USING A COMPLEX NUMERICAL AND MULTIMEDIA DATABASE IN INTERNAL MEDICINE

Pre-release Evaluations

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Abstract: The paper presents a software tool implemented using Firebird and Delphi technologies, dedicated for managing and querying medical multimedia databases. The database contains images related to the internal medicine area. This on-line application allows creation of complex medical files of patients that can be viewed and updated both by internist and general practitioner. The main functions of the application are: managing patients contact information, examinations, imagery and personal folders; simple text based query; content based query using color characteristic for images provided by medical devices. It can be used in individual offices, laboratories or in the hospital clinics and departments. The application provides security and confidentiality for patient's data.

1 INTRODUCTION

Internal medicine is an important component of the general medicine that can be regarded as basics for many specialties: cardiology, pneumology, gastroenterology, nephrology, haematology, rheumatology, etc. It needs large amounts of paraclinical exploration performed by different devices that generates visual and numerical data used for diagnosis and for follow-up of treatment or evolution. Numerical information is given by functional and biological assays while various imagistic devices provide image data. In his reports, the doctor is making qualitative descriptions of abnormalities he found and elaborates reports that will be forwarded to the patients or to his colleagues from other departments. That is why internal medicine departments usually accumulate huge quantities of medical data, including thousands of image files, millions of numerical values and thousands of written reports.

Because most of the patients in these services are chronically ill patients, with frequent visits and frequent use ambulatory services, the rapid access to an archive containing both numerical and imagistic data would be an advantage. More than that, because access to high tech medical services is quite limited in some countries, many patients are frequently investigated in geographically dispersed medical centres. By using a dedicated application, the local doctor will be able to check simultaneously all the investigations and to give a diagnosis. Thus, he can integrate better all diagnostic data, manage the visits or the therapy taking into account all the concomitant pathology, or send the patient to another department for other investigations. As consequence, other specialists are able to see information from local or regional database and can query the archives.

These are some reasons for creating a complex application for managing and querying a database containing information and images from medical domain. Our database is implemented in Firebird (Interbase) that is a free and modern database management systems (Interbase, 2006).

The application is implemented using Delphi programming language that has important facilities for database management (Kermann, 2001). It can

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be used on-line, so the users have access from distance.

Besides managing patient information, including their consultations, the application has the possibility for managing and viewing the images provided by medical devices.

An element of originality is content-based visual query using color characteristic. It permits selection of a query image and finding all similar images from the database (Del Bimbo, 2001; Smith, 1997). This option could be very helpful for establishing the diagnosis.

2 THE DATABASE STRUCTURE

In this section, database structure used by the application including tables and logical connections between them is presented in detail. The database contains a number of tables populated when installing the application. The tables contain a series of codes that makes easier the work of updating patient information and the investigations. These tables are:

- Medical units with a specific code and name: the medical units can be an individual office, a laboratory or hospital clinics and departments.
- Users groups: this table stores information about user groups, administration rights for each group (administrators, doctors, nurses etc.). The table also contains a group identifier and a group name that can be specified for each group. Each unit has specific management rights.
- Users: is a table that contains user identification, name, password, and corresponding group.

The data confidentiality is ensured by user name and password that are provided separately for each unit. In order to increase the data security, the password is encrypted. Each doctor has access to information regarding his own patients, but he can share some data that can be seen by other specialists. He can also access both statistical and scientific data regarding all patients in database but in this case the identification data about patients is hidden and the ID number, name and address are blinded. At information management level, anonimizing all information concerning clinical data ensures confidentiality; diagnosis, paraclinical information, treatments are also blinded and only statistical data can be viewed. On the other hand, the office secretary can see personal information about patients and referring doctors, but no diagnosis and treatment elements are accessible.

- Diagnosis table is used for storing the diagnosis code and name.
- Analyses table codifies paraclinical and biological data. It has the following structure: code, description, and minimal and maximal value.
- Clinical examination table includes the following elements: code, description, and value.
- Patient groups include code and description. The patients can be grouped by the category of disease (digestive, cardiology, renal etc.), by the medical insurance category or by participation to different programs (national health programs or clinical studies).

The following tables are the most important in the database because they store information about patients, examinations, investigations and results:

- Patients table is used for storing information about patient's visits: personal ID number, name, doctor, county, city, address, phone/fax number, email and program – if any.
- A patient might have several examinations, for each of them storing in the Consulting table, the diagnosis, date and treatment. Each examination might contain one or several clinical examinations (it is stored code, description, a series of analyses identified by code and obtained value).
- Images table is storing information about still or moving images, obtained from a patient during his whole disease history. These data are: path and name of the image file, type of image and color information automatically extracted for later content-based image query on color feature.

3 THE FUNCTIONS OF THE APPLICATIONS

3.1 Set-up

This function permits updating auxiliary tables in database as for example tables containing diagnosis codifications, clinical examinations, analyses codifications, departments, user groups and users.

3.2 Patients Information Management

This function is one of the main functions in the application, and the information about patients has the following organization:

a) **Contact information** (personal ID number, name, address, phone, fax, email, category and National License Number of the examining doctor).

b) **Examinations**

The management of this information is implemented in a window that contains several secondary windows, as seen in figure 1. The first secondary window contains a record for each patient examination with the following information: examination date, diagnosis and results of the visit (solved/unsolved). This window is associated with four secondary ones, having the following functions:

1. Collecting data from clinical examination. For each analyzed system or segment the user can specify if he found normal or abnormal relations. A short description of the found abnormalities can also be added.
2. Collecting numerical data from laboratories and adding other information about important data.
3. Storing, as descriptive text, the results of various investigations: radiological, echography, endoscopy descriptions.
4. Storing treatment recommendations and prescriptions resulting from diagnosis.

