A Filmless Radiology Teaching Conference System for Pertinent Displaying and Image Searching

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To solve the problems of image displays in filmless radiology conferences for the purpose of teaching, we made an experimental design of a conference system with dual 50-in. plasma monitors for displaying larger images and a shared folder containing shortcuts to images for quick display during conferences on the desktop of each client computer in a picture archival and communication system. The image quality of the monitors was evaluated using the TG18-QC test pattern. The display time of images was measured in 20 cases when the shared folder was used and when it was not. Monitor screen size and image quality, operability, display time of images, and overall impression given by the system were evaluated subjectively by five radiologists. Although the image quality of the monitor was not as high as that of the high-resolution monitors used for diagnostic radiology, its performance was good enough for teaching. The average display time using the shared folder (2.6 ± 0.39 s) was significantly shorter than without it (16.9 ± 5.04 s; $p = 2.85 \times 10^{-6}$). Despite the need for certain improvements in monitor size and in the operability of the system, the radiologists considered the system suitable for radiology teaching conferences. We believe that this system is useful for institutions that intend to introduce a filmless system for filmless radiology teaching conferences.

KEY WORDS: Digital radiography, PACS, conferences, monitors, computer applications

BACKGROUND

With the recent development and spread of the picture archival and communication system (PACS), the use of conventional film for image interpretation is being superseded by a filmless environment with a computer monitor.¹⁻⁴ Filmless PACS offers many advantages. Digital images from many departments including radiology

are linked and are accessed seamlessly from multiple end-user peripherals. As a result, workflow, patient throughput, and patient safety are improved, and cost is decreased.⁵⁻⁸ The ability to create, search, access, and archive digital imaging teaching files has also dramatically improved.⁹⁻¹²

However, there are also limitations. Installation of PACS requires a high initial investment. High-resolution computer monitors are needed for image interpretation.^{13,14} Presenting clear, easily legible images during radiology conferences is still a problem because the more commonly used computer monitors are too small for image presentation in such gatherings, where groups of people must be able to view them at the same time. Searching a PACS list for a relevant image during conferences also takes time. A literature search found few reports offering solutions to these problems.^{15,16}

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Accordingly, we made an experimental design of a filmless radiology conference system with large-screen monitors for image presentation and a shared folder created in the PACS and holding shortcuts to images to save time for searching for images during teaching conferences. This system was also evaluated.

METHODS AND MATERIALS

Monitors and PACS

Two 50-in. plasma monitors (PX-50XM4J; NEC, Tokyo, Japan) with a resolution of $768 \times 1,365$ pixels, equipped with a double-picture display function and able to be rotated into vertical or horizontal positions so as to allow displays of two images on each, in vertical or side-by-side orientation, were installed as monitors of PACS (SYNAPSE 3.0 MR-001; Fujifilm, Tokyo, Japan) using a graphics board (NVIDIA Quadro NVS 280 PCI; NVIDIA, California, USA). The monitors and the graphics board are marketed to the public.

The image-fetching time of a case from PACS, e.g., that of a computed radiography image ($1,760 \times 2,140$ pixels) or the initial few dozen images of computed tomography (512×512 pixels) or magnetic resonance imaging (512×384 pixels), is a few seconds. Figures 1 and 2 show an overview of the radiology conference room and an example of the two 50-in.-wide plasma mon-

itors displaying conference materials. The main functions of the PACS for radiology conferences are as follows. The monitor can show a single image or be divided up to display all the images in a series or to show images according to predefined screen layouts at any time, even during displays, so that free and unrestricted usage is achieved. Each series of images for examination is automatically allocated to a screen position. Images or series of images can be moved manually from one division of the screen to another, regardless of size. The mouse can be used to scroll through the stack of images allocated to each division of the monitor screen. If the scanning area is the same, paging of the images in each series is carried out simultaneously. Automated comparison of old and new examinations by the same modality is possible. The basic visualization tools, e.g., window width and level adjustment, image measurement, amplification, and cine, are available.

