ISSN NO. 2320-5407

Journal homepage:http://www.journalijar.com
Journal DOI:10.21474/IJAR01

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

A comparative analysis of various approaches used for feature extraction in content based image retrieval.

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Manuscript Info

Manuscript History:

Received: 12 May 2016
Final Accepted: 29 June 2016
Published Online: July 2016

Key words:
Image retrieval, images, feature extraction,CBIR.

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Abstract

Image retrievalis a technique to retrieve images by utilizing the features of the image like color, shape and texture. Almost all of the current image retrieval or CBIR (content-based image retrieval) system allow for querying-by-image, a technique wherein animage (or a single feature of an image) is selected by the user as the query. The system extracts the features of the query image, searches for images with similar features in the database, and return relevant result in the form of image to the user in order of their similarity to query. Image retrieval is very useful in many areas like art collection, face finding, crime prevention, photograph archives etc. There are several techniques or algorithms that are used for feature extraction in content based image retrieval. This paper create a review of techniques or number of those methods that are used for feature extraction in content based image retrieval that are Color histogram, Color moments, Gabor filter, Wavelet Transform, Zernika Moment(ZM) ,Chain code etc.

Introduction:-

Content based image retrieval (CBIR) is a practical application or technique of for imageretrieval problem, for searching the digital images in large scale databases according to the user requirements[1].The content basedimage retrieval used for image retrieval based on their visual content, normally called as image features. The basis for content based image retrieval is basically its low-level features (like color, shape, texture) [2]. There are mainly two frameworks of image retrieval: text-based, content-based. Text -based are used high level semantics like text, keyword, descriptor etc. & content based used low-level image features. To retrieve images using CBIR, users provide the retrieval system with example image (query image) as represented in figure 1. Content based image retrieval is a task of searching images from a database and retrieval of an image based upon their feature matching that are similar to a given example or query image. Content-based image retrievaluses the visual contents of an image such as color, shape, texture, and spatial layout to represent and indexthe image [3]. In typical content-based image retrieval systems, the features of the images in the databaseare extracted. The features of the query image are matched with the image feature database and desired results are provided to the user.

The CBIR system consists of following components: [4]

- **Query image**: it is the input image to be search in the image database to retrieve the similar image present or not.
- **Image database**: it contains n number of images depends upon user choice.
- **Feature extraction**: it extracts low-level features from the image (color, shape, texture) and saves them in database.
- **Image matching:**the feature of each image is matched with query image.

- **Resultant retrieved images:** it retrieves the images that are very close to query image based upon their similarity. Figure1 given on a next page shown the basic framework along with these components.

Applications of CBIR are following: [6]

- The advantages of such systems that help the user for searching a particular image throughbrowsing on the web.
- Various types of professionals like police force for picture identification in crime prevention.
- Medicine diagnosis.
- Architectural and engineering designs.

