Medical Image Resource Center—making electronic teaching files from PACS

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A picture archive and communications system (PACS) is a rich source of images and data suitable for creating electronic teaching files (ETF). However, the potential for PACS to support nonclinical applications has not been fully realized: at present there is no mechanism for PACS to identify and store teaching files; neither is there a standardized method for sharing such teaching images. The Medical Image Resource Center (MIRC) is a new central image repository that defines standards for data exchange among different centers. We developed an ETF server that retrieves digital imaging and communication in medicine (DICOM) images from PACS, and enables users to create teaching files that conform to the new MIRC schema. We test-populated our ETF server with illustrative images from the clinical case load of the National Neuroscience Institute, Singapore. Together, PACS and MIRC have the potential to benefit radiology teaching and research.

KEY WORDS: Electronic teaching files, PACS, computer server, Radiological Society of North America, Medical Image Resource Center, medical education

THE LEARNING OF RADIOLOGY requires systematic study of a large knowledge base of medical images. Traditionally, case-based hard-copy teaching files have been created from radiology studies of real patients. Each teaching file consists of filmed radiology images accompanied by relevant clinical data and a short write-up of the pathological condition. Libraries of representative teaching files are highly desirable in radiology teaching programs, but the organization and maintenance of these collections can be problematical.^{1,2}

With the advent of picture archive and communicating systems (PACS), the acquisition, viewing and organization of medical images for teaching and research should theoretically be

simplified, as such data would be natively digital.^{3,4} Furthermore, in the electronic environment, powerful and versatile tools may be developed to maintain, organize, and search for images.^{5,6} However, none of the PACS vendors now provides a solution for the creation of electronic teaching files (ETF) as a commercial option.⁷ Hence, the potential for PACS as a teaching and research tool has not been maximized. Many teaching hospitals and universities have therefore designed in-house solutions, using a variety of methods to create their own ETF libraries.⁸⁻¹⁰

Recently, the Radiological Society of North America (RSNA) has defined standards for a Medical Image Resource Center (MIRC).¹¹⁻¹³ A set of Extensible markup Language (XML) schemas for information exchange such as MIRC query, MIRC query result, MIRC site index, and MIRC document have been developed. By complying with these schemas, individual teaching files servers around the world can be linked together through the World Wide Web to form a global MIRC community. Thus

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Fig 1. Schematic of ETF server components. PACS: picture archiving and communications system; DICOM: digital imaging and communication in medicine; ETF: electronic teaching file; MIRC: medical image resource center.

MIRC has the potential to be the worldwide standard for teaching and research data exchange in the same way that Digital Image and Communication in Medicine (DICOM) has become the standard for PACS.

Our hypothesis was that using DICOM and MIRC standard schema, a method could be developed to bridge the interface between PACS and electronic teaching files. This report describes a proof of concept ETF server that creates MIRC teaching file from images and data in PACS.

MATERIALS AND METHODS

Our ETF system consists of four major components (Fig 1):

1. PACS interface module;
2. Relational database;
3. Web interface module; and
4. MIRC interface module.

We used JAVA programming language, and Apache Tomcat Web Server to build these components. The image server, a foreground application written in JAVA *programming language*, is started automatically when the computer starts up. The DICOM applications were developed in-house, based on a third-party toolkit (JDDK, Emageon, Birmingham, AL).

The PACS interface module is responsible for querying and retrieving images from PACS using established DICOM protocols. Our system queries the PACS database using the DICOM *C_FIND* service, and retrieves images from PACS by

using DICOM *C_MOVE* and *C_STORE* services. All transactions are standard DICOM services, and should be vendor independent. After the radiological images are received from PACS, a DICOM "anonymizer" is used to remove patient identifiers. The anonymizer algorithm we developed replaces identification information with random alphanumeric codes, using an internal look-up table within the database.

