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A Review on CBIR Analyzing Various Feature Extraction Techniques and Distance Metrics

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***Abstract* - Due to tremendous growth of digital imaging and internet technology, development of efficient and intelligent techniques for image retrieval from large image data sets has become an important research issue. This paper presents a review on various methodologies used for feature extraction, similarity matching and image retrieval. The paper starts with discussing a generic CBIR system. Various types of image features are discussed further. This paper reviews the rise in efficiency of accurate image retrieval when color, texture, shape and spatial information features are used combinedly. Finally we analyse and compare various methodologies so as to understand their advantages.**

***Index Terms - Content Based Image Retrieval, Features Extraction, Retrieval System*.**

I. INTRODUCTION

According to the sixth edition of Business Cloud DOMOs' report, there are 2.5 quintillion bytes of data created each day at our current pace, but that pace is only accelerating with the tremendous rise in the field of the Internet of Things (IoT). In the last two years itself, 90 percent of the data in the world was generated. In this digital era, most of the data generated is in multimedia form. Some of the major sources of these huge image collections are facebook, twitter, instagram, google and many more. But the major challenge we face is in retrieval of these images as per the requirement.

In the past, the image retrieval from image databases was done using Text Based Image Retrieval (TBIR) systems. TBIR is based on keywords or description surrounding the images, that describe how the image is. These keywords are also known as 'tags' or 'metadata' associated with the image. Initially a query image is submitted and based on the keywords associated with the query image, the images from the database with similar keywords are retrieved. Google, one the famous search engines, were using the text based approach for image retrieval in earlier days. Text based approach assumes that each image has an associated tag to it. But this approach fails in case of large databases where users can upload their own files without any keywords or tags assigned to the image file. So the only solution was to manually add labels to the images. But this task of manually labeling the images with associated tags is time consuming and error prone. Another disadvantage of this method is the semantic gap between the user keywords or tags and the visual content of the image. For example, if a user submits a query "amazon", he may be looking for the picture of 'Amazon kindle' or he may be looking for 'Amazon jungle'. To overcome this semantic gap, we needed an approach which includes the visual contents of the image in the query rather than user specified tags.

Above limitations were overcome by the Content Based Image Retrieval (CBIR) system which is also known as Query By Image Content (QBIC). In content based approach, visual contents of the image which are also known as features of the image are used for similarity matching. Features such as color, shape, texture and spatial information are extracted from the query image and are compared with the database image features. In this way we can get more accurate retrieval of images from large databases as compared to the traditional text based approach.

II. GENERIC CBIR MODEL

The term CBIR originated in 1992, when it was used by T. Kato to describe experiments into automatic retrieval of images based on color and shape characteristics, from large databases. Generally, the term is used to describe the process of retrieving images similar to query images from a large collection on the basis of image features.The techniques, tools and algorithms that are used were adopted from fields of statistics, pattern recognition and machine learning.

content-based visual information retrieval also called CBIR, is the application of computer vision techniques to the image retrieval problem, that is, the problem of searching for digital images in large databases. Here 'content-based' means that the search will analyse the actual contents of the image. The term 'content' in this context refers to color, texture, shape or any other information that can be derived from the image itself.

A generic CBIR system has following steps:

1. *Collection of Database:* A database containing a number of images is required.
2. *Query:* Provide an image as a query.
3. *Feature extraction:* Various features such as color, shape, texture, etc are extracted from query image as well as images in the database, based on the system requirement.
4. *Similarity matching:* It includes comparing these features to yield a result that is visually similar. Distance is used commonly as a similarity measure. There are different distances available such as Euclidean distance, City Block Distance, Canberra Distance and Manhattan distance.
5. *Retrieval:* The system provides a ranked and ordered images retrieved from database based on similarity measures.

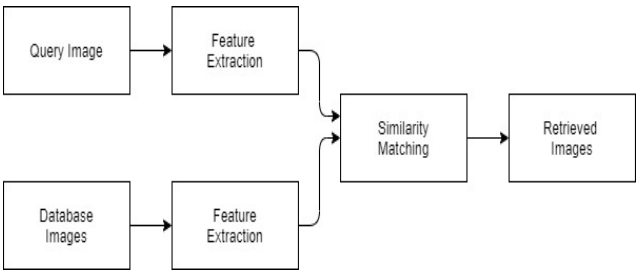

Fig 1. Generic CBIR Model

III. Types of Image Features

Features are the facts or data extracted from images in terms of numerical values that are difficult to understand and correlate by humans. Suppose we consider the image as a huge information, the facts extracted from the data are known as features. Mostly, features extracted from an image are of lower dimension compared to that of the original image. Dimensional reduction decreases the overheads of processing the bunch of images.