User:-

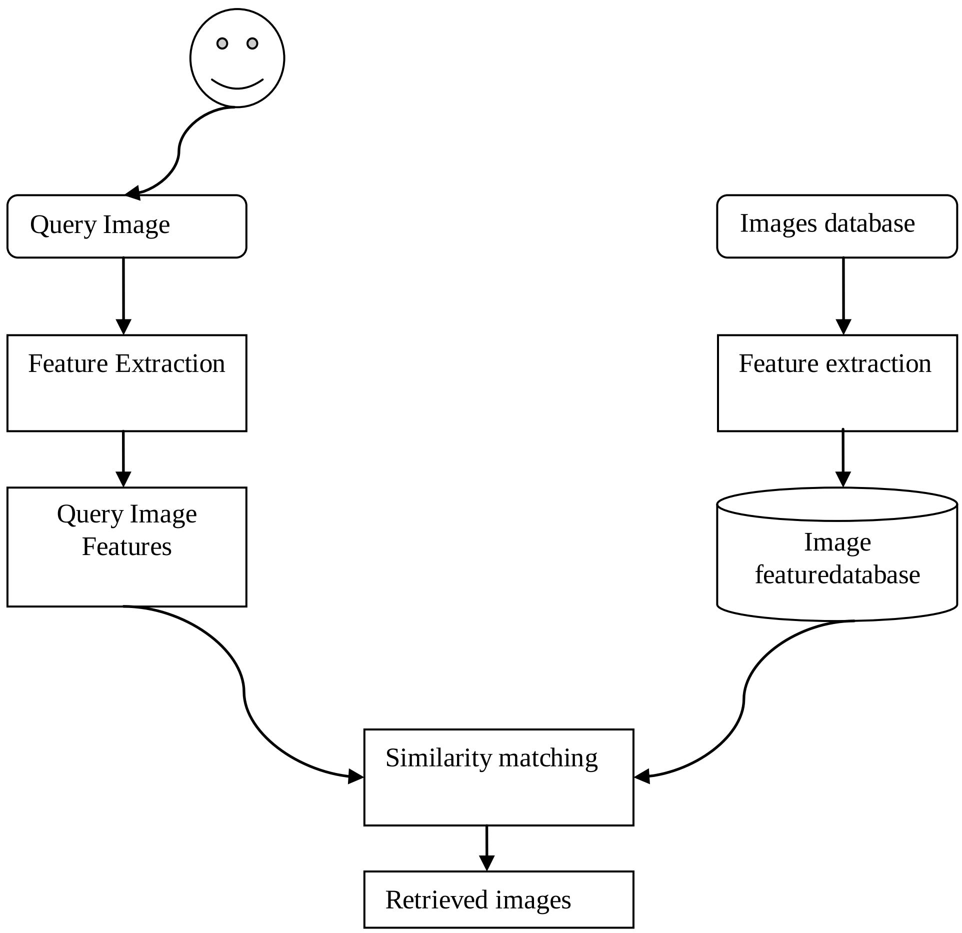

Figure 1:-Basic framework of content-based image retrieval

Steps used in image retrieval phase are as follows:

- Step 1: input the query image.
- Step 2: extract the features of query image (color, texture,shape).
- Step 3: combine these features for matching process.
- Step 4: compare these features with the features that are stored in thedatabase.
- Step 5: display the relevant result according the image similarity.

Feature extraction

Feature extraction is defined of extracting compact but semantically valuable information from images. This information is exploited as a key signature for the images. Similar images should have similar signatures. This section includes retrieval of images based on image features that include mainly two kinds:

1. Visual features
2. Semantic features

If we look at the image shown in figure 2, the white color and the texture of the building are feature properties. As alike, the sky can be described by its blue color. Furthermore, we can take the size of the objects in the image into account. Mainly extracted features are: texture, shape, and color, for image retrieval.[12]

Representation of images needs to identify which features are most useful for representing the content of images and which methods can effectively code the features of the images.

Figure 2:- Example of image properties[16]

Feature extraction of the image within information is often conducted off-line therefore computation complexity is not a significant issue.

Low-level image features:-

Many refined feature extraction algorithms havebeen designed and good sights are available. Here we define the features used in CBIR:

Color feature:-

Color feature of image is an important or one of the most commonly used features in image retrievalfor examining image because of its fast computation[5]. There are many methods for color feature representation like color histogram, color moments, color sets [7].

Texture feature:-

Texture is not well-defined as color features. Some systemsdon't use texture features because it is difficult to represent texture.[2]However, texture provides necessary information in image classification as it describes the content of many real-world images such as fruit peel, clouds, trees, bricks, and fabric etc. Texture features commonly used in image retrieval systems include spectral characteristics, like features obtained using Gabor filtering or wavelet transform, statistical features.

