MyCases—A Portable Application for Radiologic Case Collections

Ferdinand Josef Kammerer · Rolf Janka ·
Manuel Kramer · Matthias Hammon · Michael Uder ·
Philipp Martin Schlechtweg

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Abstract Radiologists come across interesting patient cases almost every day. This work proposes a novel case database server for quick and easy storage of such cases including whole image series, patient data, and annotations. Cases can be added to the database by saving DICOM images into a predefined directory on the local network. The application automatically extracts patient and study data from the DICOM header and saves it in the database while images are stored as anonymized JPEG files. Users can mark their cases as private or public (visible to all users). Different data fields for annotations and categorization of a case are available. The user frontend also provides several retrieval mechanisms allowing for browsing the cases and performing different kinds of search queries. The stored series can be scrolled interactively in the form of scrollable image stacks. The project is realized as a web-based application using a portable web and database server software package (XAMPP). This makes the system very lightweight and easy to run on almost any desktop computer, even from a USB flash drive, without the need for deeper IT knowledge and administrative rights.

Keywords Image libraries · Information storage and retrieval · Internet technology · Web technology

Background

Radiologists stumble upon interesting cases almost every day in routine work. Many of those cases can be used in medical

education (lectures, teaching files) as well as in publications or are valuable to store in a reference collection for differential diagnosis. Others might only be of particular interest to the reporting radiologist in order to be followed up (e.g., in uncertain diagnoses).

In the past at our institute, some colleagues simply took screenshots of interesting images and saved them somewhere in their personal folders. Others were maintaining lists on pieces of paper, in text files, or spreadsheet programs to preserve or follow up interesting cases. We believe that this is still practiced at many other radiological departments that have no feasible centralized solution.

Several projects already exist that provide methods to preserve cases stored in a picture archive and communication system (PACS), most of them aiming at the creation of teaching files [1–6]. Some of the systems already facilitate the data input by extracting relevant information like patient name or birthdate from the DICOM header. This does not only save time but also prevents common mistakes like typing errors or other mix-ups. Input methods for annotations and different search strategies are usually provided. However, we could not find an existing solution that meets all of our requirements for a reasonable case database:

- Easy set up procedure without the need for help from specialized PACS engineers to install, configure, and start the different services etc.
- Use of free open source software modules
- A simple case input procedure demanding only a minimum amount of time from the user
- A clean, intuitive user interface with powerful search strategies (full-text search and categories)
- Preservation of patient data to be able to keep in touch with the case (e.g., look for follow up examinations or clinical data)

F. J. Kammerer (✉) · R. Janka · M. Kramer · M. Hammon ·
M. Uder · P. M. Schlechtweg
Department of Radiology, University of Erlangen, Maximiliansplatz
1, 91045 Erlangen, Germany
e-mail: ferdinand.kammerer@uk-erlangen.de

- Direct and anonymized presentation of relevant key images or whole image series that can be easily copied for usage in lectures, publications, etc.
- Multiple user access

Methods

To stick to our requirements mentioned above (free of cost and multiple user access), we used only open source software and decided to build the system as a web-based application that can generally be accessed by any computer connected to our intranet using a web browser.

In order to facilitate installation and minimize configuration efforts, we designed the whole system as a portable application. The PortableApps project [7] provides software solutions that can be installed on almost every storage device, even portable hard drives, USB flash drives, or memory cards by simply copying a single directory. No special hardware, no additional software, and no modification to the used computer (e.g., Windows registry) are needed.

XAMPP [8] is a preconfigured server package that contains an Apache HTTP web server, MySQL as a relational database and PHP as a scripting language. We use XAMPP in the lite version 1.8.1 which comes in an archive that will need around 150 mb of space when extracted. A control center to start, stop, and configure the server environment is provided. Hardware requirements are minimal; the XAMPP development team recommends at least 64 MB of RAM and Windows XP or newer.

System Architecture

Our system comprises several script files that are located within the document root folder of the Apache web server and a single database for the storage of patient and study data. The images are not stored within the database but in a subfolder of the document root in order to be accessible by the web server. A password protection is implemented using the apache web server's basic HTTP authentication procedure.

A patient case can be added to the database by saving DICOM images in a predefined directory which can either be located on the same computer acting as a server or on any other computer within the network to which the server has access. Most PACS vendors provide a function to export images to the file system in DICOM format. The PACS used at our institute (syngo.plaza, Siemens, Erlangen, Germany) allows exporting single images as well as parts of series or whole series. However, the images do not necessarily have to be exported out of a PACS but can also come from any other source providing DICOM files, e.g., a CD-ROM. Figure 1 illustrates the system architecture.

