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A SURVEY ON SEMANTIC CONTENT BASED IMAGE RETRIEVAL AND CBIR SYSTEMS

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Abstract- In this survey, we will present the basic idea behind the image retrieval systems. Image retrieval is becoming very important and emerging field. IR (Image Retrieval) is the part of image processing that extracts features of image to index images with minimal human interventions. There are many feature extraction techniques such as color, shape or texture retrieval among which texture retrieval is the most powerful and optimal technique. Semantic-based image retrieval has attracted great interest in recent years. The system segments an image into different regions and extracts low level features of each region.

Keywords: Semantic Content, Content-Based Image Retrieval, CBIR, Imaging Informatics, Information Storage and Retrieval, Image Segmentation, Feature Extraction.

I. INTRODUCTION

Advances in technology such as scanners, digital cameras, storage media and large online archives have led to a proliferation of both professional and personal collections of digital images [1]. Image retrieval has been an extremely active research area over the last 10 years, but first review articles on access methods in image databases appeared already in the early 80 decade [2, 3]. The fundamental content based image retrieval system consists of two major parts, feature extraction and classification (Figure 1). The images are kept in a database called Image Database. After preprocessing, images are segmented by using the method described.

CBIR system consists of two major steps [4]. The first one is the feature extraction, where a set of feature is generated to represent content of each image. The second one is similarity measurement where a distance between the query image and each image in database is computed using their feature vectors. The work focused on using low level features like color, texture, shape and spatial layout for image representation[5]. The earliest use of the term CBIR in literature seems to have been used by authors in [6] to describe their experiments of automatic retrieval of images from a database by color and shape features.

There are four phases of retrieves the images from the database based on the geometric properties of the input query images boundary [3].

- Image database generation phase
- Input images from scanner, thinning editing's
- Outline based image retrieval phase
- Identify the global shape similarity
- Global hash table generation phase

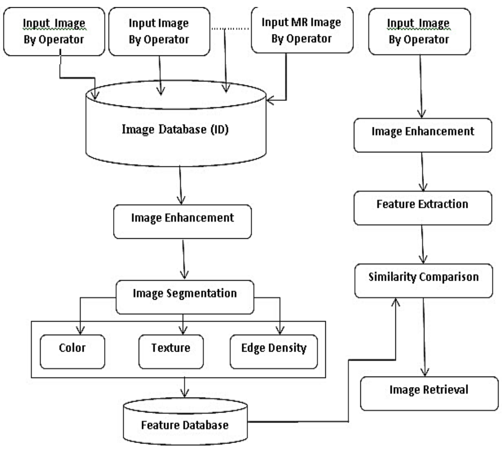


Figure 1. A scheme of a typical CBIR system

II. CASE STUDY

A. Image Database (ID)

Image database or Image Database Management System (IDBMS) [7-9] are emerging as an important component of Picture Archiving and Communications Systems (PACS) in order to support administrative, clinical, teaching and research activities. In image retrieval systems, operators inputs images in image database. It is proposed that an IDB system consists of a user friendly interface and graphical tools facilitating the interaction between the user and the various system components. The user is allowed to interact with the IDB and correct the results of image segmentation. Content-based image retrieval systems retrieve images from that image database which are similar to the query image.

The purpose of image segmentation is to identify and extract regions (or objects) of interest from all images, a task if crucial importance for the correct characterization of image content in any IDB system. In CBIR, each image that is stored in the database has its features extracted and compared to the features of the query image. It involves two steps [3, 10]:

1- Feature Extraction: The first step in this process is to extract the image features to a distinguishable extent.

2- Matching: The second step involves matching these features to yield a result that is visually similar.

B. Feature Extraction

In CBIR systems automatic image segmentation is a difficult task to compute. Images have to be represented by features and these features are compared to search for images similar to a given query image. Each image is represented by a set of features. An image contains several types of visual information which are difficult to extract and combine manually by humans [11]. Feature (content) extraction is the basis of content based image retrieval. In broad sense, features may include both text based features (keywords, annotations, etc.) and visual features (color, texture, shape, faces, etc) [12].

