Database as a Crucial Element for CBIR Systems

Tatiana Jaworska
(Systems Research Institute, Polish Academy of Sciences, 6 Newelska Street, 01-447 Warsaw, Poland)

Abstract: In this article we focus on the presentation of the inner structure of the database for the Content-Based Image Retrieval (CBIR) system containing, in our case, house images. The main body describes the structure of the database (DB) managed with the Oracle 10g DB system. We present to the reader the main differences and problems connected with constructing image and spatial DB in comparison with a text DB. For our system, Matlab is applied in image preprocessing, as well as retrieval of images which are answers to user's queries.

Keywords: the Content-Based Image Retrieval (CBIR) system; image processing; Oracle database.

1 Introduction

Determining how to store images in large databases, and later, how to retrieve information from them, is an active area of research in many sectors of computer science, including graphics, image processing, information retrieval and databases. Although attempts have been made to perform CBIR in an efficient way based on shape, colour, texture and spatial relations, it has yet to reach maturity. A major problem in this area is computer perception. In other words, there remains a big gap between retrieval images based on low-level features such as shape, colour, texture and spatial relations and retrieval images based on high-level semantic concepts such as windows, roofs, flowers, etc. [8]

In the 90's the Chabot project at UC Berkeley [6] was initialized to study retrieval and storage of a vast collection of digitized images. Also, at IBM Almaden Research Centre CBIR was prepared with a very interesting query interface which enabled the users to define their own graphical queries [5]. This approach allowed the users to find images on the basis of extraction of a set of features. These features were defined for the whole images.

Albeit much effort has been put to CBIR, many techniques have been proposed and many prototype systems have been developed [2], the problems with retrieving images according to image content are far from being solved. In the field of CBIR, new researches still tend to use the low-level features which are characteristic of the whole image. Other researches are based on the user's implicit feedback with the use of, for instance, the ostensive relevance approach [9].

In contrast with the approach mentioned above, our system takes into account not only low-level features but mutual localization of elements in the image as well. We also highlight the fact that the whole system, currently under construction, is intended to be entirely automatic. The purpose of this paper is to present the DB system which retrieves images based on individual elements of image, according to graphical user's query. The system consists of 3 main blocks:

(1) the image preprocessing block (responsible for image segmentation) applied in Matlab;

(2) the Oracle Database, storing information about whole images, their segments (here referred to as image objects), segment attributes and object localization;

(3) the graphical user's interface on a WWW site.

2 CBIR Conception Overview

Our CBIR system is built to support estate agencies. In the estate database there are images of houses, bungalows, and other buildings. To be effective in terms of presentation and choice of houses, the system has to be able to find the colour image of a house with defined architectural elements, for example: windows, roofs, doors, etc. Images are downloaded from the Internet in the JPEG format. Figure 1 shows a block diagram of our CBIR system. As can be seen, the left part of this system is *the image content analysis* block. This system part is implemented in Matlab (version 2008a) with the supporting toolboxes. The DB system is applied in Oracle Designer version 6i and it is implemented in Oracle 10g, whereas the graphical user's interface is created in Perl for WWW users.

Each new image added to the CBIR system must be preprocessed, which is presented in the *image content analysis* block as a *segmentation level* frame. All key architectural elements (such as windows, doors and roofs, etc.) must be segmented and extracted from the background at the stage of unsupervised preprocessing. The crucial issue is such an object extraction from the image background that further storage of these objects in the DB could be carried out without supervising.

For this purpose, we apply a two-stage segmentation, enabling us to extract in detail the desired objects from the image [4]. In the first stage, image is divided into separate RGB colour layers according to three light levels. In the second stage, individual objects (referred to as architectural elements of the house) are extracted from each layer. Next, the low-level features are counted for each object, understood as a fragment of the entire image. These features are: colour, area, centroid, eccentricity, orientation, texture parameters, moments of inertia, etc. Object storage in the DB takes place after counting the object low-level features and their logical features (juxtaposition, for instance) – details in sec. 3.

The right part of the diagram is dedicated to the users and it is processed on-line. Its first element is the graphical query interface block. In our system the user's interface is offered on a WWW page. If the users have a vague target image in mind, they have the possibility to computer-design their imaginary house and the system presents them with some optional houses based on these designs [3].

