MedXViewer: An Extensible Web-Enabled Software Package for Medical Imaging Adapted for Electronic Interval Cancer Review

Mark D. Halling-Brown, PhD, Royal Surrey County Hospital (Presenter); Mishal N. Patel, PhD; Kenneth C. Young, PhD; Matthew G. Wallis, PhD

Hypothesis

The almost complete digitisation of the NHS Breast Screening Programme (NHSBSP) and the huge amount of research involving medical images has led to a widely accepted need for comprehensive collections of medical images to be made available for research. In addition to the data, software and systems are required to facilitate evaluations, training and research with these images. In order to effectively support evaluation and training within a screening program, national and centralized software systems are needed, which are able to provide remote and collaborative access to images and data.

Introduction

Collections of images are required to undertake research and development in image perception studies, training and quality assurance. The collection of large set of medical images with full annotation for research purposes is challenging. The same challenges are present when envisioning the identification, collection and centralization of cases of interval cancers within a screening program.

Interval cancers (cancers arising between screens) are a key measure to monitor screening performance. Radiological analysis of the imaging features and retrospective classification are an important educational tool for readers to improve individual performance. Within the NHSBSP, the classification of interval cancers takes place at screening unit level and involve a selection of readers from each unit reading all the screening images independently (often reporting onto paper proformas) and then reviewing the screening images again with the annotated diagnostic images. Classification is made on the basis of the number of readers prospectively identifying the cancers on the screening films. However, the process lacks appropriate scientific rigor as there is no accurate localization system available and no record of any false marks can be made. Interval cancers after assessment are similarly reviewed and/or discussed using paper proformas.

When the NHSBSP was using film-screen imaging, managing these reviews was relatively straight forward and only required the provision of multiple light-boxes. Now that the breast-screening programme is almost completely digital, these meetings are increasingly difficult to organize, as there are very few facilities with access to more than a few workstations, which means that regional review outside of the three yearly QA visits will be unsustainable.

The requirements of remote, collaborative image review sessions are variable and demand a flexible and configurable software solution that is not currently available on commercial workstations. A software solution separate from the commercial workstation software allows for a reproducible and consistent viewing environment in large multi-centre trials. The wide range of requirements for both data collection and cancer review sessions have precipitated the development of an extensible medical image viewer. MedXViewer (Medical eXtensible Viewer) is an application designed to allow workstation-independent,
PACS-less viewing and interaction with medical images in a remote, collaborative manner, providing centralised reporting and web-based feedback [2]. This makes it ideal for adaption to create an electronic interval cancer review system.

Methods

MedXViewer was developed in Java and uses the DICOM library Dcm4Che (http://www.dcm4che.org) and the Java Advanced Imaging (JAI) library. Dcm4Che allows DICOM files to be read and in conjunction with JAI images can be created from the files. MedXViewer was developed for use in digital mammography and DBT but the modern programming techniques and a generic approach to the design allows MedXViewer to be easily extended for use in other imaging modalities.

Data acquisition and image perception/review studies require the marking and annotation of medical images to establish the ground truth. The software allows different ROIs to be drawn on images to localise the abnormalities. The number, content and types of questions are all configurable for each study.

MedXViewer can integrate with the Oncology Medical Image Database (OMI-DB) [1]. This allows images and software to be downloaded from a central store and results to be uploaded to a database. All the results and behavior are transferred to the server as the study is taking place. Alternatively the software can be run offline with images and results stored locally.

A semi-automated process which allows the centralization of interval cancer cases has been developed. This stand-alone, flexible image collection toolkit provides the extremely important function of bespoke, ad-hoc image collection at sites where there is no dedicated hardware available and a lack of staff familiar with the intricacies of the collection process. Provided the workstation it is deployed upon has a working Internet connection, the system is designed be provided with a folder of images for collection. It then anonymises or pseudonymises the cases, optionally extracts data from a local associated cancer database, allows the definition of ground truth and then transfers all collected information to a centralised server. The pseudonyms are held securely at the collection site.

MedXViewer has been customized to allow interval cancer review sessions to be deployed to remote participants. Web interfaces have been created which allow a national or regional administrator to organise, coordinate and administer interval cancer review sessions and deploy invites to session members to participate. The same interface allows feedback to be analysed and deployed.

Results

Interval cancers (cancers arising between screening episodes) are a key measure to monitor screening performance. Radiological analysis of the imaging features and retrospective classification are an important educational tool for readers to improve individual performance.

A pilot web-based interval cancer review programme (eICR) based on the OMI-DB and tools described in this paper have been developed. This programme involves:
• retrieval and anonymization of images and data (from NBSS) from clinical sites
• tools to annotate lesion locations on digital images and storage within the central database
• web-based display and mark-up of images using standard clinical workstations at any site with internet
• tools to record radiologists’ opinions on sets of test cases with location specific detail
• The eICR would
• Provide a uniform process for classifying interval cancers across the NHSBSP
• Enable / facilitate prospective and timely registration and recording of interval cancers on NBSS for programme monitoring
• Promote greater access and involvement of all mammography readers in interval cancer review
• Improve feedback to individual readers
• Improve opportunities for self-directed learning and research
• Facilitate rapid access to a robust ‘external’ review for patients and their relatives seeking answers about why their cancer was ‘missed’

In order to achieve this, the eICR needs to be able to acquire and centralise current and previous screening images, associated case data (from NBSS), ground truths (biopsy proven locations of malignancies) and provide remotely accessible tools to allow the participants to view and annotate the cases on their own workstation. The system provides the results of the review to participants in a suitable format (e.g. heat map overlaid images) that can be reviewed locally or at a regional meeting with minimal infrastructure. Finally, common themes can be identified that can be used to direct training and promote research.

Figure 1 shows a graphical outline of the eICR workflow. Image collection and centralization is undertaken using a specially adapted version of the stand-alone image collection system previously developed [1]. The system includes the automated collection of NBSS data from each site (3b) and the pseudonymisation of all data and image collection (3a). An integrated version of MedXViewer allows the definition of groundtruth (3c). Once these stages are complete, the eICR software then compresses and encrypts the images and data and transfers them to the centralised server (3d). Secured web access to the administrator eICR site would allow review session organizers to prepare and distribute sessions to participants (5). An adapted version of MedXViewer would be utilized to allow the remote interaction with review session participants (6).

Conclusion

Tools have been implemented which interact with the OMI-DB and associated study databases for remote imaging viewing and interaction. Combined, these provide the ability to run remote paper-less observer studies, provide a training infrastructure or coordinating remote collaborative interval cancer review sessions in a centralised manner without the antiquated laborious transfers of images to remote sites PACS and paper-based data manually curated into databases.

An electronic interval cancer review system has been developed to a pilot stage allowing the centralisation of interval cancer cases and subsequent review by clinicians in a remote, collaborative manner utilizing the MedXViewer software. Web interfaces have been created to setup and administer the review sessions and to view and process feedback.
References


Keywords

Medical Image Database, Electronic Interval Cancer Reviews, Remote Image Perception Studies