The Primary Interpretation Workstation: Information Beyond Image Data

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With the advent of picture archival and communication systems (PACS), the importance of design surrounding primary review workstations has become apparent. To help acceptance of filmless medical imaging, workstations must be developed that serve the needs of both radiologists and referring clinicians. This report will discuss integral requirements of workstation design, including information creation, medical management, medical knowledge, and enabling technologies.

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PICTURE ARCHIVING and communication systems (PACS) have made possible the viewing of radiographic images on computer workstations both where interpretation occurs and where clinical care is delivered. With the advent of this technology, much development has been focused towards improving both aspects of these deployments from an image-centric perspective. This report will serve to discuss the experiences of the Massachusetts General Hospital-Advanced Imaging Laboratory's (MGH-AIL) design and development of primary interpretation and clinical review workstations that include not only image data, but also the integration of a variety of other essential patient information and medical knowledge.

PRIMARY RADIOLOGIC INTERPRETATION

The ideal primary radiologic interpretation workstation serves to provide the radiologist with not only the sets of images for clinical interpretation, but a host of tools and other information necessary to make this process more efficient and accurate. While our currently deployed workstations are primarily DICOM-based image display stations running C++ display applications in UNIX OS, future workstations will run Active X components on NT OS layers. Because of this trend, the features added to the existing workstations by the MGH-AIL are occurred on Microsoft OS platforms using Active X modules. To interface to existing UNIX

workstations, these modules incorporate TCP/IP level communication and allow the current display stations to become an integrated interpretation tool rather than merely an image display device. We foresee the future primary interpretation workstation as enabling the radiologist to readily obtain all required medical and technical information efficiently and rapidly. This translates into each workstation incorporating the following: medical data,¹ medical knowledge, information creation, medical management, and a robust help system.²

Medical Data

Medical data encompasses both images and text. The workstation should allow the radiologist to access and manipulate both of these data forms. Access of images should be accomplished via the workstation seamlessly to local DICOM archives and enterprise-wide DICOM archives, as well as local storage; this is accomplished using DICOM queries and standard query language (SQL) when available. Once images are obtained, the radiologist should be able to manipulate images, including defining hanging protocols, for example, whether priors films are presented before current studies, after current studies, or concurrently. They should be able to manipulate images with various imaging tools, including magnification, inversion, rotation, and window/level. Last, they should have access to image-processing tools, including reconstruction, maximum-intensity projects, and rendering.³ (Most of these tools are available on modern display stations and, with few exceptions, are not the subject of the presentation.)

Accompanying all images are large amounts of textual data. The workstation must access pertinent data through integrating radiology information systems (RIS) and hospital information systems (HIS), as well as other Health Language 7 (HL-7) devices. Workstations must be able to access for the radiologist, other pertinent enterprise-wide data that could assist in interpretation and diagnosis. The system should allow manipulation of textual information with free text, searching through various systems, as well as intelligent presentation, for example, letting the physician obtain information on each

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patient who has presented with the diagnosis of tuberculosis in the previous month.

Medical Knowledge

The primary interpretation workstation must allow access to various segments of medical knowledge. Primary to the radiologist is information including anatomy, pathology, and physiology, as well as differential diagnosis, image data, and example cases. In addition, to remain current, access to keyed Internet searches would allow for acquiring knowledge pertinent to interpretation and diagnosis that would not be available in dated texts (Fig 1).

Information Creation

Paramount to the radiologist's role in patient care and management is the creation of reports representing analysis of image data. The report represents the translation of image data to text for the referring physician and encapsulates much of the radiologist's interpretation. Due to its paramount role, the process must be made more efficient through integration and automation. Integrating voice recognition (VR) allows prompt turnaround of reports, as well as improved accuracy of data. In addition, VR allows structured reporting using templates and macros to automate much of the routine features of report generation. In the future, as the structure of the report changes and various novel methods of

distribution become commonplace, the workstation should allow the radiologist to select key images, as well as function to distribute the multimedia report to referring clinicians through various notification schemes, including alphanumeric pagers and email.

Medical Management

Integral to every radiology practice are the tasks of routine medical management. To make the process more efficient, the workstation will endeavor to apply tools to obtain procedure and indication coding directly into the image interpretation process. The workstation should also harvest data to present outcomes analysis, as well as physician feedback to empower the radiologist to modify operating practices to serve the patient in a more effective manner.

Help System

Last, with many new technologies and features being incorporated into the primary interpretation workstation, a robust help system must be accessible to manage operational questions inherent to the technology. A powerful help system can reduce costs in technical support and also accelerate the interpretation process. The help system currently under developing at the MGH-AIL uses a combination of natural language understanding (NLU) and VR technology to assist the radiologist in soliciting information to solve common problems. Using the

Fig 1. Medical knowledge database accessible at workstation by radiologist.

VR transcription microphone, the user poses the help system with a verbal question. Subsequently, they are presented with a list-based selection of topics providing possible solutions. Common functions are stored in tab format for easy recall and review (Fig 2). The NLU engine of the help system will be automatically improved as the system is deployed within the department and requesting content is collected.

PRIMARY CLINICAL INTERPRETATION

Conventionally, once images have been reviewed and interpreted, the report has been the primary mode of communication between the referring physician and the radiologist. With the installation of electronic image distribution, this paradigm will be radically altered; referring physicians will be able to review images in conjunction with reports in clinical delivery locations, as well as obtain consultation in real time with the radiologist. These workstations are being developed with task-specific medical data in mind—units will be tailored to clinical location and image type focusing on workstations for intensive care units, operating rooms, emergency rooms, and outpatient clinics (Fig 3).

Technologically, this translates to PACS developers experiencing a fundamental shift from current

UNIX platforms to less expensive and more ubiquitous personal computers (PCs).⁴ In addition, clinical review of images will necessitate the use of Internet-based distribution technologies. This will require the use of thin clients and thin networks for distribution that maintain the use of standard Internet protocols. Other MGH-AIL research efforts have shown the utilization of Wavelet and JPEG compression algorithms to decrease delivery times of image data over the Internet. This poses many challenges, including browser compatibility with various operating systems and platforms, and use of various languages and wrappers, including Java, ActiveX, beans, plug ins, and image tools for clear display of images. Common to all of these challenges is the need to centralize version control. With recurrent updates to improve distribution and display of images to thousands of users, modification must be based on a centralized model with additions and updates being made to a server-residing software object, which will have an impact on all client workstations.

Clinical interpretation workstations will also require adherence to state and institutional patient confidentiality requirements. Acceptance of the use of advanced Internet security protocols such as HTTPS, virtual private networks (VPNs), and other encryption schemes will be essential to keep elec-

Fig 2. NLU voice-driven robust workstation help system sample screen.

Fig 3. Sample screen from specific task workstation.

tronically distributed, medical imaging data confidential.

CONCLUSION

In conclusion, with the advent of PACS, interpretation and review workstations are becoming commonplace. To bolster acceptance of filmless medical imaging into the enterprise, workstations must be developed that serve the needs of both radiologists and referring clinicians. The primary radio-

logic interpretation workstation must include all of the radiologist's informational needs, including textual, reference and help systems beyond just image data. Primary clinical interpretation stations must allow the referring physician to gain access to pertinent clinical information in an up-to-date and convenient manner. This begs the design of specific intent workstations, which are centralized Internet-based systems employing thin clients and networks.

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