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Précised Analysis on Hybrid & Intelligent Image Retrieval Systems Using Different Feature Extraction Techniques

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A B S T R A C T

This paper portrays the research carried by various researchers so far in the area of Content based image retrieval systems (CBIRS), and its associated fields. Various feature extraction techniques related to color, texture and shape which are being used in designing for efficient CBIR systems are analyzed here. Different types of image retrieval techniques, its scope, importance, applications and performance in different areas have been discussed in detail in this survey paper. At last, the datasets that are used in the research are presented in this manuscript

Keywords: Color moment, Local Binary Pattern LBP, Canny Edge Detector, Support vector machine

1. Introduction

The multimedia databases are increasing rapidly due to the high usage of digital cameras, internet, smart phones and digitization in various areas. Digital images are the prime content of this multimedia information. Millions of images are being uploaded daily on different applications, so there is a considerable need of searching the relevant images from huge databases. Conventionally, images were retrieved on the basis of text i.e, keywords were used which was entered manually and was known as Text based image retrieval (TBIR) systems[1][2]. That system was very burdensome and time consuming. Besides that, these systems suffer from various other constraints such as synonyms, homonyms etc. that may lead to false retrieval of images. [3].

To overthrow all these limitations of TBIR systems, another alternative system was created in 1992 by Japanese scientist T. Kato which was named as Content based image retrieval (CBIR) systems. In these systems images are retrieved on the basis of their low level features such as color, texture and shape.

Feature extraction and similarity measurement are the chief steps while designing any CBIR system. The features are extracted both from the query image and the database images and after that similarity is computed by using various distance metrics or some other algorithms. The distance measures that are generally used are Euclidean, Manhattan, Minkowski etc. [4].

The CBIR system is favorable to both user and the system as there is no human interference. Moreover it also overcomes the issue of the annotation of the images that occurs in the conventional TBIR systems. So, the larger databases that are generated in this digital era by the image capturing devices can be handled and managed in a proper way by an efficient CBIR system.

Despite of various advancements in the field of CBIR systems, there exist some limitations and the most challenging of them is “Semantic gap”. This is the difference between the basic image features taken by the system and the human perception [5]. In order to remove this gap an intelligent strategy is required which is referred as Relevance feedback (RF). The diagram showing how RF works is presented in Figure 1. Relevance Feedback is a technique through which an image is refined on the basis of the feedback obtained by the user. The query image is entered in the CBIR system and set of images are retrieved [6]. The images are then inspected by the user and with the help of RF technique query image are refined by the best matching retrieved images. The process repeats until the user gets desired results. RF strategy can be implemented by some optimization algorithms such as Rochhio algorithm or by query refinement techniques such as query expansion, query movement etc.

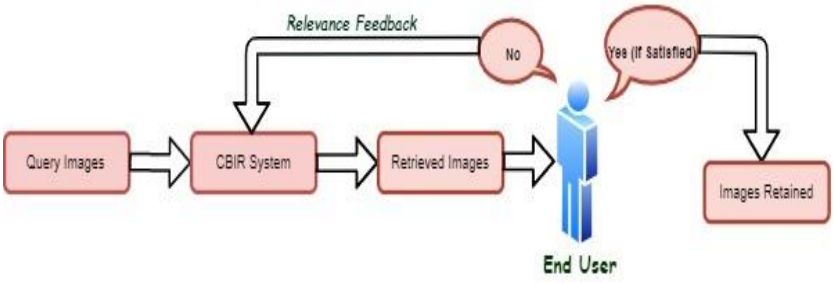


Fig 1: RF based image retrieval system

The remaining manuscript is structured into different sections. 2nd section presents feature extraction in which all the important techniques used for creating these systems are discussed. Section 3 is all about the latest hybrid and intelligent image retrieval that are being developed by different researchers. Performance evaluated parameters and different datasets used for examining these systems are presented in the section 4 and at last concluding summary is discussed.

