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AN ACADEMIC TEACHING FILE AUTHORING ENVIRONMENT TO SUPPORT HIGHER EDUCATION IN MEDICINE

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Abstract

Teaching files serve the educational process in medicine and especially in the field of radiology in a variety of ways. This paper presents a novel teaching file authoring environment that serves as a middleware to bridge the healthcare enterprise with the academic world. The proposed environment integrates medical images and related information from PACS systems and other DICOM servers using a multilayer collaborating web services environment, provides tools for reach searching of all image related information, supports teaching file authoring as well as construction of quizzes for self-evaluation and formal examination. Finally, the teaching files and related quizzes can be exported in a variety of forms, such as plain HTML, MIRC compatible for submission to a MIRC server and in the SCORM schema for automatic integration with general purpose learning management systems.

Introduction

There is currently an international trend to involve information and communication technologies to support medical curricula and continuing medical education. When new technologies were first introduced in education, there was a considerable hype about the emerging electronic teacher, which soon enough subsided to reveal serious limitations of the computer-to-student education model. Today, it is recognized that the traditional two-fold model of medical education, i.e. theoretical instruction based on textbooks and clinical practice with one-to-one interaction, need not be reformed [1], but rather supported and enhanced, mainly by extending the amount and availability of knowledge and instruction as well as the place and duration of the educational process.

Supporting the dissemination of information is the easiest and most straightforward achievement of information and communication technologies. They have extensively and successfully been used to give quick, easy and cheap access to information sources, such as books, textbooks, atlases, medical and biological databases, research journals etc. However, there is another source of data and information when medical education is considered: processed data that arises from the clinical practice and routine medical procedures. In this respect, new technologies can mostly help dissemination of information in medical education by providing tools and middleware solutions to bridge the networked healthcare domain with the classroom. More advanced levels of the educational process involve knowledge (i.e. structuring and organizing information with a particular educational purpose) and understanding (which implies experience as well as inquiring) [2]. Managing and supporting these levels of the educational process is a rather complex issue. A major contribution in this area is the creation of digital teaching files for the medical student to practice, together with tools that support continuous self-evaluation and mediate teacher-learner exchange.

Teaching files serve the educational process in medicine and especially in the field of radiology in a variety of ways. The most common way is as peer-reviewed archival information resource used as a means for formal professional scientific communication. Recently, interest is also shifting towards using digital teaching files repositories to support the undergraduate medical educational process [3]. The current challenge is to bridge and technologically integrate the educational environment, where clinical information is consumed, with the healthcare enterprise where clinical data is generated. Requirements for teaching file authoring solutions that support such information exchange and integration include the following:

1. ability to search the entire DICOM information space to identify interesting teaching cases that can serve a particular teaching goal and automatically retrieve DICOM images and related information
2. integrate with commonly available formats and notions for teaching file distribution in professional radiology practice, e.g. the Medical Image Resource Center (MIRC) specifications
3. integrate with general purpose learning management systems that support education in higher academic institutions via appropriate e-learning standards, e.g. SCORM
4. at the same time offer all functionality as a standalone tool, so that teaching files can be created and managed irrespective of the existence of a fully deployed PACS and/or learning management system

This paper presents a novel teaching file authoring environment that fulfils all the above requirements.

Background

During the last few years there has been an increasing interest to develop tools and solutions for digital teaching file creation and management. As a result, nowadays teaching files can be created and managed in a variety of ways, ranging from the very simple word processing documents (with no integration with the radiology enterprise, the web or the educational environment), to more complex integrated approaches, mentioned in the following paragraphs.

There are numerous collections of radiological teaching files (clinical and anatomy) on the web. A characteristic case is that of EURORAD (European Association of Radiology e-Learning Initiative, ISSN: 1563-4086, http://www.eurorad.org, last visited on May 2006), which was launched in 1998 as a peer-reviewed teaching file collection by the European Association of Radiology and today it is established as an electronic scientific publication. Digital radiology teaching files have gained such a success on the web, so that special portals and search engines have been built to help with navigation and discovery [4], while it has been already suggested that some sort of academic credit and reward should encourage contributions to teaching file web collections [5].

