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Medical Multimedia and Multimodality Databases Systems

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ABSTRACT

In this paper we make a review of some medical multimodality and multimedia systems. After that, we discuss the main objectives and system architecture for a project of building a medical multimedia and multimodality database system. The MEDIMAGE system is presented as an example prototype for the proposed project.

Keywords: Medical multimodality systems, Medical multimedia systems, Medical images, Databases

1. INTRODCTION

Recent advances in computer technology and software have resulted in a shift from paper-based medical record to electronic medical record systems. Although electronic databases have been used in medical research for analysis of data for years, computerized information systems rarely have been used for collection of data during actual patient-physician interactions. Essential parts of these data are the medical images. Management of medical images has become a major issue for the development of healthcare in the last decades. Several medical devices produce medical images, such as: X-ray, X-ray computed tomography (CT), magnetic resonance (MR), magnetic resonance spectroscopy (MRS), single photon emission computer tomography (SPECT), positron emission tomography (PET), ultrasound, electrical source (ESI), electrical impedance tomography (EIT). Medical systems have tools to analyze multidimensional and multimodal medical images in order to improve diagnosis and therapy, especially when therapy is guided by medical images (video-surgery, interventional radiology, radiotherapy, etc.). Extraction of quantitative parameters are useful for diagnosis (shape, texture, motion), spatial registration of images acquired at different times, fusion of multimodal images, differential geometry, analysis of deformable motion, construction and use of digital anatomical atlases, morphometrical and functional brain analysis, building virtual patients and simulation of surgery, virtual and augmented reality in medicine, spatial localization of patients and surgical tools. Fused image data from different modality can improve medical diagnosis, surgery planning and simulation as well as intraoperative navigation.

Up to now, the main emphasis has been put on advances in technology that increases the capability to produce images, to manipulate them and improve medical diagnosis. However, the increasing number of images leads to fragmentation of information while a comprehensive therapeutic approach would go to integration of data. These data are of different types and provide medical images from different sources and modalities.

The rest of this paper is organized as follow: in section 2 we give an overview of medical multimodality and multimedia systems; section 3 will discuss the medical multimodality and multimedia systems objectives; followed by the system architecture in section 4. Our conclusions will be given in section 5.

2. REVIEW OF MEDICAL MULTIMODALITY AND MULTIMEDIA SYSTEMS

Medical multimedia and multimodality databases support multimedia and multimodality data types, need to handle very large number of multimedia objects and have cost-effective storage and information retrieval capabilities. Such a system includes features for acquisition, review, interpretation, management and communication of multimodality images, expandable and open system architecture, database management with a user-friendly interface. Theses systems are continuation of the development of image database systems.

There are several specific requirements for using medical images such as: (a) What kind of images to be acquired? (b) How the interested characteristics to be obtained?

The specific aim in this field is to develop a query languages and indexing methods for retrieval, based on the contents of the multimedia objects such as images. The traditional text-based image retrieval approaches have the following specifications:

- Using text-based query languages such as SQL, and retrieving partially matched results with similarity ranking;
- Handling abstract concepts and high-level objects;
- Having difficulties to describe visual features like color, texture, and irregular shapes;
- Limiting the scope of the search to a predetermined domain provided by the system's author;
- Indexing due to the limited speed of entering the description text manually.

Recently developed content-based approaches have the following features, which are also applied for medical images:

- Using color, texture, shape, and an extendable set of descriptors such as Fourier descriptor and moment invariant. Therefore, they are capable to query based on visual characteristics of the data e.g., irregular shapes and texture features;
- Indexing procedure is relatively fast compared to the text-based method;
- Queries and retrievals are directly based on the visual objective properties of the data, so that they are reproducible procedures.

The most of the existing content-based image retrieval methods are directly based on the visual features of the images like color and texture. These methods use a similarity measure after feature extraction for classification indexing.

There are several medical systems working with multimedia and multimodality information. Some of them are:

