

A Web-based Tool for Training Radiologists in Medical Imaging

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Abstract

The massive growth in applications of radiological imaging and image-guided treatments has met a worldwide shortage of trained radiologists. Therefore, several radiology training environments which combine traditional learning opportunities with advanced e-learning platforms have recently been developed with the goal of supporting the acquisition of radiological expertise.

A new research web-based tool which has been customized in order to incorporate learning capabilities for training and guidance of newly employed or resident radiologists is presented. Such tool allows panels of experts to collaborate at different hospitals and research centres by means of integrating a Picture Archiving and Communication System (PACS) to store the Digital Imaging and Communications in Medicine (DICOM) files as well as a database with the eXtended Markup Language (XML) files containing the experts' annotations for each clinical case. First prototype is being evaluated on digital mammography images.

1. Introduction

Nowadays, medical imaging plays a fundamental role in achieving correct diagnosis for many diseases. However, it involves changes concerning the management, storing and retrieving of digital images. Thus, in order to improve the current imaging systems, it is necessary to develop architectures and medical databases, as well as PACS [1] systems. Besides, systems based on web applications [2-4] are particularly interesting due to recent advances in computer technology and in communications systems and protocols, which have allowed the development of online software and data recovery in a reliable and inexpensive way [5]. Therefore, the use of Web

Services applied to medical domain has experienced an important growth during the last years, and has become a communications system in itself. The main advantages of web-applications are obvious: easy accessibility, users can connect from anywhere in the world, time-saving and efficient mechanism to find special information which can be saved directly to one's computer without the tiring tasks of searching in libraries [6], providing high levels of security system, downloading medical annotations using query forms and also can be used as a high level of interactivity among health professionals.

Moreover, the introduction of the XML (eXtended Markup Language) file format [7] allows information exchange regardless of the platform, thus, introducing a standard format to include diagnosis on the images [8].

The purpose of this work is to provide a useful tool to the medical and scientific communities in order to manage a mammographic image database including their associated diagnoses featuring the advantages and functionalities of a web service (i.e. authentication, security and data retrieval).

2. System Architecture

The proposed system has been designed as a web-based application within the Zend Apache server [9] which is also used as a MySQL database server for data storage. The application links both the PACS and the XML servers which store clinical cases (as DICOM and annotation files). All data transmissions between users and the web server are encrypted in order to ensure complete confidentiality of the data. Currently, the Secure Socket Layer (SSL) cryptographic protocol is used. Queries to the prototype are performed through a web form and provide a user with a list of clinical cases according to the query parameters, including the image and the annotation files.

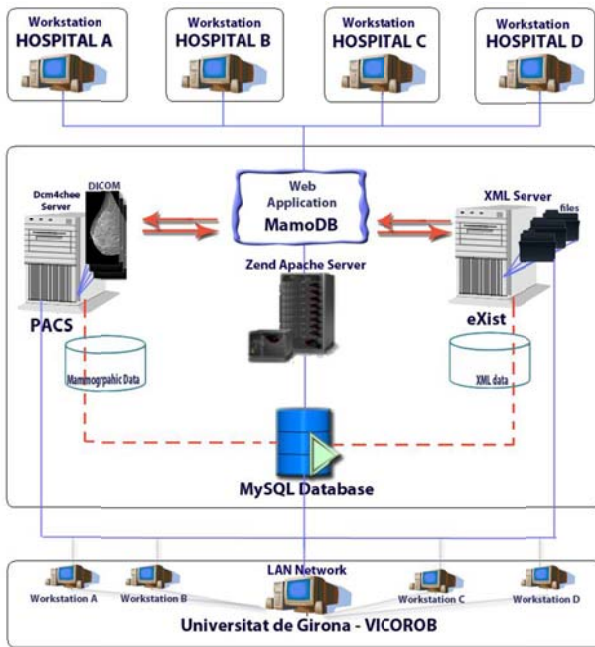


Figure 1. Architecture model of prototype

Figure 1 shows the system architecture of the prototype. The application is stored in a Zend Apache server, while this server is configured with a MySQL database manager. In addition, when the PACS is linked, a database (pacddb) is also created in MySQL and therefore directly related to Zend Apache server. This architecture allows to access to the PACS server for analysing new cases but keeping them unchanged, since the information concerning the annotations is stored in the MySQL database.