To find images similar to a given query image [13]. Feature (content) extraction is the basis of content based image retrieval. In a broad sense, features may include both text based features (keywords, annotations) and visual features (color, texture, shape, faces). In order to perform image retrieval process, the extraction of suitable features from the images are very important and by which, both the query image and database images are compared to retrieval of very similar images to query image from the database [14]. In radiology feature Extraction, generally used image features for content based image retrieval were followings: (a) Color, (b) Shape, and (c) Texture [15, 16].

The similarity feature, which is used for comparing the various features is the Euclidean Distance (*ED*). The formula of Euclidean distance is:

$$ED = \sum_{i=1}^{n} |x_i - y_i| \tag{1}$$

The minimum distance value signifies an exact match with the query [17]. Euclidean distance is not always the best metric. Four features were extracted from the image regions as we discuss in following subsections.

B.1. Color-Based Retrieval

The color feature is one of the most widely used visual features in image retrieval. It is relatively robust to background complication and independent of image size and orientation. Color the use of color cues in image description dates back to one of the earliest CBIR proposals. Some representative studies of color perception and color spaces can be found in [18-20]. Among all the visual features, color is perhaps the most distinguishing one in many applications. It may be represented by a color histogram [21] (Figure 2), color moments. Color moments can be effectively used as color features.

Although simple, these features are inexpensive to calculate. If the value of the *i*th color channel at the *j*th image pixel is *p*, then the color moments are defined as [12]:

$$\mu_i = \sum_{j=1}^{n} P_{ij} \tag{2}$$

$$\sigma_i = \left(\frac{1}{N}\sum_{j=1}^{n}(p_{ij} - \mu_i)^2\right)^{1/2} \tag{3}$$

$$S_i = \left(\frac{1}{N}\sum_{j=1}^{n}(p_{ij} - \mu_i)^3\right)^{1/3} \tag{4}$$

where, n is the number of pixels in an image.

Color histogram is the most common method for extracting the color features of colored images. Color histograms are widely used for CBIR systems in the image retrieval area [17]. The image histogram shows the variations of gray levels from 0 to 255, these all values cannot be used as a feature vector as dimension is too big to be stored or compared. The approach more frequently adopted for CBIR systems is based on the conventional color histogram, which contains occurrences of each color obtained counting all image pixels having that color.

Although most of the images are in the Red, Green, Blue (RGB) [22] color space, this space is only rarely used for indexing and querying as it does not correspond well to the human color perception. Other spaces such as hue, saturation, value (HSV), and LUV spaces are much better with respect to human perception and are more frequently used. Comparing the color content of images is an obvious, and consequently popular, choice for performing image retrieval duties. Color acts as a robust descriptor that can often simplify the tasks of object identification and extraction from a given image [22].

Figure 1. Sample image

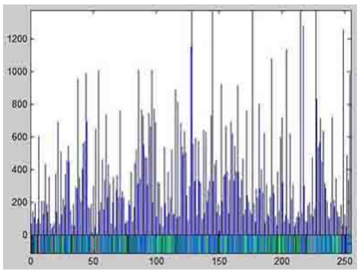


Figure 2. Corresponding color histogram of Figure 1

A single color or intensity performing image retrieval based on texture features in many ways resembles the basic methods of color based CBIR. Color informations import all pixels mapping to color lookup table.

A color from the color lookup table that is very near to the image pixel color is then selected and it will be stored as new color pixel in the image [16]. These operations will be done using the Euclidean distance formula.

$$d(p,q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + ... + (q_n - p_n)^2} = \\ = \sqrt{\sum_{i=1}^{n} (q_i - p_i)^2} \quad (5)$$

B.2. Texture-Based Retrieval

In CBIR, one of the salient common attribute is texture. In image classification [23, 24] texture provides important information as in many images of real world. Texture refers to the visual patterns that have properties of homogeneity that do not result from the presence of only different methods had been tried to gain information about the texture of an image using different aspects. In this paper, Gray-Level Co-Occurrence Matrix (GLCM) is created to supply some texture information[25].

