Web-Based Architecture to Enable Compute-Intensive CAD Tools and Multi-user Synchronization in Teleradiology*

Neville Mehta, Suryaprakash Kompalli, and Vipin Chaudhary

Computer Aided Diagnostics and Interventions,
University at Buffalo, Amherst, NY, 14260

Abstract. Teleradiology is the electronic transmission of radiological patient images, such as x-rays, CT, or MR across multiple locations. The goal could be interpretation, consultation, or medical records keeping. Information technology solutions have enabled electronic records and their associated benefits are evident in health care today. However, salient aspects of collaborative interfaces, and computer assisted diagnostic (CAD) tools are yet to be integrated into workflow designs. The Computer Assisted Diagnostics and Interventions (CADI) group at the University at Buffalo has developed an architecture that facilitates web-enabled use of CAD tools, along with the novel concept of synchronized collaboration. The architecture can support multiple teleradiology applications and case studies are presented here.

The architecture is associated with a GUI that enables DICOM viewing and annotation, capabilities that are standard in popular workflow solutions. The architecture integrates computer vision algorithms that normally require large computing power into the workflow process. Unique enhancements have been added to the UI in the form of collaboration tools developed specifically for teleradiology.

1 Introduction

The demand for electronic, web-enabled solutions in health care has led to several advances in UI designs and architectures for diagnostic imaging. Workflow solutions currently provide several useful features: single interface for multi-modality images, measuring tools, support for hand-held device, access to remote/local patient information, encryption [1,2,4,6]. These measures that were revolutionary a few decades ago, are now standard tools in health-care facilities. However, significant potential remains untapped in the design of collaborative interfaces, and integrating image processing routines into workflow designs.

We have implemented an architecture that enables Computer Aided Diagnostics (CAD) and synchronized teleradiology solutions (Figure 1). Popular PACS features like DICOM image loading, encryption etc. are provided along the lines

* This work was supported in part by a grant from NYSTAR.

D. Weerasinghe (Ed.): eHealth 2008, LNICST 1, pp. 186–190, 2009.

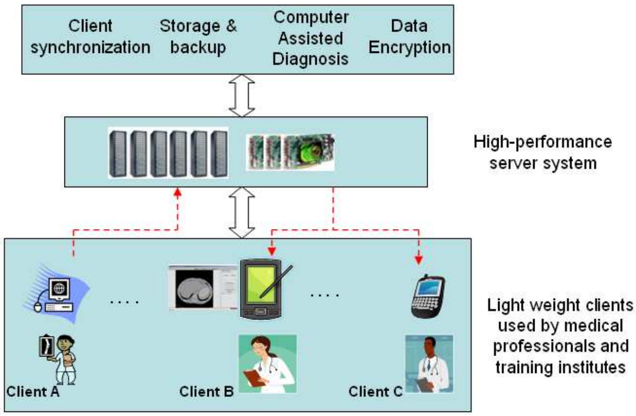


Fig. 1. Architecture of proposed teleradiology system. The normal workflow is shown in block arrows, where client systems interact with the servers independent of each other. The dotted arrows indicate synchronized workflow; interactions performed by client A is sent to clients B and C.

of industry-standard client-server architecture. The novel aspect of our design is the introduction of CAD tools in the server application, and the provision of synchronized collaboration.

2 CAD Tools

Surgery and treatment planning often involves the review of several images, sometimes of various modalities. Physicians have to frequently note salient image features manually and use the annotations to make diagnostic decisions during surgical planning or treatment. For example, in radio-therapy, the boundaries of neural structures like the optical nerve or brain stem are marked. The locations of these structures is used to guide therapy decisions. Similarly, physicians mark out boundaries of the liver and other salient organs prior to performing abdominal procedures. Several image processing algorithms are available to automate the identification of such structures [3,5,7,9]. The compute power needed for such image processing tools is significantly higher than the compute power needed to perform tasks like image viewing/browsing. For example, some automated techniques for liver segmentation require more than 120 seconds on a high-end processor like the NVIDIA 8800 GTX.

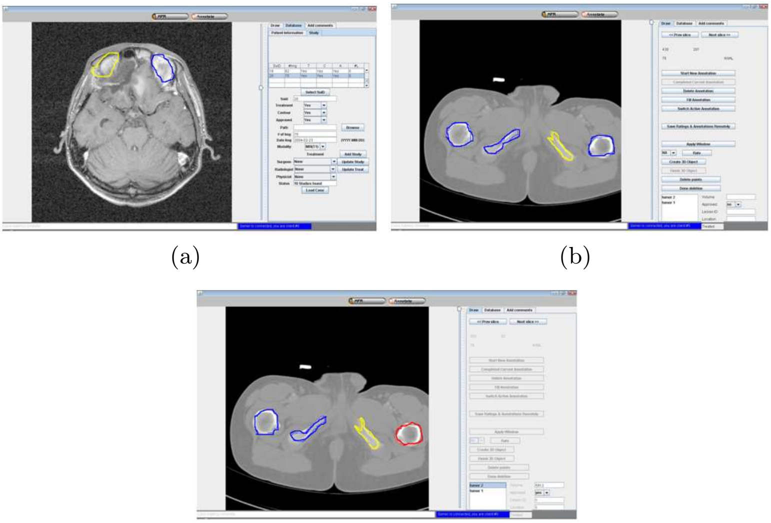
Several image analysis algorithms cannot be executed on thin clients like PDAs or laptops, but the automated features of these algorithms can significantly assist physicians in surgical and treatment planning. Our architecture separates the compute requirements from the client; the compute intensive image analysis algorithms are executed on a server system which has a high bandwidth network connection. The image analysis algorithms often use parametric models which need to be tweaked by suitable user input(s). UI controls are provided to enter the values of such parameters. For example, in case of MRF based segmentation, the user needs to provide one point within the liver. The seed point and liver image is transmitted to the server where an MRF algorithm [3] is applied to grow a region around the seed point and obtain the liver boundary.