The need to orchestrate such activities led the Strategic Planning Committee of the Radiological Society of North America (RSNA) to suggest that a Medical Imaging Resource Center (MIRC) should be created to facilitate the distribution and sharing of medical images and related information on web, thus integrating local imaging and teaching file repositories on independent sites available on the web (RSNA MIRC, http://www.rsna.org/mirc/, last visited on May 2006) [6]. The project set the first requirements in 2001 and progressed substantially thereafter, and a number of MIRC servers and teaching file repositories and related tools have been developed internationally, e.g. [3,7,8,9,10]. There are various alternatives for participation in the MIRC teaching cases network: (a) installing MIRC software that supports teaching file creation and dissemination, (b) implementing standard MIRC storage and query services for an already existing teaching file web repository, (c) creating and submitting a MIRCsite-index and MIRCdocument of an existing teaching file repository to the RSNA MIRC center, or (d) create teaching files on the basis of the MIRCdocument schema and submit them to an existing MIRC server.

Although PACS systems have in theory the potential to create, archive and present radiological teaching files, in practice this potential is not satisfactorily realized [11]. So, a number of different proprietary tools have been proposed to support the process of creating and managing radiological teaching files. Most of these approaches use general purpose software to compile a teaching file and then publish it on the web through a process that is partially (or not at all) automated or integrated, but requires sequential manual data exports and imports among various software packages as well as irreversible data transformations from DICOM to other general purpose formats, e.g. [12].

However, recently there have been attempts for partial or full integration of PACS systems with teaching file authoring tools. For example, Lee et al developed a web-based teaching file authoring tool that imports DICOM images and transforms them into a variety of general purpose image formats [13], while Mongkolwat et al exploited the email functionality of certain PACS systems to email images at screen resolution to a dedicated teaching file authoring tool [14]. Other approaches include sending DICOM images to an intermediate archiving server, and transformed into JPEG format before being available as teaching cases through a web server [15], or providing tight DICOM interfaces with PACS systems, e.g. Casimage [8,9], MyPACS.net [16], and the MIRC server [10]. The need to integrate teaching file authoring tools directly with PACS has been recently realized by the Integrating the Healthcare Enterprise (IHE) initiative (http://www.ihe.net, last visited on May 2006). Towards this end, IHE has introduced a new integration profile "Teaching File and Clinical Trial Export" that specifies the requirements for a PACS systems in order to support data export for academic and research purposes.

As presented above, existing tools, solutions and initiatives have so far concentrated on enabling the automated creation and management of teaching file repositories on the web with the main purpose to support professional information exchange between peers in radiology and medicine and to provide a means for continuing education for residents and specialists. However, the idea of incorporating teaching files in e-learning environments that support the undergraduate and graduate education has only recently been introduced [17, 18,19].

Robust web-server based Learning Management Systems (LMS) are currently used by most Universities to support the structured management of teaching material in higher education, and they have gained success in Medical Schools. The term LMS refers to a suite of functionalities designed to deliver, track, report on and manage learning content, learner progress and learner interactions, and it can apply to very simple course management systems, or highly complex enterprise-wide distributed environments. LMSs usually support, among other services, back-end connections to other information systems, sophisticated tracking and reporting of student activity and performance, centralized registration, online collaboration and adaptive content delivery

As LMS became ubiquitous in academia, industry, governmental bodies and other elements of the society, the standardizing work of SCORM entered the picture as a key element in establishing reusable, sharable learning objects and adaptive learning strategies. SCORM (Shareable Content Object Reference Model) has been designed by the U.S. Government's initiative in Advanced Distributed Learning (ADL, http://www.adlnet.org/, last visited on May 2006) as a set of eXtensive Markup Language (XML) based specifications to define, manage, access and deliver modular educational objects so that they can be easily shared among different learning management systems. SCORM currently provides an Application Programming Interface (API) for communicating information about a learner's interaction with content objects, a defined data model for representing this information, a content packaging specification that enables interoperability of learning content, and a standard set of meta-data elements that can be used to describe learning content and a set of standard sequencing rules which can be applied to the organization of the learning content [20]. SCORM supports the notion of learning content composed from relatively small, reusable content objects aggregated together to form units of instruction such as courses, modules, chapters, assignments, etc. SCORM has recently been employed to describe and deliver learning content in nursery [21], clinical [22] and in radiology [18] education.

This paper presents a novel teaching file authoring environment that serves as a middleware to bridge the healthcare enterprise with the academic world. The proposed environment integrates medical images and related information from PACS systems and other DICOM servers, provides tools for rich searching of all image related information, supports teaching file authoring as well as construction of quizzes for self-evaluation and formal examination. Finally, the teaching files can be exported in a variety of forms, such as plain HTML, MIRC compatible for submission to a MIRC server and in the SCORM schema for automatic integration with general purpose learning management systems.