There are two types of features that can be extracted from the images namely local features and global features. Features are also known as descriptors. Global descriptors are mostly used in image retrieval process, object detection process and classification methods, whereas the local descriptors are used for object recognition or identification scenarios. There is a huge difference between object detection and object identification. Detection is finding the existence of an object i.e. whether an object exists in image or not while recognition is finding the identity of an object.

Global features describe the image as a whole to the generalize the entire object whereas the local features describe the image patches i.e. key points in the image of an object. Global features consists of contour representations, shape descriptors, as well as texture features whereas local features include the texture in an image patch. Some examples of global descriptors are Shape Matrices, Invariant Moments, Histogram Oriented Gradients (HOG) and Co-HOG. Whereas some examples of local descriptors are SIFT, SURF, LBP, BRISK, MSER and FREAK.

For low level applications like object detection and classification, we use global features whereas for higher level applications like object recognition, we use local features. Combining of global and local features increases the accuracy of the recognition at the same time increasing the computational overheads.

Furthermore features are also classified into three types in image processing, that is low, middle and high. Low level features are color and texture. Middle level feature is shape. And a high level feature is the semantic gap of objects i.e. spatial information.

A. *Color Features*

The commonly found features in an image are the color features. Color is one of the intuitive feature which plays an important role in image matching. Color features are generally used widely for similarity matching because of their ease of availability and fast computations. Almost all image retrieval systems use color space, histogram, moments, color coherence vector, and dominant color descriptor to represent color. Color features are extracted using various techniques namely color histogram and color correlogram [20].

A color histogram indicates the distribution of colors within an image file. For digital images, a color histogram shows the number of pixels that have colors corresponding to each of a fixed set of color ranges, that span the image's color space and the set of all possible colors. The color histogram can be built for various kinds of color space, but is generally used for three-dimensional spaces like RGB or HSV. The main drawback of histograms for classification is that the representation does not take into account the shape and texture of the object being studied. It dependents solely on the color of the object being studied.

The spatial correlation of colors is represented in the color correlogram, which is be used to show the global distribution of local spatial correlation of colors.

B. *Texture Features*

Texture is a feature which partitions the images into regions of similar interest and cluster them together. Texture provides Spatial information regarding the spatial arrangement of colors or intensities in an image. Texture is distinguished by the spatial distribution of intensity levels in the surrounding neighborhood. As texture represents a repeating pattern of local variations in image intensity, it cannot be defined for a point alone.

For example, below image has a 50% black as well as 50% white distribution of pixel intensities.

Fig 2. Texture variation

These three different images having the same intensity distribution, but have different texture patterns .

Texture consists of texture primitives or texture elements, known as texels. Texture is often described as fine, coarse, grained, smooth, etc. Such features are present in the tone and structure of a texture. Tone is dependent on pixel intensity properties in the texel, whereas structure represents the spatial relationship between texels.

A gray level co-occurrence matrix (GLCM) contains data about the positions of pixels having same gray level values. Texture of an image can be defined using three methods namely structural approach, statistical approach and texture segmentation. Moreover wavelength transforms are used for texture features.

C. *Shape Features*

Shape is a very powerful middle level feature. An object can be recognized from its boundaries. It can be defined as the structure of an object regardless of its position, orientation, color and size. Hence, shape features are invariant to translation, rotation as well as scale in an effective image retrieval system.