The TG18-QC test pattern was used for image viewing to indicate the capability of the monitor.¹⁷ Figure 3 shows the TG18-QC test pattern used in this study. Patches with 16 steps of luminance from black (lower left corner) to white (lower right corner), the two patches at 0 and 100% contain the patches for 5 and 95% (just inside the black and white patches), and the contrast-detail letters that spell out "QUALITY CONTROL," with background contrasts at 0, 50, and 100% (just below the black and white patches) were used for the luminance response evaluation of the monitors.

Fig. 1. An overview of a filmless radiology teaching conference room with a capacity of 40 people. The room is adequately lit. The dual 50-in. plasma monitors are installed in the center. A large monitor on the left shows the patient's history typed using a keyboard. A large monitor on the right shows information from the hospital information system (HIS) and the radiology information system.

Fig. 2. An example of the dual 50-in. plasma monitors displaying in the radiology teaching conference. The each monitor is divided into two areas, where CT arterial portography (*upper half of the left monitor*), CT hepatic arteriography (*lower half of the left monitor*), and unenhanced CT after chemolipiodolization (*upper half of the right monitor*) for hepatocellular carcinomas are paged simultaneously. The patient's folder of images or patient's information from HIS (selected by clicking) appears in the *lower half of the right monitor*.

Results from the 50-in. plasma monitor were compared with those from the 2-megapixel (M) and 3-M monochrome monitors for diagnostic radiology. The 2- (G 20, Eizo Nanao, Ishikawa, Japan; resolution, $1,200 \times 1,600$ pixels; pixel pitch, 0.255×0.255 mm; size, 20.1 in.) and 3-M (FC 2090, Eizo Nanao; resolution, $1,536 \times 2,048$ pixels; pixel pitch, 0.207×0.207 mm; size, 20.8 in.) monitors were those for image diagnosis on the PACS. The images were looked at directly because of the image degradation occurring at other viewing angles.

Shared Folder

A shared folder was made as follows. Because management of the settings of a shared folder is one of the functions of the Windows operating system (Windows 2000 Professional; Microsoft, Redmond, WA) installed within each PACS computer, no special software is needed, and

managing the settings was very easy. First, a new folder was created on the relevant disk drive of the PACS, and the access privileges of users (such as radiologists) for this folder were input. Then, shortcuts to the folder were set up on the desktop of each client terminal computer of the PACS. The shared folder was created only once, at the time of the first setup, not before each conference. Users can store image shortcuts in the shared folders that were set up by a drag-and-drop functionality within the PACS user interface or access the shortcuts, rather than the actual images, for presentation at any time, using any terminal computers. Therefore, presenters can show suitable images quickly during conferences by storing image shortcuts in the shared folder before each conference. Such a shortcut can be performed at image series, examination, or patient level.

For 20 cases selected randomly from the database of our radiology conferences, the times taken to display the first image of a case by the

Fig. 3. The TG18-QC test pattern.

operators were measured when the shared folder was used and when the images were retrieved directly from a PACS patient list without using the shared folder. The image display time included the time for searching the PACS list or the shortcuts in the shared folder and the time for fetching images from the PACS. The time was measured three times at 1-week intervals to avoid learning bias for each case. Statistical significance was determined by applying the paired Student's *t* test. A difference was considered significant at the level of $p < 0.05$.

Evaluations of Monitor and System by Radiologists

The screen size and image quality of the monitor, operability, the display time of images, and the overall impression made by the system in radiology teaching conferences were evaluated subjectively and independently by five radiologists (three attending physicians and two trainees) using a five-point rating scale: 5, definitely suitable; 4, probably suitable; 3, uncertain; 2, probably unsuitable; and 1, definitely unsuitable. "Definitely suitable" was used when the radiologists deemed that either the monitors or the system was the best for radiology teaching conferences; "probably

suitable" was used when they were good but some minor improvements for each factor were needed; "uncertain" was used when it was unclear if they were suitable or not because many minor improvements were needed; "probably unsuitable" was used when they were not good because many major improvements were needed, and "definitely unsuitable" was used when they were deemed quite unfit. For the image display time, a rating scale was marked for when the shared folder was used and for when images were retrieved from a list of PACS without using the shared folder.