Shape:-

Shape is a fairly well-defined concept. Shape features ofgeneral applicability include Fourier descriptor, Moment invariants, consecutive boundary segments[2] etc. Shape features have shown to be useful in many categories of applications like shape retrieval, shape alignment and shape approximation. [13] Shape may be defined as the characteristic surface configuration of an object. [6] Shape representations can be generally divided into two categories:

Boundary-based, and region-based:-0

Boundary based involves the external features or pixels at outer boundary of the object, whereas region-based involves

The internal features of the region selected.

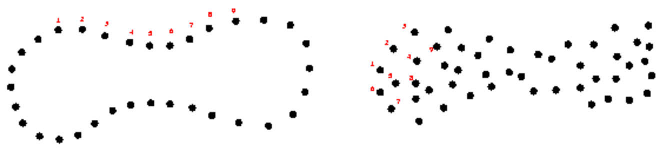

Figure 3:- Boundary-based & Region-based[6]

Feature extraction techniques for image retrieval:-

Color feature:-

Color is the basic feature captured by human eye. Color is mostly represented by RGB (red, green, blue). Following methods are used for color feature extraction:

Color histogram:-

The most popular and robust technique to represent color as a feature in CBIR is color histogram. The histogram represent the color of an image.in color histogram quantization process is used which combine similar color pixels into a single bin, which reduces the space required to store histogram detail. [16] The number of pixels that has same color is given by value of each bin [5].The problem with this method is that as a feature for a particular image we have to store the whole histogram. Another problem is this, suppose we have two different images having same color histogram it will not be retrieved correctly this is shown in following figure.[8]

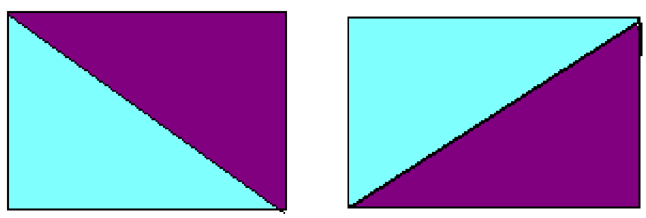

Figure 4:- Two images having same color histogram.

Due to its easy computation, it is very useful in indexing and retrievalof image database. Colorhistogram is very efficient and effective. There are twotypes of color histogram which are the global featureindex and the local feature index[9]. Global feature index represent whole image while local feature index concentrate on parts of the image.

Color moments:-

Moments are defined by expectation of random variable. Color moment has lower computational complexity andlower feature vector dimension. As a color feature we have taken three moments of HSV color model. First thing we need to do is convert RGB image to its equivalent HSV image. We have taken moment upto its third order. Finally we have calculated three moments of each of the three components of h, s and v image. Hence we are storing dimensional feature vector.

This process is summarized in following steps:
Step 1: convert image in HSV format.
Step 2: equalize h, s and v image.
Step 3: find three moments of h, s and v image.
Step 4: three moments are mean, variance and skewness.
Step 5: combine these moments in a single 9 dimensionalfeature vector. [8]

Color correlogram:-

Acolor correlogram is a table indexed by color pairs, where the kth entry for (i, j) specifies the probability of finding a pixel of color j at a distance k from a pixel of color i in the image [7]. Let i represent the entire set of image pixels and ic ((i)) represent the set of pixels whose colors arec(i).Then, the color correlogram is defined as:

$Y(i, j)^{(k)} = pr_{p1€c(i).p2€i}\ [_{p2\ €ic(j)}|p1\text{-}p2|=k]$
Where i, j€{1, 2 …, n}, k€{1, 2 …. D}, and | p1– p2 | is the distance between pixels p1 andp2.
If we consider all the possible combinations of color pairs the size of the color correlogram will be very large (o(n2d)), therefore a simplified version of the feature called the color autocorrelogram often used instead. The color autocorrelogram only captures the spatial correlationbetween identical colors thus reduces dimension to o (nd).[7]

