Color Image Query Using Hierachical Search by Region of Interest with Color Indexing

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Abstract: Indexing and Retrieving images from large and varied collections using image content as a key is a challenging and important problem in computer vision application. In this paper, a color Content-based Image Retrieval (CBIR) system using hierarchical Region of Interest (ROI) query and indexing is presented. During indexing process, First, The ROIs on every image in the image database are extracted using a region-based image segmentation technique, The JSEG approach is selected to handle this problem in order to create color-texture regions. Then, Color features in form of histogram and correlogram are then extracted from each segmented regions. Finally, The features are stored in the database as the key to retrieve the relevant images. As in the retrieval system, users are allowed to select ROI directly over the sample or user's submission image and the query process then focuses on the content of the selected ROI in order to find those images containing similar regions from the database. The hierarchical region-of-interest query is performed to retrieve the similar images. Two-level search is exploited in this paper. In the first level, the most important regions, usually the large regions at the center of user's query, are used to retrieve images having similar regions using static search. This ensures that we can retrieve all the images having the most important regions. In the second level, all the remaining regions in user's query are used to search from all the retrieved images obtained from the first level. The experimental results using the indexing technique show good retrieval performance over a variety of image collections, also great reduction in the amount of searching time.

Keywords: Color Indexing, JSEG, Hierachical Search, CBIR

1. INTRODUCTION

Interest in the potential of digital images has increased enormously over the last few years, fuelled at least in part by the rapid growth of imaging on the World-Wide Web [1] and digital image database. Therefore, the need of effective database management is required in order that user can retrieve most relevant images from the database. Content-based image retrieval (CBIR) is an approach, which uses content derived from the image itself as image indices. The basic features used in CBIR system are low-level features such as color, texture, and shape [2]. However, color features such as color histogram [3] and color correlogram [4] are widely used since they are easy to be computed and can effectively represent human perception of color image. However, the retrieval performance is still unsatisfied since it is difficult to derive meaningful object features in an image due to the limitation of the segmentation algorithm used to partition the image. Therefore, in this paper, we present the usage of efficient segmentation algorithm named JSEG [5]. The JSEG is suitable for segmenting objects with various types of texture, which is usually the difficult case in image segmentation. After meaningful regions of the objects in an image are extracted, their features can be derived and stored in the database as the image indices. In the query process, the proposed system allows user to select his/her regions of

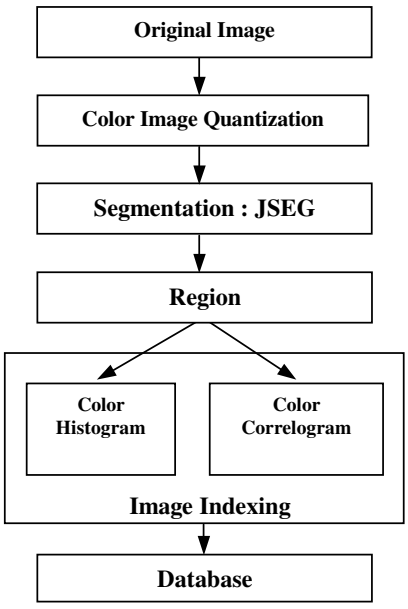

Fig. 1 Schematic of proposed indexing technique.

interest (ROIs) over the sample images. The selected regions are matched with the regions of each image in the database using hierarchical region-of-interest query. Then, the system returns the relevant images to the user as the retrieval results.

This paper is organized as follows. Section 2 details the proposed indexing technique. Section 3 describes the retrieval system while section 4 presents some experimental results. Finally, conclusion and future work are discussed in section 5.

2. THE PROPOSE INDEXING ALGORITHM

We adopt the following steps for the proposed indexing technique. The block diagram of proposed technique is shown in Fig. 1. During indexing process, original images typical 24-bit true color in general natural scenes usually thousands of colors, which makes it difficult to process directly by spatial algorithm. Accordingly, image colors can be more coarsely quantized by using vector quantization (VQ) [6] and a modified general Lloyd algorithm (GLA). During quantization process, first, a peer group filtering algorithm [7] is applied to remove noise without edge blurring. The final quantized colors are devided to 64 color ranges. Secondly, each image is segmented into N homogeneous regions using JSEG algorithm. From the previous step, original image becomes to the class-map image. The value of each point in the class-map can be viewed as spatial data points located in a 2-D plane. By using JSEG algorithm in this process, the region growing is applied on *J*-image that produced by JSEG algorithm. At the initialization, seeds are determined by simple heuristics, and then seeds are grown by connecting pixels to form growing areas. After that, the region merging technique is applied for further refinements after the growing process since pre-segmented image constructed in previous section is over-segmented. These regions tend to be merged based on their feature similarity. Finally, an agglomerative method is applied to merge the regions.