The application is also related to the eXist manager [10], responsible for the XML database, incorporating its own server for access and management via web interface. We opted for the creation of the XML annotation files in the database in order to preserve the integrity of the original DICOM files and to ensure their full support if they come from different acquisition systems. All XML files that are stored in the eXist database are related to their corresponding mammographic images as these are the files containing the records of diagnosis made by radiologists. For this reason, it can be seen in the architecture model of Figure 1 that there is a direct relationship between the MySQL database and the eXist manager. Finally, we have defined the key field identifier or files with their breast imaging, so that the database and the files are correctly matched.

In order to facilitate the access to the application, and with the idea to serve both the medical experts

present at the hospital itself and the outside professionals, we decided to design a web application.

One of the key elements in this application is the data and information security across the network, especially when it comes to confidential data related to medical examinations. In this sense, the three modules shown in Figure 1, that constitute our system architecture (Zend Server, PACS and eXist), have internal security measures to avoid vulnerabilities from the transfer of information, so that besides using a control User ID private keys, the algorithms have systems that protect and encrypt the information during its transmission.

Finally, the access system has been designed in order to facilitate both local and external users. The users should log in correctly using a unique username and password independently if the connection is via intranet or external.

3. Web-application

We propose the use of the web-application prototype as a part of the problem-based learning paradigm. This section describes the most important features of the application. It has been divided into three different subsections: identification and security, control panel and accessibility, and management and training query form.

3.1 Identification and security

Firstly, the secure access user to the application is ensured by a username and password generated by the system administrator. The system incorporates mechanisms of authentication and protection against fraudulent use of identity.

The system has a three-level security setting for user profiles. The 1st level (Standard User) allows users to submit queries on the various medical cases stored in the prototype (images and diagnosis). This level corresponds to a profile of a student or auxiliary medical personnel, who uses the application for remote diagnostics, training, etc. The 2nd security levels, in addition to the permissions of the 1st level, allows access to PACS and eXist for addition and modification of the mammographic database content and clinical cases (images and diagnosis). Essentially, it corresponds to a profile of advanced student or medical specialist partner in the construction of the mammographic database, who needs access to the system locally or remotely. The 3rd security level serves for system administrators, adding user account management to the list of permissions.

3.2 Control panel and accessibility

Once a user is identified correctly in the system, the home page of the prototype as the control panel for his profile appears in the browser. Depending on the type of user accessing the system, the control panel shows different possibilities.

3.3 Prototype functionality

The most important part associated with the learning capabilities for training and guidance of newly employed or students, is shown in this section. Therefore, the management and training form, finding results, and characterization analysis of the mammographic findings are presented.

This e-learning platform uses queries to the prototype through a web form and provides a user with a list of clinical cases according to the query parameters, including both the image and the annotation files.

The first step required from the student for this training process is the use of the query form. In order to obtain desirable results the user should select appropriate criteria, as directed by the expert or medical staff. Their work is to find mammographic studies according to the criteria used by the user. The search is performed in all the XML files stored in the eXist database and the list of results is shown in the web interface.

In addition to a comprehensive list of clinical cases contained in the database, the query forms allow to search according to some specific medical criteria: reported diagnosis, BIRADS classification, presence of abnormalities (micro-calcifications, structural distortions, masses, etc.). Depending on the volume of records obtained from the results list, the application uses automatic paging group records in a more visual way as can be seen in Figure 2.

