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An efficient similarity measure for content based image retrieval using memetic algorithm

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ABSTRACT

Content based image retrieval (CBIR) systems work by retrieving images which are related to the query image (QI) from huge databases. The available CBIR systems extract limited feature sets which confine the retrieval efficacy. In this work, extensive robust and important features were extracted from the images database and then stored in the feature repository. This feature set is composed of color signature with the shape and color texture features. Where, features are extracted from the given QI in the similar fashion. Consequently, a novel similarity evaluation using a meta-heuristic algorithm called a memetic algorithm (genetic algorithm with great deluge) is achieved between the features of the QI and the features of the database images. Our proposed CBIR system is assessed by inquiring number of images (from the test dataset) and the efficiency of the system is evaluated by calculating precision-recall value for the results. The results were superior to other state-of-the-art CBIR systems in regard to precision.

1. Introduction

Recently enormous number of images database are available worldwide [1–3]. In order to utilize these databases an effective and robust retrieval and search approach is required. The traditional process for image retrieval is performed by describing every image with a text annotation and retrieving images by searching the keywords. This process has become very laborious and ambiguous because of the rapid increase in the number of images and the diversity of the image contents. Herby the content based image retrieval (CBIR) received a lot of attention [4]. A handful number of researches in the past decade were working on retrieving images from the huge repositories by analyzing image contents [5], since the beginning of 1990s CBIR was an active field for multimedia community research [6].

The aim of a CBIR algorithm is to determine the images that are related to the QI from the database [7]. CBIR can retrieve images that are similar to the query input image using the "query by example" technique which requires the user to input any description about the query image. The system of CBIR works mainly by extracting features from the query image, then searching for these extracted features. These extracted features are used to calculate feature vector for the query image, CBIR represents every image in the database with a vector, after inputting the QI, the CBIR system computes its feature vector then compares it with the vectors stored for every image in the database. CBIR system returns the images that are similar in features to the QI.

Das et al. [8] described a method for extraction of features through binarization of images to enhance images retrieval and identification using content based image recognition. The authors tested their system using two public datasets with a sum of 3688 images. This method reduced the size of features to 12 regardless of the dimensions of image. The statistical measures (based on precision and recall results) were adopted for the evaluation purpose. One disadvantage of this method is the misclassification of query images which would affect the performance of the retrieval compared to other existing approaches.

Ashraf et al. [9] proposed a technique for representation of image and feature extraction using bandelet transform, this approach consistently returns the main (core) objects' information that are contained in an image. The artificial neural networks were used for image retrieval, the system performance and achievement was assessed using 3 public data sets namely: Coil, Corel, and Caltech 101, the precision and recall values were used for the retrieval efficiency evaluation

Seetharaman and Selvaraj [10] proposed a method for image retrieval using statistical tests, such as Welch's *t*-tests and F-ratio. Both of the structured or textured input query images were examined. In the experiment, the entire image is considered in

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the textured image, while in the structured image, the shape is separated into various regions based on its nature. The first step of the foresaid test is applying F-ratio test and the passed images proceeded to the energy spectrum testing. Then if images succeeded the two tests it was decided that these images are similar. Else, they are different. For validation and verification of the performance Mean Average Precision score was used.

Feng et al. [11] proposed an image descriptor (Global Correlation Descriptor) for texture and color feature extraction respectively so that they had the same influence on CBIR. Global Correlation Vector and Directional Global Correlation Vector were also proposed, they integrated the benefits of structure element correlation and statistics of histogram to describe texture and color features. Corel-10 K and Corel-5 K datasets were used for validation, and the recall and precision were used for the efficiency evaluation.

In Zeng [12] a local structure descriptor is proposed for image retrieval. Local structure descriptor is created based on the local structures underlying colors; it has combined the color, shape and texture as a one unit for retrieval of images. In addition, they proposed an algorithm for feature extraction which is able to extract local structure histogram using local structure descriptor.

Madhavi et al. [13] proposed an approach known as image retrieval using interactive genetic algorithm for calculating a high number of selective features then comparing of related images for these features. The approach was tested on a group of 10,000 general images to prove the efficiency of the proposed approach.

