特集論文／ ONCO-MEDIA

Diagnostic Decision Support by Intelligent Medical Image Retrieval with Electronic Medical Record for Dementia Treatment Enhancement

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Abstract

In most hospitals, medical images such as computed tomography (CT), magnetic resonance imaging (MRI), and X-ray films are stored in Picture Archiving and Communication System (PACS). However, clinicians make differential diagnosis of patients in the Electronic Medical Record (EMR) system with references to laboratory results and the medical images reports. To establish a prototype model for intelligent access of medical image database, this study integrated EMR, Radiology Information Systems (RIS) and PAC for a clinician to retrieve the clinical information automatically. Dementia was chosen to establish the prototyping system for Content-Based Image Retrieval (CBIR) with EMR because it is a neurological disease usually with a long histopathology, and presents itself with a variety of abnormalities in brain images such as those obtained through CT, MRI or Positron Emission Tomography (PET). If a clinician wants to diagnose a condition, he will need a series of images to make this diagnosis and to decide on what therapeutic strategies to pursue. Therefore, the image database, in conjunction with clinical information, can be crucial in the care of dementia patients. Moreover, treatments for dementia patients usually involve intensive collaboration among neurologists, radiologists and other clinical specialties. The implementation of this study, an intelligent medical image retrieval system coupled with the EMR system, is expected to enhance the early diagnosis and monitoring of disease progressions in both Dementia and other chronic pathologies.

Key words: Content-based image retrieval, Electronic medical record, Dementia, Diagnostic decision, Essential clinical information

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1. Introduction

A report by the American Hospital Association suggests that US hospitals use only 1.5~2.5% of their Hospital Medical budgets on data information systems, which is less than the 5~10% of similar funds dedicated to such systems found in the budgets of other industries. Moreover, as computer data storage capacity increases and the technology involving digital imaging progresses rapidly, the traditional image has been replaced by Computer Radiography (CR) or Digital Radiography (DR) derived imagery, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Digital Subtraction Angiography (DSA). This advance reduces the space and the

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cost associated with X-ray films, speeds up hospital management procedures improving also the quality of the medical imagery-based diagnosis quality. American hospitals, in particular, often consult image diagnostic professionals from India via Internet due to budget consideration. The clinical information gathered by this study will alleviate the budget issue because the tele-consultation regarding image diagnostics will then be feasible.

In Taiwan, the National Taiwan University Hospital (NTUH), which is traditionally the leading medical center, has recently adopted a complete health recording system, including an Electronic Medical Record (EMR) system linked to Hospital Information System (HIS), Research and Information System (RIS), Picture Archiving and Communication System (PACS), and other clinical information systems. National Taiwan University (NTU), one of the research partners of ONtology and COntext related MEdical image Distributed Intelligent Access (ONCO-MEDIA) project[*11] is leading a study of the integration between the Content-Based Medical Image Retrieval (CBIR) and EMR systems as well as on its implications in providing improved clinical diagnostic and therapeutic decision support.

This study focused on Dementia as a pathology model, in order to elaborate a prototyping system for CBIR〔2〕with EMR. Dementia is a neurological disease, usually characterized by a slow histopathology, and presents itself with a variety of characteristic abnormalities in brain imagery such as CT, MRI, or PET. In the course of the treatment, a doctor may need a series of images to make the proper diagnosis or to make critical decision for therapeutic strategies. Therefore, an image database infused with clinical information could become a major component for the improvement of the dementia patient care.

Dementia has become more and more prevalent in recent years. In the United States, there are approximately 5 million people suffering from dementia and that number is projected to rise above 16 million by the year of 2050. Presently, Americans pay US$5000 per patient per year for dementia medication and associated nursing care costs〔6, 7〕. In Taiwan, there were approximately 140 thousand people suffering from dementia in 2005 and there will be 650 thousand dementia cases by the year of 2050.

Since Dementia, as a disease, is an important and long term problem that causes significant burdens for families and societies, this study has endeavored to find a viable procedure to ameliorate the treatment of dementia patients and to enhance the early diagnosis and monitoring of its progression〔8〕.

