plate of images based on the CDA standard. The template can be used to exchange clinical documents, including multimedia data such as texts and images, and offers the flexibility needed to create reports for multiple modalities and institutions by providing the template of a basically empty report. It uses coded vocabulary such as LOINC and SNOMED. This representation facilitates the automated software recognition of findings and observations, intrapatient comparison, and correlation to norms and research outcomes.

The proposed radiological reports based on the CDA standard are used to facilitate interchange between different healthcare institutions, and are presented in an XML-compatible web browser. The SR generator module and concept presented in this paper show promise as a tool to improve healthcare delivery and can also be used to integrate with other DICOM SR compliant PACS. In addition, it may be integrated into HL7-based information systems.

Especially in order to provide benefits such as removal of redundant data entry and archival of reports in the same system, this system will function as an integral part of the Integrating the Hospital Enterprise (IHE) compliant solution through its provision of better integration with HIS and PACS using HL7 and DICOM.

This paper has focused on the adoption of medical informatics standards and XML technology into the healthcare domain and the integration with the existing CDR regional repository system using HL7 to send and restore CDA documents, thus overcoming difficulties in the integration and compatibility of medical information systems.

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NMQC: A NEMA-compliant Software Application for Gamma Camera Quality Control

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Background:

The purpose of quality control (QC) tests for nuclear medicine gamma cameras is to detect changes in performance which
might degrade the accuracy of clinical images. To avoid image artifacts due to camera malfunction, hospital technicians regularly perform various quality control tests—some daily, others weekly, monthly or yearly. After acquisition, the data is checked visually and, in parallel, analyzed by specialized software to generate statistics characterizing camera performance. In order to standardize these tests and to allow for comparison of the performance of different cameras, the National Electrical Manufacturers Association (NEMA) has compiled a document which describes how to perform and report scintillation camera QC tests. The latest NEMA standard, NU-1 2001, contains both instructions for how to perform QC experiments and guidelines for analyzing the resulting data.

We have developed a software application which implements the basic scintillation camera QC analyses as described in the most recent NEMA standard. Our software allows multiple types of QC test data to be analyzed within a single application, and enables the comparison of different cameras in a uniform way. Thus our application complements manufacturers’ software (which performs similar functions for specific cameras), by providing an independent analysis of data from different camera types and from different manufacturers. Both planar and tomographic QC tests are implemented, allowing examination of camera performance in a number of important areas.

Our application is written using the Matlab environment, which has several benefits, foremost of which is cross-platform compatibility. Since Matlab runs on Windows, Linux, Mac OS X and Solaris, so does our software. Also, using Matlab as a development environment facilitated creation of this full-featured application in only four months.

**Evaluation:**

Our application reads and analyzes DICOM or Interfile format files. In addition to the QC analysis functions, the program has features for examining and searching file headers, viewing magnified images or sections of images, and exporting results. All of the application’s features are accessible through a unified graphical user interface (GUI).

The software was written with an underlying philosophy that automation is nice, but the ultimate decision regarding input parameters should always be left to the user. Therefore, the software automatically follows standard procedures, but at any point the user can alter the parameters used for the analysis. For example, during planar uniformity analysis the program automatically chooses what it calculates to be the optimum Useful Field of View (UFOV). However, if the user decides upon examination of the image that they would prefer a different UFOV, they have the option to manually specify a different area to be used for analysis. Another example of how our program addresses real-life quality control analysis issues is its handling of pixel size information. In our clinical experience, we have often found that the pixel dimensions specified in the file header are incorrect. Permanently correcting the file headers themselves may be troublesome, especially if the files are stored on read-only media such as CD-ROM. Instead, our software allows the user verify the header information and (if necessary) substitute corrected values to be used for the QC calculations. By making use of automation when possible but always giving the user the final choice, the program stays useful while retaining the flexibility to handle real-world QC test data.

One of the major aspects of this project was the short timeline (4 months) and small development team (2 supervisors and 1 developer). In addition, it was important that the QC program be cross-platform—able to run not only on Windows but (at least) on Linux as well.

As mentioned, these constraints were among those which helped motivate our choice of Matlab as a development platform. First, cross-platform issues are handled by the fact that Matlab code runs on several operating systems, including Windows, Linux, Mac OS X and Solaris. Secondly, Matlab has a wealth of features which assist with rapid application development: the Image Processing Toolbox provides useful image manipulation routines, and developing a user interface is facilitated with the drag-and-drop Graphical User Interface Design Environment (GUIDE). These advantages convinced us that Matlab was the the best choice for this application, compared to C++ and Java development environments. Although both of these alternative platforms can address cross-platform issues and both have libraries available for image processing and GUI development, the short timeline and limited development resources caused Matlab to be our final choice.

For all its development advantages, Matlab would not be a desirable platform if users were required to own a copy of Matlab in order to execute our program. However, by installing the free Matlab Common Runtime (MCR), anyone can run our software, even if they do not have Matlab or the Image Processing Toolbox. Alternatively, the program can be run directly from within Matlab by users who do have a copy installed.

