elephants Class

Selected the query image from the Elephants class randomly and retrieve the most top 10 images that are similar to the query image. output is shown in Figure 4.3.
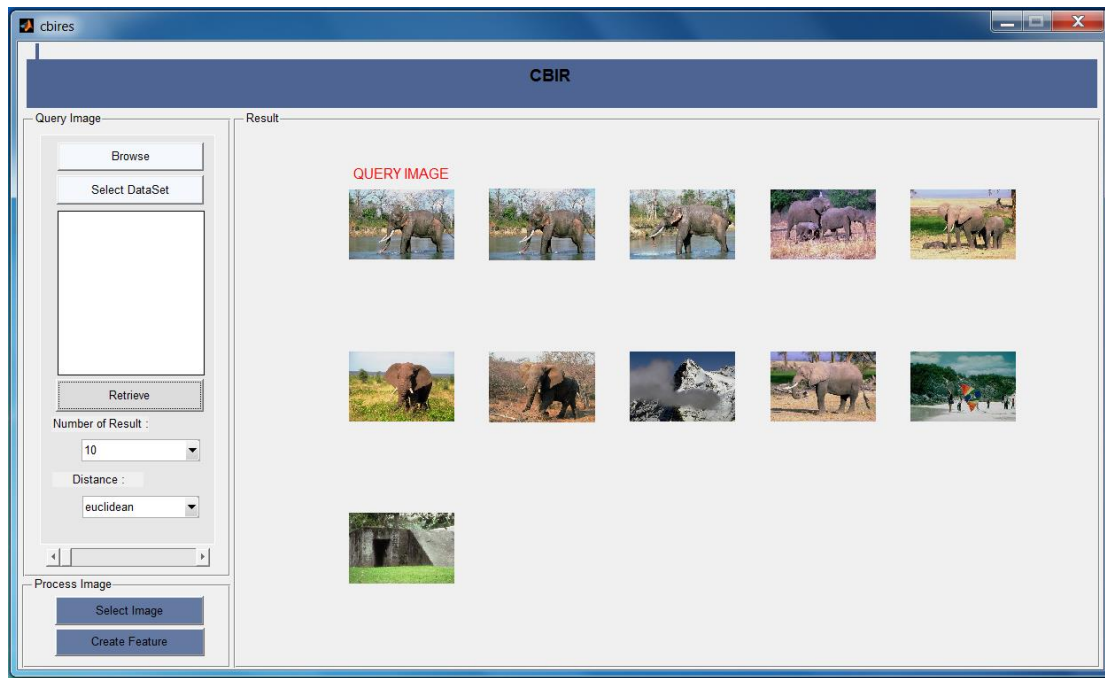
Figure 4.3 Elephants Query result

The result by the system are not relevant to query image. The retrieved images are belonging to other class of the query image, like Mountain, Beach, African People. So the system retrieves only a few correctly. Because number of relevant for the top 10 images retrieved is 7 relevant images and 3 irrelevant images for query image as Elephants.

