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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 in combination. Finally we analyse and compare various methodologies so as to understand their advantages.*

Key Words: **CBIR, Wavelength Transform, SVM, Color Movement, Euclidean Distance, Manhattan Distance.**

1. INTRODUCTION

In the past, the image retrieval from image databases was done using Text Based Image Retrieval (TBIR) systems. TBIR is uses keywords or tags that are related to the images called as metadata of the image. This method had various limitations due to inconsistency in the data or tags associated with the images. The visual and semantic content of the image was never considered for classifying the images. Content based image retrieval techniques were discovered to address this issue. In CBIR, the content of the image namely visual characteristics such as color, texture and semantic information such as objects and their relation were considered for similarity matching criteria.

Huge amount of image data is produced per hour due to the growth of internet and Iot era. This image data can needs to be analyzed and retrieved as per the requirement. This task is not possible manually as it involves complex image processing calculations. In order to automate the image retrieval process and to increase the accuracy of retrieval a new method of content based image retrieval is proposed which analyzes various features vectors and compares them with the images database and retrieves the relevant images as per the input query image.

The main aim here is to increase the similarity matching score between the input query image and the database images. Various such methodologies are proposed until now. This paper provides a review on some good methodologies of content based image retrieval and compare them.

2. GENERIC CBIR MODEL

The term CBIR originated in 1992, when it was used by T. Kato to explain the experiments about retrieval of images based on color and shape characteristics, from large databases. Generally, this term is used to define the method of retrieving images similar to query images from a large database of image features. The techniques, various tools and methods that are used were adopted from fields of statistics, pattern recognition and machine learning.

It is the problem of searching for particular images in large databases based on their content. In this context, 'content' means the color, texture, shape or any other data that can be obtained from the image only.

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.

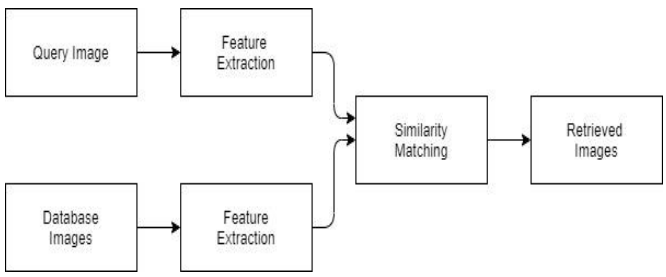

Fig -1: Generic CBIR Model

3. TYPES OF IMAGE FEATURES

Features are the facts obtained from images that is numerical values which are difficult to understand by humans. Consider the image as a set of vast information, the data extracted from this is known as feature set. Moreover, features obtained from an image are of lower dimension compared to that of the original image. Dimensional reduction decreases the burden of processing the large number of images.

There are two categories of features that can be obtained from the images namely local features and global features. Global features are mainly used in image retrieval systems, object detection systems and classification methods, whereas the local features are used for object recognition or identification scenarios. There is a vast gap between object detection and object identification. Detection is searching the existence of an object that is whether an object is present in the image or not while recognition is proving the identity of an object..

Global features define the image as a whole to generalize the entire object on the other hand the local features define the image patches. 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 whereas some examples of local features are SIFT, BRISK and FREAK.

For low level applications like detecting objects in an image, 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.

1.1 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 shows the distribution of colors or intensities of an image. In case of digital images, the color histogram indicates the number of pixels that have colors according to each of a fixed set of color ranges, that cover the image's color space and the set of possible colors. Various kinds of color histograms can be built, but is generally used for three-dimensional spaces like RGB or HSV. The main limitation of histograms for classifying is the representation. It does not consider the shape and texture of the object being studied. It dependents only on the color of the object under work.

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

1.2 Texture Features

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

Texture consists of texture elements, called as texels. Texture is often defined as fine, grained, smooth, coarse etc. Such information is present in the tone as well as structure of a texture. Tone varies with pixel intensity properties in the texel, whereas structure defines the spatial relationship between texels.

A gray level co-occurrence matrix (GLCM) contains information about the positions of pixels having similar 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.

1.3 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.

1.4 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.

4. 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 among the features of query 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].

