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Content Based Image Retrieval: Survey and Comparison of CBIR System Based on Combined Features

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Abstract

In image processing, computer vision and pattern recognition, the Image retrieval is a most popular research area. In this paper, performance of various CBIR systems, based on combined feature i.e color texture and shape, are compared.

Keywords*: CBIR, HSV Color Histogram, BDIP, BVLC, Canny Edge Detection*

1. Introduction

Content-based image retrieval is a method where relevant images from large scale image databases are searched according to users' interests' .It has become an active and fast advancing research area since last two decades. During the past decade, remarkable progress has been made in both theoretical research and system development. However, there still remain many challenging research problems that continue to attract researchers from multiple disciplines [1].

Early techniques to image retrieval were not basically based on visual features but based on the textual annotation of images. It means that images were first annotated with text and then searched using a text-based approach from traditional database management systems. [1]. However, the performance of traditional approach to image retrieval is very sensitive to the keywords employed by the user and the system. Therefore, content-based image retrieval (CBIR) has received much attention in multimedia retrieval community. It deals with the image content itself such as color, texture, shape and image structure instead of annotated text [2].

Main idea behind CBIR is to analyze image information by low level features of an image, such as color, texture, shape and color layout etc., and to create feature vectors of an image as its index. The features are stored in an image feature database for future use [2]. When a query image is given, the features of the query image are extracted to match the features in the feature database by a pre-established algorithm, so that a group of similar images to the query image can be returned as the retrieval images [3-5].

Basically, one of the key points for realizing CBIR is to extract appropriate feature vectors to represent image content correctly. Color is one of the most widely used low-level visual features and is invariant to image size and orientation [4, 5]. Color histogram is invariant to orientation and scale and this makes it powerful in image classification. Hence, color histogram-based color descriptor has been extensively studied and widely used in CBIR systems for its simplicity and effectiveness [6].

Before a color descriptor can be selected, the underlying color space has to be specified.

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Texture is also one of the most used low level visual features that refer to innate surface properties of an object and their relationship to the surrounding environment [7].

For image retrieval, Object shape features can also be used to provide powerful information, because humans can recognize objects solely from their shapes. Basically, the shape contains semantic information of object, and it is different from other elementary visual features, such as color or texture features [3].

Over the past decades, many researchers have focused on the studies of CBIR by using only a single feature. However, it is hard to attain satisfactory retrieval results using a single feature because an image generally contains various visual characteristics [5]. Therefore, it is necessary to extract and select efficient features that are complementary to each other so as to achieve a satisfactory retrieval performance.

In this paper, we will discuss about various content based image retrieval systems and throw light on their feature extraction methodologies along with their advantages and disadvantages.

2. Color Feature Extraction

One of the most straightforward visual features of an image is the color because human eye is sensitive to colors. Color features are the basic characteristic of the content of images. Using color features, human can recognize most images and objects included in the image. Several methods for retrieving images on the basis of color similarity have been proposed, but most are variations on the same basic idea. Each image added to the database is analyzed to compute its feature. Two traditional approaches have been used. Global Color Histogram (GCH) is used for representing images by their histograms and the similarity between two images will be determined by the distance between their color histogram. This approach does not represent the image adequately. Furthermore, this approach is sensitive to intensity variations, color distortions, and cropping. Local Color Histograms (LCH) divide images into blocks and obtain the histogram for each block individually. So, an image will be represented by these histograms. To compare between two images, each block from one image will be compared with another block from the second image in the same location. The distance between these two images will be the sum of all distances. This approach represents the image more deeply and enables the comparison between image regions [8].

RGB color system is most commonly used color system for image retrieval. Unfortunately, the RGB is not well suitable for describing colors in terms that are practical for human interpretation. Whereas, the HSV (hue, saturation, value) model is an ideal tool for developing image processing algorithms based on color descriptions that are natural and intuitive to humans [9]. Here we will discuss and compare about some CBIR systems which used HSV color space to generate color histogram and outperformed other systems based on RGB color space.