2. Methods

1) Establishing a Definition of Essential Clinical Information in Dementia

In this study, a prototype model was designed to assist the procedure involving the physician-in-the-loop approach〔3〕. In this prototype model, a group of neurologists and radiologists collaborated to establish a common language involving the image diagnosis. At the beginning, definitions of essential information regarding dementia were discussed as follows:

A. Literature review from journals, textbooks and clinical reports
B. Selecting relevant medical image reports from department of medical imaging
C. Using representative cases to simulate medical image distributed intelligent access integrated with EMR to select crucial clinical information
D. Finalizing structure and items of essential clinical information regarding dementia, and
E. Dependence on the Unified Medical Language System (UMLS) to facilitate the development of a prototype model that follows the international language of biomedicine and health.

2) Integration of RIS, EMR, PACS and Clinics to Support Diagnosis

At present, most hospitals store the medical images from CT, MRI, DSA and X-ray film in PACS. The clinicians make differential diagnosis of a patient in EMR system with references to laboratory results and image reports. Therefore, we have to provide the essential information from EMR, PACS and RIS to clinicians, such as neurologists, to support their decision. On the other hand, in the department of medical imaging, the radiologists also need

[*11] ICT Asia project ONCO-MEDIA: www.onco-media.com

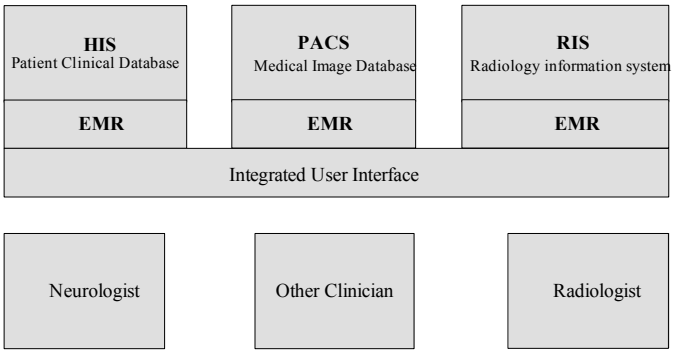

Fig. 1 System structure of prototype model.

to refer to medical information recorded by other specialties to interpret medical image for their reports on the RIS [4]. The image report by the radiologists could assist the clinicians to make correct diagnoses; however, the correct image interpretation also depends on the crucial medical information that clinical doctors must input. This co-dependence demonstrates the need for two-way communications between imaging professionals such as radiologists and their clinical counterparts that are treating the patients. Therefore, in this study, the integration of EMR, RIS and PACS and clinics input was implemented to establish a prototype model for intelligent access of medical image database, and retrieve clinical information automatically (**Fig. 1**).

3. Results

In the model, the essential clinical information of dementia included is summarized as follows:

A. Base information
- a. Sex
- b. Age
- c. Country
- d. Residency
- e. Education (yr)
- f. Occupation (pre-retired work)
- g. Language (dialect)

B. Clinical history
- a. Handedness
- b. Age of onset
- c. Initial symptom sequence(multi-choice):i.memory, ii.personality, iii .language, iv.gait and v.bradykinesia
- d. Course: i.rapid progression(< 1 year), ii.chronic progression, iii.stepwise and iv.fluctuated
- e. Risk factors (multi-choice): i.CVA, ii.HTN, iii.DM, iv.cardiac disease, v.hyperlipidemia, vi.obesity, vii.physical inactivity, viii.vegetarian, ix.parkinsonism and x.family history

C. Clinical diagnosis
- a. Normal
- b. MCI (Mild Cognitive Impairment)
- c. AD (Alzeimer Disease)
- d. VaD (Vascular Dementia)
- e. Mixed type
- f. FTD (Frontotemporal Dementia)
- g. DLB (Dementia with Lewy Bodies)
- h. Dementia, other types

D. Lab

a. CBC
b. Electrolyte
c. BUN/Cre
d. GOT/GPT
e. T4/TSH
f. B12/folate
g. Lipid profile
h. VDRL
i. Hachinski ischemic score
j. MMSE
k. CDR

The prototype system is designed to recognize a positive dementia diagnosis and reconfigure its patient information presentation accordingly. For example, an input of the ICD-9 (International Classification of Disease, Ninth Revision) 331.0 code for Alzheimer's Disease will alter the patient information, such as: base information, clinical history, lab results and medical images (**Fig. 2**).

On the other hand, if dementia has not been yet, the neurologists would still like to know the patient's base information, clinical history, and lab results. Using this clinical history, the neurologists may make a choice reflecting the initial symptom sequence, course, and risk factors, which will also support him to make an early diagnosis in the future (**Fig. 2**).