2.1 Synchronization Tools

Radiologists often discuss difficult pathologies with colleagues, or provide information sessions to patient groups. Participants in such sessions may be from different geographic locations, and off-the-shelf teleconferencing, or desktop sharing packages are used to conduct the proceedings. We have devised a system where the ability to perform such collaboration has been integrated into the teleradiology interface.

A synchronize menu is available in the UI to initiate collaborative sessions. For a particular user (Client A in figure 1), the menu displays a list of users who are authorized to view their images. The authorization scheme is determined by workflow restrictions or HIPAA polcies, and any set of conditions can be encoded into the program by IT administrators. As Client A selects users from the menu, a request to collaborate is sent to the selected users. When a user (Client B, C in figure 1) accepts a request to collaborate, the server examines the patient information displayed by Client A, and sends the same information to clients B, C. Any interaction that is made by Client A on his UI is also transmitted to Clients B, C. For example, if Client A moves from slice 10 to slice 14, or performs window level operation, the same operations are performed in that sequence in the UIs of clients B and C.

The synchronize feature is a significant move away from using teleconferencing or desktop sharing packages. Off-the-shelf packages do not provide an accurate reproduction of the pathology information, especially the detail needed in cross-consultation for difficult cases. Software and hardware restrictions placed by teleconferencing tools destroys the ability to access patient information using small form factor devices like PDAs. Since only the UI controls are transmitted between collaborating clients, the bandwidth requirement is low and UI response is instantaneous in our case. For instance, once the patient information that is being seen by Client A has been reflected on clients B and C, the only information transmitted is about actions have been performed with UI. The server can embed UI controls into small messages like “Set window level to X/Y”, or “Change to slice 14”. The messages are transmitted over the network, automatically interpreted by the client software, and suitable changes made in the UI. This process requires no more bandwidth or compute power than is needed to display patient data. In addition, patient data and images do not leave the secure, encrypted, HIPAA compliant environs of the architecture. Some of the user interfaces are shown in figure 2.



(a) (b) (c)

Fig. 2. Screen layout of the UI

3 Case Studies

The teleradiology architecture has been deployed in the Roswell Park Cancer Institute (RPCI) at Buffalo, NY. Physicians at RPCI measure the effectiveness of treatment by tracking brain lesions over a period of time. Our architecture provides an intuitive paint-like interface to draw annotations over brain MRI, enter pathology information related to the lesions, and save the information to a database. The system has been deployed with three clients connecting to a server that has regular backup. The system is integrated with several CAD routines that are discussed in [3,8].

The architecture is being deployed in the Dent Neurological Center at Amherst, NY to help facilitate radiologist and patient education programs. Periodically, radiologists at different geographic locations discuss certain difficult pathologies, or provide information sessions to patient groups about radiology problems. Currently, off-the-shelf teleconferencing packages are being used to conduct such collaborative sessions, and information meetings. The radiologists have indicated a need to have a dedicated system that can relay images and pathology data. This has found to be more critical in radiologist interactions than in patient information groups.

A data collection process and study of the UI and segmentation algorithms has been initiated in collaboration with Dr. Stanley Lau from the Women and Children's hospital of Buffalo, NY [3].

References

1. Digisonics, http://www.digison.net
2. Vital images inc., http://www.vitalimages.com/home.aspx
3. Alomari, R.S., Kompalli, S., Lau, S.T., Chaudhary, V.: Design of a benchmark dataset, similarity metrics, and tools for liver segmentation. In: Proceedings of the SPIE Medical Imaging Conference (2008)
4. AMICAS. Amicas corp., http://www.amicas.com/
5. Florin, C., Paragios, N., Funka-Lea, G., Williams, J.: Liver segmentation using sparse 3D prior models with optimal data support. In: Karssemeijer, N., Lelieveldt, B. (eds.) IPMI 2007. LNCS, vol. 4584, pp. 38–49. Springer, Heidelberg (2007)
6. GE Corp. Ge advaantage workstation, http://www.gehealthcare.com/usen/aw/index.html
7. Hinz, M., Pohle, R., Oh Shin, H., Toennies, K.D.: Region-based interactive 3d image analysis of structures in medical data by hybrid rendering, vol. 4681, pp. 388–395. SPIE (2002)
8. Kaur, G., Tan, J., Alam, M., Chaudhary, V., Chen, D., Dong, M., Eltahawy, H., Fo-touhi, F., Gammage, C., Gong, J., Grosky, W., Guthikonda, M., Hu, J., Jeyaraj, D., Jin, X., King, A., Landman, J., Lee, J., Li, Q.H., Lufei, H., Morse, M., Patel, J., Sethi, I., Shi, W., Yang, K., Zhang, Z.: Casmil: A comprehensive software/toolkit for image-guided neurosurgeries. International Journal of Medical Robotics and Computer Assisted Surgery 2(2), 118–130 (2006)
9. Whitaker, R., Breen, D., Museth, K., Soni, N.: Segmentation of biological volume datasets using a level set framework. Volume Graphics, 249–263 (2001)