2. Feature Extraction Techniques

Feature extraction is the chief step while designing any CBIR systems. In this step, visual attributes from the images are extracted which are having the capability to define the contents present in the images. These features comprises of color, shape, texture and spatial information. To extract these features, system does not require any human intervention. These are general type of features and are application independent. Important low-level features are explained below:

2.1 Color

It is the most influential features of an image through which objects are easily identified. This feature is insensitive to rotation, translation and scaling but it is dependent on illumination changes. Numerous types of color descriptors are there through which this feature can be extracted. Every technique has its own advantages and limitations and can be applied on different color spaces. One of the most commonly used color descriptors is color histogram. It calculates the number of similar pixels of the image and stores that pixels [7]. The main limitation of this technique is that the spatial information is not evaluated during its computation. And secondly the two divergent images will produce the similar histograms with same color distribution. Color moment technique is most preferable for the extraction of this feature due to its lower complexity and faster response than other methods like color histogram or dominant color descriptor (DCD). It computes the statistical properties which have the capability to capture the finer details present in an image [8].

Different descriptors used for extracting color feature are shown in Figure 2.

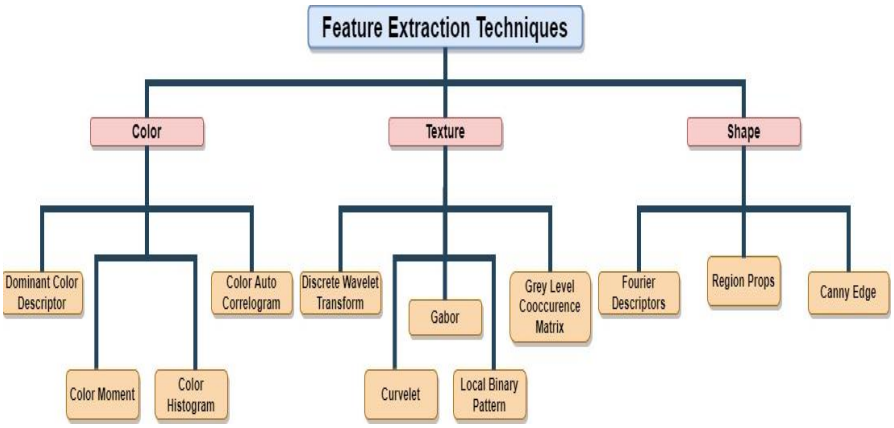


Fig. 2: Different feature extraction techniques

2.2 Texture

It is also one of the dominant low-level features among all. It provides the spatial arrangement of the visual patterns presents in the images. The texture features are either statistical based or transform based [9]. The statistical approach makes the use of spatial distribution of pixel values with the help of The properties of texture include roughness, regularity, coarseness, contrast etc.

The first order are not enough to provide the required information from the view point of human perception. It includes mean, deviation, variance, skewness and kurtosis. While, the second order statistics provide sufficient information as it calculates the relationship between the neighborhood pixels.

These methods are easy to implement and have high adaptability power along with strong robustness. But they are sensitive to noise and rotation [10]. LBP, Grey level co-occurrence matrix (GLCM), Variants of LBP, Autocorrelation function (ACF) etc are second order statistical based approaches.

The other texture descriptors are transform based. Discrete wavelet transform (DWT), Curvelet and Gabor transform, Ridgelet transform etc. falls under this type of category. These approaches are used when the texture is not specified in its original space. They can transform one texture space to another new texture space. They are insensitive to direction and noise. They are also capable to provide multi resolution information of the image. However, it is difficult to implement as compared to statistical type of techniques.

2.3 Shape

The human eye can view different shapes of the same target from different positions or different angles so the shape descriptors have these properties such as they should be robust for scaling, rotation and translation. Then only the accurate matching of the image on the basis of shape can be performed. Shape feature descriptors are basically categorised into two types i.e., boundary based and region based. Boundaries based are known as global or contour descriptors and were initially used for determining the shape of the objects. They have less computational complexity but are not accurate in calculating the shapes of particular regions of the image [11].

On the other side, the region-based descriptors are insensitive to small variations on the shape as the change in boundary does not alter the area of that shape. Hence, they do not provide different results so they are much robust in terms of noise as compared to boundary-based descriptors.

