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Evaluation of Self-Contained PACS Viewers on CD-ROM

Richard Edward Hosch · Andrew L Rivard

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Abstract Providing patients and clinicians with self-contained PACS viewer on CD format is a common and necessary tool to share vital imaging data. However, to be useful, this tool should be reliable, robust, and convenient. Numerous PACS viewer options are available, often without empirical data to guide in choosing one for routine use. To assist in making a standardized choice for our institution, we chose four common viewers, benchmarked on four different workstations reflecting the variety of environments used by non-radiologist clinicians who would receive a CD. Four CD-based DICOM viewers from eFilm, Philips, Pacsgear Gearview, and iSite were examed on two radiology PACS workstations, a standard desktop computer, and a laptop using a test case consisting of a multi-series CTA with 13 series and 3,035 total images. Multiple objective measures, subjective measures, and presence of key features were evaluated including program time to load, image time to load, cine/movie mode, ability to adequately window and level, pan and zoom functionality, basic measurement tools, and perceived lag when scrolling through a multi-image series. Substantial differences in speed of operation and behavior on multiple systems were documented, which could potentially add several minutes to the time required to open and view a patient's imaging data. The eFilm and iSite viewers operated consistently and reliably across all tested computer environments. The iSite viewer, having among the quickest load times in the group tested and consistently low subjective scroll lag during series viewing, and also beneficially allowing partial viewing while images load in the background, was found to generate the best overall user experience. Because of these significant differences, we have recommended that our institution standardize all patient imaging CD creation using the iSite viewer.

Keywords PACS · Clinical workflow · Clinical image viewing · Computers in medicine · Computer graphics · Data display · PACS system performance

Introduction

Health care policy continues to accelerate implementation of electronic health records and patient data, medical imaging has long since transitioned into the digital age, and industry and national radiology organizations continue to work toward universally exchangeable and viewable imaging data. Radiology departments routinely import remotely generated imaging studies into their institutional PACS for consistent viewing. However, it is still often necessary to provide such information to patients who are increasingly involved in their health care management, and to referring and other clinicians in a portable format. Although DVD ROM provides significantly higher capacity, this typically is in the format of a self-contained PACS viewer on the more widely compatible CD-ROM. Our institution faces a common problem in that many potential PACS viewers are available without empirical data to guide in choosing one for routine use. As a vital tool in modern health care, a viewer should be reliable, robust, and convenient. To assist in making a standardized choice, we choose four common viewers, benchmarked on four different workstations reflecting a variety of environments used by non-radiologist clinicians who would receive a CD.

R. E. Hosch (✉) · A. L. Rivard
University of Mississippi Medical Center, 2500 North State Street, Jackson, MS 39216, USA
e-mail: rehosch@umc.edu

A. L. Rivard
e-mail: arivard@umc.edu

Materials and Methods

The four CD-based DICOM viewers chosen for comparison are "eFilm" (eFilm Lite 3.1), "Philips" (Philips DICOM Viewer R2.5 L1-SP3), "Pacsgear" (Pacsgear GEARView Basic 1.0.3), and "iSite" (Philips iSite CD Direct 3.5), each available to our institution. Many scenarios were considered for use as a test case, and a computed tomographic angiography (CTA) study is chosen for its large file size and complexity as representing the most demanding use of self-contained viewers. This study is a multi-series CTA consisting of 13 separate series and a total of 3,035 images. The largest single series consists of 2,003 images. A CD-ROM was created for each PACS viewer using a Pacsgear CD/DVD creation utility.

