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Content based image retrieval based on relative locations of multiple regions of interest using selective regions matching

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ABSTRACT

In this study, a novel technique for image retrieval based on selective regions matching using region codes is presented. All images in the database are uniformly divided into multiple regions and each region is assigned a 4-bit region code based upon its location relative to the central region. Dominant color and Local Binary Pattern (LBP) based texture features are extracted from these regions. Feature vectors together with their region codes are stored and indexed in the database. During retrieval, feature vectors of regions having region codes similar to the query image region are used for comparison. To reflect the user's intent in query formulation in a better way, an effective technique for Region of Interest (ROI) overlapping block selection is also proposed. Region codes are further used to find relative locations of multiple ROIs in query and target images. The performance of the proposed approach is tested on the MPEG-7 CCD database and Corel image database. Experimental results show that the proposed approach increases the accuracy and reduces image retrieval time.

1. Introduction

Content Based Image Retrieval (CBIR) is browsing, searching and navigation of images from large image databases based on their visual contents. CBIR has been an active area of research for more than a decade. Many CBIR systems have been developed; like QBIC [8], Simplicity [28], and Blob world [3]. A detailed survey of CBIR techniques can be found in [15,25,26]. Traditional CBIR systems use low level features like color, texture, shape and spatial location of objects to index and retrieve images from databases. Low level features can be global or local (region based). Global feature based CBIR [7,11,29,32] fails to compare the regions or objects in which a user may be interested. Therefore Region Based Image Retrieval (RBIR) is more effective in reflecting the user requirement.

A typical query image consists of both relevant and irrelevant regions. The irrelevant regions limit the effectiveness of existing content based image retrieval systems. Irrelevant regions can be removed by defining ROI in the query image. Depending upon the method of formulating region based query, RBIR can be categorized into two classes: (1) System Designated ROI (SDR) and (2) User Designated ROI (UDR). These systems have various ways of querying and representing images in the database.

UDR approach is more promising as it enables the user to express his intent in the query formulation. But in UDR approaches, it is difficult to formulate an accurate query if there are variations in the sizes of ROI [24,33]. This paper presents a method to select ROI overlapping blocks, based upon the features and overlapping areas of ROI. However, if multiple ROIs are selected by the user, then it is always beneficial to consider relative locations of ROIs in the image. Only a few study

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[14,18] have reported solution to the problem of finding relative locations of ROIs. In addition, these methods fail to give a detailed level of relative location similarity. Consideration of relative locations of several ROIs in retrieval techniques requires complex algorithms and results in the increase of computation time. To overcome this problem, this paper presents an effective method based on region codes, which inherently supports the notion of relative locations of multiple ROIs resulting in less computation time.

Major contributions of this paper are first, use of region codes for reduction of overall computation time without affecting accuracy of retrieval, second, an efficient technique for ROI overlapping block selection has been suggested, third, a method to find the similarity while considering the relative locations of multiple ROIs is proposed and lastly, effective combination of features is utilized for ROI image retrieval. The experimental results show that the proposed method can meet requirements of a user more accurately while consuming less time in comparison to existing methods.

The remainder of this paper is organized as follows. We first present overview of related work in Section 2. The proposed work is described in Section 3. Results are given in Section 4. Conclusions are drawn in Section 5.

2. Related work

Color and texture features have been extensively used in RBIR [22]. Liu et al. [16] have proposed a microstructure descriptors (MSD). Microstructures are defined by edge orientation similarity with underlying colors, which can effectively represent image features. MSD integrates color, texture, shape and spatial layout information for effective image retrieval. However, it lacks global properties of the image and is unable to utilize relation between locations of different objects in the layout. Xingyuan et al. [31] have proposed a more effective Structure Element Descriptor (SED) that combines color and texture information. The histogram computed from SED in the HSV color space (quantized to 72 bins) has been employed for image discrimination. The proposed global descriptor can represent the spatial correlation of color and texture in the image. However, this descriptor is unable to represent region based properties of images. Also, the feature vector length is high and does not encode the spatial relation between different objects in the image.

Saykol et al. [21] have proposed a histogram based scheme that combines color and shape features. To extract shape, distance and angle histograms are used and the color is encoded using quantized 166 bin histogram in HSV color space. Texture information is not used in the retrieval. The scheme can identify shapes of individual objects but fails to capture spatial relations between various objects in the image.

The color information of the image is also used for object detection using Color Co-occurrence Histogram (CCH) [5] and Color Edge Co-occurrence Histogram (CECH) [17] based features. CECH can represent the gross spatial information about the layout but it is incapable of discerning subtle shape differences. This is useful for handling object distortions but fails in classifying shapes having minor variations.

Apart from low level features, considering spatial locations of different regions and their relation in the image has also shown to play an important role in increasing the performance of a region based image retrieval system in the literature.

Hsiao et al.'s approach [12] partitions images into five regions with fixed absolute locations. To avoid noise during the local match, the system allows users to select the ROI from the segmented five regions and only selected region is compared with regions of other images in the database.

In the technique presented in [24], images are divided into blocks of a fixed size (e.g. 2×2, 3×3, and 5×5) as shown in Fig. 4. However, the size of the user designated ROI may be different from predefined block size. This may result in an inaccurate representation of ROI features. To address this problem, authors have represented features of blocks by their proportion of overlap with ROI in the calculation of similarity measure. The main drawback of this method is that it only compares the blocks having similar spatial locations as of ROI. Therefore, blocks lying in locations different from ROI are not retrieved.

The method proposed by B.G. Prasad et al. [20] uses automatic specification of regions within the image with the help of dominant color. The images are divided into blocks of size 3×3 and each block is given a location index (Fig. 4). The block having the largest overlap area with ROI is designated and its feature vector is matched with database image's blocks having the same location index. As shown in Fig. 4, block 4 is designated and its features are matched merely with block 4 of database images. This method faces the problem as ROIs are not directly identified by the user and regions are compared only from the fixed locations. Multiple ROIs are also not supported.

Technique given by B. Moghaddam et al. [18] facilitates the user to select multiple ROIs and retrieve blocks in locations different from ROIs. However, this method has high time complexity as it requires comparison of all blocks within the query region. It is also compared and reflected whether blocks in the target image are in the same location as multiple ROIs in the query image. This method fails to provide a detailed level of relative location similarity as it simply indicates whether blocks in the target image are in the same locations as multiple ROIs in the query image.

Chan et al. [4] suggested a ROI image retrieval method based on Color Variances Among the Adjacent Objects (CVAAO) feature. CVAAO features can describe principal pixel colors and distinguish the objects with inconsistent contours. Furthermore, it is insensitive to scale, shift, rotation, and distortion variations. Concerning the image querying aspect, CVAAO-based ROI image retrieval method computes the location and size of the target region image R_T in a database image using shape, area, and position of the largest object on the query region image R_Q, where R_T is more similar to R_Q. However, this method does not consider relative locations of ROIs in the retrieval process and hence not suitable for multiple ROIs based retrieval.