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An efficient technique for retrieval of color images in large databases ☆

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ABSTRACT

Traditional image retrieval systems match the input image by searching the whole database repeatedly for various image features. Intermediate results produced for these features are merged using data fusion techniques to produce one common output. In this paper, a new image retrieval technique is presented, which retrieves similar images in three stages. A fixed number of images is first retrieved based on their color feature similarity. The relevance of the retrieved images is further improved by matching their texture and shape features respectively. This eliminates the need of fusion and normalization techniques, which are commonly used to calculate final similarity scores. This reduces the computation time and increases the overall accuracy of the system. Moreover, in this technique, global and region features are combined to obtain better retrieval accuracy. Experimental results on two databases (COREL and CIFAR) have shown that the proposed technique produces better results while consuming less computation time for large image databases.

1. Introduction

Content Based Image Retrieval (CBIR) is the process of searching similar images from the database based on their visual contents. A general purpose CBIR system has applications in many areas. There are many issues which affect the designing of a CBIR system e.g. selection of image features, dimension of feature vector, retrieval algorithm and method for presenting final results [1]. Generally a CBIR system uses low level features of the image to index and retrieve images from the database. However, it is very difficult to fill the semantic gap by using only low level features of an image because of the large diversity of image databases. Therefore an image retrieval algorithm and method for presenting final results need to be improved so that image features can better represent the semantics of the images.

Retrieval algorithms used in traditional CBIR systems search the whole database independently for different image features. Each of the features is represented by a point in the corresponding feature space. Some systems use several feature spaces to represent the same feature to improve retrieval accuracy. In this case, search in each feature space is performed independently, followed by data fusion methods to merge the retrieved sets (intermediate outputs) into one common output. An output is a ranked set of retrieved objects, which is an answer of the retrieval system to a given query. To merge the results of retrieval in different feature spaces, it is common to use linear combinations of the ranks of an element in each intermediate output as its rank in the common output [1]. For example, if CBIR is based on color, texture and shape feature

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of images, the system produces intermediate output by comparing color, texture and shape feature respectively with whole database. Fusion and ranking techniques are then employed to merge these intermediate results to produce final output of the system. A detailed description of fusion and ranking techniques used in image retrieval is discussed in [2].

These approaches, however, tend to have less accuracy as all intermediate results are formed by searching the whole database independently, based on specific features. These approaches also take high computation time due to searching of database multiple times and further fusion and ranking of the intermediate results. Apart from this, it is also not efficient to compare the combined feature vector of different feature spaces at once and produce the final result without producing intermediate results. Since different feature spaces contain different values of features and each feature has a different relative importance of retrieval.

To deal with the aforementioned issues, a new scheme for image retrieval is proposed in this paper. For image indexing in the database, global features based on color and texture are computed. These features are combined with contour based shape feature to form a single feature vector to be indexed in the database. When a query image is given as input to the system, the retrieval of similar images occurs in stages based on color, texture and shape similarity respectively. Intermediate results thus produced act as an input to the next stage i.e. the output images of each stage act as a database image for next stage, thereby reducing the number of images to be compared at each stage. This approach also eliminates the requirement of fusion and normalization technique required to get a final similarity score.

An image database contains a wide variety of images but images which are relevant to the query may be few. To better meet the user intent, the proposed system performs a search in relevant images only. This is different from traditional CBIR systems which search the whole database for every feature. Relevance of the images is first established by comparing their color feature. Search based on texture and shape features is performed only on the images having color similarity with query image. This approach reduces the diversity of database by removing irrelevant images at each stage so that low level features can better represent the semantics of images. Experiments have shown that the proposed system produces desired results with greater accuracy.

The remainder of the paper is organized as follows: Section 2 gives the related work done in the field of image retrieval which is relevant to this work. The architecture of the proposed system is presented in Section 3. Section 4 provides the details of the feature extraction process. In Section 5, experimental evaluation and results are presented. Conclusions are summed up in Section 6.

2. Related work

Traditional CBIR systems search independently in each feature space under consideration and use fusion and ranking techniques to merge intermediate results to produce a final similarity score. Two commonly used fusion techniques are: weighted sum of individual distances and a linear combination of the individual distances in a sorted order. We have studied a number of image matching techniques employed in different benchmark image retrieval systems. Some of the significant techniques are discussed in this section. A review of various ROI image retrieval techniques is given in [3].

Visual Seek [4], finds the matches of a query image with a single region, queries on color set, region absolute location, area and spatial extent independently. The results of these queries are intersected and from the obtained candidate set, the best matching images are taken by minimizing a total distance given by the weighted sum of the four distances mentioned.

Draw search [5], uses color/shape subsystem; the similarity between two feature vectors is given by the cosine metric. The similarity score between a query and a database image is calculated as a weighted sum of the distances between the two color vectors and shape descriptors.

In FIDS (Flexible Image Database System) [6], the distance between wavelet coefficients, is some weighted difference. An overall distance can be calculated by taking the weighted sum, maximum, or minimum of the individual feature distances, which preserves metric properties.

In VIR Image Engine [7], when comparing two images, for each primitive in the current query combination, a similarity score is computed using the distance function defined within the primitive. These individual scores are combined in an overall score using a set of weights in a way characteristic to the application. This score is then stored in a score structure, which also contains the individual similarity scores for each primitive. This allows a quick re-computation of the overall score for a new set of weights.

Wang et al. [8] have proposed an image retrieval scheme combining color feature like dominant color of region, texture feature like steerable filter and shape feature based on pseudo Zernike moment. To calculate similarity between features different similarity measures are employed. Final similarity between the query image (I) and the database image (Q) is calculated by taking the weighted sum of individual feature distances given as:

$$S(I,Q) = W_C S_{Color}(Q,I) + W_T S_{Texture}(Q,I) + W_S S_{Shape}(Q,I) \quad (1)$$

where $S_{Color}(Q, I)$, $S_{Texture}(Q, I)$ and $S_{Shape}(Q, I)$ are individual distances of color, texture and shape feature respectively. W_C, W_T and W_S are the weights.

In Blobworld [9], the quadratic form distance is used to match two color histograms. The distance between two texture descriptors is the Euclidean distance between their coordinates in representation space. The distance between centroids is the Euclidean distance. The distances are combined into a single final distance.