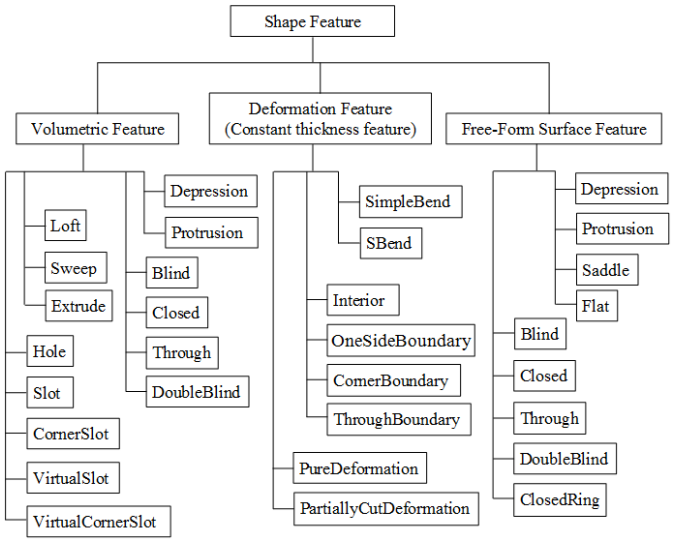

Fig 3. Shape features

D. *Spatial Features*

Spatial data indicates the shape, size and location of the features. Spatial features would be features which exploit location or spatial information. In case of images, an example would be the dense Locally Binary Pattern (LBP) features in which an image is divided densely from a grid where for each grid box, the LBP feature is extracted. This is specially useful for face recognition in which case the location of different facial parts are to be in order.

Spatial location is also important and is used for region segmentation. Spatial location is described as top/bottom, top left or right and back or front as per the position of an object in an image. Consider an example where the sea and sky may have the same characteristics of texture and color but the spatial information is not the same. Sky typically represents the above portion and sea is at the below portion of an image. Hence, the spatial information of various objects in an image indicates important information for retrieval of images.

IV. Related Work

Khawaja Tehseen (2019) et. Al proposes the CBIR method using object and color signatures. Initially the image is converted into grayscale image. This grayscale image undergoes image convolution with gaussian of variance in order to remove the noise and enhance the image structure. Mexican Hat Function Approximation (MHFA) is used for detecting similar regions in the image(spatial information). Principal component analysis is used to reduce the feature vectors into a set of linearly uncorrelated variables. RGB channels are used to gain information of the color feature vectors. Bags-of-words architecture is used to represent features of image which increases the accuracy of similarity matching and forms a cluster of similar images. The system showed high precision and recall results on Caltech-101 and Corel=1000. However, the method was unable to report significant results due to the clustered background objects and overlay texture information [1].

In [2], a CBIR method is proposed which uses color features by calculating gray histograms of the images. Here, Bhattacharyya Distance is used to measure the similarity between the query image and database images. The proposed system shows fine refinement in the accuracy compared to the traditional CBIR systems.

S. Selvam (2017) et. Al proposed a more generic CBIR system using color, shape and texture features. Color moments were used as a color similarity measurement between images. Gabor filters were used for extracting texture features. Edge histogram features were used as shape descriptors. Above three descriptors were combined and optimized using genetic algorithm and HARP clustering

algorithm was used for classification of images. Proposed system showed that the precision and recall parameters increased with the number of features increased (best result was obtained with color, texture, shape features together)[3].

Nikhil Chaturvedi (2014) et. Al proposed method which combines the concept of Texture based Image Retrieval system and clustering based on color component. Fuzzy clustering algorithm was used to represent color clusters of image. Each R,G,B colors had respective five subclusters namely very low, low, medium, high and very high to represent the degree of appearance for each color. Texture features namely energy, entropy and contrast were used in this method of retrieval. This system showed higher efficiency than the Texture Based CBIR and Color Based CBIR alone[4].

K. Kamala (2018) et. Al proposed a content based IR system using Gray level Co-Occurrence Matrix (GLCM) and Binary Threshold Histogram (BTH). GLCM features determined the texture of an image whereas color feature description was provided by BTH. Euclidean distance was used as a similarity measure between the features of query image and database images. Also a genetic algorithm was used to reduce the feature set [5].

Yinghui Zhang (2018) et. Al proposed a CBIR system dedicated to finding similar patients with Breast cancer. Gray-Level Co- Occurrence Matrix along with histogram and correlation coefficient is used for creating the CBIR system. Texture and color features are used along with shape descriptors [7].