4.3.4 Experiment (4): Flowers Class

Selected the query image from the Flowers class randomly and retrieve the most top 10 images that are similar to the query image. output is shown in Figure 4.4.
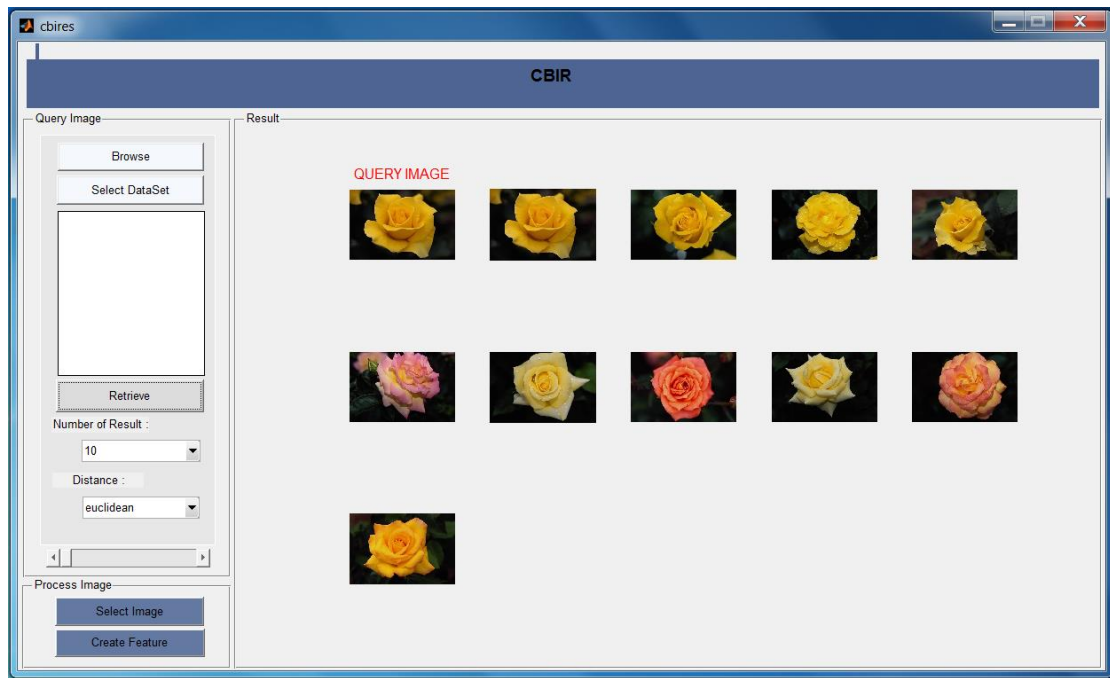
Figure 4.5 Flowers Query result

The result by the system are not relevant to some query image. The retrieved images are belonging to same class. So, the system retrieves almost all correctly. Because number of relevant for the top 10 images retrieved is 10 and 0 irrelevant images for query Images for query image as Flowers.

4.3.4 Experiment (5): Mountain Class

Selected the query image from the Mountain class randomly and retrieve the most top 10 images that are similar to the query image. output is shown in Figure 4.5.

Figure 4.5 Mountain Query result

The result by the system are not relevant to query image. The retrieved images are belonging to other class of the query image, like Beach. So the system retrieves only a few correctly. Because number of relevant for the top 10 images retrieved is 6 relevant images and 4 irrelevant images for query image as Mountain.