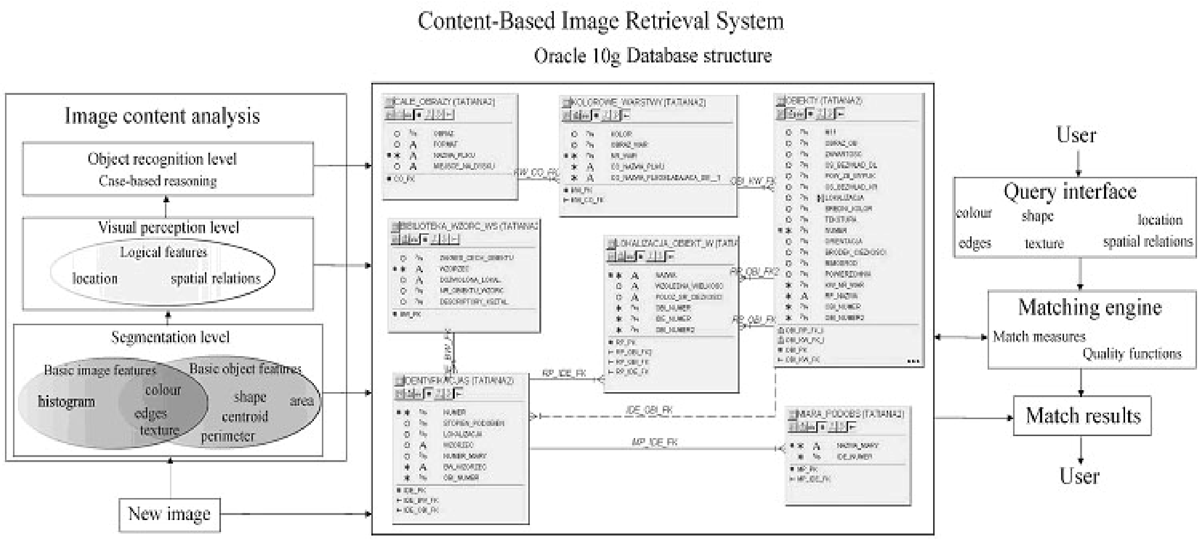

Fig. 1 Block diagram of our content-based image retrieval system

The next element of the system is the matching engine, which uses a distance function between the features on the low-level [7], the dissimilarity measures on the visual perception level and case-based reasoning on the high-level to search for "the best matched images". Retrieval results are presented by the user's interface.

3 Inner Structure of the Database

3.1 The inner structure of database of the CBIR system

All project stages of our DB were carried out in Oracle Designer, version 6i [10]. We used the entity-relationship modeller to generate all schemas [1].

The end-product of the modelling process is an entity-relationship diagram (ERD). Having transformed the entity-relationships diagram by the DB designer, we obtained the database server model which is presented in the middle of fig. 1. In the table models we can also see ID numbers and foreign keys which the Oracle transformer added automatically.

Image is the crucial information for the CBIR system. Hence, the CALY OBRAZ table stores the most general information about the image, such as: image file name, disc path and the image itself in graphical form (BLOB). According to the segmentation algorithm, an image is divided into colour layers, so the next table, called KOLOROWA WARSTWA, stores information about: the layer number, its colour and the layer graphical image. The foreign key between the above mentioned tables is of the many-to-one type. OBIEKT is the most capacious table of all, containing information about parameters of graphical objects which were extracted from particular colour layers. Here there are the following attributes: object ID, object image, solidity, major axis, area of the convex hull, localization, average colour, area, centroid, eccentricity, orientation, texture parameters, moments of inertia and a number of other objects. In case there is a necessity to add more parameters for object identification, we can easily increase the number of these table attributes because Matlab generates as many as 24 features of a graphical object.

The next table focuses on an object location. Therefore, the LOKALIZACJA OBIEKTOW table consists of information about the mutual location of two object centroids. For this reason, the table has two foreign keys to the OBIEKT table and, additionally, it has a connection with the IDENTYFIKACJA table, which identifies objects in terms of human perception. Such object identification is based on object parameters and localization, as well as a comparison with the pattern library. The object identification must be unique. Identification is understood as an assignment of each graphical object, consisting of a set of pixels (eg. a square or a triangle) to a pattern name. These patterns are the names of architectural elements applied by the user, such as windows, doors, etc. The assignment of an object to a pattern is based on (dis)similarity measures. Hence, there are two additional tables: BIBLIOTEKA WZORCOW and MIARA PODOBIENSTWA. The BIBLIOTEKA WZORCOW table contains information about pattern types, shape descriptors, object location and allowable parameter values for an object. The MIARA PODOBIENSTWA table consists of only names of similarity measures which will be used by Matlab to determine the degree of object (dis)similarity to a pattern and to retrieve an image required by user's query from images stored in the DB.