Fig. 1 System architecture. Any PC on the intranet may act as a server by simply starting the widely preconfigured portable app which can be located on an external USB drive, on the local hard drive or even on a network drive. A PACS workstation or any other DICOM image source delivers patient images to the import folder. Any PC connected to the intranet can access the case collection server via the server's IP address using a web browser

When the user frontend is accessed by visiting the server computer's IP address via a normal web browser, an import script is started automatically that checks the predefined directory mentioned above for new DICOM files. In case that there are new images, every file is analyzed, and the DICOM tags are extracted using the DICOM toolkit DCMTK [9] developed by the OFFIS computer science institute (Oldenburg, Germany). The DICOM tags extracted for the further processing are listed in Table 1.

The internal database resembles the hierarchical structure of a PACS ("patient–study–series–images") and provides corresponding tables for data storage. When iterating through the images, the system checks if the patient is already listed in the database and whether there are studies or series. If necessary, the new patient data is registered, and the images are stored in a proper hierarchical order. We defined a subdirectory structure in which the AccessionNumber and SeriesNumber are used as folder names, and the images receive an anonymized, unique number. All images are converted to the JPEG file format at the original resolution of the DICOM image allowing for good quality/size ratios. Figure 2 gives an impression of the workflow and mentioned process.

The user frontend is written in the server-side PHP scripting language which allows the creation of dynamic web pages in the HTML standard that can be displayed in a client's web browser. User interface elements like lists, buttons, and text fields can be created. Several dynamic content elements like tab browsing of different studies also demanded the use of JavaScript as a client-side scripting language. A special JavaScript was developed to realize scrolling through an image stack as if sitting at a real PACS workstation. No

Table 1 List of the automatically extracted DICOM tags that are stored in the database

DICOM tag	Description
0008,0050	AccessionNumber
0008,0022	AcquisitionDate
0008,0060	Modality
0018,0015	BodyPartExamined
0020,0011	SeriesNumber
0010,0010	PatientName
0010,0020	PatientID
0010,0030	PatientBirthDate

preloading technique for the images was necessary as smooth scrolling through the images is possible by loading them on demand.

Results

The system was successfully installed in our environment on a normal desktop PC (Intel I5-2400 CPU @ 3.1 GHz with 4 GB of RAM) running Windows 7 (Microsoft, Redmond, WA, USA) as operating system. We decided to copy the software to the local hard drive and created a shared folder with the required read/write permissions on the same computer as an import folder for the DICOM images. This speeds up the system a little compared to running it from an external disk.

A very brief instruction how to import patient cases into the database was given to all colleagues at our department. As mentioned above, the user frontend is accessible using a standard web browser via the server computer's IP address. We successfully tested the system with the latest version of Mozilla Firefox 20.0 (Mozilla Foundation, Mountain View, CA, USA) and Microsoft Internet Explorer 8.0 (Microsoft, Redmond, WA, USA). To simplify access to the system, we saved a bookmark to the server's IP address on every PACS workstation.

User Interface

The intuitive frontend interface uses a plain, tabbed navigation. A quick search option allows for fast retrieval of certain patient cases by conducting a full-text search in the patients' names, diagnosis, and annotations.

The navigation tab “My Cases” lists all the private and public cases of a certain user (Fig. 3). The patient ID, name, birthdate, short diagnosis, and the input date are shown. Sorting can be done by clicking on the respective column in the table. A delete option is also provided in this view. “All patients” shows all public cases of all users. Layout and usage are the same as in the “My Cases” tab except for the delete button.

The “Search” page (see Fig. 4) allows more complex search queries. The results can be filtered using different criteria like birthdate, case input date, body region, or disease type as well as by modality. The search results page resembles the listings shown above.

By choosing a patient in one of the listings, the user is directed to a detailed page for viewing or editing the case data (see Fig. 5). There are fields for a short diagnosis and for more detailed annotations and two drop down fields to categorize the case regarding a body region and disease type (e.g., “thorax” and “inflammation”). The lower part of the page shows all of the imported imaging studies separated in a tabbed navigation. The user can scroll through the series using the mouse wheel as if sitting in front of a PACS console. A mouse click on one of the series opens a new window containing the respective series. The window is automatically opened in an optimized size fitting the screen and may be resized and positioned freely (Fig. 5). Multiple images or series can be opened at the same time for comparison purposes.