4.3.5 Experiment (6): Food Class

Selected the query image from the Food class randomly and retrieve the most top 10 images that are similar to the query image. output is shown in Figure 4.6.
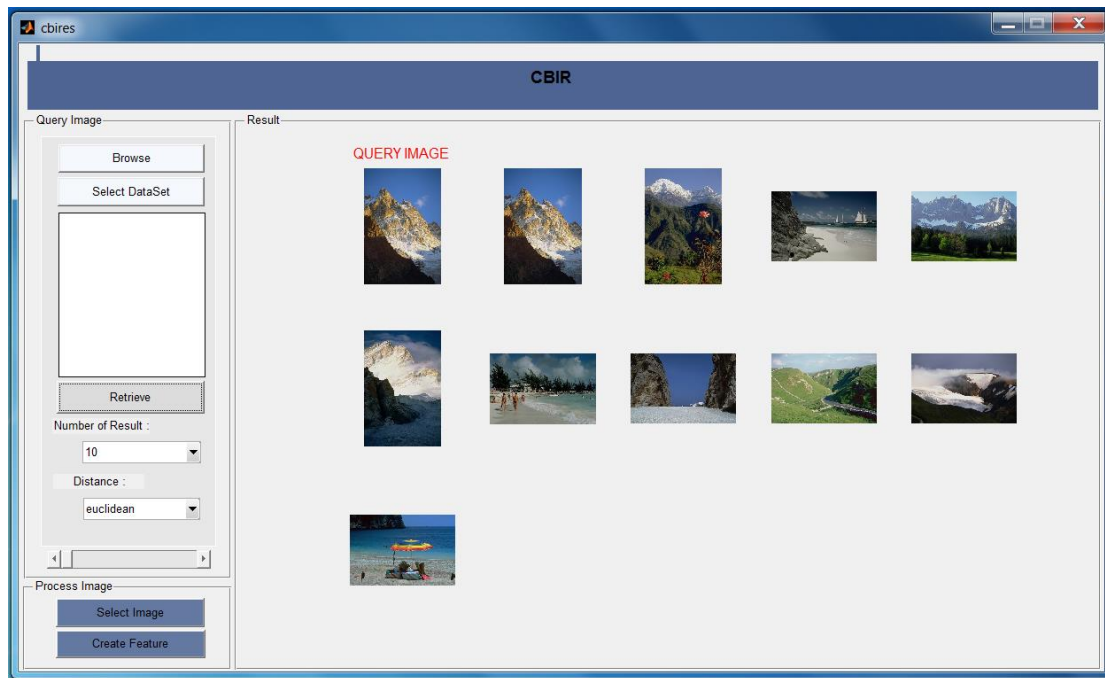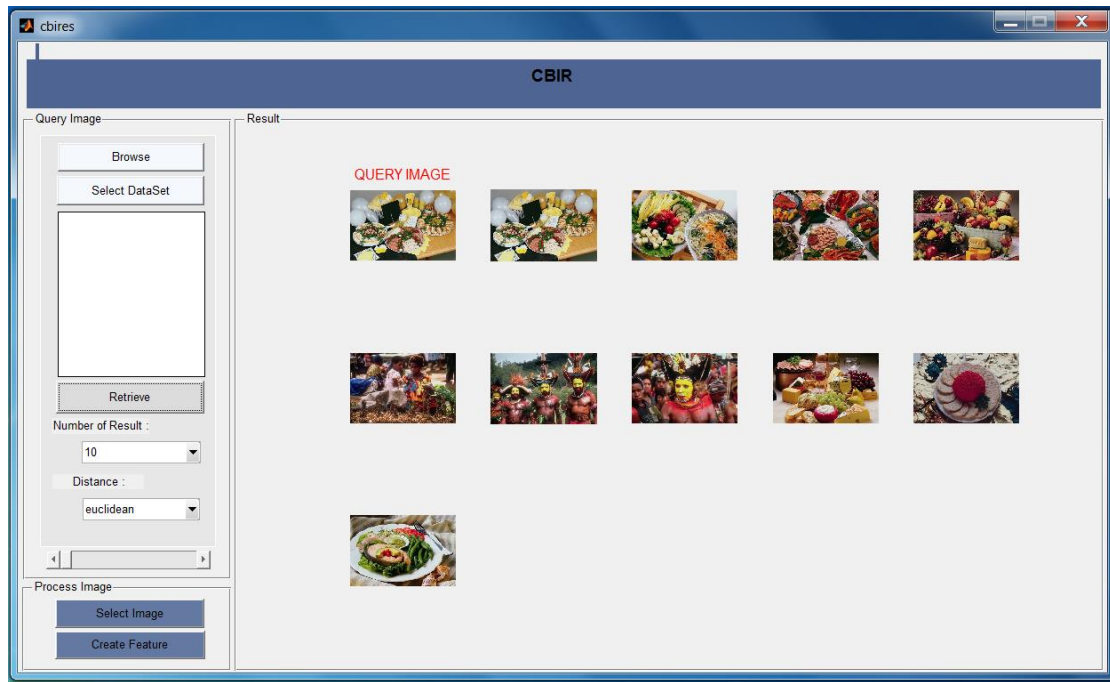
Figure 4.3 Food Query result

The result by the system are not relevant to query image. The retrieved images are belonging to other class of the query image, like African People. So the system retrieves only a few correctly. Because number of relevant for the top 10 images retrieved is 7 relevant images and 3 irrelevant images for query image as Food.