Four computers are chosen to represent the spectrum of computer environments which self-contained PACS viewers might face in typical use. Computer 1 consists of a radiology PACS workstation having dual Intel Xeon (Pentium 4 architecture) 3.6 GHz processors, discrete nVidia Quadro FX1400 graphics card, 3 GB of main system RAM, and running Windows XP Service Pack 3 operating system. Computer 2 is a somewhat newer PACS workstation having an Intel E8400 (core2duo architecture) 2.0 GHz processor, discrete nVidia Quadro FX1700 graphics card, 3.2 GB of main system RAM, and also running Windows XP Service Pack 3 operating system. A typical midrange desktop (computer 3) is selected as the third representative, having an Advanced Micro Devices (AMD) A8-3820 2.5 GHz accelerated processing unit (a combined general system processor based on K10 architecture and graphics processor based on ATI HD6550 series), 8 GB shared system and graphics RAM, and running Windows 7 64 bit operating system. The final system chosen for comparison (computer 4) is a laptop having an Intel P7450 (core2duo) 2.13 GHz processor, integrated AMD HD4850 graphics, 6GB shared system and graphics RAM, and running Windows 7 64 bit operating system.

Multiple parameters are chosen for comparison to represent the typical use and necessary features of self-contained PACS viewers in real world clinician and patient usage scenarios. These include several timed objective measures, including time to load the program both using each disc's autorun feature and by launching the viewer directly from the executable contained on each disc, time to load all images, and time to load the largest series. Three data points are obtained for each of these metrics and the averages presented below. The presence of selected features targeted for non-diagnostic ease of image viewing is also tabulated; these include a cine/movie mode, ability to adequately window and level the image, pan and zoom functionality, ability to make simple measurements of distance and opacity/density, and presence of an autorun feature. Any problems with system crashes or hangs on launching, during use of, or when closing the program are noted. An additional qualitative or subjective assessment of perceived lag when scrolling through the multiple image series is included to represent the responsiveness to typical user input in worst case (high image count) scenarios. This measure is evaluated by a single reviewer using a five-point subjective scale from minimal to severe perceived lag.

Results

Figure 1 shows the time to load each viewer using the autorun feature contained on each disc, which ranges from 32 s with Pacsgear on computer 2 to nearly 4 min using eFilm on computer 1, the oldest workstation (mean of 88 s±55 s). During this comparison, it is noted that the autorun feature did not operate on computer 4, the laptop, for any viewer, and for this reason, the time to load by launching the viewer executable directly for each disc is included in the study with results presented in Fig. 2 on the same relative scale as Fig. 1. All viewers load substantially faster (mean of 15 s±14 s) when launched directly from the executable.

The second primary quantified metric is image load time once the viewer has been successfully launched. A fundamental difference is noted in behavior between the eFilm viewer, which requires loading all image files before allowing viewing of any series, and the remaining viewers which all allow partial viewing while remaining images continue to load in the background. To standardize a measure of image load time among these background loading viewers, a cine loop of the largest series consisting of 2,003 images is started when the viewer is open and images begin loading. Time to fully load this series, which contains the majority of total images within the CTA study, is presented together for brevity with results from the eFilm viewer image load times in Fig. 3.

A qualitative assessment of image lag as the mouse is scrolled through a series of images is judged by a single reviewer using a five-point scale (1–5, ranging from minimal to severe) and presented in Fig. 4. This ranking represents the

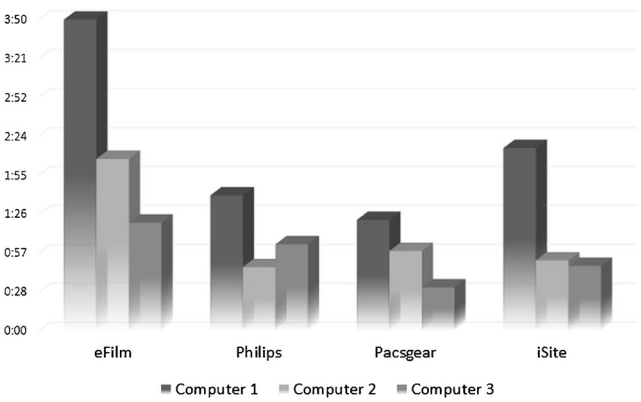

Fig. 1 Time to load viewer using autorun feature, plotted in mm:ss (lower is better). No data is obtained for computer 4 as a system setting disables the autorun feature