As mentioned above, the system automatically checks for new images when the index page is accessed. The import process may however also be started manually using the “Import images” tab in the main navigation. Once new images are imported, the case is listed under “All patients”. Patient data (name, birthdate, etc.) and study data (date and modality)

Fig. 2 Workflow and process. The radiologist at a (PACS) workstation exports DICOM images to a predefined folder. The import script extracts DICOM tags and creates anonymized JPEG images which are stored in a relational database and a directory structure. The user frontend can be accessed using a standard web browser

Fig. 3 Navigation tab “My Cases” showing the public and private cases of a certain user

The screenshot shows the 'My Cases' tab in the MyCases application. The header includes the application logo, the user's name 'kammerfd', and navigation buttons for 'My Cases', 'All patients', 'Search', and 'Import images'. A 'Quicksearch' bar is also present. Below the header is a table listing patient cases with columns for ID, Name, First name, Birthdate, Diagnosis, Input date, and Action. The table contains 10 rows of data. At the bottom, there are navigation controls for 'Start', 'Previous', 'Page 1 of 2', 'Next', and 'End'.

ID	Name	First name	Birthdate	Diagnosis	Input date	Action
1008130690	Heute	Heute	29.04.2009	Sinus thrombosis	27.03.2013	
1000456399	Heute	Heute	03.12.1934	SLAC-Wrist	27.03.2013	
1001142743	Heute	Heute	07.04.1954	Morbus Kienböck	27.03.2013	
1009869891	Heute	Heute	27.10.2010	Meningomyelocele	27.03.2013	
1009999950	Heute	Heute	24.03.2003	free air	27.03.2013	
1008540734	Heute	Heute	03.06.1986	Giant cell tumor	27.03.2013	
1005165779	Heute	Heute	29.06.1970	Ewing Sarkoma	27.03.2013	
1002112205	Heute	Heute	23.02.1923	Sigmoid volvulus	27.03.2013	
1009107710	Heute	Heute	31.12.1946	Lung edema	27.03.2013	
1000394981	Heute	Heute	09.07.1964	Pneumocystis jirovecii pneumonia	27.03.2013	

are automatically extracted from the DICOM header and stored in the database.

Discussion

Radiologists have always been hunters and gatherers of interesting patient cases. The introduced system allows for quick storage of such cases including images and patient data at the moment when a case is identified without major interruption of the routine workflow. Different search strategies and filter mechanisms facilitate retrieval of certain cases.

Referring to our requirements of a reasonable case database listed in the introduction, some features with respect to their

combination make the MyCases portable application different compared to previous work.

First of all, the proposed system has a special, much more lightweight system architecture compared to existing solutions [1–6]. All of the existing systems known to us seem to require a considerable amount of knowledge in information technology for installation and maintenance. Our approach has no need for complex installation procedures because the widely preconfigured portable app may be run from almost every standard data medium, even a simple USB flash drive, and can be accessed from any PC on the intranet using a standard web browser. Setting up web servers and database systems usually demands administrative rights on a computer in order to install, configure, and start the different services, etc. that may only be (or permitted to be) carried out by

Fig. 4 Advanced search form

The screenshot shows the 'Advanced search form' in the MyCases application. The header is identical to Figure 3. The form is divided into two main sections: 'Patient data' and 'Study data'. The 'Patient data' section includes fields for ID, Name, First name, Birthdate, Input date, Physician (a dropdown menu), Diagnosis (a text field), and a checkbox for 'search all textfields'. The 'Study data' section includes fields for Date, Modality (a dropdown menu), and a 'Start search' button. There are also dropdown menus for 'Body region' and 'Disease type'.

Fig. 5 A detailed view containing all the information about the case. The different studies are separated in a tabbed navigation. In this example, the CR image has been opened and resized in a separate window

specialized PACS engineers. The proposed system can be started almost straight “out of the box”. The only configuration change usually necessary is an adaption of the import folder path, where users store their case images. We use the XAMPP Version compiled for Microsoft’s Windows operating system, but the package is also available for Mac OS, Solaris, and Linux, so the system should be easily adaptable to other environments. As all of the used software components are open source, the whole system is free.

Existing systems can be roughly divided into two groups: those linking to a PACS and storing only patient data (name, birthdate, etc.) as well as annotations like diagnosis, patient history, etc. [1, 2] and others which additionally or exclusively retrieve key images or even whole image series from the PACS and store them in their own databases [3–6].

Regarding the first group, our opinion is that the storage of laborious selected images in a system separate from PACS is obligatory in spite of the need for additional hard disk memory. Furthermore, in many PACS environments, not all patient studies can be provided for direct access (online) but are kept in nearline or offline storages which need time to recopy the

selected studies. Especially concerning rather old cases in a collection the images might not be directly accessible.

The second group of systems follows different strategies concerning image retrieval from PACS. One project uses a PACS vendor specific function that e-mails studies to a teaching file server [3]; some use direct DICOM communication via FIND/MOVE/STORE commands [6] while others perform DICOM SEND commands to specially designed servers [4, 5]. Concerning image data input, we believe that importing DICOM image files represents the easiest and most flexible solution. Most PACS vendors provide functions to export images to the file system. As DICOM is a standardized image format, vendor neutrality should be given. However, a PACS is not necessarily required as DICOM images from other sources like CD-ROMs or files received by email can also be imported.