4.4 Retrieval Efficiency

We have improved the efficiency of the proposed system by assigning different weights to each feature. This process perform on the database as an offline step by select some images randomly from each class as queries and then we use the weight vector to multiply by each feature vector, the result of this process is new feature vector and save in database. We use the new feature vector to enhance the performance of the retrieve images and compute the total average precision of each query image. We applied these queries again without Re-weighting image's

feature vectors and a compared with result that obtained using Re-weighting.

Table 4.1: Comparing of the average retrieval precision obtained using Re-weighted features and without using Re-weighting features.

Class	Without Re-weighting Features	After Re-weighting Features
	Average Precision (%)	Average Precision (%)
African People	0.24	0.32
Beach	0.24	0.44
Building	0.36	0.68
Buses	0.4	0.48
Dinosaur	0.36	0.64
Elephant	0.6	0.76
Flowers	0.28	0.72
Horses	0.52	0.56
Mountain	0.28	0.36
Food	0.32	0.72
Total Average Precision (%)	*0.36*	*0.56*

From table 4.1, it is seen that the average precision(%) based on (color histogram + color moment + canny edge + Gabor filter) without Reweighted features is *36* and the average precision(%) based on (color histogram + color moment + canny edge + Gabor filter) with Re-weighted features is *56*. Thus the compared demonstrates clearly using

(color histogram + color moment + canny edge + Gabor filter) without Re-weighted features is lower performance than (color histogram + color moment + canny edge + Gabor filter) with Re-weighted features of image retrieval.

4.5 Comparison With Other Studies

In this section we evaluate the retrieval accuracy of our proposed system and compare with some of the existing CBIR system's results. The comparison of the proposed system with some other existing system that use three features to represent images. Our proposed system result is compared the performance of Amanbir Sandhu and Aarti Kochhar's method [39], Nupur Kandalkar et al [20] and Alexey Ponomarev et al [45]. The comparison is see in Table 4.2.

Table 4.2: Comparison of precision of the of the proposed system with other existed system

	Reference[39]	Reference[20]	Reference[45]	Proposed method
Average Precision(%)	30	50	57	**56**

The comparison results in Table 4.2 show that our proposed system performs better than other systems except for Reference [45]. This is good indicator for the effectiveness of our system.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

In this Chapter we present the conclusions from this thesis and some recommendation for future works.

6.1 Conclusion

In recent years, the quantity of the digital image collection is growing rapidly due to the development of the internet and the availability of image capturing procedures and devices. The problem appears when retrieving these images from storage media. Thus, image retrieval systems become efficient tools for managing large image databases. A content based image retrieval system allows the user to present a query image in order to retrieve images stored in the database according to their similarity to the query image. In this research, we have proposed a method for retrieval using the color, texture and shape feature of an image. The method used to extract the gray level feature is the histogram approach, and the color moments of the color distribution were calculated from the images and used as color descriptor. For texture features, we use Gabor Filter which is a powerful texture extraction technique in describing the content of image. The Canny's edge detection approach is used to extract the shape feature vector. To find the similarity between the images the Euclidean distance is used. The images are ranked according to the similarity value by using the sorting algorithm. To evaluated the performance of system, we used precision in retrieving the images. The efficiency of the system is improved through extraction of the feature color, texture, and shape and integrating them in one feature vector then calculate the similarity between the images. The final

similarity value is computed between the images after the assignment of the weights to the different features.

The experimental results showed that the proposed system has increased the average precision - retrieval accuracy - to 56%. This is better than the 36% result reported by other systems which combine these three features without weight assignment.

6.2 Recommendations

Although the research used different feature extraction techniques and assignment of the weights for the different features to give good results, but still the results are not highly satisfied to reduce semantic gap. There are a number of issues that can be improved in future:

1. The system architecture and modules used in this research. Can be further optimized

2. A generalized CBIR system which increase the system searching ability and provide more accurate results by combine different feature extraction technique and use other distance measure can be build and tested.

3. Reduce the semantic gab between the local features and the high level user semantic to achieve higher accuracy.

4. Improve the retrieval results by introducing feedback and user's choice in the system.

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