The relational database (Oracle Relational Database Management System version 9.0, Oracle Corp, Redwood Shores, CA) forms the heart of the ETF server and links radiological images to information in database tables. These tables comprised DICOM data (including name, study date, etc), and teaching file data (including key words, diagnosis, etc). All user requests in the system are processed by JAVA servlets. Authoring functions were implemented by a servlet that enables users to query database records by various indexes, including patient name, ID, age, diagnosis, etc. The user can then create teaching files by entering clinical information through the client-side graphic user interface, via http protocols. The Web interface module was developed to utilize off-the-shelf Web browsers (such as Internet Explorer) to navigate within the database. Using this method, ETF that conform to the XML format of MIRC document schemas can be created.

Finally, the MIRC interface module, consisting of MIRC query service and MIRC storage service implemented as JAVA servlets, enables the user to communicate with the global MIRC community.¹² The MIRC storage service stores the teaching files in the server's disk space. It will respond to all queries made to the teaching files it maintains. These query criteria are enclosed in an XML file compliant with the MIRCQuery Schema. Upon receipt, the MIRC storage service searches the database, and returns the matching teaching file links in an XML file compliant with the MIRCQueryResult schema. The MIRC query service maintains a list of MIRC storage services, including their

Fig 2. PACS connection user interface. This screen allows users to query the PACS database.

names and Web addresses. It receives the searching criteria from a Web page form input by the user, forms an XML file compliant with the MIRCQuery schema, and sends it to MIRC storage sites by using the "http post" method. On receiving the results from the MIRC storage sites, the MIRC query service assembles the results, presented as a Web page to the requestor. Software libraries (Xerces and Xalan, Apache Software Foundation, Forest Hill, MD) are used to handle the XML documents.

The ETF system was set up on a computer server that was connected to a clinical PACS (Pathspeed version 8.1, General Electric, Waukesha, WI) in the Neuroradiology Department of the National Neuroscience Institute of Singapore. This is a specialized inpatient and outpatient neuroimaging center that performs 23,000 computed tomography, magnetic resource, and angiography studies each year. It is part of a teaching hospital and is staffed by attending neuroradiologists as well as basic and advanced radiology trainees (residents).

RESULTS

The ETF server was interfaced successfully to PACS on a local area network without notice-

able impact on the clinical PACS performance or workflow. It was necessary for PACS to recognize and grant access to the ETF server as a DICOM application entity. This necessitated minor configuration by the PACS field engineer, after which DICOM query and retrieval of radiological images could be performed. The graphic user interface, based on the Web browser "look and feel," was user-friendly and familiar to most doctors and data entry clerks making use of the ETF server. This intuitive layout resulted in negligible time spent for user education.

With the ETF server in place, users can create a MIRC ETF record from a patient study in PACS. The user first selects a patient study and retrieves it from PACS. With single mouse click to "retrieve" images (Fig 2), a series of events takes place in the background in a manner transparent to the user without any further user intervention:

The screenshot displays the MIRIP software interface, which is organized into several sections:

- Menu Bar:** Query, Image, Edit Record, XML, Tools, PACS, Help.
- Toolbar:** Contains icons for file operations (open, save, print, etc.).
- Patient Information:**
 - Patient ID: 8-21-53
 - Patient Name: ZZZ 3D HEAD + M
 - Age: 038, Age Unit: Y
 - Description: test data
 - Anonymized Patient ID: NNID-622 (indicated by a large grey arrow)
 - Anonymized Patient Name: NNIP-2064983144
 - Sex: Female
 - Race: (empty dropdown)
- Document Description:**
 - Doc Type: ☒ TF, ☐ DS, ☐ ED, ☐ TD
 - ☐ Locked
 - Case Level: Primary
 - Lexicon: ACR
 - Access: Public
 - ☐ Reviewed
 - Reviewer: (empty dropdown)
 - Publish Date: 2003-05-02
 - Copyright: (C)Copyright 2003
 - Title: (empty text field)
 - Author 1: (empty dropdown)
 - Author 2: (empty dropdown)
 - Affiliation: (empty dropdown)
 - Affiliation: (empty text field)
 - Contacts: (empty text field)
 - Contacts: (empty text field)
 - Contacts: (empty text field)
- Case Record:**
 - Abstract: (empty text area)
- Status Bar:** Ready, Memory: 3 MB, Free: 0 MB.
- Footer:** Java Applet Window

Fig 3. Examples of data fields of DICOM and text. An anonymized record identification (arrow) is automatically generated when the images are retrieved from PACS.