A user should not be forced to select certain key images from a patient study as this can be a rather time-consuming procedure. Regardless of whether the images will someday be used in teaching files or for other purposes, it is most often useful to store not only a single, static image showing a certain

pathology. The review of multiple images is essential in order to understand imaging findings and to formulate a diagnosis especially in cross-sectional imaging [10, 11]. The ability to scroll through an image stack gives the most realistic impression of a certain case.

Since the image files are converted to an anonymized JPEG format, they can be directly reused, e.g., in presentations by performing copy&paste right out of the browser window. The patient's identity is only stored in the database so that the complete case history including other imaging studies, pathology reports, or laboratory parameters can be reviewed at any time. To ensure the protection of data privacy, the system is supposed to be used in a secure intranet environment only. The privacy policies of individual countries should be taken into account.

To our knowledge at present, no system exists that combines all of the abovementioned features for a reasonable case database. Our solution is currently not primarily designed for the creation of teaching files. However, the development of further functionality like quiz modes and the implementation of an interface compliant with the MIRC standard [12] are already under way. Another future ambition could be an adaption to the Teaching File and Clinical Trial Export (TCE) integration profile that was developed by the Integrating the Healthcare Enterprise (IHE) initiative in order to further facilitate the workflow when creating electronic teaching files [13, 14]. Apart from that, further testing in other PACS environments has to be conducted to ensure vendor neutrality.

References

1. Wilkinson LE, Gledhill SR: An integrated approach to a teaching file linked to PACS. *J Digit Imaging* 20(4):402–410, 2007
2. Do BH, Wu A, Biswal S, Kamaya A, Rubin DL: Informatics in radiology: RADTF: a semantic search-enabled, natural language processor-generated radiology teaching file. *Radiographics* 30(7): 2039–2048, 2010
3. Mongkolwat P, Bhalodia P, Makori A, Gehl JA, Kogan A, Channin DS: Informatics in radiology (infoRAD): integrating MIRC-compliant semiautomated teaching files into PACS work flow. *Radiogr Rev Publ Radiol Soc N Am Inc* 25(2): 543–548, 2005
4. Kamaau AWC, DuVall SL, Robison RJ, Liimatta AP, Wiggins RH, Avrin DE: Vendor-neutral case input into a server-based digital teaching file system 1. *Radiographics* 26(6):1877–1885, 2006
5. Gentili A, Chung CB, Hughes T: Use of the MIRC DICOM service for clinical trials to automatically create teaching file cases from PACS1. *Radiographics* 27(1):269–275, 2007
6. Tchoyoson Lim CC, Yang GL, Nowinski WL, Hui F: Medical image resource center-making electronic teaching files from PACS. *J Digit Imaging* 16(4):331–336, 2003
7. PortableApps.com - Portable software for USB, portable and cloud drives. PortableApps.com - Portable Softw USB Portable Cloud Drives. Available at: <http://portableapps.com/>. Accessed 12 Mar 2013
8. XAMPP | PortableApps.com - Portable software for USB, portable and cloud drives. PortableApps.com - Portable Softw USB Portable Cloud Drives. Available at: <http://portableapps.com/de/apps/development/xampp>. Accessed 12 Mar 2013
9. dicom.offis.de - DICOM Software made by OFFIS-DCMTK-DICOM Toolkit. Available at: <http://dicom.offis.de/dcmtpk.php.en>. Accessed 12 Mar 2013
10. Cornfeld D: A step-by-step solution for embedding user-controlled cines into educational Web pages. *AJR Am J Roentgenol* 190(3): W218–W221, 2008
11. Yam C-S, Levine D, Nishino M, Sitek A, Larson M: A simple method for displaying cine images on web-based teaching files. *AJR Am J Roentgenol* 184(2):691–694, 2005
12. Radiological Society of North America. RSNA Medical Imaging Resource Center. Available at: <http://mirc.rsna.org>. Accessed 31 July 2013
13. Integrating the Healthcare Enterprise IHE Radiology Technical Framework Supplement 2004–2005, Teaching File and Clinical Trial Export (TCE). Available at: http://www.ihe.net/Technical_Framework/upload/IHE_TF_Suppl_Teaching_File_Clinical_Trial_Export_TI_2005-04-22.pdf. Accessed 20 Mar 2014
14. Kamaau AW, Whipple JJ, DuVall SL, Siddiqui KM, Siegel EL, Avrin D: IHE teaching file and clinical trial export integration profile: functional examples. *Radiographics* 28(4):933–945, 2008