3. Analysis on Hybrid and Intelligent Image Retrieval Systems

This Section Portrays The Research Carried Out So Far In The Area Of Hybrid Image Retrieval Systems And Its Related Fields. Various Feature Extraction Techniques Are Being Used Successfully While Designing An Image Retrieval System. Initially A Single Feature Was Used For The Extraction Of Features But With The Progress In The Systems, Multiple Features Were Extracted Simultaneously And Combined To Get Better Retrieval Results. Those Systems Are known As hybrid CBIR systems. A very distinct type of CBIR system is framed in [12]. In this, the system works in two layers so as to enhance the accuracy of the designed framework. In the first layer, the filtering step is performed by applying color moment technique to the complete dataset. By applying this, the searching space is reduced and the overall system becomes speedier as the total numbers of images are now reduced based on the color technique. After that, in the next layer another two features i.e., texture and edges are extracted on the remaining images with LBP and canny edge detector respectively. Performance parameters that are computed in this are precision, overall time and recall. Datasets taken are Wang and Corel-10K. A somewhat similar type of system is proposed by Singh et al. which is also a bi-layer implementation. Here, one feature is common in both layers. The first layer i.e., in the filtering layer two features i.e. texture as well as shape is extracted with Zernike moments and Gabor filters respectively. In the second layer, image number is reduced and now the features are extracted from color and shape. The techniques used for this is color histogram and again Zernike moments [13].

An interesting and different type of system is framed in [14] where all the three features are utilized for the purpose of image retrieval. It is a hierarchical based system in which features are extracted in three layers. After every layer, the irrelevant images are discarded and hence the size of the dataset gets reduced. A simple combination of color and shape is used by Reshma for designing CBIR system. CCV is used for color and for calculating the shape feature several parameters are computed such as mass, solidity, centroid etc. [15].

For designing intelligent image retrieval systems, intelligent algorithms and techniques are employed in order to overcome the issues that which could not be resolved by the simple systems. Support vector machine (SVM) is used in [16] which works as a classifier. Here, fusion of DWT and color edge directivity descriptor is done. Elnemr et al. also employed multi-class SVM as a classifier over a hybrid feature vector. Color histogram and curvelet transform techniques are used for the purpose of feature extraction. Shubhangi et al. compared the working of various clustering techniques on the proposed CBIR system. The techniques that are compared are ant colony optimization, PSO, K-means clustering and ACPSO (hybrid of ant colony and PSO) [17]. The work proposed in [18] used two CNNs for the image feature extraction. The CNN layers extract the deep features of the images and can manage the large datasets efficiently. In this, an additional layer is designed known as bilinear root pooling to reduce the dimensions of the image features. The system uses deep learning algorithm and hence provides superior results when tested various datasets like Oxford 5K and Oxford 105K.

The combination of CNN and SVM is proposed in [19], here deep CNN extracts the image features and SVM performs the classification process accurately. CNN is used at the input side and SVM is used to make the classes at the output side. SVM makes the data linearly separable by making a hyper-plane.

4. Performance Parameters of CBIR System

The performance or competence of any designed CBIR system can be computed by three important parameters which are:

$$Precision = \frac{Number\ of\ relevant\ images\ retrieved}{Total\ number\ of\ images\ retrieved} \quad Recall = \frac{Number\ of\ relevant\ images\ retrieved}{Number\ of\ relevant\ images\ present\ in\ the\ database}$$

