Evaluation of Commercial PC-Based DICOM Image Viewer

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TEXAS CHILDREN'S HOSPITAL is a tertiary care pediatric facility in the Texas Medical Center with a large-scale, DICOM-compliant Picture Archiving Communication Systems (PACS). The PACS includes Computed Radiography (CR), Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Ultrasound (US), Digital fluoroscopy (DF), Nuclear Medicine (NM), and 3 film digitizer acquisition modalities. The computer room stores 104 Gbytes of Redundant Array of Inexpensive Disk (RAID) storage, 2 Terabytes of Optical Disk Jukebox (ODJ) long term archive, and Radiology Information System (RIS) interface. An Oracle image database and three archive servers control image routing and retrieving from numerous review stations. In order to reduce cost of proliferation of workstations throughout the hospital and affiliated clinics, and to identify a vehicle for teleradiology to radiologists' homes, the hospital and affiliated clinics, and to identify a vehicle for teleradiology to radiologists' homes, the hospital initiated a search for a PC-based DICOM image viewer.

METHODS

A small group consisting of radiologists, administrative, and technical personnel identified a collection of functions needed for the PC based DICOM viewer software, both in its role as a clinical review station and a platform for home teleradiology. Several vendors were invited to demonstrate their DICOM viewer Software at Texas Children's Hospital. The checklist of selection criteria was sent to each vendor prior to their performance date. The list also included the names of other vendors being evaluated. The evaluation was based on each viewer product's ability to perform the primary functions listed in Table 1, as well as auxiliary functions listed in Table 2.

Viewers evaluated included Meta Solutions, Inc. RadWorks, CompuRad, Access, AGFA RP5, and AGFA CS 500. All venders received an I.P. address, AE title, and the DICOM port number to access our network and Archive. At the time of the evaluation, the PACS operated on the hospital broadband 10 Mbps Ethernet, but revisions were underway to upgrade to a 100 Mbps Fast Ethernet service.

RESULTS

Meta Solutions, Inc. RadWorks Version 2.0

Recommended specifications for the PC hardware is Pentium Pro (200 MHZ) with 64 MB memory and 2.5 GB SCSE Ultra wide hard drive and an ultra wide SCSI controller, and Windows NT 4.0 Workstation, Microsoft Office 97, Netscape Gold, McAffee Anti-virus.

The software successfully performed DICOM Query and Retrieve from our archive. The viewer displayed all exam images individually, in miniature "thumbnail" size on the left side of the monitor in a vertical column. The product allowed users to predefine window and level setting preferences according to modality. Measurements were reported in pixel units: centimeters or millimeters were not available. Little speed loss was noted while viewing images and retrieving multiple exams from our archive. Multiple magnification ratios were demonstrated, but a much-needed roaming magnifying box was not available. Cine functions were demonstrated simultaneously using images from four different patients. The cine ran from beginning of exam to end, and each exam advanced synchronously. Users have six choices of edge enhancements to apply to images of all modalities. The software supports wavelet compression. This was not available for the demonstration on images from our archive, but the vendor showed images that had been pre-loaded on the hard-drive. Recommended printing is to a DICOM laser camera, or to paper: no other device will work. An interface to our Radiology Information System (RIS) to view the radiologist report was not available. Ultrasound color Doppler and color Doppler energy images were transmitted to the PC by an Ultrasound vendor who was testing their product on our network. These transmitted color images were display very well on any size format. A toll-free telephone help line is available for users, but the hours of service were not specified.

CompuRad Version 2.0

The vendor recommended hardware and software are as follows: Pentium 133 to 200 with 32 MB RAM and a 1 G.B. hard drive, 1.44 MB floppy drive, color monitor with 1 MB to 4 MB VRAM for

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Table 1. PC Viewer Primary Functions

	Framework	RadWorks	CompuRad	RP5	CS500
DICOM Query and retrieve from our Archive	yes	yes	yes	yes	yes
Automatically calibrate distance measurements	no	no	no	no	no
Displayed the radiologist report to include exam status	no	no	no	no	yes
Displayed number of images in the study on the main menu	yes	yes	yes	yes/extra function	yes/extra function
Define functionality independently, according to user	no	yes	yes	no	no
Receive images while reviewing others, without speed penalty	yes	no	no	no	yes
Display 12 bit and 16 bit images	yes	yes	yes	yes	yes
Multiple image window/level settings	yes	yes	yes	yes/in stack mode only	yes
Able to Zoom and roam images	yes	yes	yes	yes	yes
Magnify image to multiple size of different ratios, and have Magnification glass	yes	yes/no mag glass	yes/mag glass	no	no
Annotate on the image, transmit, and save annotations to archive	no	yes	no	no	no
Select and display individual series of MR exams	yes	yes	yes/even divides each image	no	no

SVGA display, Microsoft Windows 95 or Windows NT 4.0.