Texture feature extraction:-There are some techniques for texture feature extraction. These are explained as:
Extraction of texture using wavelet texture features:-
Wavelet transformation forms the image into a multi-scale representation withboth spatial and frequency characteristics. This allows foreffective multi-resolution capacity, image analysis with lower computational cost. [5] Unlike Fourier transforms that uses of sine functions to represent signals. In wavelet transform, we use functionsknown as wavelets, wavelets are restricted in time, yet theaverage value of a wavelet is zero [8]. Wavelets provide good energy compaction and multi resolution capacity, so retrieve both shape and texture efficiently. [5] In a sense, a wavelet isa waveform that is limited in both frequency and length. While the Fourier transform change a signal into acontinuous series of trigonometric function waves, each of which is of constantfrequency and amplitude and of infinite duration, most real-worldsignals such as music or images have a finite durationand abrupt changes in frequency. As compared to this wavelet transform has better efficiency. This is because wavelettransforms convert a signal into a series of wavelets, whichcan be stored more efficiently due to finite time, and can beconstructed with rough edges, thereby better approximating real-world signals [8].Examples of wavelets are coiflet,morlet, mexican hat, haar and daubechies. Discrete wavelet transform changes an image in four dissimilarparts horizontal, vertical, diagonal and one approximaterepresentative image. This following figure has shown this decomposition. Further decomposition may result indifferent texture pattern. L represents low frequency and H represents high frequency.

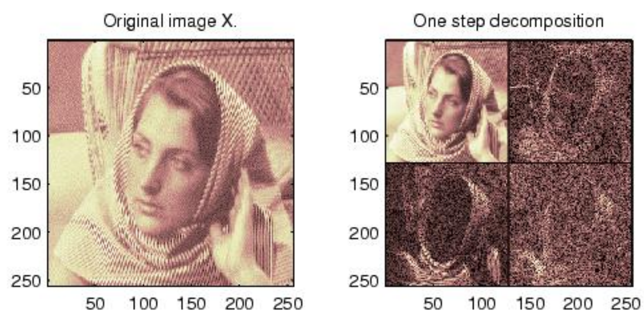

Figure 5:- 2d discrete wavelet transform in matlab

Step 1: apply first level decomposition and divide the image in 4 subparts i.e. HH, HL, LL and LH.
Step 2: apply second level decomposition and again decompose LL into four subparts i.e. HH1, HL1, LH1 and LL1. Apply gird level decomposition and again decompose LL1into its 4 subparts HL2, LL2, LH1 and HH2.
Step 3: take mean and variance of total 10 images i.e. HH, LH, HL HH1, LH1, HL1, HH2, LH2, HL2, LL2 and store as a feature vector of texture.[8]

Extraction of textures using Gabor filter:-
Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequencyand orientation representation of gabor filter are found to perform better than wavelet transform and particularly appropriate for texture representation anddiscrimination. [16]

The feature extraction process using gabor filter is asshown in following steps.
Step 1: convert the image into gray scale image.
Step 2: make Gabor filter using different phase angles and frequencies. Apply total 12 Gabor filterto database image with frequencies 2, 4, 8 and phases 0, pi/4, pi/2 and 3pi/4.
Step 3: calculate mean and standard deviation for each and every filtered image and store in feature vector. [8]

Shape feature extraction:-
Content based image retrieval (CBIR) systems based on shape using moment invariant and zernike moment.

Moment invariants (MI):-

MI is poor in the representation of image shape due to its non-orthogonality. [10] Moment invariants (MI) are also called geometric moment invariants. Geometric moments, are the only of the moment function with the basisψpq=$x_p y_q$, whereas complete, isn't perpendicular. Geometric moments perform $m_{pq}$of order (p+q)) is given as:
$M_{pq}= \sum x \sum y x_p y_q(x,y)$ p,q=0,1,2…
The geometric central moments, that are invariant to translation, are outlined as
$\mu_{pq}=\sum x \sum y$ ()x-x-p(y-y)q f(x,y) with p,q=0,1,2...

whereverx-=m10/m00and y-=m01//m00

MI is computationally simplest. Furthermore, they are constant to rotation, grading and translation. However, they have many cons [11]:
• Information redundancy: because the basis is not orthogonal, these moments suffer from a high degree of information redundancy.
• Noise sensitivity: higher -order moments are tender to noise or any distortion.
• Large variation in the dynamic range of values: since the basis involves the power of p and q, the moments computed have large variation in the dynamic range of values for different orders. This may cause numerical errors when the image size is large.

