A DATABASE MANAGEMENT SYSTEM KERNEL
FOR IMAGE COLLECTIONS

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Abstract: The paper presents a single-user, relational DBMS kernel, for managing visual information. The functions of this multimedia DBMS are: creating/deleting databases and tables, adding constrains, inserting, updating, deleting records, text based querying and content based visual querying using the color characteristics. The originality character of this DBMS is given by two aspects: the first aspect refers to the Image data type that permits binary storage of images and extracted color information represented by the color histogram with maximum 166 colors; the second aspect refers to the visual interface for building content-based image query using color characteristics, that generates a modified SELECT command that will be sent to kernel for execution. This DBMS has as advantages the low cost and easiness in usage, being recommended in medical or art domains where large amounts of visual information are collected, managed and queried.

1 INTRODUCTION

Multimedia enhances in quality and quantity the sent information. That is the reason why multimedia and imaging represent an important component in computing. Multimedia information is complex, needs a lot of disk space and operations as updating, concurrent access and elements searching. The best solution to store, manage and find multimedia information is to use a multimedia database management system. A MMDBMS must have a series of important characteristics: support for multimedia data types, possibility to manage large number of multimedia objects, hierarchical storage management, conventional database capabilities and information retrieval capabilities (Khoshafian and Baker, 1996).

In conclusion, MMDBMS must have complex, high level interfaces for browsing and querying the multimedia objects.

Browsing and navigation is a technique where the user finds the object he wants to see or to update, starting from higher-level root objects. Such a technique is used in CAD/CAM/CASE applications, or in hypermedia documents databases (Khoshafian and Baker, 1996). This technique is not always adequate because the user might want to find associated objects, namely objects that have in common certain characteristics or attributes. The user specifies the query using a query language or a visual query tool, and then it is sent to the MMDBMS for processing. The query may relay on multimedia objects attributes or can be content-based (Khoshafian and Baker, 1996).

The paper presents a single-user, relational DBMS kernel that supports managing medium sized collections of digital images. For this, besides the usual data types (int, char), the proposed DBMS allows storage of images using Image data type. Excepting traditional operations in a database, the DBMS offers a visual interface for building, in an interactive manner, the content based visual query, using the color characteristics. To do this, when the user inserts an image in the database, besides storing the image in binary format, the algorithms for automatic extraction of the color information are executed. The RGB color space is transformed in HSV color space and quantified to 166 colors. The histogram represented by 166 colors, is also stored with the binary image in the database.

The proposed kernel for DBMS is original in the way it manipulates the images and because it gives the possibility for content based retrieval using color characteristics. It is easy to use in areas that manage not only traditional information (numbers and strings) but also visual information (medicine, art). The benefits of the content-based visual query in several areas of the medical domain were

emphasized (Muller et al, 2005). The presented DBMS has a low cost and might be an alternative to high level but also very expensive solutions like: Oracle 10g and Intermedia that support all types of multimedia; or MS SQL Server with Image data type, but in this case a complex application for managing visual information is needed (Chigrik, 2007, Oracle, 2005).

2 THE FUNCTIONS OF THE DBMS KERNEL

Next, the functions of the software tool will be presented.

2.1 Database Management

To create a new database, the user must specify the name of the database in the dialog window. First, the created databases are empty. For each database there will be made a new folder in the "Databases" folder, and all the pieces of information will be stored in the new folder. The name of this folder is the name of the database. After creating a database, it will be listed in the tree on the left side of the application window. This tree is used to see all databases, including their tables.

To eliminate a database, it must be selected from the tree on the left side of the window. Before completing the delete, the user must confirm the action because the database will be deleted entirely, including the database folder and all the files.

2.2 Table Management

To create a table, the user must select a database. Also, he must specify the name of the table, the columns, primary and external keys if any. The names of the tables in a database are unique. For each table it will be created a new file with a specific structure (a header area and a recording area). This file is created in the database folder having the name of the table and the ".tbl" extension. The user has to specify the structure of the table: the columns, data types, size, applicable constrains. The name of a column has to be also unique. This aspect is ensured by the DBMS.