The GLCM is a matrix created from the information about each pixel and its neighbors *d* blocks away. Numeric features are extracted from this matrix to provide different texture meanings or measures. The numerical measures used in this study are described as follows [26]:

$$contrast = \sum_i \sum_j (i-j)^2 P_d(i,j) \quad (6)$$

$$energy = \sum_i \sum_j P_d^2(i,j) \quad (7)$$

$$entropy = \sum_i \sum_j P^2(i,j) \log_d^p(i,j) \quad (8)$$

$$\begin{cases} inverse\ difference = \sum_i \sum_j (P_d(i,j)) / (ABS(i-j)^2) \\ i \neq j \end{cases} \quad (9)$$

The above four independent numerical texture features are extracted for each block from the extracted GLCM, and stored as the texture features.

B.3. Shape-Based CBIR Retrieval

Shape is an important visual feature for describing an object [27]. The shape feature is essential as it corresponds to the region of interest in images. Low level visual features are used for representation and retrieval of images. Each object/region within an image is indexed by object/region based shape feature vector. The shape feature vector is invariant to translation, rotation and scaling [28]. We use term shape to refer to the information that can be deduced directly from images and that cannot be represented by color or texture. As such, shape defines a complementary space to color and texture [29].

A shape based representation of the image content in form of point sets, contours, curves, regions, or surfaces should be available for computation of shape based features [13]. At low level vision, human can identify objects according to their shapes. Therefore, shape is another important feature to describe objects in an image. Since robust and accurate image segmentation is difficult to achieve, use of shape features for image retrieval has been limited to special applications. Shape features are less developed than their color & texture counterparts because of inherent complexity of representing shapes [30].

C. Image Retrieval Applications

A brief summary of some of the CBIR systems has been presented in this section:

C.1. QBIC

QBIC [3, 31], query by image content system, developed by IBM, makes visual content similarity comparisons of images based on properties such as color percentages, color layout, and textures occurring in the images.

C.2. VIPER

The design of the VIPER (Figure 3) search mechanism, which is now part of the GIFT architecture as a plugin, borrows much from text retrieval. It uses an inverted index of up to 80000 features, which are like terms in documents. For each image, roughly 1000 features are extracted.

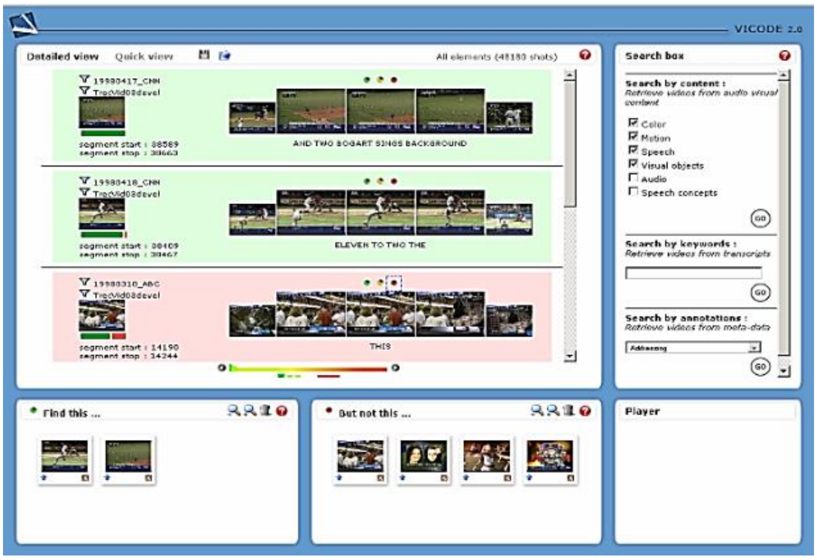


Figure 3. The VIPER content based image retrieval system

C.3. TinEye

TinEye [32] is a reverse image search engine. You can submit an image to TinEye to find out where it came from, how it is being used, if modified versions of the image exist, or to find higher resolution versions. TinEye is the first image search engine on the web to use image identification technology rather than keywords, metadata or watermarks.