Zernike moments (ZM):-
Orthogonalmoments, viz. ZM can be used to represent an image with minimum amount ofredundancy. [10] Orthogonal moments allow for correct reconstruction of the image, andmakesbest utilization of shape details. ZM have many suitable characteristics like rotation invarianceand robustness to noise. The complex ZM are derived by projecting the image function onto an orthogonal polynomial over the interior of a unit circle.

Zernike moments (ZM) have the following advantages: [13]
• Rotation invariance: the magnitudes of zernike moments are invariant to rotation.
• Robustness: they are robust to noise and small variance in shape.
• Expressiveness: since the basis is orthogonal, they have minimum information redundancy.

ZM also have some disadvantages:
• Co-ordinate space normalization: where the orthogonal polynomial is defined the image coordinate space must be changedto the domain.
• Computational complexity: as the order becomes large computational complexity also increases.

Chain code:-
Chain code is a commonly used approach for representing different shapes as line-drawings, planar curves, or contours. Chain code describes an object by a sequence of unit-size line segments with a given orientation& can be viewed as a sequence of straight-line segments with corresponding length. [13] First introduced a chain code that describes the movement along a digital curve or a sequence of border pixels by using 8-connectivity or 4-connectivity. By encoding relative, rather than absolute position of the contour, the basic chain code is invariant to translation. We can match boundaries by comparing their chain codes, but it contains two main problems: 1) it is very sensitive to noise; 2) it is not rotationally invariant. To solve these problems, (DCC) differential chain codes and resampling chain codes (RCC) were proposed.

Table 1:- Comparative analysis of techniques used for feature extraction in content-based image retrieval

Features	Techniques	Advantages	Disadvantages
Color feature	Color moment	Easy to compute.	Low retrieval performance, no spatial info.
	Color histogram	Simple & fast computation.	Spatial information is not included.
	Color correlogram	Include spatial information.	High computational cost, sensitive to noise.
Texture feature	Wavelet transform	Reduction of noise pixels, multi-resolution capacity, bounded in both frequency and	Loss of generality.

		duration.	
	Fourier transform	It is easy to implement &based on well- developed Fourier analysis.	Constantfrequency and amplitude and of infinite duration.
	Gabor filter	Retrieval performance high.	Computationally intensive.
Shape feature	Moment invariant(MI)	Invariable to translation & rotation.	High degree of info. Redundancy, very sensitive to noise.
	Zernika moment(ZM)	Robust to noise, minimum info. Redundancy.	More computational complexity.
	Chain code (CC)	Reduce storage volume.	Very sensitive to any distortion.

Literature review:-

Ying Liu et al. [2007]:-

In this research paper author has presented content-based image retrieval using high-level semantics. The author has identify five salient categories of the state-of-art techniques in reducing the 'semantic gap': (1) utilizing object ontology to characterize high-level concepts (2) utilizing machine learning techniques to link low-level components with query concepts (3) utilizing important relevance feedback to learn user's intention (4) producing semantic layout to map low-level feature to high-level concepts (5) combining the confirmations from textual and visual features of images for image retrieval on web [2].This paper also provide useful perceptivity how to obtain major low-level features to help semantic gap reduction.[2]