Priyanka Saxena (2018) et. Al proposed a CBIR system which uses a combination of color, texture and edge features. Color features are extracted using first and second order color moments. Local Binary Patterns (LBT) are used for extracting texture features. Canny Edge Detector is used for edge detection along with Gaussian Blur which reduces the image noise and speckles. The fusion of SVM along with color, texture and edge features reduces the retrieval time. Relevance feedback is used to reduce the semantic gap between the low level and high level feature [9].

Shubha .G. (2017) et. Al proposed a CBIR system for classifying satellite images with a similar query image. Initially the images are segmented into several parts using J-seg algorithm and then a region based representation is built for each image. Texture features are extracted by Gray Level Co-occurrence Matrix and used for comparison. At the end, Bayesian classifier which classifies images using a probabilistic approach is used for retrieving end results.[18].

S. S. Tadasare (2018) et. Al proposed a system which uses a hybrid feature along with various distance measures for content-based image retrieval. Color correlogram, color moments and color histograms are extracted as color features. Stationary wavelength transform, Binarized Statistical Image Features and Gabor wavelength transform are extracted as texture features. Color and Edge Directivity Descriptor which uses color and texture information into single histogram bin are used for reducing the feature sets. This experimentation was carried out with Euclidean distance, City Block Distance, Minkowski Distance, Mahalanobis Distance and Chebyshev Distance anong which Euclidean Distance showed higher precision result [13].

S. Rubini (2018) et. Al proposed a CBIR system depicting color features using color descriptors to obtain better retrieval efficiency from large databases. Initially the RGB query image is converted into grayscale image and then four morphological gradients of edge maps are generated. Seven moments of each edge map are calculated i.e. total 28 features are stored. Based on the minimum distance metrics top ten images are retrieved. Canberra Distance is used for similarity matching. [19].

V. COMPARISON TABLE

TABLE I
COMPARISON BETWEEN TECHNIQUES

Sr No	Paper	Methods Used	Features Extracted	Evaluation Parameter	Advantages
1	Convolution, Approximation and Spatial Information Based Object and Color Signatures for Content Based Image Retrieval.	Mexican Hat Function Approximation, PCA	Color and Object Signatures	Precision, Recall	Improves IR, robust feature set
2	A New Approach for Content Based Image Retrieval Using Statistical Metrics	Gray Histogram, Bhattacharyya Distance	Color Features	Precision, Recall, F Measure, Accuracy	Improves Image Retrieval
3	A New Architecture for Image Retrieval Optimization with HARP Algorithm	Genetic Algorithm, HARP clustering	Color, Shape and Texture Features	Precision, Recall	Minimizes Semantic gap with GA & HARP
4	Amalgamation of Data Mining and Image Processing Techniques in Image Retrieval	Gray level Co-Occurrence Matrix, BTH, Euclidean Distance	Color and Texture Features	Retrieval Efficiency	Narrow down search space, Handle large database
5	Satellite Image Mining using Content Based Image Retrieval	J-seg algorithm, GLCM, Bayesian classifier	Texture and Color Features	Accuracy	Fast retrieval

VI. RESULTS

The proposed method in [1], shows following evaluation results when used on Corel-1000 data set.

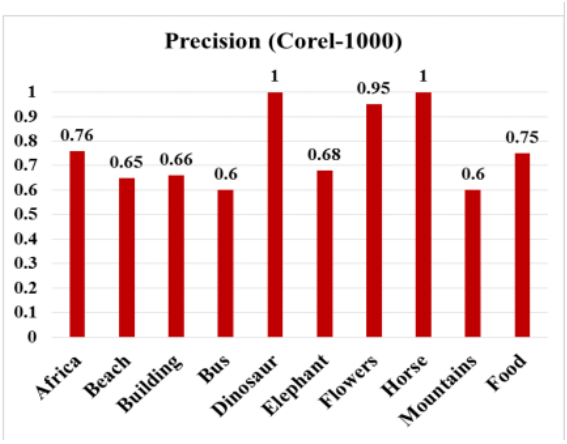

Fig 4. Precision data

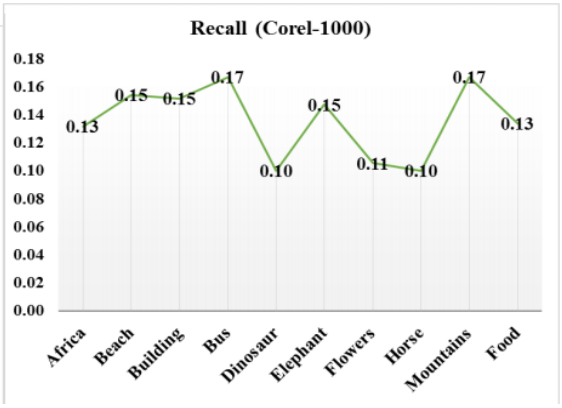

Fig 5. Recall data

The proposed method in [2], shows following evaluation results when used on Corel-1000 data set.