**Discussion:**

Our application implements all of the basic nuclear medicine camera QC tests, including:

- a. calculation of planar uniformity
- b. intrinsic resolution calculation
- c. profile analysis (Full Width at Half Maximum/Full Width at Tenth Maximum)
- d. center of rotation calculation
- e. sinogram/linogram display and calculation
- f. tomographic uniformity calculation
- g. plotting of planar uniformity test history.

These tests cover the most important areas for evaluation of gamma camera performance: uniformity, resolution, and rotational alignment. Measurements of these properties are performed as part of daily, weekly or periodical QC tests. Additionally, comprehensive acceptance tests are done on installation of new systems. Because of the frequency of QC tests, it is important that the analysis be simple and straightforward. Further, numerical test results are very useful for accurate
evaluation of camera performance. Our software meets both of these requirements.

By providing analysis which is both independent of and complementary to manufacturer’s proprietary software, our program gives a useful overview of a camera’s current performance. Additionally, by allowing the user to plot test results versus time, gradual degradation in performance can be detected. Also, data from cameras of different brands can be used as input to our program and analyzed in a uniform way, allowing a fair comparison of different cameras’ performance.

Conclusion:

We have implemented a cross-platform application for analyzing gamma camera quality control data according to NEMA standards. By leveraging the Matlab development environment, a useful application with a full GUI was developed in a short time. This software performs all of the basic quality control tests necessary for planar and SPECT scintillation cameras. Our application is easy-to-use, cross-platform, and serves as an independent complement to gamma camera manufacturers’ proprietary quality control software.

Optimizing Workflow When Integrating Multi-Vendor RIS and PACS Solutions

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Background:

Radiologists interact with several information systems for image interpretation and report generation. In addition to a radiology information system (RIS) and a picture archiving and communication system (PACS), radiologists may require access to an electronic medical record (EMR) for viewing additional patient information, a Laboratory Information System, and a system for dictation/voice recognition. Particularly when institutions implement products from different vendors, the systems may not share information, and may have separate logons, user interfaces, and input devices. This scenario can introduce inefficiency in radiologist workflow, make it difficult to locate critical information, and introduce the possibility of error. This presentation summarizes the design and functionality of a multi-vendor RIS/PACS workstation, which addresses these issues.

Evaluation:

The Radiology Department of Froedtert Hospital and the Medical College of Wisconsin (Milwaukee, WI) utilizes the Horizon Medical Imaging PACS (McKesson Medical Imaging Group, Richmond, BC, Canada). The department is actively implementing a new RIS (Epic Systems Corporation, Madison, WI), which includes dictation functionality. The RIS implementation is part of an enterprise-wide EMR installation. The desire to drive Radiologist workflow with the RIS application, and enable immediate access to the patient’s EMR, required the RIS to be integral with Radiologist workflow.

Discussion:

A set of high-level functional requirements for integrating the RIS application into the Radiologist workflow were identified. These included:

- Single-sign-on opens both RIS and PACS applications simultaneously
- RIS application displays on a separate color monitor
- Patient context is preserved between RIS and PACS
- Workstation employs a single keyboard and mouse
- RIS-centric workflow
- RIS updates study status in PACS
- Utilize RIS dictation functionality and advanced microphone capability
- Integration does not degrade the speed or performance of either application

Several options were considered to achieve these requirements, including separate workstations for the RIS and PACS applications, RIS running via Citrix on the PACS workstation, and RIS installed as a thick client on the PACS workstation. After consideration, the integration option selected was RIS client software installed as a thick client on the McKesson Horizon RadStation (HRS) workstation. This required a custom interface between applications.

To achieve the high-level requirements, a Microsoft COM application programming interface (API) was implemented for communicating between the rich-client RIS and PACS applications. This API includes commands for secure challenge-response authentication, opening studies, closing studies as dictated or final, and handling workstation and application timeouts. By default, the RIS drives the opening/closing of all images and the PACS work list is disabled. If a patient opened by the RIS does not have images, the PACS screen is cleared. Custom mechanisms using this API allow access to the PACS work list for emergency cases when the study is not available in the RIS. In this situation, the RIS is secured until the PACS work list is closed.

The integrated workstation provides a RIS-centric approach to radiologist workflow. A single logon (username/password) opens the RIS and PACS applications simultaneously. The RIS opens on a dedicated color monitor, separate from the high-resolution grayscale monitors. A radiologist selects a study to review from the RIS, which automatically opens the associated images on the PACS. Image manipulation, adjustment, and hanging protocols are controlled through the PACS. A 3D/MPR tool is also available through PACS. Patient context is preserved between applications at all times.

A Radiologist can report via dictation, or create a report utilizing templates in the RIS. Upon completing the report, the RIS updates the study status in PACS, advances to the next exam on the worklist, and opens the associated images automatically.