Three types of data are implemented: int, char and image. For the fixed length strings, the user specifies the maximum size. A new type of data is introduced – Image. It permits storing in the database an image having one of the following formats: bmp, gif or jpg. When creating a new table,

the user may also specify the primary key. It can include one or several columns.

The user may specify a 1:m connection between two tables: a parent table (on the 1 side of the connection) and a son (on the m side of the connection). For this it must be used the Foreign Keys tag, in the same window. The user easily chose the parent and son table and the foreign key. The primary key and the foreign key must have the same type and the same size. If there is a connection between two primary keys, the connection will be 1:1. The structure of the table might be seen at any moment in the main window of the DBMS, using Components tag. Once the table is created, the user can add new records, modify or delete existing ones, using the record editor.

2.3 Updating Data in Tables

The user can add a new record only if the previous record was correctly added and saved in the corresponding file of the table. A record is correct if all the fields are filled with information having the type described in the structure. If one of the table's fields has the Image data type, when inserting, the "Chose image" dialog window is opened to permit the user to choose the image he wants to add.

In content-based visual query on color feature (the color is the visual feature immediately perceived on an image) the used color space and the level of quantification - meaning the maximum number of colors - are important. The color histograms represent the traditional method of describing the color properties of the images. They have the advantages of easy computation and up to certain point are insensitive to camera rotating, zooming, and changes in image resolution (Del Bimbo, 2001, Smith, 1997). In this DBMS the images are represented in HSV color space because of its properties: uniformity, completeness, compactness and naturalness (Smith, 1997), properties which make the space good for utilization in the process of the content-based visual retrieval. The transformation from the RGB color space to HSV color space is nonlinear, but still easy to implement (Smith, 1997).

Quantifying operation is needed to reduce the number of colors used in content-based visual query from millions to tens. The solution proposed by J.R. Smith was chosen, the one referring to quantification of the HSV space that produces a compact set of 166 colors (Smith, 1997).

The effectuated studies on nature and medical images have shown that the use of the quantified HSV color space to 166 colors is one of the best choices in order to have a content-based visual query

531

process of good quality (Smith, 1997, Stanescu et al, 2006). So, when the user inserts an image in the database, all these operations (color space transformation and quantization) are executed. In the column defined as Image type, the binary image and the color histogram are stored.

Regarding the delete operation, a record can be deleted only if it was selected before in the table editor. The user selects the line corresponding to the record he wishes to delete then he uses the delete-record option.

Each column in a record can be updated using the table editor. For updating, the user has to select it, namely to put the mouse pointer in the corresponding cell. When he moves the pointer in another location, all the updates will be saved in the table file.

2.4 Content-Based Image Query on Color Feature

Content based retrieval implies selection of an image as a query image and finding all the other images in a database that are more alike query image. This process can be executed at image level (CBIQ) or using only certain query regions of the image and considering their relative or absolute localization (CBRQ). Content-based visual query is mainly based on extracting image characteristics: color, texture, shape (Del Bimbo, 2001, Faloutsos, 2005).

The DBMS presented here gives the possibility to create content based visual queries based on color, at image level, in a simple manner, using the Query window that is presented in figure 1. The elements of this window are:

− From – the table used by the query is chosen from the list with the names of the tables
− Select – allows the user to select the field or fields that will be listed in the result query
− Similar With – opens the dialog window for selecting query image
− Where – specifies the Image type column on which content-based image query is applied
− Comparing method – there are few types of methods to calculate the similarity between the query image and the target images in the database: histogram intersection, Euclidian distance and quadratic distance between histograms.

The effectuated studies on medical images have shown that each of the methods listed above provided closely results in the content-based visual query. The studies have also shown that the results are complementary to each other (Stanescu et al, 2006). For example, if the doctor makes the same query several times, choosing different methods, he will obtain more relevant images.