Simardeep Kaur et al. [10] presented HSV based color space image retrieval method, based on the color distribution of the images. The performance of content based image retrieval using HSV color space is evaluated and then RGB and HSV model is compared. The CBIR using HSV color space scheme transfers each pixel of image to a quantized color and using the quantized color code to compare the images of database. This HSV values has a high recall and precision of retrieval, and is effectively used in content based image retrieval systems. S. P. James [11] presented an image retrieval system (CBIR), using HSV color features, which can retrieve facial images from the extracted facial features. K-Means clustering technique is applied to the images are initially clustered into a group which has similar HSV color content. Then the chosen group is clustered using K-Means clustering algorithm. The experiment result is compared with Euclidean distance metric where the clustering technique produces accurate image retrieval and better classification of images. In [12], the color feature is extracted from the joint histogram based on the combination of the hue and saturation and the texture feature is extracted using the GCLM feature. The k-means clustering is used to cluster the feature of the image. The ROC curve is drawn in order to evaluate the performance of the feature extraction. The chi-square is used to find the similarity between the two images. The evaluation results demonstrate the accuracy of the retrieval based on the precision and recall false positive and negative ratio. The ROC curve is used to compare the efficiency of the color, texture and the combination of both the color and the texture. Iyad Aldasouqi and Mahmoud Hassan [13], proposed a fast algorithm for detecting human faces in color images using HSV color model without compromising the speed of detection. The algorithm is fast and can be used in some real-time applications. Vadivel, A et al. [14], did a detailed analysis of the properties of the HSV (Hue, Saturation and Intensity Value) color space, laid emphasis on the visual perception of the color of an image pixel with the variation in hue, saturation and intensity values of the pixel. Using the results of this analysis, they determined the relative importance of hue and intensity based on the saturation of a pixel and applied this concept in histogram generation for content-based image retrieval (CBIR) from large databases. In traditional histograms, each pixel contributes only to one component of the histogram. However, they proposed a method using soft decision that contributes to two components of a histogram for each pixel. Shamik Sural et al. [15] analyzed the properties of the HSV (Hue, Saturation and Value) color space with emphasis on the visual perception of the variation in Hue, Saturation and Intensity values of an image pixel. They extracted pixel features by either choosing the Hue or the Intensity as the dominant property based on the Saturation value of a pixel. The feature extraction method has been applied for both image segmentation as well as histogram generation applications – two distinct approaches to content based image retrieval (CBIR). The K-means clustering of features combines pixels with similar color for segmentation of the image into objects. The histogram retains a uniform color transition that enables them to do a window-based smoothing during retrieval.

As a summary, we can come to the outcome that HSV color space, to generate histogram, gives better and effective results over RGB color space.

3. Texture Feature Extraction

Texture is one of the crucial primitives in human vision and texture features have been used to identify contents of images. Examples are identifying crop fields and mountains from aerial image domain. Moreover, texture can be used to describe contents of images, such as clouds, bricks, hair, etc. Both identifying and describing characteristics of texture are accelerated when texture is integrated with color, hence the details of the important features of image objects for human vision can be provided. One crucial distinction between color and texture features is that color is a point, or pixel, property, whereas texture is a local-neighborhood property. The main motivation for using texture is the identifying and describing characteristics of texture feature. Since the power of texture increases when combined with color, the content-based retrieval system provides techniques for querying with respect to texture and color in an integrated manner [16].

In image processing literature, there exist three main approaches to the task of texture feature extraction: spectral approach, structural (or syntactic) approach and statistical approach.

Conventional texture features used for CBIR are statistic texture features using gray-level co-occurrence matrix (GLCM), edge histogram descriptor (EHD), which is one of the MPEG-7 texture descriptors, and wavelet moments. Recently, BDIP (block difference of inverse probabilities) and BVLC (block variation of local correlation coefficients) features have been proposed which effectively measure local brightness variations and local texture smoothness, respectively. The excellent performance of BDIP and BVLC comes from that both of them are bounded and well-normalized to reduce the effect of illumination. These features are shown to yield better retrieval accuracy over the compared conventional features. They are extracted from 2*2 blocks into which a query image is partitioned to measure local image characteristics in great detail [16]. Related to the illumination variation problem, BDIP (block difference of inverse probabilities) and BVLC (block variation of local correlation coefficients) operators, which have been applied to image retrieval, face detection, ROI determination, and texture classification, and yielded very good results. BDIP is a kind of nonlinear operator normalized by local maximum, which is known to effectively measure local bright variations. BVLC is a maximal difference between local correlations according to orientations normalized by local variance, which is known to measure texture smoothness well. Chun et al. [17], proposed a content-based image retrieval method as its texture features, BDIP and BVLC moments of the value component image are adopted. The color and texture features are extracted in multiresolution wavelet domain and combined. Young Deok et al. [18] proposed block difference of inverse probabilities (BDIP) and block variation of local correlation coefficients (BVLC), for content-based image retrieval and then presented an image retrieval method based on the combination of BDIP and BVLC moments. Their presented retrieval method yields about 12% better performance in precision vs. recall. Yu-Len Huang et al. [19] presented a computer-aided diagnosis (CAD) system with textural features for classifying benign and malignant breast tumors on medical ultrasound systems. The proposed CAD system utilized facile textural features, i.e., block difference of inverse probabilities, block variation of local correlation coefficients and auto-covariance matrix, to identify breast tumor. The proposed system identifies breast tumors with a comparatively high accuracy. Ying Ai Ju et al. [20] proposed a face recognition method using local statistics of gradients and correlations. BDIP (block difference of inverse probabilities) is chosen as a local statistics of gradients and two types of BVLC (block variation of local correlation coefficients). The fused features of BDIP and BVLCs are more robust to variation of illumination and facial expression and so the proposed method yields good results.