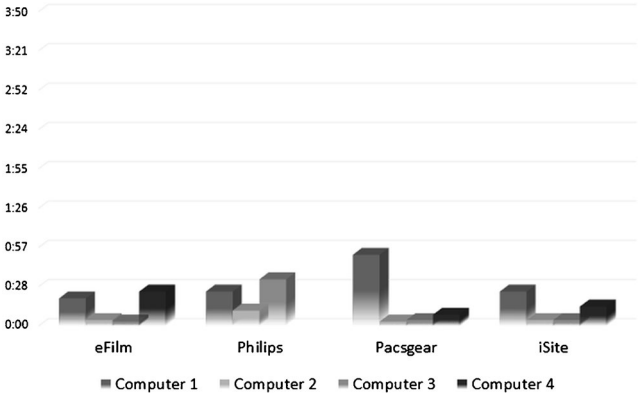

Fig. 2 Time to load viewer directly from executable, plotted in mm:ss (lower is better). After the autorun feature has been disabled, each viewer is launched by navigating directly to the executable file found on each disc. No data is obtained for the Philips viewer on computer 4, as it consistently becomes unresponsive during viewer loading

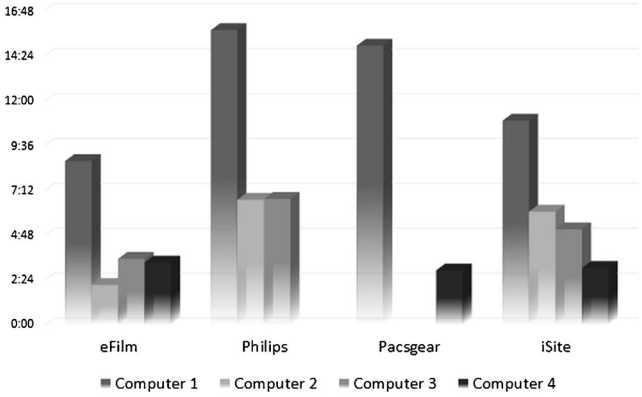

Fig. 3 Time to load images, plotted in mm:ss (lower is better). For the eFilm viewer, this time represents loading of all images for all series. For remaining viewers, which allow partial viewing while images continue to load in the background, these times represent loading of the largest series (2,003 images) during a cine loop. No data is obtained for the Philips viewer on computer 4 as it becomes unresponsive or for the Pacsgear viewer on computers 2 and 3 as the viewer issues unhandled exceptions when playing a cine loop during image loading

composite assessment after evaluating this qualitative measure in all series, both during image loading (for viewers which have this feature) and after all images are completely loaded. Standard behavior and problematic behaviors for each viewer are also noted. All viewers include the abilities to appropriately window and level images during display, pan and zoom, and make simple measurements. None of the viewers are found to cause complete system crashes, either during use or on disc eject. The Philips viewer, however, repeatedly ceases to respond upon attempted launch after approximately 10 min on computer 4, the laptop, with no data obtained for viewer or image load times (Figs. 3 and 4). The Pacsgear viewer repeatedly issues an unhandled exception when using a cine loop during image loading in the larger series on both computers 2 and 3; however, computer 2 does finally load all images and allows viewing of all series if delaying cine loop until after images have completed loading. This behavior prevents assessment of the image load time on these two computers.

Discussion

Substantial differences in speed of operation and behavior on multiple systems were discovered among the embedded DICOM viewers tested, potentially adding several minutes to the time required to open and view a patient's imaging data. For referring and other non-radiologist clinicians who continue to look for increased efficiency to offset declining reimbursements, these are meaningful differences. A literature search reveals an absence of empirical data to guide in choosing an embedded PACS viewer to provide to patients and clinicians, and we believe our findings will help to promote a higher level of perceived quality for our department within our institution.