RESULTS

Evaluation of Monitors Using the TG18-QC Test Pattern

For luminance response evaluation, in all monitors (50-in. plasma monitors, 2- and 3-M monitors), the difference of brightness between each of 16 luminance patches and the adjacent patch was clearly discernible.

In the test pattern, the two patches at 0 and 100% contain the patches for 5 and 95%, respectively. In all monitors, these internal 5 and 95%

patches could be differentiated from the 0 and 100% background patches.

With use of the 50-in. plasma monitor, the contrast-detail letters, "QUALITY CONTROL," with background contrasts at 0, 50, and 100%, were confirmed to be readable up as far as the "Y" of "QUALITY" at all contrast levels. They were confirmed in the 2-M monitor to read "QUALITY CONTR" and in the 3-M monitor, "QUALITY CONTROL"—in both cases, at all contrast levels.

Display Time of Images

The average time taken to display the first image of a case by the operators was significantly shorter when they used the shared folder (2.6 ± 0.39 s) than when they searched the PACS list and fetched the image without using the shared folder (16.9 ± 5.04 s; $p = 2.85 \times 10^{-6}$).

Evaluation by Radiologists

The results of the evaluation of the monitors and the system by radiologists are shown in Table 1. All categories except for the display time of images when images were found by searching a PACS list and were fetched without using the shared folder were rated at 3 or more. The display time of images fetched without using the shared folder was in rating categories 1 through 3 (average was 2). All of the radiologists' overall assessments of this system were in category 4.

DISCUSSION

When conventional films were used in radiology conferences, problems commonly occurred with

the preparation of films—specifically, many radiographs in the patient's X-ray film jacket were frequently not arranged chronologically, and some could not be located because of misfiling or outright loss. This situation sometimes made it difficult to find suitable films for conferences, and much time was spent preparing films for conference presentations. PACS is a very effective solution for these problems. PACS makes the sorting of patient's images very easy and quick and eliminates loss and misplacement of films,¹⁸⁻²⁰ so that radiology conference presentations are greatly facilitated. However, to show images smoothly and efficiently for comfortable viewing at conferences, the patient's identification details, the date of examination, and the imaging modality must be recorded beforehand. However, even with proper preparation, some time may be spent searching the PACS list during a presentation, which will occasionally disturb the smooth progress of the task at hand. The shared folder that we presented is very useful in dealing with this problem. In this study, the operators found that when using this folder, the average time taken to display the first image of a case (by searching the shortcuts in the shared folder and fetching images from the PACS) was significantly shorter than when it was not used (by searching the PACS list and fetching images from the PACS) because the operators using the shared folder do not need to search the PACS list but only to access the shortcuts in the shared folder. The image display time of this case is similar to the image fetching time. On the other hand, the operators not using the shared folder take more time to search the PACS list using the patient's identification details, the date of examination, and the image modality. The image display time of this case is the sum of the image

Table 1. Evaluation of the Monitors and the System by Radiologists

Factors	Rating Scale					Average
	Radiologist 1	Radiologist 2	Radiologist 3	Radiologist 4	Radiologist 5	
Screen size	4	4	4	4	4	4
Image quality	5	3	4	4	4	4
Operability	4	4	4	4	5	4.2
Display time						
Shared folder (+)	4	5	5	5	5	4.8
Shared folder (-)	3	2	2	1	2	2
Overall impression	4	4	4	4	4	4

searching time and the time for fetching from the PACS. The fetching time of the second and subsequent images depends on the performance of the PACS (in the case of our PACS, it is an instantaneous process). The results of the evaluation of display time when the radiologists used the shared folder were superior to those obtained without it. To our knowledge, only one report describes a specially designed software for radiology conferences in PACS.¹⁶ However, no shared folder was mentioned.

