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Research and Implementation of Medical Images Management System Based on DICOM Standard*

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Abstract. The demand for the management and transmission of medical images is growing faster. In this paper we discussed how to transmit and query the medical images within LAN, and presented a novel medical images management system based on the DICOM standard. We used a new semantic image retrieval method, which exploits the high level semantic similarity. This system firstly parsed DICOM files and stored both the DICOM image files and the corresponding patient medical records information into the database together. Therefore it completely supported the workflow of the hospital with the digital images. The experimental results met the demands of current picture archiving and communication system for mass data storage, and clearly showed the convenience and the value of the presented methods.

1. Introduction

Medical images play a central role in patient diagnosis, therapy, surgical planning, medical reference, and medical training. With the advent of digital imaging modalities, as well as images digitized from conventional devices, collections of medical images are increasingly being held in digital form. It becomes increasingly expensive to manage medical images manually. So the image database is becoming an important element of the emerging information technologies. It has been used in an a wide variety of applications such as: computer-aided design and manufacturing systems, multimedia libraries, medical image management systems, biology, geology, mineralogy, astronomy, house furnishing design, anatomy, criminal identification, geographical information systems, etc. Meanwhile they are becoming an essential part of most multimedia databases. So with the development of the health information technology and digitalized hospital, how to coordinate the massive digital information which is produced by imaging equipment, and how to preferably support the hospital's daily clinic activities become hot topics. Hospital data is very valuable resource, and it has a very important value to medical, management, research and teaching. The data contains not only the original data but also the results which are obtained from the process of the original data. Currently, many hospitals still use film to save data. It's difficult to manage the data and poor to access to data in real-time, and not conductive to the sharing of data resources. Therefore, how to better use of medical digital image data in the organization, storage, query and display is an urgent problem to be solved.

Traditional medical image database management only manages the image information, while ignores the importance of information in electronic medical records. The main task of this research

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implement a new method based on DICOM standard which could store the DICOM image files and the corresponding patient medical records information into the database together, completely supporting the workflow of the hospital with the digital images. Its main purpose is to enable the medical image information managed well, more convenient and efficient to support the routine medical treatment and related research activities.

2. Materials and methods

2.1 The choice of storage method

Medical image management system built on the database has special requirements, the choice of storage methods such as security and operating performance has a direct impact. In general, there are two kinds of medical imaging storage solutions. One is to store image data directly to file, and the other is to store images in separate files in which the database only manages part of the information and its storage path. Generally a medium-sized hospital can create a huge number of medical image data needed to be archived every day, and it's likely to lead to the expansion of the database and greatly increase the difficulty of database maintenance using the former. Sharing medical information real-timely is focused highly, but the image pixel data stored in a large binary field, so that the data is inconvenience to be shared and transferred. Besides the database will encounter bottlenecks and is difficult to access quickly. Combined the above analysis, this research establishes a separate file for medical image storing, which is in order to ensure the stability of the database and improve system more efficiency.

2.2 The database structure

In accordance with the DICOM (digital imaging and communication in medicine) standard, image information can be divided into four layers, namely the Patient, Study, Series and Image, each layer defines the mapping properties of the basic information of this layer, and the direct relationship between two layers is one-to-many relationship [1]. Figure 1 shows the tree structure.

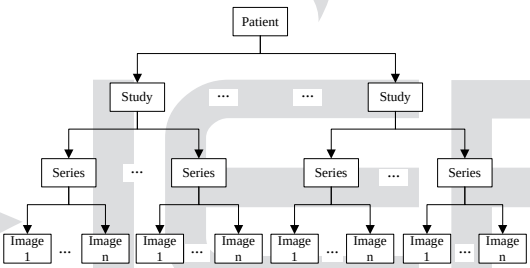

Figure1. The tree structure

Through analysing the system's function, a medical image database storage structure is designed. The system consists of five tables which are the basic information sheet for patient information table, study information table, series information table, image information table and medical record information table.

a) Patient information table: Describe the patient's basic information such as name, age, date of birth and so on. This information is basically unchanged, and will always be kept in the hospital database, For each patient treatment, the hospital will call up this information, each patient is assigned a corresponding number Patient ID as the sole identification number.
b) Study information table: Primarily store a part of patient's clinical information in a specific hospital such as checking ID, checking logo ID, check the medical information and so on. The Study ID is the identification number.

c) Series information table: it mainly store patient records of each inspection which contain examination of different parts of the information, such as Series number, Series ID, diagnostic parts, imaging equipment, and other causes. The Series ID is the identification number.

d) Image Information Table: It mainly store information of specific medical imaging, such as the image number, Image ID, image size, image description, image storage path, Window Center, Window Width, etc. The Image ID is the identification number.

e) Medical records table: All the check information is described in this table, such as study date, study place, study type, clinical diagnosis, examination, conclusions, etc. The EMRID is the identification number.