Academic Teaching File Authoring & Management Environment

The proposed teaching file authoring environment is comprised of a teaching file authoring application, a teaching file database, and tools and mechanisms for radiological data discovery and retrieval, as well as for teaching file export in a variety of formats. The proposed teaching file authoring application treats the teaching file as a collection of various fields. Main fields include information on the title and author of the teaching file and some basic information about the patient demographics (e.g. age and sex), the imaging modalities used and keywords. The body of teaching file comprises of the following fields: patient history, findings, diagnosis and discussion, while all images are numbered and can be accompanied by a short description. A typical screen of the authoring application is shown in Figure 1. Once a teaching file has been created, the application supports the additional development of quizzes for self-evaluation and assessment. The author can select any combination of the various fields that comprise the teaching file to form the material for a given question and then construct the question in multiple-choice format. Correct and incorrect answers are defined by the author and comments for each answer can also be included. Typical screens for the quiz authoring are shown in Figure 2.

Figure 1: Typical screen of the teaching file authoring application

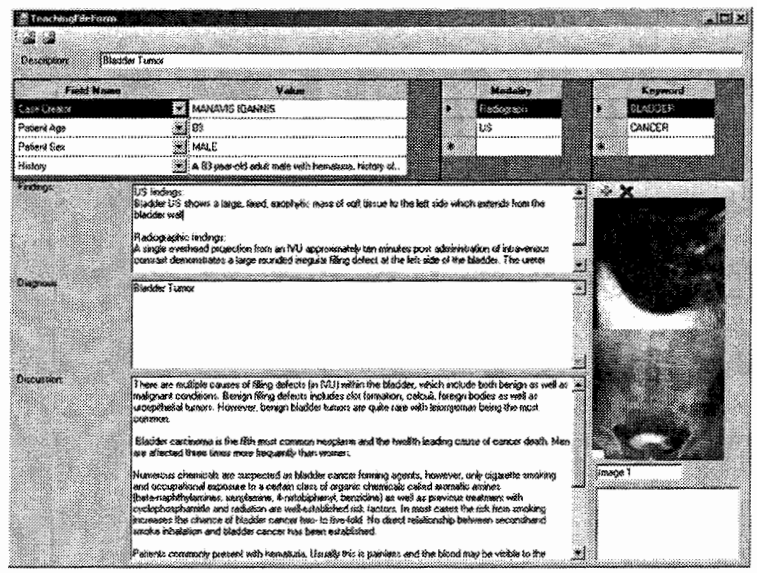
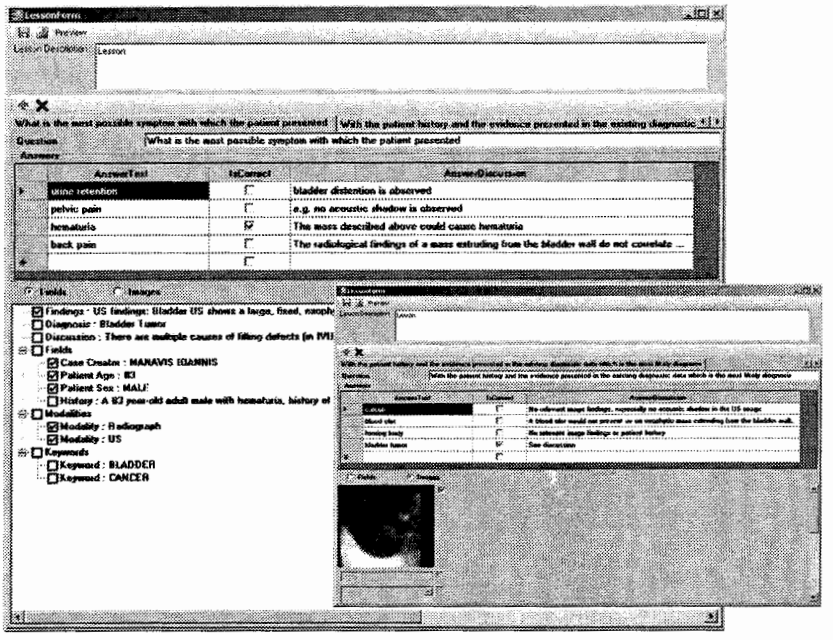


Figure 2. Typical screens for the creation of quizzes for a given teaching file.



Teaching file and related quizzes data are stored in a relational database. The schema of this database involves two distinct layers (a) the teaching file related tables and (b) the quiz related tables. It should be noted that although images are stored as raw data, all DICOM attributes are also stored and are available at any time.