A literature search found only two reports about the installation of a large-screen display in a radiology conference room.^{15,16} Wang et al.¹⁵ investigated the performance of a digital radiology conference system including a dual-screen workstation with two multimedia projectors. They reported that their system had a very reasonable price (\$470) and was viewed favorably by radiologists. However, in our experience with projectors, the images displayed were generally not bright enough, and the room had to be considerably darkened to facilitate viewing. Additionally, any obstacle, such as a presenter, between projector and screen threw a shadow on the screen, disturbing the presentation. By contrast, the use of plasma monitors allowed clear viewing in a well-lit room (Fig. 1). We conduct radiology conferences in well-lit rooms, and the present study was done under such conditions. Furthermore, presenters can move around or approach the monitors freely without casting shadows. A 50-in. plasma monitor costs \$4,500 at a general merchandising store in Japan—which is not cheap, but it is likely to be considered acceptable because of its cost effectiveness. The graphic board used in this study, however, is very inexpensive (\$200).

Svahn et al.¹⁶ used a large 67-in. display screen for radiology conferences, but they did not state the specifications of the monitor. It is thought, judging by the photograph of the monitor in their paper, to have been a special-order product. In the monitors used in this study, the contrast-detail letters that spelled out, "QUALITY CONTROL," were confirmed to be visible as far as the "Y." The major cause of the visibility is that the maximum luminance of these monitors (120 cd/m²: actual measured value because the date is undisclosed) is not as high as the 2- (650 cd/m²) or 3-M (700 cd/m²) high-resolution monitors usually used in diagnostic radiology, and the monitors were not

calibrated because they are marketed to the public and have no calibration function. The other is that the resolution of these monitors is not as high as the 2- or 3-M monitors. However, the difference of pixel value between the letter "Y" and the background is approximately 3% (the pixel value ratio). Even a 50-in. plasma monitor has sufficient luminance response performance. The evaluation of the image quality of the monitor by radiologists was "probably suitable" for radiology teaching conferences (Table 1). Our results suggest that such monitors are sufficient for radiology conference presentations for the purpose of teaching. However, in this study, the radiologists felt that the size of the 50-in. monitors was not completely satisfactory for radiology conferences because the demonstrated images were a little bit small for the audiences sitting in the back of our conference room (a capacity of 40 people). There are no reports stating how large monitors should be to be suitable for radiology conferences. Larger and more affordable monitors are expected to be developed.

A rear-projection high-resolution system may be another option for displaying large images. We have no experience in using that projection system and there are no scholarly reports about its installation in a radiology conference system. Evaluation of the image quality of the projection system is needed.

The operability of this radiology conference system depends in large part on that of the existing PACS because the system was designed with the PACS software. The results of the evaluation of the operability of this system by radiologists were "probably suitable" or better (Table 1). However, in this study, the radiologists' experiences were that the software for operating the PACS included far too much usage of the mouse to be efficiently usable in routine work, as Svahn et al.¹⁶ described. Further improvement of existing PACS operability is needed.

Nevertheless, the overall impression of the radiologists for the teaching conference system studied was "probably suitable" (Table 1).

A limitation of our study is the subjective scoring system that we used for the evaluation of the monitors and the system by radiologists. The definitions of differences between the scores were not rigorous. However, there is no adequate objective method for evaluating the radiologists'

impressions of the monitors and the system, which could be of sufficient use for developing the monitors and the system. Therefore, a subjective scoring system was used. Our objective results for the image quality of the monitors and the display time of the system are adequate for radiology teaching conferences. Consequently, the results of subjective evaluation by radiologists as "uncertain" or better may be considered consistent.

CONCLUSIONS

We made an experimental design of a filmless radiology conference system for teaching purposes, with dual 50-in.-wide plasma monitors for displaying larger images and with the shared folder for smooth searching for images during conferences, and evaluated it. While results were judged to be suitable for filmless radiology teaching conferences, some improvements were needed in the monitors and the operability of the system. We believe that this system is useful for institutions that intend to introduce a filmless system for filmless radiology teaching conferences.

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