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

Tab-1 : Comparison between techniques

5. DISCUSSION

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

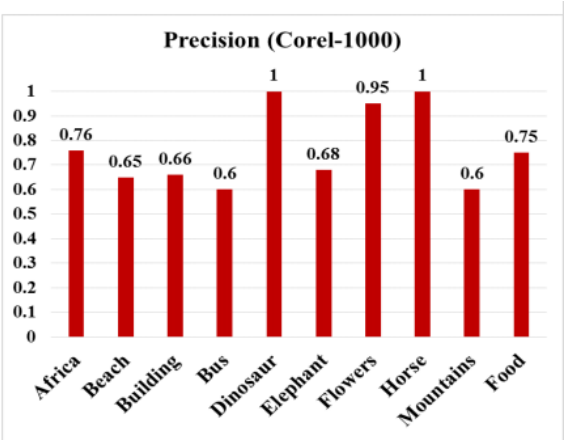

Fig-3 : Precision data

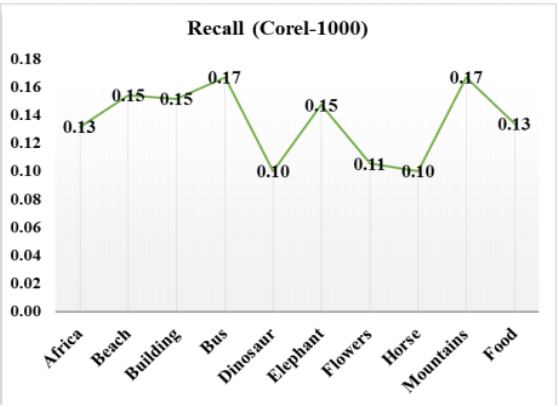

Fig-4 : Recall data

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

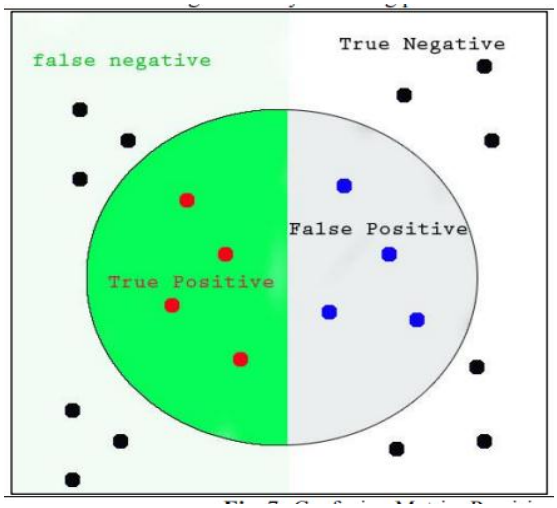

Fig-5 : Confusion Matrix Representation

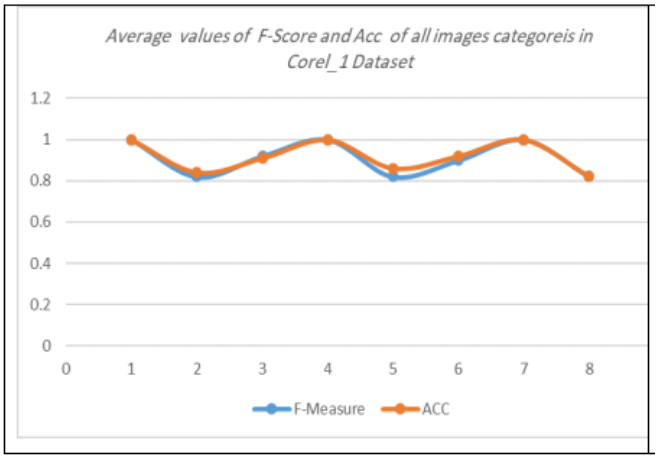

Fig-6 : F-score and accuracy

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

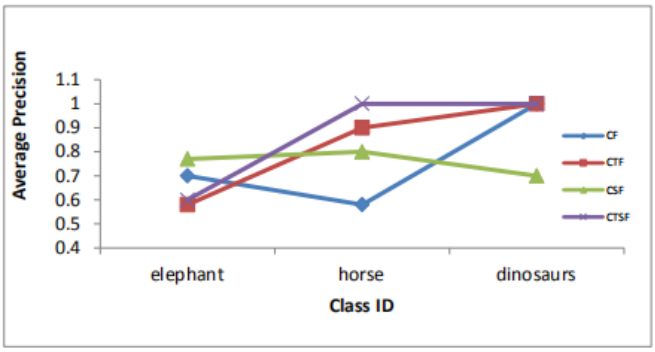

Fig-7 : Comparison of precision with various types of features

6. 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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