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An efficient framework for image retrieval using color, texture and edge features☆

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ABSTRACT

This paper proposes a new hybrid framework for Content-Based Image Retrieval (CBIR) system to address the accuracy issues associated with the traditional image retrieval systems. The proposed framework initially selects pertinent images from a large database using color moment information. Subsequently, Local Binary Pattern (LBP) and Canny edge detection methods are used to extract the texture and edge features respectively, from the query and resultant images of the initial stage of this framework. Then, the Manhattan distance information about these two features corresponding to the query and selected images are calculated and combined, and then sorted using bubble sort algorithm. Wang's, Corel-5K and Corel-10K are the three databases used for evaluating the performance of the proposed hybrid framework using precision and recall measures. The average precision measured on these three databases gives approximately 11.8%–22.315%, 8.025%–18.935% and 10.755%–32.221% higher accuracy than the state-of-the-art techniques.

1. Introduction

Nowadays digital imaging has become an indispensable segment in many applications such as medical imaging, remote sensing, crime prevention, education, multimedia, data mining, etc. These applications require digital images as a source for various processes like segmentation, object recognition, tracking, and others. To index and search suitable images from the rapidly increasing digital image collections, an image retrieval system is used. In image databases, for fast and efficient retrieval, images are indexed and searched in two ways, namely, using keywords and using visual contents of an image. The traditional Text-Based Image Retrieval (TBIR) system uses keywords for semantic image retrieval. But this system fails to handle large database because of its non-automatic keyword generation scheme and it fully relies on the perception of human experts who are employed in the keyword generation task. This often leads to inappropriate keyword generation for an image. Whereas, in a Content-Based Image Retrieval (CBIR) system, the visual contents i.e., color, texture, shape, etc., of an image are utilized to give plausible results from the large database [1]. Among the visual contents, color plays a vital role in human perception by giving a pleasant view of the environment. It can also be used to identify an object and distinguish one object from another. Hence, in CBIR, color can be considered as the leading descriptor due to its simplicity in calculation and invariant behavior towards translation, rotation and change in the viewing angle [2]. Color information can be extracted from the image by both global and local techniques. Most traditional global color extraction methods use color histogram

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which gives the total count of each color pixel present in an image. Even though color histogram is prominently used to label the color information in an image, it has flaws in representing the spatial information since it gives same histogram representation for entirely different images if their color distributions are identical [3]. Like color, texture can also be a robust descriptor in image retrieval system. In today's systems, most of the commonly used texture extraction methods follow the local template structure for mining the texture information [4]. The texture information is often estimated locally from the gray-level representation of an image [5,6]. The shape of the object is a salient part in recognizing similar images from the database. This shape details can be extracted from the Fourier transformed images [7]. The CBIR system based on mapping between any one of the visual features and the relevant image has a large semantic gap. In order to account for this, a system based on the association between more features has been evolved. The most familiar combination in feature level fusion is the color-texture fusion. Furthermore, texture-shape and shape-color based systems are more ingeniously developed. But still, these coupled feature based systems have failed to meet the user requirements, mainly due to the inability of the feature fusion techniques to relate specific information present in the query image with the database image. Hence, unification of all visual content based retrieval systems is introduced.

In recent years, combined feature based image retrieval is an active research area in CBIR. Because of issues that exist in finding suitable feature extraction methods and their combinations, precision of the retrieval system is still scanty. The proposed framework mainly concentrates on improving the retrieval accuracy of the CBIR system by integrating the low-level features such as color, texture and edge of an image in a multilevel fashion. The main contributions of this work in the CBIR field are as follows: 1) Propose a new framework for image retrieval system which is in contrast to the existing system that uses unification of different features in the same level. 2) Reduce the search space of the similar image retrieval system with the help of color based selection process and hence the system distance measure for color feature need not be taken into account. 3) Individual and proposed integrated feature-based relevant image retrieval systems are extensively tested over the standard database.

The remaining section of this paper is framed as follows: Section 2 describes related works on the field of combined feature based CBIR system. The novel features integration technique is explained in Section 3. Section 4 gives the experimental results and discussion. Conclusion and future scope of this work are discussed in Section 5.

2. Related work

This section presents the state-of-the-art methods in CBIR system based on the combination of multiple features. Color histogram and Gray Level Co-occurrence Matrix (GLCM) features are fused by Yue et al. [8] to give more accurate retrieval results in CBIR system. Here, global and local histograms are evaluated over HSV color space image. Local histogram ends up giving better performance than global histogram and then GLCM is used to extract the texture feature of a gray level image. Local histogram and GLCM features are fused by giving equal weight to color and texture features. Color Co-occurrence Matrix (CCM), Difference Between Pixels of Scan Pattern (DBPSP) and Color Histogram K-Mean (CHKM) image features are fused [9] to get the highly similar image results. Among the three features, two features (CCM and DBPSP) are used to extract the texture information and the third feature (CHKM) is used to extract only the color information.

Multi-scale edge field method for multimedia retrieval [10] uses Canny edge extraction as a part of process to obtain the object boundaries in different scales. Agarwal et al. [11] have applied Canny edge detection on the luminance channel of the YCbCr color image in order to improve performance of the image retrieval system. Liu and Yang [12] have proposed Color Difference Histogram (CDH) on Lab color space that is completely different from long established color histogram method. Lab color space is preferred for estimating CDH because it uses the color difference between color and edge orientation texture details of the image. Subsequently, Canberra distance metric is used to measure the similarity between query and database images. Furthermore, texture and color features based retrieval is obtained by local extrema peak valley pattern and RGB colour histogram [13]. The texture and shape features are mined using Local Ternary Pattern (LTP) and geometric moments to pull off large amount of relevant images [14].

Recently, neural network structure [15] is proposed to reduce the semantic gap in image retrieval. The network is trained from the Bags Of Images (BOI) which have the third level decomposed wavelet packet tree information and the mean eigenvector of each Gabor filter response image. Then, Pearson correlation co-efficient is used to find the similarity between the feature vectors. Finally, the outputs are refined with the help of relevance feedback mechanism. But, the training phase complexity and convergence time of this approach are high.

Color, texture and shape features are integrated by Wang et al. [16] to give efficient retrieval by CBIR system. Color feature is calculated via slightly modified Dominant Color Descriptor (DCD). Here, the image is segmented into eight coarse parts, and then mean value of each segment acts as its quantized color. Next, the clustering is used to merge the nearest colors. Finally, five dominant colors and its percentages are obtained. The texture feature is extracted by taking convolution between image and band pass filter with 4-directions namely horizontal, vertical, 45° and -45°. Also, Pseudo- Zernike moments are used to compute the shape feature of the image because this moment is invariant to rotation and insensitive towards noise. The color and texture [17] details are taken from Lab color space using modified CDH then additionally Angular Radial Transform (ART) based invariant shape features are extracted. The extracted features are normalized using min-max and Z-score normalization methods. Among the two normalization methods, min-max based values gave highly accurate images.