Ka-Man Wong et al. [2007]:-

In this paper author proposed a new dominant color structure descriptor (DCSD). In this paper a single compact descriptor used to represent both color and spatial structure detailof images. It is a combination the two techniques: 1. Dominant color descriptor (DCD), which extracts the features by clustering the colors. DCD sacrifice retrieval accuracy due to lack of spatial details; 2. Color structure descriptor (CSD) based on color structure histogram. It provides more accurate retrieval than DCD because of including spatial information but fixed. Color space requirement results redundancy. Experimental results show that DCSD has significant improvement on both descriptor size and retrieval performance. [15]

Dr. H.B.Kekre et al. [2010]:-

In this paper author present a content-based image retrieval using texture feature. The proposed system describes three major algorithms: 1. Gray level co-occurrence matrix (GLCM), 2. Lindo-buzo-gray (LBG), 3. Kekre's Proportionate Error (KPE). LBG and KPE algorithms are used for texture feature extraction and results are also compared with GLCM. This paper additionally provides the clear distinction between LBG and KPE. The procedure in both these algorithms is same but in KPE by adding proportionate error the disadvantage of the LBG inefficient clustering is overcome. [14]

Duraisamy Yuvaraj [2013]:-

In recent years the interest on searching digital images is greatly increased. The researcher in this paper analyse attributes of images and provide efficient image retrieval by measuring the degree of similarity. Most commonly images are retrieved based on visual features like color, shape and texture of an image. The proposed technique evaluate the similarity of each image in the database to the query image in context of color, shape ortexture and returned the images that have desired range of similarities or very close to the query image. [3]

Table2:- Comparison of Previous work

Sr. No.	Name of author	Technique used	Function of technique	Features Extracted	Results
1.	Ying liu et al. [2007]	High-level semantic based image retrieval.	This paper attempts to provide the survey of techniques used for reducing 'semantic gap'.	Semantic gap	Smaller the rank of image, better the performance.
2.	Ka-man Wong et al. [2007]	Dominant color structure descriptor (DCSD).	It provides an effective way to represent both color & spatial detail of an image with single descriptor.	Color & spatial structure information	It gives better retrieval performance and descriptor size that original DCD.

3.	Dr. H.b.Kekre et al. [2010]	Gray level co-occurrence matrix (GLCM), LBG, KPE.	To extract the texture feature for image retrieval using LBG & KPE. Results are also compared with GLCM.	Texture	KPE perform better than LBG by eliminating the inefficient clustering. Precision & recall is much better than GLCM.
4.	Duraisamy Yuvaraj [2013]	Multiple attribute.	The main purpose of it is to analyse visual features of an image & provide result based on similarity.	Color, shape, texture	It is evident that combination of several attributes leads to better result than single one.
5.	Joby Elsa Abraham [2015]	Dominant color using a clustered database.	It is used to extract color feature. A new clustered & indexed database used to reduce retrieval time complexities.	Color	Precision and recall values interpolated. Time taken for retrieval is less than other systems.

Joby Elsa Abraham [2015]:-
In recent years the importance and increase of digital images had a large increment. During the searching process the color feature of the image is one of the important characteristic. To extract the color feature of an image a new method is introduced known as dominant color extraction scheme. After extracting dominant color quantization is used, based on quantized value cluster the database and do the indexing to store the images. Query image is searched by identifying the cluster. With the proposed feature experiment results found that precision ofretrieval has improved and time complexity of retrieval is reduced. [11]

Conclusion:-
Content based image retrieval using image feature is very versatile subject of discussion. This paper proposes evaluation of many image retrieval techniques. And result varies according to the used approach. The main focus of proposed work is to show the comparative study ofdifferent techniqueused in image retrieval. From above study we identify that image retrieval is that area in which people show their interest due to its application of fast retrieval with less time. A clear idea from this review paper is that various image retrieval systems are providing society with new and improved methods of identifying and retrieving images, which are helpful in making our work easy in any field .This paper may provide as a platform for further research areas in content-based image retrieval.

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