The DB discussed here has been generated and tentatively fulfilled with data calculated by Matlab earlier.

3.2 Information flow in the CBIR system

As it has been mentioned in the introduction, the system consists of three main blocks. Each block uses a different standard application which runs on a different operating system (on another physical server). The separation of particular functions among applications, as it is shown in fig.1, is not self-evident. That is why, the information flow in our CBIR system should be explained.

All the image content analysis is carried out by Matlab, but it is not a sequential process. Firstly, a new image is segmented and parameters of this segmentation are sent to Oracle and stored in the database. This procedure is implemented with the support of the following Matlab Toolboxes: Image Processing, Statistics and Wavelet. DB Toolbox supports the communication between Matlab and Oracle.

Secondly, the stored parameters pertaining to the DB are transferred to the matching engine (also implemented in Matlab) for object identification. Having carried out that identification, the matching engine can react to a user's query which is then, generated by the user's interface on the WWW site.

Thirdly, the matching engine results are sent to the DB. Then, the DB selects the best parameters received from the matching engine and sends them to the WWW site as an answer for the user.

4 Conclusions

The construction of a CBIR system requires combining different systems, which results in various conceptual, as well as purely technical, problems. Having built the image processing module for automatic segmentation we had to design the DB to store the generated information about images and their segments. The technical problems, which emerged on linking Matlab and Oracle via interfaces, were due to the fact that the Matlab server works in the Windows XP environment, whereas the Oracle server works on Unix; the difficulties were further aggravated by the differences between the applications themselves. The ongoing problem is also communication of these two servers with the WWW site.

After inputting data on images and their objects in the database, the next vital stage will consist in designing appropriate architectural object patterns. It is significant in so far as if we select pattern parameters in the wrong way, a window, for example, can be recognized as a French window, etc. This is even more difficult because object identification, similarly to image segmentation, is to be a fully automatic process. That is why the information obtained from the images is transferred to the match engine implemented in Matlab. Consequently, the achievement of all the above-mentioned stages will enable us to complete the CBIR system in its fully-fledged form.

References

[1] Barker R. (2005) Entity-Relationship Modelling. Case Method$^{SM.}$ Addison-Wesley Pub. Co. London (1995)

[2] Deb S. Multimedia Systems and Content-Based Image Retrieval, IDEA Group Publishing, Melbourne (2004)

[3] Fauqueur J., Boujemaa N.: Mental image search by Boolean composition of region categories, Multimedia Tools and Applications, Vol. 31, No. 1 Springer Netherlands, 95-117, October (2006)

[4] Jaworska T.: Object extraction as a basic process for content-based image retrieval (CBIR) system. In: Opto-Electronics Review, Vol.15, No. 4 (2007) 184-195

[5] Niblack W., Flickner M. et al. The QBIC Project: Querying Images by Content Using Colour, Texture and Shape, SPIE 1908 (1993) 173 187.

[6] Ogle V., Stonebraker M.: CHABOT: Retrieval from a Relational Database of Images, IEEE Computer **28**, No. 9 (1995) 40-48

[7] Rubner Y., Tomasi C., Guibas L.: The Earth Mover's distance as a Metric for Image Retrieval, International Journal of Computer Vision, Vol. 40, No. 2, Springer Netherlands (2000) 99-121

[8] Tan K-L., Ooi B. Ch., Yee Ch. Y.: An Evaluation of Color-Spatial Retrieval Techniques for Large Image Databases, Multimedia Tools and Applications, Vol. 14, Springer Netherlands (2001) 55-78

[9] Urban J., Jose J. M., van Rijsbergen C. J.: An Adaptive Technique for Content-Based Image Retrieval. Multimedia Tools Applications, Vol. 31 (2006) 1-28

[10] http://www.oracle.com/

Author Biography

Tatiana Jaworska received her MS degree in precision engineering from the Warsaw Technical University, Poland in 1992 and PhD degree in computer science from the Silesian Technical University in Gliwice, Poland in 2001. Since 1996 she has worked in the Systems Research Institute, Polish Academy of Sciences in Warsaw. Since 2005 she has been working on the house content-based image retrieval system. Her current research interests include image processing, wavelet analysis related to images and content-based image retrieval systems.