CompuRad sent a hard-drive, and accompanying software for their demonstration. CompuRad was able to DICOM Query and Retrieve exams from our Archive, but initially only the DICOM header information displayed, with an error message indicating a problem of no pixel information. CompuRad took three weeks to correct this problem, with several phone calls to assess the situation. Eventually, they flew in their expert to solve the problem. The demonstration of CompuRad was held in the main reading room. Direct comparison of images from AGFA RP5 DICOM Viewer software (already in use), and the AGFA RS 3000 dual monitor review station (version 3.0 software) was evaluated.

CompuRad software had a sign-on menu prompt that begins the application, allowing individual users to have their own sign-on. Query and retrieve from our archive was performed successfully, but the prior error message and problem (no pixel information) recurred again toward the end of the second day. A specific patient search is conducted by Medical Record Number (MRN) and/or patient name. Only one patient's exam can be retrieved to local cache, so compiling a list of multiple patients' exams takes a long time. Window and level settings can be developed for bone, soft tissue, liver, and lung to suit user preferences. Icons not often used

Table 2. Axcilliary Features Evaluated

	Framewave	RadWorks	CompuRad	RP 5	CS 500
Measurements in Centimeters and/or Millimeters, and Angles	no	yes/units only	no	no	yes/calibrates only on the left of screen
Available Web browser product	yes	no	yes	no	no
Able to support J PEG or Wavelet Compression	yes	no	JPEG	JPEG	JPEG
Simultaneous Cine display of multiple images to include cross-section studies	no	yes	yes	no	no
Availability of Software for in-house testing after primary demonstration	yes	no	yes	yes	yes
Image Manipulation via mouse	yes	yes	yes	yes	yes
Able to display color images	no	yes	no	yes/only on 1/1 format only	yes
Will supply a list of sites installed and their names	no list given	no list given	yes/list given with names	yes	n/a
Automatic management of local disk resources	yes	no	yes	no	yes
Available toll free 24 hour Help line	yes	yes	yes	yes	yes
DICOM Print to PACS network laser printers	no	no	no	no	pending testing

can be hidden from the tool bar display, along with the option of temporarily eliminating the complete tool bar. Further manipulation of the tool bar allows for moving it to any part of the screen. The zoom function has five steps of magnification, with three size choices for a square magnifying glass that roams on the image. No interface with our RIS is available to view the radiologist's report. The cine function was demonstrated to cycle through four different patients files, from beginning to end, all on the same screen. A toll-free help line offers assistance 24 hours a day, with a call back of 20 minute callback response after business hours.

Access Framewave

Access provided their own PC for the demonstration. The recommended PC hardware specifications are 128 MB of RAM, Windows N.T. 4.0 with a 2-4 gigabyte hard drive, Matrix Millennium VGA MB 220 MHZ Video Card. The vendor recommends no less than 64 MB of RAM to be able to run the software adequately.

Access was able to perform DICOM Query and Retrieve from our archive exams for their demonstration. A specific patient search is conducted by patient name only, and a second query must be made for their specific exam. The time an exam was acquired is not displayed on the patient listing, making same day repeats or follow-up images difficult to sequence. The software divides MRI exams into individual series, but in order to compare two of four series side-by-side, you must delete two of them from the local display, leaving only the pair of interest. To view complementary two series together, you must retrieve them again. The time to retrieve images from the archive was comparable to the other venders, that is, about one to two minutes for a CR image on our existing 10 MB Ethernet. Window and level adjustments perform easily. Their zoom/magnifier has multiple sizes, to suit user preferences. Side-by-side comparisons of prior studies can not be done. Pre-loaded wavelet compression images were demonstrated, but the vendor had to be continually manipulate the initially upside-down images to restore them to the correct orientation. Apparently, there is no method of saving image orientation, since every new observer had to wait until the pre-loaded images were flipped again. Measurements and annotation functions were characterized by Access as being "too expensive for software PC product." Other limitations of the software include no printing to laser film or paper printers, no color image display, no RIS interface for displaying a radiologist report, no user-defined window/level functions, and no cine functions.

AGFA Referring Physician Software (RP5) Version 2.16

The vendor recommended hardware and software for the PC: Pentium 120 IBM or compatible PC with 32 MB of RAM, 1 GB of hard disk, and Windows NT 4.0, Microsoft MS-DOS 6.22, Microsoft Windows 95.