After segmentation task, color features are extracted from each region such as histogram and color correlogram [3 , 4, 8] which expressed as in equation 1 and 2, respectively. Color correlogram is a spatial extension of the histogram. Given any pixel of color C_i in the image, color correlogram gives the probability that a pixel at distance k away from the given pixel is of color C_j. In this paper, the correlogram is adopted in addition to color histogram. The correlogram provides spatial correlation between colors. The vectors of histogram and correlogram features of segmented regions are used as indices for each image in the database.

$$h_{ci}(I) = \frac{H_{ci}(I)}{n} \tag{1}$$

$$\Gamma^{(k)}_{c_i c_j}(I) = \sum_{(x,y)\in Ici} \Big(\lambda^{c_j,h}_{(x-k,y+k)}(2k) + \lambda^{c_j,h}_{(x-k,y-k)}(2k) + \lambda^{c_j,v}_{(x-k,y-k+1)}(2k-2) + \lambda^{c_j,h}_{(x+k,y-k+1)}(2k-2) \Big) \tag{2}$$

3. THE RETRIEVAL SYSTEM

In the proposed system, users are allowed to impose their desired requirements on the query image using rectangular box. The ROI selection area is then segmented into N regions using JSEG algorithm as in the indexing process. Color histogram and color correlogram are extracted from each region in the ROI. In matching process, color features from ROI are used to compare with these of indexing images in the database using similarity comparison. The similarity measure used is the modified L1 distance [9] of color histogram and color correlogram as shown in equation 3 and 4, respectively.

$$\left|I - I'\right|_{h_1 d_1} \triangleq \sum_{i\in[m]} \frac{\left|h_{c_i}(I) - h_{c_i}(I')\right|}{1 + h_{c_i}(I) + h_{c_i}(I')} \tag{3}$$

$$\left|I - I'\right|_{\gamma_1 d_1} \triangleq \sum_{i\in[m]} \frac{\left|\gamma^{(k)}_{c_i,c_j}(I) - \gamma^{(k)}_{c_i,c_j}(I')\right|}{1 + \gamma^{(k)}_{c_i,c_j}(I) + \gamma^{(k)}_{c_i,c_j}(I')} \tag{4}$$

where I and I' are the query and the indexing image. $h_{ci}(I)$ and $h_{ci}(I)$ are the color histograms and $\gamma^{(k)}_{Ci,Cj}(I')$ and $\gamma^{(k)}_{Ci,Cj}(I)$ color correlogram of I and I' images, respectively.

To retrieve relevant images, hierarchical query is performed instead of static query, which searches for N query regions to retrieve N query results and uses all the retrieved results to produce a single query result. Static query requires a large amount of search time due to a large number of regions containing in each indexing image. Even though hierarchical query requires less amount of search time, it is possible that a mistake from one level can propagate to next levels and cause retrieval errors at the end of query. Therefore, in this paper, two-level search is proposed, which not only can reduce the search time compared to the static search algorithm but also can reduce the effects of the mistakes propagating from one level to the next.

The hierarchical search is a combination of the static search and the traditional hierarchical search. In the first-level query, the most important regions from user's query, usually the largest regions at the center of user's query, are matched with the regions in the indexing images using the static search technique. Fig.2 shows example of regions used to search in the first level. The red window represents user's selected ROIs. To select the important region for first-level search, we consider the blue window positioned at the center of selected ROIs. The region covering more than 20% at the blue window is chosen and used to search for the first-level. The indexing images, which contain all the most important regions and have matching errors less than predefined thresholds, are retrieved from the database. The refinement search is performed in the second-level query to look for the remaining regions in user's query from first-level retrieved images. The schematic of this hierachical searching is presented in Fig. 3.

During matching task, the distance between the ROIs and feature of the indexing images in the database is calculated as shown in equation 5. Let w_1 be the color histogram weight and

w_2 be the correlogram weight, which are defined the value as 0.8 and 0.2, respectively.

$$Dis\tan ce(I,I') = (|I-I'|_{h,d_1} * w_1) + (|I-I'|_{\gamma,d_1} * w_2) \quad (5)$$

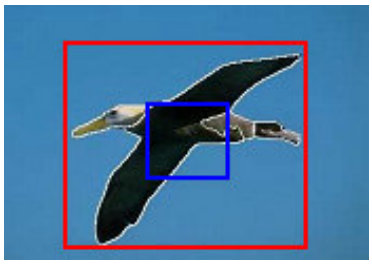

Fig. 2 The example of ROI selection and the most important region from user's query.

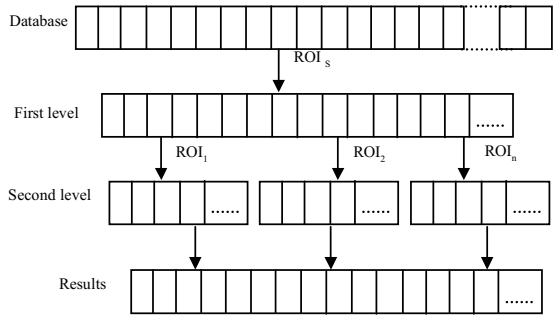

Fig. 3 Schematic of the hierarchical searching which produce the results from user's query.