$$F - measure = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

5. Datasets Used

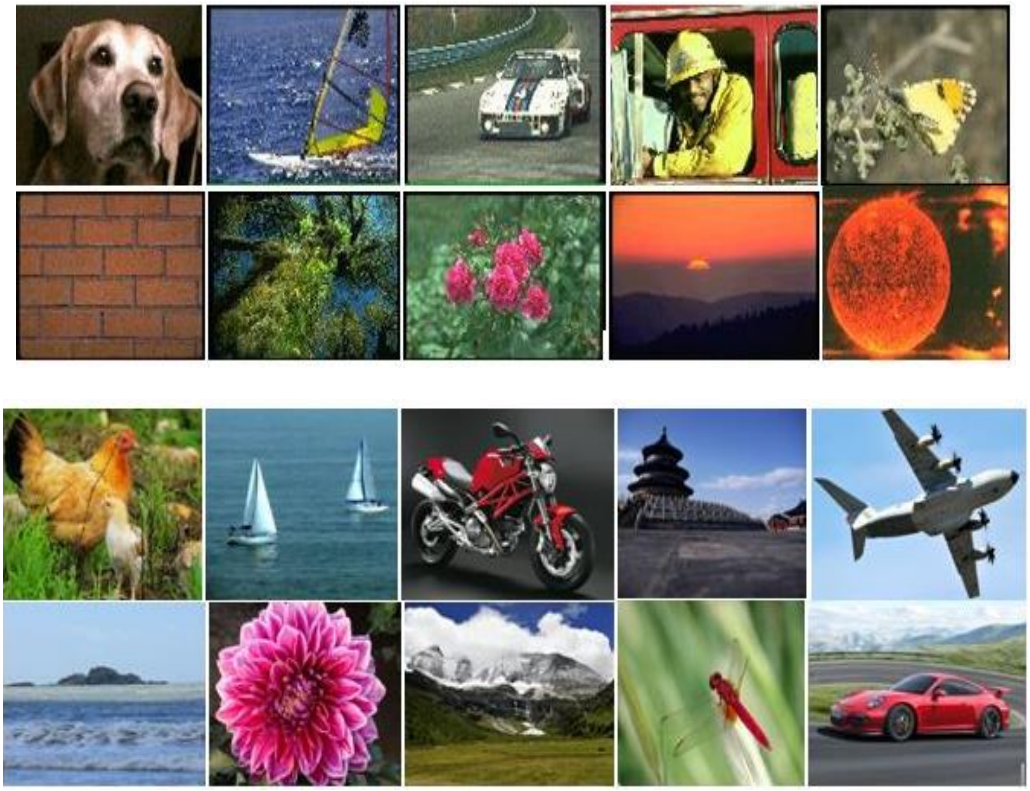
Various benchmark databases are available for CBIR systems in different domains such as medical field, satellite images, astrology, texture-based images, natural images etc. The database selection depends upon the application that we are working on. These databases are of different sizes; the size may vary from hundreds and can be up to millions. Some details and sample images of the important datasets are discussed in this section.

The evaluation of the proposed systems can be performed on natural image databases and texture image databases. In this section, different benchmark natural image databases of variable sizes and two types of texture image databases are discussed

Table 1: Details of datasets

Name of Dataset	Total Categories	Images per Category	Total Images	Size of the Image
Corel-1K Natural images	10	100	1000	256 ×384 or 384 256
Corel-5K Natural images	50	100	5000	128 ×187 or 187× 128
Corel-10K Natural images	100	100	10,000	128 ×187 or 187× 128
GHIM-10K Natural images	20	500	10,000	300 ×400
Brodatz Texture images	91	16	1456	128 ×128

Some of the sample images from both natural and texture based datasets are shown in Figure 3.



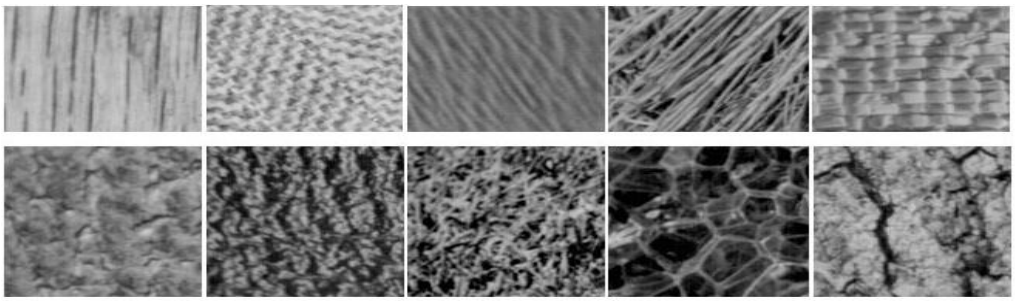


Fig. 3: Sample images of different datasets

6. Concluding Summary

In this manuscript, different important feature extraction techniques along with their utilization in designing various image retrieval systems are discussed. The current research mainly deals with the datasets that are available online so the system should be tested on real datasets so that the research can be enhanced and the systems can be utilized efficiently. The present systems mainly work on complete images, so the work can be extended by designing Region of Interest (ROI) based CBIR systems by using advanced intelligent algorithms.

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