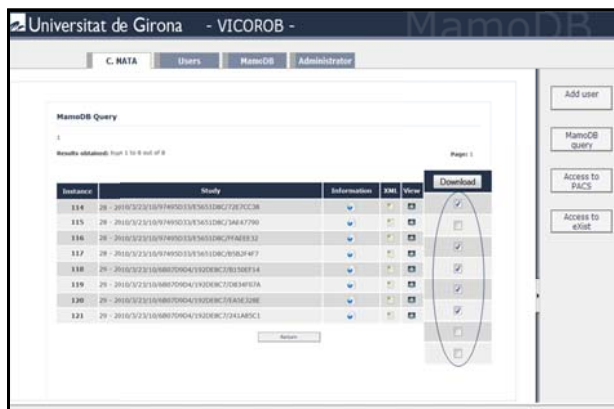


Figure 2. Results obtained after the training query form

For each of the records obtained, the system allows three actions: see information on the DICOM image stored in the PACS server, check the diagnosis associated XML file formats, and display the mammographic image.

As for the characterization and analysis of the mammographic findings, three different actions are available once the records have been obtained:

- Display the information contained in the DICOM file.
- Get the diagnosis linked to the case, stored in a XML file.
- Display the digitized images contained in the DICOM file.

When the list of results is obtained, the user can get information about all studies and compare them in order to perform a classification and selection of the best results according to the preferences selected in the query form. This is the educational part of this e-learning tool and it is useful to understand its methodology. For each case a student can display acquisition information contained in the DICOM file, read annotations about the study included in the XML file, and display the images included in each study.

In Figure 3 two examples of DICOM images associated with the selected study are displayed. It also shows overlays marked by doctors and their individual annotations. This information is very important because users should compare and classify studies in order to later download all the cases useful for the learning purposes.

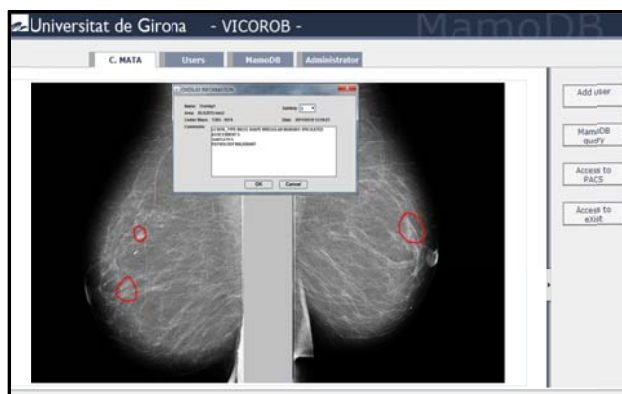


Figure 3. DICOM images with their associated overlays

The last step when students study all mammographic cases is to download all the causes useful for them. An important feature of the system is that the records can be visualized on the screen or downloaded locally to the workplace selected by the user. The system offers the possibility to download a

single record or use an automatic selection. Once selected, the DICOM files together with their associated XML files become part of the ZIP file which is downloaded by the user.

4. Conclusions and Future Work

Digital medical imaging technologies have become beneficial in modern medical practices and health care systems, providing powerful tools for diagnosis, treatment, and surgery. The volume of medical images being generated has grown rapidly due to an increase in the number of clinical exams performed in digital form and to the large range of available modalities. Therefore, the demand for online medical imaging systems that allow visualization and processing has increased significantly.

Although nowadays public databases of mammographic images are available, many of them have been acquired digitally by analogic acquisition and subsequent digitization of the films. For breast imaging, this process involves an inherent loss of quality, depending on the digitizer system, loss of information acquisition and non-standardization of image formats. The proposed system architecture is able to manage and centralize a public database of digitally acquired mammographic images. Furthermore, using the proposed web application, a user can have access to information both locally and remotely.

The prototype has been designed as a web-based application within the Zend Apache server which is also used as a MySQL database server for data storage. The application links both the PACS and the XML servers which store the clinical cases (as DICOM and annotation files). Database queries are performed through a web form and provide the user with a list of clinical cases according to the query parameters, including both the image and the annotation files.

As future work to improve the prototype, we propose to define a single XML file format for the medical community, which would correspond to the annotations of the images associated with mammography. Moreover, we plan to define custom search forms that ensure optimal results and are

tailored to the needs of the user. Finally, further improvements could be investigated in terms of security and data transfer and the use of new algorithms to improve data encryption and provide a more secure and robust system.

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