- QUICKSEE - a system for endoscopic exploration uses 3D radiological images and text [http://cobb.ece.psu.edu/krishnan/krish_home.html];
- The database of the anatomic MRI brain scans of children across a wide range of ages to serve as a resource for the pediatric neuroimaging research community [6];
- BrighamRAD teaching case database, department of radiology, Brigham and Women's Hospital Harvard Medical School [2];
- BrainWeb Simulated Brain Database site of a normal brain and a brain affected by multiple sclerosis [3] http://golgi.harvard.edu/biopages/medicine.html;
- MedPix™ [http://rad.usuhs.mil/synapse/radpix.html] - a fully web-enabled and cross-platform database, integrating images and textual information. The primary "target audience" includes physicians, medical students, graduate nursing students and other post-graduate trainees. The data are organized by disease category, disease location (organ system), captions, and by patient profiles. MedPix™ can be searched through multiple internal image and text search engines. In addition, search formulations can be sent directly to PubMed, or to other outside search engines;
- A Medical Image Database System for Tomography Images - described in [http://www.ics.forth.gr/ICS/acti/cmi_hta/publications/papers/1988-1994/car89/car89.html]. The attention has been focused on techniques for the automated description of anatomical crossections in terms of geometrical features, which facilitate matching operations and can be used to access tomographic images by content. The organization of the image database and possible strategies for image retrieval by content are available;
- MediMedia [http://www.infowin.org/ACTS/NEWS/CONTENT_UK/981101uk.htm] - an extensive database of medical case histories and surgical procedures. An example of the application of the MediMedia database is in pre-operative planning for the execution of medical interventions, such as hip surgery. X-ray images and CT scans taken prior to the operation are processed by the system to make 3D computerized models of the patient's bones. The system enables the surgeon to visualize the area of interest and plan the precise details of the surgical intervention, such as the orientation and alignment of the various cuts.

3. THE MEDICAL MULTIMODALITY AND MULTIMEDIA SYSTEMS OBJECTIVES

Medical Multimedia and Multimodality Databases Systems are radically different from conventional information systems. Many novel issues need to be addressed. The system should be capable of providing access to the content of images. Where symbolic and numerical information are identical in content and form, images require a delicate treatment to approach their content. To search and retrieve items on the basis of their

pictorial content requires a new, visual way of specifying the query, new indices to order the data and new ways to establish similarity between the query and the target. A major problem stems from the fact that an interpretation of an image has no unique meaning especially for medical images.

Now we will present our project to built a multimedia and multimodality system. The core of the system will be a new multimedia retrieval system based on the semantic information embedded in the data. The main source of information will be images with the associated text and possibly speech. Special algorithms will be applied to "understand" the data content and retrieve the required information. The system's query will be based on a description of the subject or by examples. The database will be structured in a modular fashion, in such a way to allow people with different knowledge to access the information in a format which can be easily understood.

An intelligent interface will allow the user to specify the query for the requested subject, either defining certain static or dynamic features of the objects to search for, or by examples. The system will search within the multimedia database for the data containing the described objects. The role of the intelligent interface will be to guide the archiving of images, text or voice, depending on their semantic content and to retrieve them.

In order to fulfil the objectives the following steps will be taken:

- to develop novel, more robust, techniques for shape-based object recognition;
- to develop new, more versatile, algorithms for speech recognition;
- to augment existing database structures to comply with the new modular database structure comprising text, and images;
- to develop a suitable user interface to access the multimedia information;
- to test the performance of the system over a significant data set providing a statistical estimate of robustness and reliability;
- to realize a prototype of the multimedia database with semantic query.

In order to reach the objectives of the project, advanced techniques based on computer vision and geometric computing will be applied. The system will be composed of several modules, devoted to the semantic processing of images, and speech and the user interface. The system will be tightly coupled with the MPEG7 standard.

This project addresses the following issues that need research for a more successful exploitation of content-based image retrieval:

- Management: multimedia and multimodality data models, distributed object management.
- Manipulation: image transformation, feature enhancement.
- Analysis: image analyses, pattern recognition, object detection and recognition.
- Search: filtering, content-based querying.
- Access: content-based indexing, personalized access control.
- Retrieval: multimedia retrieval models, content-based querying.

4. MEDICAL MULTIMODALITY AND MULTIMEDIA SYSTEM ARCHITECTURE

The three main parts of such system are: the data model, the image processing tools and the managing tools.

4.1. Medical Multimodality and Multimedia Systems Data Model

The medical multimedia and multimodality databases must support multimedia and multimodality data types, handle very large number of multimedia objects, high-performance, high-capacity, cost-effective storage and information-retrieval capabilities. The proposed model will establish taxonomy based on the systematization of the existing approaches. It will be based on the models [4, 7, 10] and will use the experiences by building the image databases [8, 9] and the medical systems [1, 5].

4.2. The Medical Multimedia and Multimodality Databases Image Processing Tools

There are mainly two general methods for image comparison: intensity-based (color and texture) and geometry-based (shape). A recently held user survey shows that users are often more interested in retrieval by object shape than by color and texture. However, retrieval by shape is still considered one of the most difficult aspects of content-based search. Indeed, systems such as IBM's QBIC, Query By Image Content (http://wwwqbic.almaden.ibm.com), perhaps one of the most advanced systems to date, is successful in retrieving by color and texture, but not too much by shape. A similar behavior shows Alta Vista photo finder (http://image.altavista.com/cgi-bin/avncgi). The departing point in the medical multimodality and multimedia systems is the shape similarity measure based on the correspondence of visual parts. While much work has already been done in the direction of matching point sets, two curves, or two regions, little attention so far has been paid to developing methods for matching a collection of

curves and regions against another collection, which is essential for the medical images. This will be a key point in the development of the image processing tools in the Medical Multimedia and Multimodality Databases System project.