Figure 4. The TinEye content based image retrieval system

C.4. CIRES System

CIRES [33] is a robust content based image retrieval system based upon a combination of higher level and lower level vision principles. Higher level analysis uses perceptual organization, inference and grouping principles to extract semantic information describing the structural content of an image (Figure 4).

C.5. PicToSeek

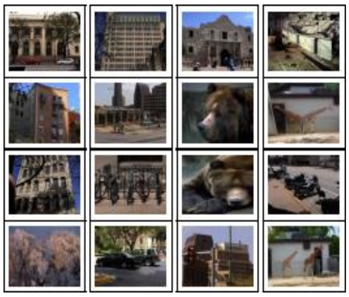
We have implemented a content based image search system, called PicToSeek [34] (Figure 6), for exploring visual information on the world wide web. In the first stage, PicToSeek collects images on World Wide Web by means of autonomous web crawlers. (a) visual browsing through pre-computed image catalogue, (b) query by pictorial example, and (c) query by image features.

Table 1 shows an overview of all live systems. The leftmost column lists systems, sorted alphabetically. The second column holds references for systems, then follow columns showing features: support of texture, color, shape, search by keywords, interactive relevance feedback, MPEG-7 descriptors [DK08] (for example dominant color), whether they are specifically designed to be used as web search engine, whether they use classification techniques or segment images into regions [35].

(a)

(b)

(c)



(d)

(e)

Figure 5. The CIRES content based image retrieval system, (a) Structure, (b) Color, (c) Texture, (d) Color + Texture (equal weights), (e) Structure + Color + Texture (equal weights)

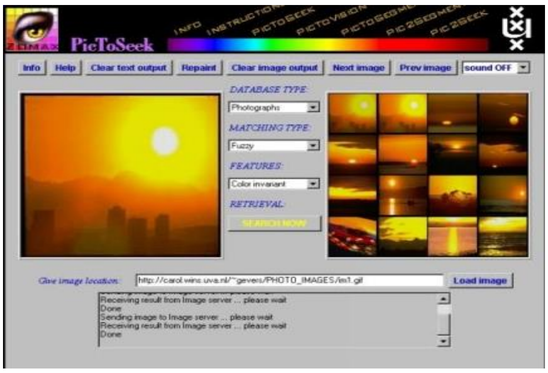


Figure 6. The PicToSeek content based image retrieval system

Table 1. Overview of all live CBIR systems

System	Reference	Texture	Color	Shape	Keywords	Interactive relevance feedback	MPEG-7 support	Designed for web	Classification	Image regions
Behold	[YHR06]	*	*		*					*
Caliph & Emir	[LBK03]	*	*		*		*			
Cortina	[QMTM04]	*	*		*	*	*	*	*	*
FIRE	[DKN04]	*	*		*	*				*
ImageFinder	[att07]	?	?	?					?	*
LTU Image Seeker	[LTU07]	*	*	*	?	?			*	
MUVIS	[GK04]	*	*	*						
Oracle Intermedia	[oim07]	*	*	*	*[2]					*
Picture Finder	[HMH07]	*	*	*	*	*				*
PicSom	[KLLO00]	*	*	*		*	*			
QBIC	[FSN+01]	*	*	*	*	*				
Quicklook	[CGS01]	*	*		*	*				
RETIN	[CGPF07, FCPF01]	*	*			*				
SIMBA	[Sig02]	*[3]	*	*						
SIMLIcity	[LWW00, WLW01]	*	*	*					*	*
SMURF	[VV99]		*							
VIPER/GIFT	[Mul02]	*	*			*				*

III. CONCLUSIONS

This paper reviewed the main CBIR components including image feature representation, indexing, and system design, while highlighting the past and current technical achievements. Although many CBIR systems have been developed, few of them can return relevant images where the image has been located. The large number of research publications in the field of content-based image retrieval especially in recent years shows that it is very active and that it is starting to get more attention.

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