2.3 The system architecture

The general architecture of the system includes six modules: (a) Image storing, (b) Information extraction, (c) Indexing, (d) Query answering, (e) Image displaying, and (f) Statistics management. There are three main points of internal interaction: (1) through the database, where every data in the system is maintained; (2) through the application programming interface (API) of the query answering module; and (3) through the API of the displaying module [2]. Figure 2 shows a schematic representation of the architecture of the system.

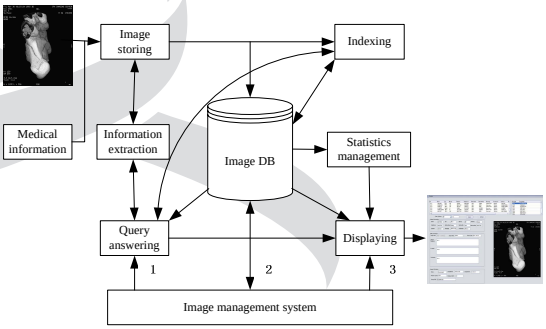

Figure2. Shows a schematic representation of the architecture of the system

2.4 Extracting image information from DICOM files

DICOM (digital imaging and communication in medicine) [3] is a standard for medical image data communication and storage. Medical Image contains the information of the image itself，and includes a lot of the corresponding information, e.g. patient information, equipment information, image pixel information and so on. DICOM standard is an object instance (images and related information) of the real world that as a DICOM file, Such a DICOM file contains a series of data sets, The data set is composed by above-mentioned images and many of the "logical group" of the images information, Such as group number "0010" data set stands for the corresponding information of patients. Table 1 shows part of the image information from DICOM file.

Table 1 Extracted part of the image information from DICOM file

Tags	Name	VR	VM
(0010,0010)	Patient Name	PN1	
(0008,0014)	Instance Creator UID	UI	1
(0008,0016)	SOP Class UID	UI	1
(0008,0020)	Study Date	DA	1
(0008,0030)	Study Time	DA	1
(0028,0051)	Corrected Image	CS	1-n
(0028,1050)	Window Center	DS	1-n

(0028,1051)	Window Width	DS	1-n
(0028,6110)	Mask Frame Numbers	US	1-n
(0032,000A)	Study Status ID	CS	1

This design extracts these information form DICOM image by DCMTK toolkit. First, configure the project, put the library files and head files into the path of the program of project, and then do some necessary configuration. Then you can use DCMTK toolkits to acquire the image information from the database [4].

2.5 The transmission of DICOM file

DICOM file transfer module idiographic actualizes Web communication based on DICOM standard. It is the interface of storage system and medical imaging equipment and other medical information systems. And it can provide image information and image data storage, query and conversion services for the medical imaging equipment and systems meets DICOM standard. Those are called STORE SCP (Service Class Provider) and FIND SCP and MOVE SCP services which are in strict accordance with the standard DICOM communications services. At the same time, they could have a fast response to the request of the client and meet the requirements of real-time.

The function of FIND SCP is mainly to find information which meets the client's query request in the database and return the information to the client. First, when the server receives C-FIND's queries requests from the client and parse out specific query from the request command, then query the database based on conditions criteria and put the match information back to client's SCU by DIMSE (DICOM Message Service Element) service.

The function of STORE SCP is mainly to receive and store medical images from the client. It can analyse the related information from images, and stored them into the database, and store the images into the storage area.

The function of MOVE SCP is mainly to receive C-MOVE's requests from client and sent the appropriate images to the specified customers. Then it is requested must have a STORE SCP service that can receive and store the images obtained. But the MOVE SCP as storage system not only is able to handle the MOVE SCU's request, but also send out the image by using C-STORE. So it must have the function of MOVE SCU.