Many of the texture features have been developed so far during the past years. As per our literature survey over texture feature detection, we concluded that BDIP and BVLC were proposed recently and showed a better retrieval efficiency in various domains including content based image retrieval.

4. Shape Feature Extraction

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

shape representation and description is a difficult task. This is because when a 3-D real world object is projected onto a 2-D image plane, one dimension of object information is lost. As a result, the shape extracted from the image only partially represents the projected object. To make the problem even more complex, shape is often corrupted with noise, defects, arbitrary distortion and occlusion. Further it is not known what is important in shape. Current approaches have both positive and negative attributes; computer graphics or mathematics use effective shape representation which is unusable in shape recognition and vice versa. Inspite of this, it is possible to find features common to most shape description approaches Usually, Shape features can be extracted from an image by using two kinds of methods: contour and regions. Contour based methods are normally used to extract the boundary features of an object shape. Such methods completely ignore the important features inside the boundaries. Region-based image retrieval methods firstly apply segmentation to divide an image into different regions/segments, by setting threshold values according to the desirable results. Whereas the boundary of an image can be obtained by applying any edge detection method to an image [21].

Shape matching is a well-explored research area with many shape representation and similarity measurement techniques found in the literature. Shape representation methods include Fourier descriptors, polygonal approximation, invariant moments, B-splines, deformable templates, and curvature scale space (CSS) [22]. Most of these techniques were developed for whole shape matching, i.e., closed planar curve matching. Fourier descriptor has proven to be more efficient and robust than is the CSS in a review of shape representation and description techniques [23]. But, as mentioned in [23], Fourier descriptor was not suitable for partial shape matching. Xu et al. [24] presented an innovative partial shape matching (PSM) technique using dynamic programming (DP) for the retrieval of spine X-ray images. B. Ramamurthy [25] proposed a novel approach for medical image retrieval based on shape feature, which uses canny edge detection algorithm for extraction of image shape and K-means algorithm for extraction of different regions of the image in order to improve better matching process between user query image and feature database images. Maini, Raman et al. [26] observed that Canny's edge detection algorithm performs better than other under almost all scenarios and performs well even under noisy conditions It has been observed that Canny's edge detection algorithm is computationally more expensive compared to LoG(Laplacian of Gaussian), Sobel, Prewitt and Robert's operator. Canny yields thin lines for its edges by using non-maximal suppression. It is also used to detect the edge points of the image. The contour of the image is traced by scanning the edge image and re-sampling is done to avoid the discontinuities in the contour representation [27]. Mousa, Allam

[28], proposed an edge-detection method to enable a Plate Recognition System through practical situations, Canny Edge-Detection method has been used to find such values of the concerned image based on local maxima of the gradient of that image. The obtained objects are identified such that the numbers object is recognized. The details of the obtained image are controlled through the standard deviation of the Gaussian filter (sigma). Ali, Mohamed [29] implemented Canny edge detector for features extraction and as an enhancement tool for remote sensing images.

5. Conclusion

In this paper we have compared different color, texture and shape feature extraction methods that are most popularly used in image understanding studies. Our comparison shows that there is considerable performance variability between the various feature extraction methods. One of the features of this study is the use of a publicly available benchmark that further studies can use.

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