Content-Based Image Retrieval with Graph Theoretic Approach

Ali Broumandnia, Mostafa Cheraghi, Mohsen Azararjmand

Abstract- The need for content-based image retrieval has increased with increment size and volume of digital images. This paper introduces the graph-based approach in order to retrieve the content-based image. In the proposed method, an image presents by a set of regions, while comparison of images are posing, each image represents by a graph, hence the estimation of the region correspondence transform into an graph matching problem. In addition, by using and image distance criteria, the difference between images obtained. Experimental results show that the proposed graph-theoretic image matching performance is acceptable.

Keywords-component: Content Based Image retrieval, Graph matching, Image segmentation, Matching Matrix.

I. INTRODUCTION

In recent years, with development of the Internet and recordable tools and produce digital images such as digital cameras, scanners and images. . . Size and volume of digital images has grown rapidly .On the other hand, in order to access and use information in the images, users require efficient tools to search and retrieve images [1].Automatic extraction of semantic information of images, something that many researchers are interested in extraction of semantic image's information in the field of database images .Content-based image retrieval is a set of techniques to retrieve images from a database based on extracted features of images automatically [2].Content-based image retrieval systems often indexed and presented images by using low-level attributes .Although these features cannot fully describe the semantic content of their images ,they can be easily extracted, measured and applied easily into mathematical formulations .However, retrieval image performance is not satisfactory just by using low-level features[3].The subject is due to gap between low-level features of visual images and high-level concepts that are contained.To reduce this gap, two techniques are widely utilized :region-based techniques to approach to the user's perceptions of image content and relevance feedback (RF) to learn the user's semantic subjectivity[4].

Many early CBIR systems perform retrieval based primarily on extraction of low-level features in entire image, including QBIC [5] and Photo book [6]. It is common that users accessing a CBIR system are looking for specific objects or conceptions.

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Thus, the aforementioned systems are likely to fail, since a single signature computed for the entire image cannot sufficiently capture the important properties of individual objects. Region-based image retrieval (RBIR) methods attempt to overcome the drawback of global features by representing images at object-level, which are closer to the perception of human visual system. [4]. As one image can contain several regions with several different concepts. On the other hand, user's query focuses on a specific part of the image. It is more logical that image to be considered as a set of semantic region than there is an overall view of image [7]. Image segmentation is a way to partition image to the area with similar visual characteristics. As images often consist of different numbers of regions, solving the many-to-many correspondence problem becomes a prerequisite for measuring image distance in region level. Also, since users often do not specify which the area of the image is more interested, designated areas of an image are also another problem that can be paid [8]. Thus, It is suggested the similarity of different image regions following the similarity of images based on their region should be defined [3]. In Content-based image retrieval systems, for searching an image with specific characteristics, the feature vector of query image with all the features vector of database images having compared. Many of these systems have utilized vectors to store and retrieve images, since Comparison of vectors is relatively simple, but in this case, spatial relationship of images region is not considered [7]. Graphs are very effective tools that not only can describe the region and objects in the images, but also they consider the relationship between them.Although, the graphs in vision systems of machine can be important and widely applied, Due to the computational complexity which is one of the crucial reasons that encounter with problem whenever comparison have been done [9]. Therefore, to incorporate both region attributes and spatial relationship into estimation, many cases represent an image as an attributed graph and transform the image matching problem into an attributed graph matching problem [3]. The organization of the paper is as follows: Graph-based approach proposed the estimation similarity of image regions and the measure similarity between images is presented in section 2. Image segmentation and feature extraction in this section described and then produce a matrix matching procedure will be explained. In section 3; experimental results is likely to be evaluated and finally section 4 will be demonstrating the conclusion.

II. IMAGE MATCHING

A. Image segmentation and features extraction

Real world images formed from various object with different colors, textures and sizes. In order to establish a relation between low level features extracted from image regions and semantic meaning

of them, an image should be segmented initially. In this paper, images segmented into several regions by using the Mean-Shift [11] algorithm. In summary, Mean-Shift algorithm works based on color of pixels in images works and in the various iterations, pixels with similar characteristic placed in one class and at the end, pixels of each class defines as region of the input image. Although the Mean-Shift segmentation algorithm Will follow Logical and reasonable procedures But it must be admitted the results May vary somewhat with the human perspective. Finally, with the image segmentation algorithm the images are partitioned into neighboring regions.

After the image segmentation, each region of the image can be depicted by using color, texture, location and size. To determine the characteristic of regions, use RGB values for Color as contrast, energy, entropy, homogeneity and solidarity [10] values for texture, and to specify the size of each region, the number of pixels forming the region can be used. Thus, the segmented image can be presented with a graph, So that each region of the image corresponding with a node in the graph and low-level features of image regions expresses graph node features. Figure 1 shows an example of image segmentation and graph representation. Now, the similarity between the segmented images can be determined based on the similarity between graphs.