2.6 Implementation of query and search functions

The system design includes the query and search functions. This system provides two kinds of search methods: the query by patients ID and the query by patient name [5]. When the user input query conditions, then complete the database connection and access by using ADO technique, and return the query information which are appropriate the conditions. Such as patient image number, image description, image storage path, study information, Instance Creator UID, SOP Class UID, clinical diagnosis and conclusion, etc. So doctors can easily see all the patients' medical records information and images information on the doctor workstation.

2.7 The show of DICOM files

Most of the current medical imaging equipments generate gray scale images of 8bits, 12bits, 16bits every pixel while each DICOM file contains only one picture and each pixel only contains one sample. For this kind of image, display it based on DICOM standards by using C + +, like the bitmap's display method, and achieve it by using DCMTK toolkit [6]. To complete the programming needs three steps as follows:

a) Design the appropriate classes for packaging different types of DICOM images.
b) Transfer the DICOM image into a bitmap.
c) Achieve image display by using the class CDib's read function.

2.8 The advantages of medical image storage system

The use of medical image management system can promote the development of medical imaging technology. The advantages can be summarized as follows:

a) Convenient and reliable storage way: Image data is stored by the archiving module, so it can be permanently preserved and not lost, damaged or incorrect filed.
b) Fast and effective way of working: Doctor's workstation equipments are distributed in the various hospital departments and each department's doctors can browse through the patient's image data from terminal. So it effectively changes the traditional way of reading ways and simplifies the workflow.
c) Efficient way to search: For the image data to be queried, system provides a simple query way through the index means (such as Patient Name, Patient ID, etc.) to quickly obtain the necessary information.
d) Reduction of the hospital's expenses: After using the medical images management system, it will be replaced traditional film. Thereby it will save film, film processing chemical agents, reduce the operator's compensation and all of those will save a lot of these funds for the hospital.

3. Results

In this study, a preliminary system of intelligent information access framework for medical image databases was designed to integrate medical images and clinical information. The system was implemented by using open standards and free software and currently runs on Windows platforms. At this time, the system holds 25,000images which are obtained from the Department of Diagnostic Radiology and 12,500 electronic medical records (EMR). The most important concern in this approach is the interdisciplinary collaboration among medical image, medical informatics and radiology experts. The second important concern would be the implementation with the critical and service-oriented hospital information system. Therefore, we will test the system by the physician-in-the-loop approach to enhance diagnosis practically and revise the system.

Security is also a very important issue in this field of research. First, we build trusted electronic relationships between healthcare customers, employees, businesses, trading partners and stakeholders. Therefore, when we use the patient's medical records information, examination data, or medical images, whether we have the patient's permission or not, there must be a set of procedures to follow accordingly. We plan to consider the security and privacy function of the system in near future.

This system can parse all DICOM formats, and it also can store the DICOM image files and the corresponding patient medical records information into the database together. Moreover it can establish a correspondence between the images and the medical records to achieve the function of checking each other. The software supports a various ways to retrieve, such as Patient Name, Patient ID, Study ID, etc. Doctors can easily get the desired image data and their medical information at any time based on different needs to improve the efficiency of medical work and timely diagnosis and to lay a good foundation for the following treatment. Experiments show that the medical image database system software achieves the Medical Diagnostic Standard and be consistent with the requirements of the hospital. Figure 3 shows the result of query and the image display.

Figure3. The result of query and the image display

4. Discussion

The growing number of digital image acquisition and storage systems in clinical routine raises demands for new access methods. Still, most medical image file formats and contents are extremely complex because it contains large amount of information and there are too many image files. This software can help users manage large amounts of medical image file information and help doctors to quickly access medical images in order to actualize the following treatment. And medical imaging management system will directly affect the quality of PACS System. Hospital-wide PACS system needs to connect the hospital image storage server to the network system to achieve the unified management of image data for the use of medical access in clinical departments. Sometimes it also needs to send image data stored in PACS back to the medical equipment workstation for processing and analysing images. Even PACS image data needs remote consultation with the outside. Therefore, medical image management system will directly affect the effectiveness and quality of applications of the PACS system. This research work lays the foundation for the further comprehensive development of PACS system and also has a great significance for the construction of hospital information.

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