Ali et al. [14] Presented a CBIR approach using integration of Speeded-Up Robust Features (SURF) and Scale Invariant Feature Transform (SIFT). The representations of these local features are used for retrieval because SIFT is robust to rotation and scale change, and SURF is more robust to illumination changes. The integration of SURF and SIFT enhances the effectiveness of CBIR. The comparisons and evaluation were conducted on Corel-1500, Corel-2000, and Corel-1000.

One of the most commonly used meta-heuristics in optimization problems is the genetic algorithm. Genetic algorithm (GA) is a search algorithm which stimulates the heredity in the living things [15]. GA is very effective in finding the optimum solution from the search space [16].

In order to enhance the performance of a meta-heuristic such as GA, a local search algorithm is needed to help the GA for exploiting the solution space rather than just concentrating on exploring the search space. One excellent local search is the great deluge algorithm. The great deluge algorithm (GDA) was presented by Dueck [17] as a local search algorithm. The main idea of this algorithm came from the analogy that someone is climbing a hill and trying to move in any direction to find a way up for keeping his feet dry and the water level is raising through a great deluge. The great deluge algorithm when inserted in the genetic algorithm was an effective way to yield a good solution instead of using the genetic algorithm alone [18].

Based on the abovementioned revision and discussion, this work utilizes a memetic algorithm (MA) to find the images that has the highest similarity with the QI from a database. During the CBIR process every image in the database is indicated by chromosome, from the QI the color signature, shape and color texture are extracted and also from the chromosomes that were generated. The next step is calculating fitness function for every chromosome using similarity difference equation. After that MA processes like crossover, mutation, great deluge local search and selection of the highest fitness chromosome are applied on the chromosomes; the CBIR retrieves the most relevant images to the QI from the images database.

2. Materials and methods

2.1. Feature extraction

The CBIR system proposed in this work determines the features in the image utilizing its optical contents such as color signature, shape and color texture. Fig. 1 represents the block diagram of the proposed method and the details of each process will be illustrated in the following sections.

2.2. Color features extraction

Color feature is an essential component for image retrieval. For huge image databases, image retrieval using the color feature is very successful and effective. Although color feature is not a persistent parameter, because it is subjected to many non-surface characteristics for example, the taking conditions such as illumination, characteristics of the device, the device view point [1,19,20]. The steps of the color feature extraction are shown below:

1. Color planes values RGB are separated into individual matrices namely; Red, Green and Blue matrices.
2. For each color matrix color histogram is calculated.
3. Variance and median of color histogram are calculated.
4. The summation of all row variances and medians is calculated.
5. The calculated features of all matrixes (R, G and B) are combined as feature vector.
6. The feature vectors are stored in the features database.

2.3. Shape features extraction

The shape feature extraction mainly aims to capture the properties of the shape of the image items. This eases the process of shape storing, transmitting, comparing against, and recognizing. The shape features should be free of rotation, translation, and scaling [1,21,22].

To store, transmit, or recognize shape, an efficient way to find the shape features is investigated. The selected features are independent from any mathematical transformation. A colored image has three values per each pixel, to extract the features we convert the color image into one two-dimensional array, and that made according to Craig, formula as follows [1,23]:

$$I_g = [I_r \quad I_g \quad I_b] * \begin{bmatrix} 0.2989 \\ 0.587 \\ 0.114 \end{bmatrix} \tag{1}$$

Where I_g is the combined 2D matrix, $I_r \cdot I_g \cdot I_b$ are the color components which construct the colored image. I_g is represented as the grey level combined image. As a preprocessing step: noise reduced by using median filter. Median filter is beneficial to reduce salt and pepper noise and speckle noise [24]. Also, median filter has edge-preserving property it is used where blurring of edges is undesirable [24]. Median filter with width w and length l algorithm is as follows:

1. Around each pixel collect all pixels with length l/2 and width w/2 around it.
2. Sort all collected pixels.
3. Update the pixel value by the pixel value in the middle order in the previous list.

After applying the median filter, the image becomes almost without noise data. Then the neutrosophic clustering algorithm is applied to separate pixels with very near values and to ignore

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