This version of software has been purchased and is in use in our Main Reading room. It is currently used by our radiologist and referring physicians to query patient exams or create a TIFF file to send to other PCs. The software was installed by our PACS operator, and it is the first PC DICOM viewer that can interface with our RIS system. Diagnostic reports can be viewed by highlighting the patient listing, and selecting the report icon. The exam does not have to reside on the local cache to access a RIS report. Query and retrieve from our archive performs successfully, but care must be continually taken to delete the local cache before the free space is less than 100 MB drive D. Free space is indicated on the lower right of the display. A specific patient search menu has three choices; patient name, accession number, and/or MRN. The patient exam list shows Accession number, patient name, MRN, type of procedure, but determining the number of images per exam, the user must highlight the exam, and click on the eyeglass (#) icon. Window and level for all exams only works on a 1/1 format and then click on the icon with a grey scale image, located on the tool bar. This works adequately on single image exams, but is time consuming with multiple image exams, especially MR exams that require window and level differences applied to each series. Up to nine window and level presets can be defined to allow for adjusting multiple image exams, but the user must invest some time determining their preferred parameters. Regardless of the modality, displayed images default to the first defined preset in the list, which might be appropriate for one modality, but usually not for the other. No magnifying glass feature exists: a one step zoom-and-roam is the only way of magnifying an image. Other features not available include: Cine, side-by-side image comparisons, measurements,

autopilot to manage the local cache, and a method for segregating MR series.

AGFA CS 500

AGFA CS500 requires Pentium 133 IBM or compatible PC with 32 MB of RAM, but 64 MB is recommended. The system requires an SVGA Monitor supporting 1024 × 768 with 256 colors, minimum number of disk space is 15 MB, Microsoft Windows 95 or Microsoft Windows NT with NTFS file system.

The pre-released Alpha version 1.0.4 of CS 500 looks a lot like AGFA's RP5 version 2.16. New functions seen are a split screen icon that allows for side-by side image comparison of a patient's prior image and the current image. More mouse functions are provided to ease manipulating images. The system still retrieves exams in a timely manner. The RIS report can still be retrieved even if the exam is not on the local cache. Functions run rapidly, even while multi-tasking and retrieving images. The pre-released product logs out of the program inadvertently while multi-tasking. The first exam on the patient list is ignored when the user highlights the patient file and moves it to the upper right menu to query for that patients exams. Measurements are supported, but when selecting the measurement icon, the calibrating green bar only comes up in the left-hand upper corner making it difficult to calibrate to an image on the right. The software includes an automatic cache clean-up that can be set by hours or days.

DISCUSSION

Testing the products at our Hospital allowed a larger number of observers to test the software. Retrieving images from our archive allowed radiologist to select images of patients with clinical findings that were already familiar. For example, when an MR of the sinus was viewed with the one-on-one display format, the image had a ridge artifact on the frontal bone. This distortion was pronounced on RP5 and CompuRad. Access and Meta Solutions had variable edge enhancement features that smoothed the artifact. While we anticipated a comparison in image quality when viewed on a PC, the evaluation process allowed radiologist and clinicians to "test drive" the products and determine first-hand the problems they would experience using the viewers in their intended roles as workstations for referring physicians and for home-based teleradiology.

The comparisons also provided valuable feedback to the vendors about the value of software features and problems associated with using them in a clinical environment.

All venders were able to query and retrieve from our Archive, although, some with less trouble than others. AGFA RP5 and CS 500 were the only products that could retrieve radiology reports, however the status of the report was only shown if the exam was in a "canceled" status.

Some vendors designed their viewers to provide full functionality only when augmented by a separate network server or gateway. This architecture compromises the notion of full DICOM compliance in a single PC platform.

CONCLUSION

While each software product incorporated some excellent features, none included the full repertoire of needed functions. Depending on the specific clinical practice setting, absence of a function could constitute an inconvenience or preclude use of the software. For a referring physician inside the hospital, another software application affords access to the radiologist report, but remote access may not be available. When the primary practice involves plain radiography, the lack of sophisticated tools for managing complex cross-sectional images is a minor inconvenience, but for a neuroradiologist it is a major inconvenience. Comparisons with prior exams and measurement tools are often used to assess changes in patient status, but these tools are primitive stage of development. Although we concluded that our staff could use these products to evaluate patient exams, we will continue to search for a product that provides full support for clinical operations.

There is apparently no technological limitation precluding inclusion of these tools of PC viewer software, rather it seems to be the result of incomplete requirement definition, inadequate software development, or deliberate decisions to limit product development. Development activity seems to have shifted from PC-based viewers to Web-based products.

Demonstration Dates

Andriko S: ACCESS Demonstration held at Texas Children's Hospital on August 6, 1997.

ACCESS Radiology Corporation; Click C and Simpson D: AGFA RP5 in use at Texas Children's Hospital at present. AGFA Medical Bayer Corporation; Click C: AGFA CS500 pre-released testing at present. AGFA Medical Bayer Corporation; Evers S: CompuRad Demonstration held at Texas Children's Hospital on June 11-12th, 1997. CompuRad, Inc; and Scism KC: Meta Solutions Demonstration held at Texas Children's Hospital on June 2, 1997. Meta Solutions, Inc.

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