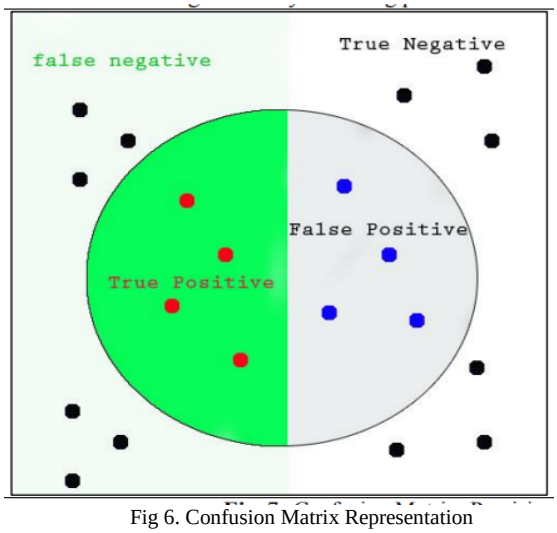

Fig 6. Confusion Matrix Representation

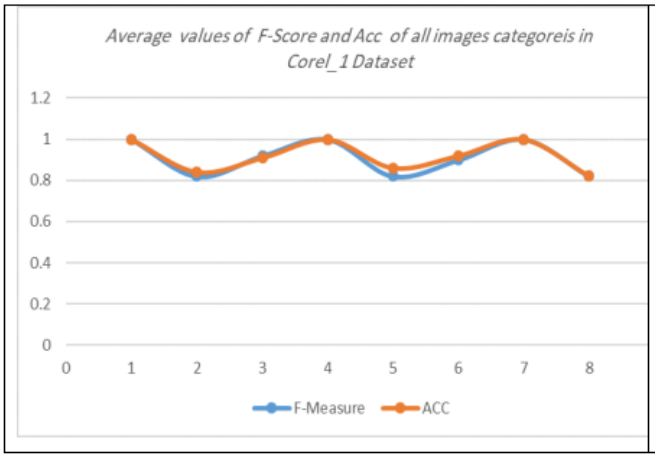

Fig 7. F-score and acc

The proposed method in [9], shows following evaluation results when used with increasing number of features.

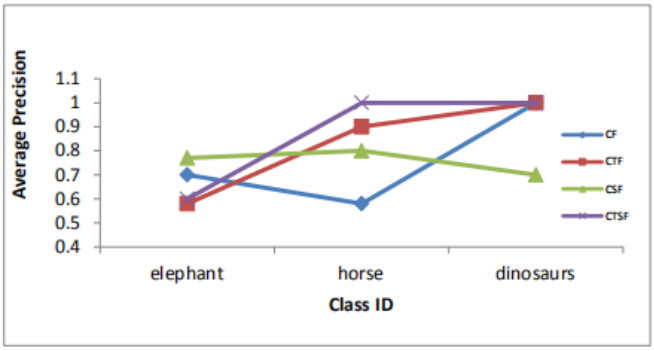

Fig 8.Comparison of precision with various types of features

VII. DISCUSSION

By analyzing the above results, we can say that the Precision, recall accuracy and other evaluation will provide better results if we combine the approach of using multiple features in [3] with modifying the extraction techniques used in [1], [2] and others. We also found that SVM is a better choice for classification in [9]. we also analyzed and found that wavelength transform gives more accurate results in case of shape and texture.

VIII. CONCLUSION

Contentment Based Image Retrieval has overcome all the limitations of Text Based Image Retrieval by considering the contents or features of image. Selection of relevant features and suitable similarity measures is a major challenge. This paper is an attempt to discover various CBIR techniques and their usage in the application field. Also this paper provides a comparative analysis on content based IR techniques which is useful for people who want to gain an understanding of this subject.

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