4.3. Medical Multimedia and Multimodality Databases Managing Tools

In medical systems the main effort is put on advances in technology that have increased the capability to produce images, to manipulate them and improve medical diagnosis. These databases are of different types and provide medical images from different sources and modalities. In the project we propose the contents of the different databases to be brought to a common description by use of the eXtensible Markup Language (XML).

4.4. MEDIMAGE – a prototype of a Multimedia and Multimodality Databases System

We determined topographic selectivity and diagnostic utility of brain atrophy in probable Alzheimer's disease (AD) and correlations with demographic factors such as age, sex, and education. A medical multimedia database management system MEDIMAGE was developed for supporting this work. Its architecture is based on the image database models [4, 7]. The system design is motivated by the major need to manage and access multimedia information on the analysis of the brain data. The database links MR images to patient data in a way that permits the use to view and query medical information using alphanumeric, and feature-based predicates. The visualization permits the user to view or annotate the query results in various ways. These results support the wide variety of data types and presentation methods required by neuroradiologists. The database gives us the possibility for data mining and defining interesting findings. A detail description of the system is presented in [11]. The MEDIMAGE system architecture is shown in the Figure 1.

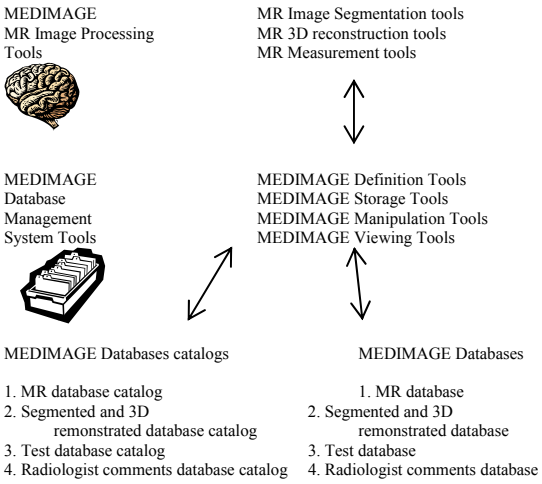

Figure 1. The MEDIMAGE system architecture

In the MEDIMAGE system there are four databases: (1) for MR images, (2) for segmented and 3D reconstructed images, (3) for test data, (4) for radiologist comments. The MEDIMAGE MR image processing tools includes: (1) MR image segmentation tools. These tools include bifeature segmentation tool and ventrical and sulcal CSF volume calculation tool. The CSF denotes the fluid inside the brain. (2) MR 3D reconstruction tools. These tools include total brain capacity measurement and region of interest definition tools. The MR measurement tools include hippocampal volume determination tool. The MEDIMAGE database management tools allow image retrieval based on alphanumeric and feature-based predicates and numerical, text, voice and statistic data retrieval. The viewing tools allow viewing images and text, numerical and voice data from the four databases supported by the system.

5. CONCLUSIONS

The advances in medical imaging over the last two decades have a compact effect on diagnosis, treatment planning and evaluation. In spite of the available medical multimedia and multimodality systems much has to be done in the future using the multimedia technology. They will cover:

- A-click-away information available for the surgeon about the previously treated patients similar to the current case especially in terms of their visual characteristics;
- Keeping track and providing conclusions about a group of patients undergone through a particular treatment plan over the past period of time;

- Evaluating the disease and results of the treatment plan, and their quantitative effects on the normal/abnormal structures/tissues of the brain based on the scanned image data sets;
- Having the previous case experiments/documents and providing easy access to the meaningful patient's information.

On the other hand, patient's medical image data form a huge source of information. The medical data for each individual patient should be augmented with the neurological knowledge and surgery experiences in the expert's mind to perform diagnosis, treatment planning, treatment evaluation, and to discover correlations between symptoms, planning, treatments, and their outcomes. Considering the huge amount of patient's data, it is impossible for a human being to keep track of all parts of it, a specially its quantitative aspects. We hope that the area of the multimedia and multimodality medical system is a very rapid growing area and we expect a lot of research in the very near future.

The main conclusion of the use of our prototype MEDIMAGE systems is that the content-based image retrieval is not the essential part in such kind of a system. Data mining algorithms play essential roles in similar systems.

Successful completion of such a project requires expertise in many technological areas, such as information systems, information indexing and data mining, image processing and analysis, computer vision, and human factors. Moreover, successful completion of this project will trigger new vistas in many application areas.

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