A key and unexpected difference, when comparing Figs. 1 and 2, the times to load/launch each viewer are significantly higher using the autorun feature included during disc creation than when launching the viewer directly from the executable file found on each disc. This marked difference in times was discovered incidentally when the autorun feature did not execute properly on computer 4. This is believed to be due to a system setting which disabled autorun universally. The additional time during autorun launch may be secondary to the disc creations using a Pacsgear CD/DVD disc creation utility, as a Pacsgear splashscreen first appears when the autorun starts but is bypassed when launching from executable. No other disc burning utility was available in our department at the time of disc creation to allow further exploration of this possibility for our comparison. Because of this significant time difference, our institution began an investigation into other methods of disc creation which might provide automated launching of the viewer in a more expedited manner.

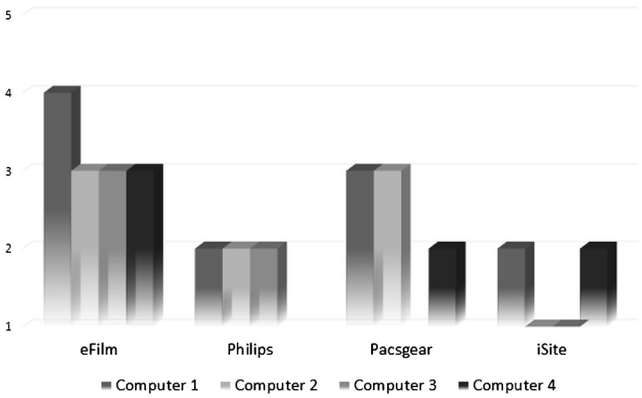

Fig. 4 Qualitative assessment of lag when scrolling through images in a series (lower is better). Subjective ranking on scale of 1–5 (minimal, minimal/moderate, moderate, moderate/severe, severe) representing the composite of scores for each series in the study. No data is obtained for the Philips viewer on computer 4 as it becomes unresponsive

The operational difference between the eFilm viewer and others during image loading, with eFilm requiring all images to be loaded before viewing was possible, and others allowing partial viewing while images continue to load in the background, has a significant impact on user experience. Thus, the comparison depicted in Fig. 3 is not indicative of the user perception of how much time must pass before the viewer becomes usable. While eFilm does load the full image set comparably fast, not allowing the user to begin partial viewing as the other options do is a net disadvantage for the eFilm viewer.

The Pacsgear and Philips viewers both exhibited undesirable behaviors in certain circumstances. As the Philips viewer became consistently non-responsive on computer 4, no quantitative or qualitative data was obtained on this system. The inability of Pacsgear Gearview to allow cine loop operation during image loading conflicted with the method chosen for standardized image load timing in this comparison and may also interfere with user operation in some circumstances. The Pacsgear viewer also consistently crashed on attempted imaging loading on computer 3, prohibiting data gathering for remaining metrics on that system.

As expected, load time and viewer performance do scale with general and graphics specific computer processing power. However, there are multiple independent variables such as CD/DVD drive read speed, CPU speed and architecture, system RAM size and bandwidth, and graphics subsystem processing power, and memory size and bandwidth which were not evaluated independently during this comparison. Additionally, there are large variances in subjectively evaluated scroll lag which are only moderately affected by computer environment. This may be inherent to the programming of each viewer.

Conclusions

The eFilm and iSite viewers operated consistently and reliably across all tested computer environments. The iSite viewer, having among the quickest load times in the group tested and consistently low subjective scroll lag during series viewing, and also beneficially allowing partial viewing while images load in the background, was found to generate the best overall user experience. Because of these significant differences, we have recommended that our institution standardize all patient imaging CD creation using the iSite viewer. In addition, our institution began an investigation into other methods of disc creation which might provide automated launching of the viewer in a more expedited manner. Finally, until there is widespread adoption of web-based image transfer and viewing, CD creation with embedded viewers will remain a vital means of sharing patient imaging studies.