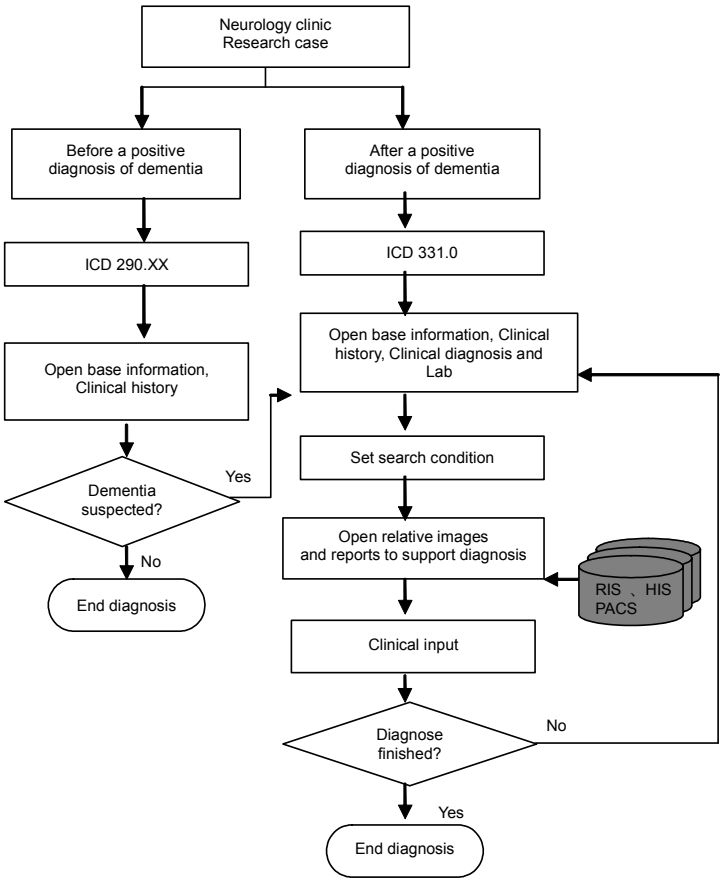

Fig. 2 Flow diagram.

Fig. 3 Prototype model: Clinical history.

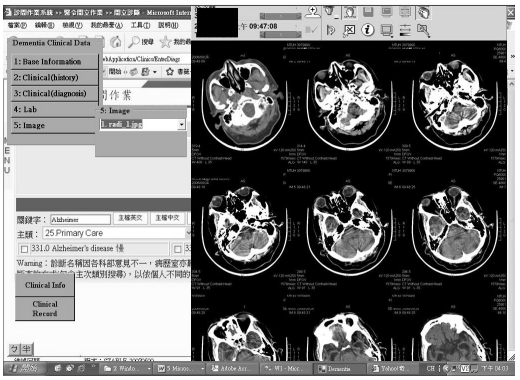

Fig. 4 Prototype model: CT image.

With the established prototype model, the data schema of the essential clinical information of dementia will be integrated into the EMR user interface in the clinical department in the EMR system of NTUH. Clinical doctors can input the essential clinical information, such as base information, clinical history, clinical diagnosis, upon initiation of dementia diagnoses and the system will present a prompt with a pop-up menu for easy data entry. At the same time, the prototype model will automatically retrieve the relative medical images and image reports by the radiologists in order to support the diagnosis (**Fig. 3**).

Moreover, the radiologists get images from PACS with differential diagnosis of dementia and the RIS can simultaneously automatically retrieve the essential clinical information related to specific image characteristics defined by a consensus of the neurology and radiology experts (**Fig. 4**). In this way, both user interfaces are designed to open a pop-up window with the pull down bar when the clinician or radiologist is ready to input data into the system (**Figs 3-4**)〔5〕.

5. Discussion

In this study, a preliminary system of intelligent information access framework for medical image databases was designed to integrate radiological reports and clinical information. The most important concern in this approach is the interdisciplinary collaboration among neurology, 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 and privacy 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 anamnesis, 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 in the system, in the future.

The implementation of this prototyping system must be well organized and the initial testing done on an offline system. The clinical data could be backed-up and copied to a separate system for the purposes of the trial. When the first prototype model becomes fully implemented, the system could be expanded by adding other neurodegenerative diseases one by one to enhance the power and comprehensiveness of the intelligent retrieval for clinical practice.

In the future, the system will be continuously developed to extend its spectrum of diseases and clinical specialties.

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