Data from each secondary window can be easily updated using coding tables that were created in the set-up phase. The solution with secondary windows was chosen because the doctor should have an instant and easy access to the whole evaluation of the patient from one examination to another.

c) **Imagery**

This option gives access to all the functions of the application referring to the imagistic data concerning a patient, images provided by different devices (echograph, endoscope, MRI, CT, etc). These images can be loaded from saved files or can be imported directly from medical devices using a real time acquisition system. The system can be launched directly from this window. Imported images will be saved directly in the patient folder. It is possible to see the images directly, or to select one as a query image and to execute a content-based image query for the whole database to search similar images.

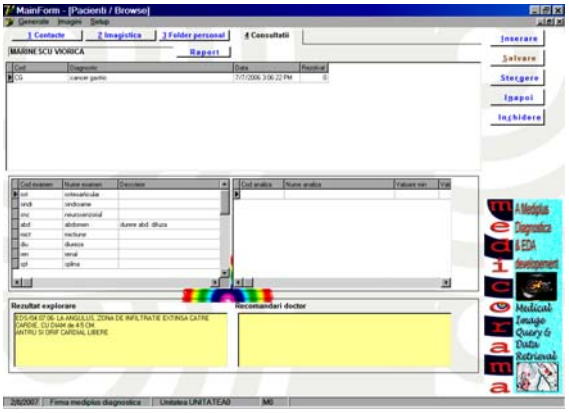

Figure 1: Window for managing patient examination data.

3.3 Database Query

It is one of the most important functions of the application. There are two types of queries: text-based query and content-based image query on color feature.

In the first case there are several search criteria that might be composed using “and”. These criteria are: patient name, personal numerical number, address, clinical exam and analyses. For the first three criteria it is used the “LIKE pattern’’ operator. Using this operator the Select command permits searching a string in all the values existing in database. For the last criteria, where information is codified in the database, the user can display a list of options to select one for search. Some useful queries that can be used are: list all the patients with a specified diagnosis, or list of all the patients that undergone a certain investigation or examination.

Visual data needs more evolved access methods. Such a method is content-based retrieval, which takes into consideration attributes or characteristics extracted from multimedia information. If we take into consideration the images, the technique is called content-based visual retrieval (Del Bimbo, 2001; Smith, 1997). This type of query implies selecting an image as query image, and finding all the images in database that are similar with it.

The medical areas where content-based visual queries methods can bring advantages are well known (Müller et al, 2004; Lehmann et al, 2004; Shyu et al, 1999):

- Diagnostic aid
- Medical teaching
- Medical research
- Electronic patient records

The reasons presented above generate the need to implement in the application the content-based visual query methods using color characteristic.

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 universal used, because the notion of color can be modelled and interpreted in different ways (Gevers, 2004).

It was proved that the HSV color system has the following properties: it is close to the human perception of colors; it is intuitive; it is invariant to illumination intensity and camera direction;

The operation of color system quantization is needed in order to reduce the number of colors used in content-based visual query: from millions to tens. The quantization of the HSV color space to 166 colors, solution proposed by J.R. Smith, is the idea used in this application (Smith, 1997).

The intersection of the histograms is used for computing the similitude between the query image Q and the target image T for color feature (Smith, 1997):

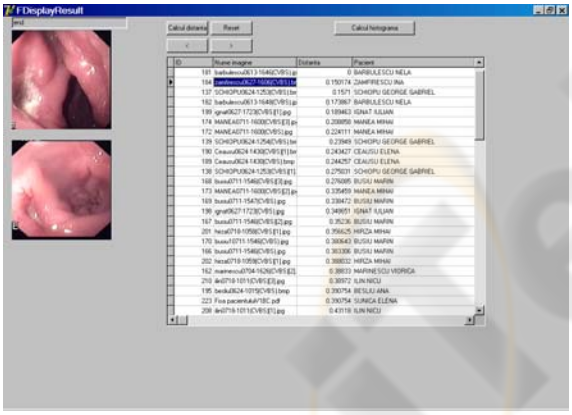

Figure 2: Window for content-based visual query.

The results of the experiments performed on a database with 960 images from the field of the digestive area are summarized in table 1.

The values in the table represent the number of relevant images in the first 5 retrieved images. For these five types of images (each type representing one diagnosis) the results are encouraging, but the experiments must be performed on a larger imagistic database and taking into account more types of color images. Only this way the conclusions can be reliable.

Table 1: Content-based image query experimental results.

Query	Nr. of retrieved images
Polyps	3
Colitis	4
Ulcer	3
Ulcerous Tumor	3
Esophagitis	4

4 CONCLUSIONS AND FUTURE WORK

The paper presents the design of a Firebird database, containing medical alphanumerical and imagistic information. The application is implemented in Delphi and can be accessed on-line. The main functions of the application are:

- Managing information about patients: contact information, visits, imagistic recordings, laboratory results, treatment
- Simple text based query that might combine several criteria
- Content-based visual query using color characteristic.
- Generates complete or synthetic reports

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