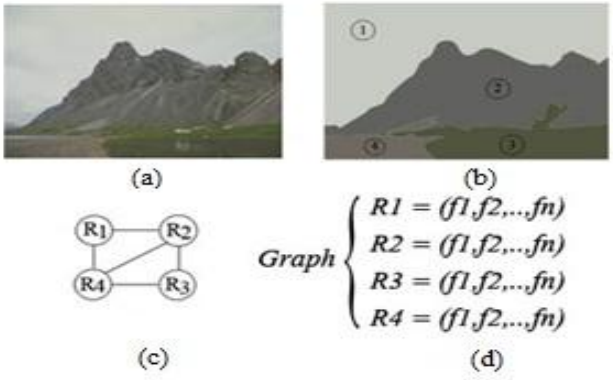


Figure1. (a) Original image, (b) segmented image, (c) graph representation, (d) feature vector

B. Use the graph to determine the similarity of image regions

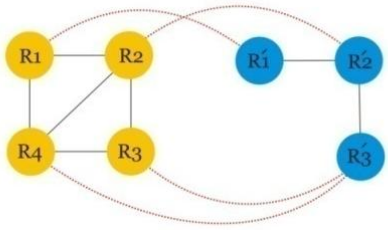
Suppose the query image as an attributed and undirected graph presented below:

$$G_D = (R_1, R_2, ..., R_3)$$

Where R_i represent Query graph nodes and feature vectors of query image regions. Each R_i represents one region of image and node feature with low-level characteristics are corresponded. Similarly, let the model graph denote a database image. The purpose of our region correspondence estimation is to determine the best matching matrix between the data graph G_D and the model graph G_M. A matching matrix S with dimension n * m is defined as:

$$S_{(i,j)} = \begin{cases} d_{(i,j)} & if\ R_j^{'}\ most\ similar\ to\ R_i \\ 0 & Otherwise \end{cases} \quad (1)$$

Our definition in (1) shows that a database image may contain unmatched regions which are irrelevant to the query image. Figure2 gives an example of the optimal matching between graph and matrix.



(a)

	$R_1^{'}$	$R_2^{'}$	$R_3^{'}$
R_1	$d_{(1,1)}$	0	0
R_2	0	$d_{(2,2)}$	0
R_3	0	0	$d_{(3,3)}$
R_4	0	0	$d_{(4,3)}$

(b)

Figure2. (a) Graph matching, (b) matrix matching

Now, given the data graph G_D and the model graph G_M, propose to determine the best matching matrix S by maximizing the likelihood probability $\rho = (G_D, G_M \mid S)$.

C. Determine the best matching matrix and Distance Measurement

This section describes and explains the differences between images, on account of low-level features and estimates similar regions of images.

Each image can be considered as a combination of regions and any region presented with low-level feature set of its constituent pixels Such as color, texture, size and location. Thus, for calculating the similarity of images the difference between the areas depending on the characteristics of low-level image features using the graph obtained and the difference between images using a combination of difference neighboring between regions can be determined. Assuming, query image with a data graph such as G_D and a database images with a model graph such as G_M are presented, the matching matrix production S is something that will continue to explain it. Since each of the graph nodes Equivalent with image regions indicates one constitutive image region Possessing graphs. $G_D = (R_1, R_2, \ldots, R_n)$ and $G_M = (R_1^{'}, R_2^{'}, \ldots, R_m^{'})$ Distance between nodes R_i و $R_j^{'}$ Can be identified as $d_{(i,j)}$ and its value calculated with the Euclidean distance between two nodes through the following equation obtained :

$$d_{(i,j)} = \sqrt[2]{\sum_{k=1}^{n} \pi_k * \left(f_{ki} - f_{kj}\right)} \quad (2)$$

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Where π_k represents the importance of the k the feature type and is referred to the attribute weight or feature weight and its value is initially 1.

Thus, comparing each regions of query image with all regions of the database image, distance Matrix which demonstrates the distance between two images can be obtained as follows:

$$D = \begin{bmatrix} d_{(1,1)} & d_{(1,2)} & \dots & d_{(1,m)} \\ d_{(2,1)} & d_{(2,2)} & \dots & d_{(2,m)} \\ d_{(1,1)} & d_{(1,1)} & \dots & d_{(1,1)} \\ d_{(n,1)} & d_{(n,2)} & \dots & d_{(n,m)} \end{bmatrix} \quad (3)$$

Where $d_{(i,j)}$ demonstrates the difference (distance) between the nodes properties. The similarity of region images expresses as distance matrix. Now, we describe how to achieve the optimal matching matrix. To do this, for every row of the distance matrix D, Element that has the greatest value remains unchanged and the remaining elements set to zero. In other words, for every node of the data graph the Node of the model graph that most similar is chosen.

For example, if i and j have the most similar characteristic, then:

$$d_{(i,j)} = \max\left\{d_{(i,1)},\dots,d_{(i,j)},\dots,d_{(i,m)}\right\} \quad (4)$$

And for the rest of the elements in row i will have:

$$S_{(i,\alpha)} = 0 \ (\alpha = 1..m \ \& \ \alpha \neq j)\left(G_D, G_M\right) = \sum_{a=1}^{n}\sum_{\alpha=1}^{m} S_{(a,\alpha)} \quad (6) \quad (5)$$

In sum, assuming a data graph and the model graph, the difference between the two regions to produce a matrix D and after that matching matrix S Is calculated. In comparing this method with other methods of segmentation-based image retrieval

The proposed method not only to consider the node properties but also considered spatial relationships between nodes.

