A MULTIMEDIA DATABASE MANAGEMENT SYSTEM FOR MEDICAL DATA

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Abstract: The paper presents a relational multimedia database management system for managing visual and alphanumerical information from the medical domain. The MMDBMS offers numerical and char data types for alphanumerical information, and Image data type used for storing in an original manner the visual information. An Image data type stores the image in a binary manner, its type, its dimensions and information about color and texture that are automatically extracted. This information will be used for content-based visual query process. The color information is represented by the color histogram quantified to 166 colors in the HSV color space. The texture information is represented by a vector with 12 values resulted from the method that uses Gabor filters for texture detection. This DBMS brings up as an element of originality the visual interface for building content-based image query using color and texture characteristics and a modified Select command. This MMDBMS, implemented using Java technologies is platform independent and can be easily used by the medical personnel.

1 INTRODUCTION

It is a fact that the number of images produced and used in the medical domain is exponentially increasing due to its development. More than 10,000 images are produced daily in large hospitals. It is considered that images from cardiology area are the most numerous, closely followed by the endoscope images. The use at large scale of the DICOM standard for image communication allows medical equipment to create a file containing both information about a patient (name, diagnostic, consultation data, doctor's name etc) and one or many images (Muller et al, 2004, Muller et al, 2005).

That is why managing and querying these large collections of images and alphanumerical information are difficult tasks. The most efficient way for solving these problems is to have a multimedia database management system with the following characteristics (Kalipsiz, 2000, Khoshafian and Baker, 1996, Lu, 1999):

- support for multimedia data types;
- possibility to manage a large number of multimedia objects;
- hierarchical storage management;
- conventional database capabilities;
- possibility to retrieve multimedia information.

Concerning the last characteristic, multimedia data (including visual information) need access methods much more complex that the simple text based query, or exact matching queries. The content based query takes into consideration attributes or characteristics extracted from multimedia information. The technique applied for images is called content-based visual retrieval and was intensely studied after 1990 (Kalipsiz, 2000, Khoshafian and Baker, 1996). The easiest way for implementation the content-based visual query is using primitive characteristics as color and texture (Del Bimbo, 2001, Faloutsos, 2005, Smith, 1997).

The directions where content based retrieval is needed in medical multimedia databases were fully specified. They are (Muller at al, 2004, Muller et al, 2005): diagnostic aid, medical teaching and medical research.

In order to manage content based retrieval for medical image collections a series of applications that use traditional DBMS (MS SQL Server, My SQL, Interbase) have been implemented. The complete solution is provided by Oracle - the Oracle 10g database server and Intermedia tool can manage all kind of multimedia data, including DICOM files. This kind of solution involves high costs for buying the database server and for designing and

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implementing complex applications for content based query (Chigrik, 2007, Kratochvil, 2005, Oracle, 2005).

This paper presents a DBMS based on the relational model, which is less expensive. The DBMS is platform independent and can easily manage medium sized image collections and alphanumerical information from the medical domain. It has a visual interface for building content based retrieval using color and texture characteristics and can be easily used by any person working in this area, even if he does not have advanced knowledge in using the computer.

2 DATA ORGANIZATION IN THE DATABASE MANAGEMENT SYSTEM

In this section it is described how the information is organized in the DBMS.

For each database a new folder is created with the same name as the name provided by the user. This folder is in the Database folder which is also created in the application main folder when the software is installed. Each table in the database is represented by a file with ".tbl" extension stored in corresponding database folder. The file has two components:

- A header – is created in the design phase
- Data area – is updated when executing traditional operations of Insert, Update and Delete

The header structure is made of:

- the number of records in table header (in the header there will be a record for each column in table, a record for primary key, and a record for each external key defined in the table).
- the size of each record from the header (a header record has information about a column of the table: name, type, length – in case of char strings; it can also store information about primary or foreign key/keys).
- the header records.

The DBMS has three types of data: int, char (fixed length strings) and image.

For the Image data type, in the data area the following attributes are stored:

- Image type (bmp, jpg or gif);
- Image height and width
- Number of bytes needed to store the image
- The image in binary;
- 166 integer values, representing the color histogram.
- 12 integer values, representing texture vector.

A series of methods frequently used in the medical domain are also implemented for the Image data type: rotating, zooming, pseudo-colors, the similarity distance between two images, a thumbnail representation, etc. The Image data type is in compliance with the SQL/MM standard (SQLMM, 2001).

There are described below the methods used for extracting color and texture information from an image and the reason why they where chosen.

The color is the visual feature that is immediately perceived on an image. The color space used for representing color information in an image has a great importance in content-based image query, so this direction of research was intensely studied (Del Bimbo, 2001).

There is no color system that it is universally used, because the notion of color can be modeled and interpreted in different ways (Gevers, 2004).

There were created several color spaces, for different purposes (Gevers, 2004). The color systems were studied taking into consideration different criteria imposed by content-based visual query (Gevers and Smeulders, 1999): the independence of the imaging device; perceptual uniformity; linear transformation; intuitive for user; robust against imaging conditions (invariant to a change in viewing direction, invariant to a change in object geometry, invariant to a change in direction and intensity of the illumination and invariant to a change in the spectral power distribution of the illumination).