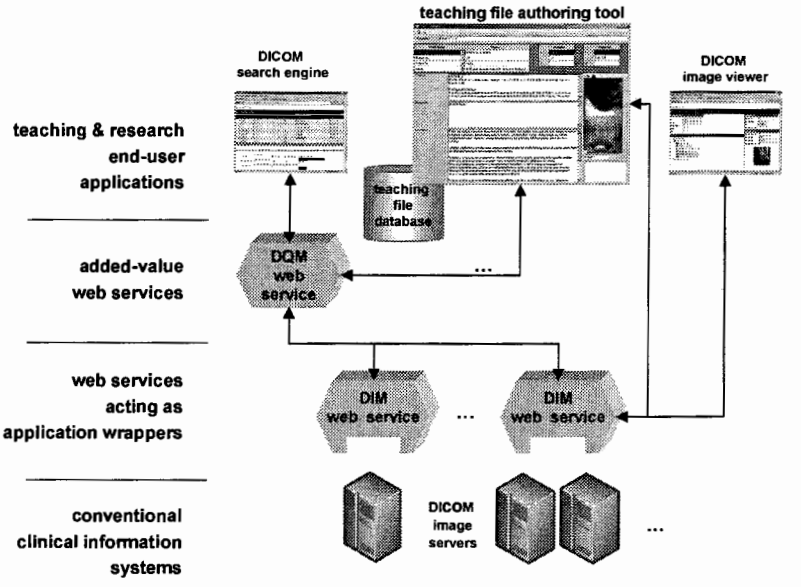
For radiological data discovery and retrieval, the authoring application exploits a modular, extensible, multilayer environment [23,24] shown in Figure 4. At a first level, the DICOM Image Management (DIM) web services act as a wrapper to conventional DICOM image servers, and expose the principal DICOM services of query, retrieve, and store to any other software application or web service over the Internet, using standard XML documents communicated via SOAP messages. Thus, DICOM image data and related information can be discovered, retrieved and maintained in a third party non-DICOM application in its fullness, and through open, standard messaging. At a second level, the DIM web service is engaged by collaborating web services that provide functionality specific to research and educational tasks. For teaching file authoring, the DICOM Query Management (DQM) web service is engaged to support complex queries that combine any DICOM attribute from different levels of the DICOM information model. In both web services, different access privileges are supported via a policy module which takes into account administrative information about the user (either client application or end-user of the client application) and the target DICOM server. Common to all methods exposed are certain input options that address security, privacy and management issues. In this respect, every method call requires inclusion of username (client application or end user specific) and password. Additionally, an optional list of target DICOM servers might be included. Finally, data anonymization is requested at method call.

Teaching files can be exported in the MIRC schema for submission to a MIRC image server. Additionally, teaching files and related quizzes can be exported as SCORM e-learning modules for direct submission to general purpose learning management systems that support higher education.

The teaching file authoring application has been developed in C# using the MS .Net Framework 2.0 (Microsoft, Redmond, USA) and the MS SQL Server 2000 Desktop Engine (Microsoft, Redmond, USA). The collaborating web services have been developed in C# using the MS .Net Framework 2.0 (Microsoft, Redmond, USA) and use the DICOM library DicomObjects 4.1 (Medical Connections, Reynoldston, UK). The SCORM compatibility was tested with the Reload

SCORM Player 1.2 (the Reload Project, Universities of Bolton and Strathclyde, UK, http://www.reload.ac.uk/) and with the SCORM compatible, general purpose, open-source learning management system Claroline version 1.7.5 (http://www.claroline.net/) which is used by hundreds of higher education institutions worldwide.

Figure 3: Collaborating web services environment to support clinical data discovery and integration.



Discussion

This work is part of our efforts to seamlessly integrate clinical data into a generic Internet based e-learning environment that will support undergraduate medical education in Democritus University of Thrace, Greece [25]. The project involves the use of open source technologies and off-the-shelve components to deploy an integrated e-learning environment, based on a conventional e-learning platform to support pre-clinical teaching, tightly integrated with teleconferencing technology for the real-time and/or on-demand transmission from an examination room or the operating theatre to the lecture room, to enhance clinical apprenticeship and provide extended real-world experience. At the core of the project is the effort to develop web service façades for legacy healthcare information systems, in order to extract and communicate educational information using common web standards (as opposed to standards proprietary to the medical environment). In this respect, the proposed teaching file authoring application and the underlying web service environment is intended to support teaching file creation based on radiological data as discovered and retrieved from clinical DICOM servers, and export teaching files and related quizzes for direct submission to the general purpose e-learning environment that supports undergraduate medical education.

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