The similarity of regions estimates as a result of the difference between the Query image and database Image in Terms of the difference between the regions, it will be calculated using the following equation:

$$\left(G_D, G_M\right) = \sum_{a=1}^{n}\sum_{\alpha=1}^{m} S_{(a,\alpha)} \quad (6)$$

III. EXPERIMENTAL RESULTS OF EXPERIMENTS

A. Evaluate the precision

Firstly, to test the proposed approach compared with the other methods presented; 10 different semantic categories have been used from a database containing 1000 images of Corel photo collection. The 10 semantic categories are: African people, beach, buildings, buses, dinosaurs, elephants, flowers, horses, mountains and food. Every database image is of size256 * 384 or 384 * 256 pixels in this set as well as their format are JPG.

As mentioned in Section 2, the proposed approach based on image segmentation and low-level features extraction therefore image regions are segmented initially, then extraction process of low-level features are applied. The region features such as Color, Contrast, Entropy, Energy, heterogeneity, and the correlation and the number of pixel incorporated in regions are determined. In addition, with selecting a query image Graph-based image retrieval Algorithms gives the similarity between the query image and each database image. And finally, Database images are sorted based on the distance with the query image, so the first image of the returned images has the least distance and the most similar to the query image.

Precision and recall are two criteria for evaluating the proposed method. The Precision is the number of relevant images returned to the retrieve ones and the recall is proportion of related images to the total number of relevant images in the database.

Figure3 compares the averaged precision-recall curves between the color histogram-based image retrieval system which is independent of segmentation and graph-based image retrieval system which is depend on segmentation as the proposed method.

This figure shows that the proposed system compared with other methods provide better results.

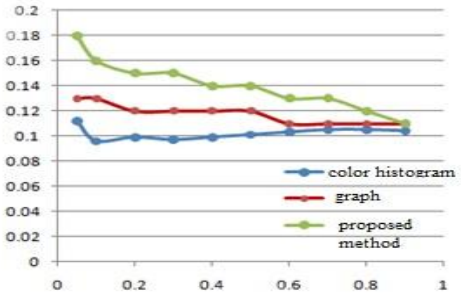

Figure3. Averaged precision-recall curves of the image-matching experiment

Figure 4 shows Average retrieval accuracy of three systems for each of the 10 categories. As may be seen in the figure, the proposed image retrieval system has lower performance for images of elephants and horses and foods comparing the image retrieval system based on graph theory, but in all categories compared with color histogram-based approach can produce better results. Surveys, on color histograms of this collection of images would make the issue clarified. Images with Dispersion color histogram is better image for the proposed system, so results would be more acceptable. Moreover, concentrated histogram images lead to having weak results. Table 1 indicates this.

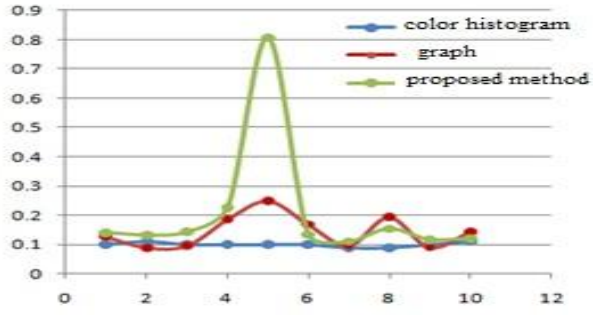

Figure4. Averaged precision for 10 categories

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As can be seen in Table, The mode parameter value for color space histogram of the image is far from than the average. The more dispersion it has, the better results it produces, versus the closer color histogram mode parameter value to the average one, the worst consequences it produces.

TABLE I. dispersion of the histogram for 10 categories

ID	1	2	3	4	5
Dispersion	201	241	215	236	321
ID	6	7	8	9	10
Dispersion	184	262	196	221	170

B. Evaluate speed

We conduct experiments on a computer system with a Core2Due 2.00GHZprocessorand2.00GB Memory and Window7 operating system.

Table 2 compares the acceleration of the proposed image retrieval system with image retrieval system based on the histogram and graph-based image retrieval system.

TABLE II. Speed of the retrieval system

Retrieval system	Color histogram	graph	Proposed method
Time	39.8	5.6	7.9

IV. CONCLUSION

The purpose of this research is to create a graph-based framework for content-based retrieval of images and comparing them. First, image segmented and spatial relationships between image regions and adjacent regions are estimated and the regions similarity transformed to the graph matching problem. The best matching between the graph equivalent matrix with an image database query and each of the images obtained. And measurement criteria to compare differences between images and retrieve images are proposed. Experimental results show the proposed image retrieval system performance is acceptable by acquiring the proposed graph-theoretic image matching.

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