1. Retrieval: The DICOM images in the study are transferred from PACS to the ETF server.
2. Anonimization: The patient identification information is removed, and a random code is assigned to the record. With appropriate authentication, real patient information may be accessed.
3. Data entry: Demographic DICOM data from PACS (age, sex, race, etc) are automatically matched and populated into the relevant fields within the ETF record (Fig 3).

Once DICOM images arrive from PACS to the ETF server, the user may begin to add data to the case record in order to generate MIRC teaching files in the form of both image and text. Illustrative DICOM images that show the abnormalities of interest can be graphically selected and added as JPEG images into the XML

case record (Fig 4). The simple toolkit we developed to input free text data fields, diagnosis, and comments are based on the MIRC schema of RSNA, including such data fields as abstract, key words, anatomical location, etc. Once data entry is completed, the case record will be available for sharing with the worldwide MIRC community. The ETF records were correctly identified in all queries when tested with the MIRC storage and query services.

DISCUSSION

Our purpose was to develop an ETF server that could interface with PACS, and could generate electronic teaching files that conform to the new MIRC schema. The proof of concept server was successfully deployed in a busy specialist neuroradiology department. The system

Fig 4. Completed MIRC electronic teaching file displayed as an extensible markup language (XML) record.

made use of well-established relational database, DICOM interface, and Web interface modules, integrated together in a JAVA environment. The advantage of using JAVA to connect these diverse modules made the ETF server flexible and powerful, with the potential to be portable, platform-independent, and scalable.¹⁴

We selected a Web-based user interface, as this was familiar to users who have used browsers before for the World Wide Web or for Web versions of PACS. This is very important in a busy clinical radiology department, which is the target of the system, to encourage usage and “buy-in” of staff and trainee radiologists. Several design features made it easier to use, such as the single mouse click automated backend function that retrieves, anonymizes, and populates DICOM data. This function freed users from repetitive data entry and allowed them to focus on relevant tasks such as selecting images and inputting educational text.

Removal of all personally identifiable data in the images is important for teaching and research. To protect patient confidentiality, guidelines such as the Health Insurance Portability and Accountability Act (HIPAA)¹⁵⁻¹⁷ mandate that patient data that is shared should

not contain information that may lead to identification of individual persons. However, simply stripping all identifiers will remove the ability to add further information as it becomes available. For example, a case that was initially diagnosed as stroke and made into ETF may, a few months later after biopsy, turn out to be a different diagnosis. At this point, a record from which all identifiers have been stripped would be untraceable, and the value of such an ETF, as a mimic of diagnostic subtlety, would be lost. Hence, we decided to code real case records with an encoding key rather than simply remove identifiers.

We showed that it was possible to use well-established components to design and implement an interface between PACS with MIRC. Although simple buttons and user interfaces were developed, the ETF server lacks a sophisticated and powerful toolkit for data and image manipulation. Furthermore, our method is limited to teaching file creation, and there is no method to develop the rich potential of an image database to assist in clinical research: for this to be a useful research tool, manipulation of the database fields and sort/query functions need to be available to users. To date this proof of concept has been tested on Neuroradiology but not on general radiology, which may have

different requirements and challenges (for example, ultrasound images, high-resolution chest radiographs, and mammography).

Expansions in educational features could also be explored, and they are easily achievable in the Web environment. A method to navigate between teaching files would be desirable, as would a standard method of indexing pathology, such as the American College of Radiology codes of radiological diagnosis. Future enhancements may also benefit from clustering several similar ETF, or creating a self-test quiz interface.¹⁸

CONCLUSIONS

We believe this to be the first seamlessly integrated interface with PACS that creates electronic teaching files conforming to the new MIRC standards. We hope this first step in setting up an electronic teaching file library will result in a steady supply of clinical radiology images of real patients. The standardized MIRC protocol may facilitate exchange of data around the world, and pave the way for future collaborations in teaching and research.

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