It was proved that the HSV color system has the following properties (Gevers, 2004): it is close to the human perception of colors; it is intuitive; it is invariant to illumination intensity and camera direction. The studies made on nature and medical images have shown that in the case of the HSV, RGB, l1l2l3 and CieLuv color systems, the HSV color space produces the best results in content based retrieval (Gevers and Smeulders, 1999, Gevers, 2004, Smith, 1997, Stanescu et al, 2006).

The operation of color system quantization is needed in order to reduce the number of colors used in content-based visual query. The quantization of the HSV color space to 166 colors, solution proposed by J.R. Smith, is the idea used in this MMDBMS (Smith, 1997), having as result the color histogram which is memorized together with the image in the data area of the file.

Together with color, texture is a powerful characteristic of an image, existent in nature and medical images, where a disease can be indicated by changes in the color and texture of a tissue. A series of methods have been studied to extract texture features (Del Bimbo, 2001), but there is not a certain

method that can be considered the most appropriate, this depending on the application and the type of images taken into account.

Among the most representative methods of texture detection is the one that uses Gabor filters. This is why it is used in this MMDBMS for determining the texture vector.

Starting from the representation of the HSV color space, the color can be represented in complex (Palm et al, 2000, Zhang et al, 2000).

The affix of any point from the cone base can be computed as:

$$z_M = S (\cos H + i \sin H) \quad (1)$$

Therefore, the saturation is interpreted as the magnitude and the hue as the phase of the complex value b; the value channel is not included. The advantages of this representation of complex color are: the simplicity due to the fact that the color is now a scalar and not a vector and the combination between channels is done before filtering.

So, the color can be represented in complex (Palm et al, 2000, Zhang et al, 2000):

$$b(x, y) = S(x, y) \cdot e^{iH(x, y)} \quad (2)$$

The computation of the Gabor characteristics for the image represented in the HS-complex space is similar to the one for the monochromatic Gabor characteristics, because the combination of color channels is done before filtering:

$$C_{f,\varphi} = \left(\sum_{x,y} \left(FFT^{-1}\{P(u, v) \cdot M_{f,\varphi}(u, v)\}\right)\right)^2 \quad (3)$$

The Gabor characteristics vector is created using the value $C_{f,\varphi}$ computed for 3 scales and 4 orientations:

$$f = (C_{0,0}, C_{0,1}, \ldots C_{2,3}) \quad (4)$$

These 12 characteristics are also stored in the Image type field.

3 CONTENT-BASED VISUAL QUERY

The presented multimedia database management system offers the possibility to build the content-based visual query, in an easy manner, at the image level. The elements of the window which permit content-based retrieval are:

- Similar With – opens the window for choosing the query image
- Select – permits to choose the field (or fields) that will be presented in the results of the query
- From – it is one of the tables in database, that will be used for the query
- Where – the image type column used for content-based image query
- Features – it is chosen the characteristic used for content based visual query – color, texture or a combination of them
- Threshold – it is chosen a threshold of accepted similarity between query image and target image. An image with a similarity under that threshold will not be added into the resulted query images
- Maximum images – specify the maximum number of images returned by the query

The similarity between the texture characteristics of the query image Q and the target image T is defined by the metric (Palm et al, 2000, Zhang et al, 2000):

$$D^2(Q,T) = \sum_f \sum_\varphi d_{f\varphi}(Q,T), where d_{f\varphi} = (f^Q - f^T)^2 \quad (5)$$

The intersection of the histograms is used for computing the similarity between the query image Q and the target image T for color feature (Smith, 1997). If both distances are used in the query, the total distance is arithmetical average between the distances.

When building the query, it is actually built a modified SQL Select command, adapted for content-based image query. This command has the following structure:

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

This modified Select command specifies that the results are obtained from Patients table, taking into consideration the values from diagnosis field, the images similar with the query image for color characteristic, and there will be 5 resulting images. In the resulting set it is also presented the distance of the dissimilarity between query image and target image. In fact this modified command is very suggestive for the users (medical personnel).

4 EXPERIMENTS

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. Some of the preliminary results are presented in table 1. In this phase it was measured the time for

displaying records (there is only one field of Image type in the records), and the execution time of the content-based visual query taking into consideration the color feature, the texture feature and their combination. The execution time for these three types of queries is good. The time necessary to display all the records is higher, because the kernel must display the binary image and all attached information. One of the solutions that can be used in order to reduce the time needed for displaying the images, is to organize the display function in pages (for example 100 records on each page). The indexing solutions that will be implemented will improve significantly the presented values.

Table 1: The experimental results.

Number of records	Display time	Query time -colo	Query time - texture	Query time - both
100	4.516	0.350	0.328	0.450
1000	15.281	0.891	0.750	1.225
10000	25.563	1.500	1.480	2.673
20000	73.042	4.750	4.515	8.428

5 CONCLUSIONS

The paper presents a database management system for managing and querying visual information from an important domain - the medical one. To efficiently manage the images, the Image data type is used. It stores, in an original manner, both the image and the visual characteristics that are automatically extracted from it (color and texture vectors). The HSV color space, quantified to 166 colors is used for representing color information. For detecting texture the method based on Gabor filters is used.

The functions of the MMDBMS are: creating/deleting databases and tables, creating constrains (primary key, referential integrity), text based querying and content-based visual querying using two characteristics (color and texture). The MMDBMS implements a new type of Select command, adapted for this complex type of querying.

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