− Threshold – the user can specify a threshold for image similarity. Under this threshold, the resulted images are listed
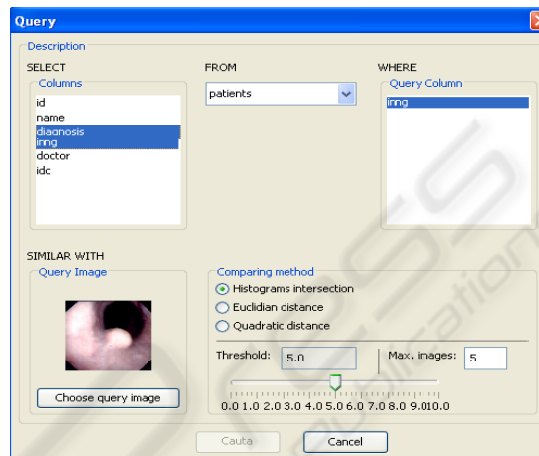− Maximum images – maximum number of images returned by the query process

Figure 1: The window that permits the building of the content-based image query.

After building this query, a modified SQL SELECT query is obtained, adapted to content-based image query. The structure of the command is:

```
Select patients.diagnosis,
patients.img From Patients where
Patients.img Similar with Query
Image (method: Histogram
Intersection, max.images 5)
```

This modified Select command specifies that the result set will be obtained from Patient table, considering the values from diagnosis field and similar images with the query image. The method used for calculation is histogram intersection and there will be listed only 5 images. The results will include also the distance of the similarity between the query image and the result image.

2.5 Data Organization

In the application folder there will be automatically created the folder named "Databases". When creating a database, a new folder is created with the name of newly created database. All the files for the database will be stored here. Every table of the database is stored in a separate file having the '.tbl' extension. This file has two components: a header and a data area. The header is added when the user creates the structure of the table, and the data area, when the user inserts, updates or deletes records.

The header will contain the following information regarding the structure of the table:

- *Number of records for header*

The header will contain a record for each column in the table. It will also contain a record for primary key of the table and a record for each external key.

- *Size for each record in header* (a header record contains data about a column in table: name, type and length in case of character string; or about primary key; or about foreign key/keys).

- *Header records*

For an image, in the data area of the file, the DBMS stores the following information:

- image type (bmp, jpg or gif);
- height and width of the image;
- number of bytes needed to store the image;
- the image in binary format;
- 166 integer values representing color histogram.

A series of methods frequently used in the medical domain are also implemented: rotating, zooming, pseudo-colors, the similarity distance between two images, a thumbnail representation, etc. The Image data type is generally in compliance with the SQL/MM standard.

3 CONCLUSIONS AND FUTURE WORK

The paper presents the functions and the data organization (file header and record area) of a DBMS that has as main goal the improving of the visual information management. In order to realize this goal, the DBMS has a graphical interface for designing the content-based visual query on color feature. The image color information is represented by color histogram with 166 values in HSV color space. The histograms intersection, Euclidian distance and quadratic distance between histograms can be used for computing the similarity between the query and the target images. The presented DBMS uses the Image data type that permits storing the image in binary mode and other necessary data (image type, dimensions, color histogram). It has a low cost and can be easily used in any domain that manages images. For implementation, Java technology was used.

The MMDBMS was tested using a system with the following characteristics: AMD Athlon 3000+ processor, 1 GB RAM Memory, 2x150Gb RAID HDD, Windows XP Professional operating system. The effectuated experiments showed that the time necessary for content-based image query process or for displaying the records (this process implies the extracting and viewing the binary images in the

database) is good. For example, in the case of 1000 records, the query time is 0.89 s and the display time is 15.28 s; in case of 20000 records, 4.7 s and 73 s respectively.

To enhance the quality of the software tool, the following directions will be searched:

- the disk space management, taking into account that the multimedia data needs a lot of space
- studying and implementation of traditional indexing algorithms and specific algorithms for spatial indexing
- adding new types of traditional or multimedia data, such as video or DICOM, taking into consideration that the medical domain is the main target for this MMDBMS
- studying and implementation of the concurrent database access
- extending content based retrieval combining color and texture characteristics

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