4. EXPERIMENTAL RESULTS

We have experimented the proposed indexing approach using color features, regional color histogram compared to a combination of regional color histogram and its corresponding correlogram. These features are extracted from regions in the indexing images and the selected ROI of user's query. The number of histogram bins used is 64 bins while the distance set k = {1, 2, 3,…,10 } is used for computing correlogram feature. The database consists of 500 images, including animals, cars, flowers, flags, cards etc. Each set of images in the database contains 10 pictures and each picture contain an object with different scales, points of view, and backgrounds. Our query set consists of 100 queries, each chosen to represent various situations such as different views of the ROI, spatial translations and backgrounds. The retrieval performance of all the queries is shown in Fig. 7.

The retrieval performance [9] is evaluated using average precision at each recall level [x] as follow:

$$\overline{P}(r) = \sum_{i=1}^{N_q} \frac{P_i(r)}{N_q} \quad (6)$$

where $P(r)$ is the average the precision at the recall level r, Nq is the number of queries used, and $Pi(r)$ is the precision at recall r for the i-th query. The retrieval results and performance using region color histogram are shown in fig. 4 and 5, respectively. Fig.6 and 7 show the retrieval result and performance using the proposed combined feature of region color histogram and correlogram. The overall performance is presented in Fig.8. It can be seen that the results obtained by the proposed indexing technique represents better precision than those obtained by the other algorithm.

In order to carry visual comparative results, six different examples of the both retrieval results of the query using each type of features are presented in Fig. 4 and Fig. 6.

Fig. 4 The retrieval results of six different examples using regional color histogram feature.

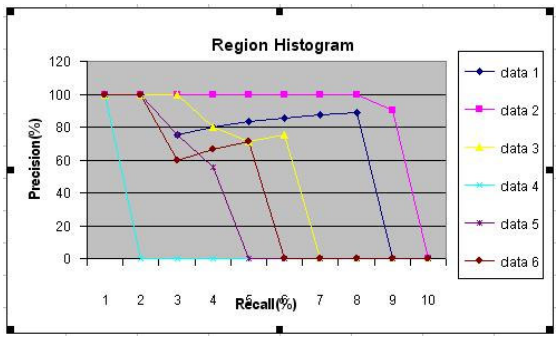

Fig. 5 The performance of retrieval system using regional color histogram feature.

Fig. 6 The retrieval results of six different examples using the combined features between regional color histogram and region correlogram.

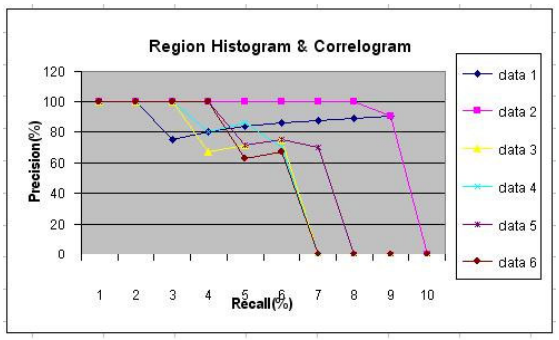

Fig. 7 The retrieval results of six different examples using the combined features between regional color histogram and region correlogram.

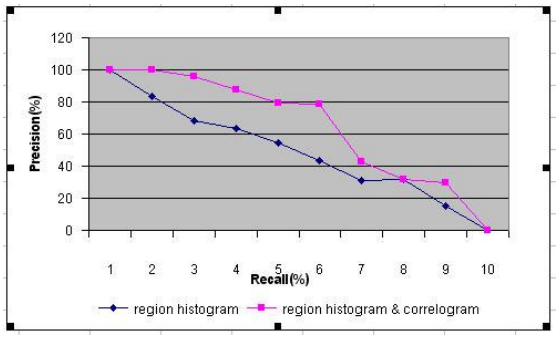

Fig. 8 Comparison of the overall performance between retrieving system that shown in Fig. 5. and Fig. 7.

5. CONCLUSION

This paper presents an indexing technique to the conten-based image retrieval problem by using region color histogram and correlogram analysis compared with the regional color histogram only. Since the results from the segmentation process using JSEG algorithm contain both color and texture on each segmented region, it can be used effectively to discriminate between different types of ROI, especially in the case of close-up objects.

The experimental results show that the proposed indexing technique is able to increase the overall performance and obtain good precision results on some data set of image categories such as cars, flags and flowers that shown in Fig. 6. Even though color indexing seems to give reasonable retrieval results, in some cases, only color features may not be enough to distinguish different types of ROI having similar colors. In order to further improve the retrieval performance, other features such as texture or shape should be incorporated with color information.

As future work, additional feature should be integrated to the proposed indexing technique to increase overall performance. The improvement of segmentation algorithm may gives retrieval results. Moreover, the appropriate range of color histogram should be appropriately specified in order to obtain the better performance of the proposed indexing algorithm.

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