

Web-Based Viewing of Picture Archiving and Communications Systems Images—Part II: The Effect of Compression on Speed of Transmission

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Now that picture archiving and communications systems (PACS) has matured, our challenge is to make the images available to the referring physician and, in a teaching institution, to make these images available for conferences and rounding. One solution is the distribution of the images using web-based technology. We investigated a web-based add-on to our PACS to determine the characteristics of the personal computer that will make this technology useful and affordable. We found that images can be viewed easily through a web-based system. We found that the optimal system to view these images at a reasonable speed and a reasonable cost is on with a medium-range processor (200 to 300 MHz) and a large amount of inexpensive RAM, at least 64 Mb.

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AS DISCUSSED in a previous article, the speed of transmission and display of images is of high importance in a busy clinical setting. Using web-based technology, images can be widely distributed around the hospital in an affordable manner. If there are additional steps to improve transmission speed, these are desirable. One method may be to reduce the size of the information transmitted by compression. Does this improve transmission speed? We investigate the effects of compression on the time to display an image (TTD).

MATERIALS AND METHODS

The equipment and connections used for this study are the same as in Part I. There was an addition of a remote personal computer (PC) connected by phone line through the hospital firewall. This was a 266-MHz machine with 128 MB of RAM. It was connected by a 56.6K (v.90) modem over a standard phone line to a 28.8K modem pool. Transmission speeds were 26.4 kbits/s.

Compression was accomplished in each case by selecting a compression button on the browser display screen. Compressions were performed in real-time on the web server using lossy

wavelet compression. On computed radiography (CR) studies, a quality factor of 65% was used for compression, and on cross-sectional images, a quality factor of 75% was used for compression.

Web browser (Netscape 4.05; Netscape Communications Corp, Mountain View, CA) and a JavaScript, Web 1000 (Mitra Imaging Inc, Hartland, WI) were again used. The same cases from Part I were accessed. The browser was shut down and memory was cleared between viewing the noncompressed and the compressed images to avoid caching in memory.

RESULTS

The averages for the 12 cases, the averages for CR alone, and the averages for cross-sectional images alone, with and without compression for various configurations are listed in Table 1. Of the computers connected by ethernet, the largest difference from noncompressed to compressed images was 2.2 seconds TTD. This also represented the largest percentage of decrease (23.2%). The average decrease in TTD was 5.1%. The decrease seemed to be more significant with the CR, the largest difference being 6.9 seconds (44.8%). The decrease in TTD for the CR averaged 20.5%. The decrease in TTD was most notable at slower speeds. The decrease for cross-sectional images was less consistent. This ranged from a decrease of 2.2 seconds to an increase of 3.8 seconds (and from 15.1% to -45.5%), with an overall increase of 5.4%. The increase in TTD seemed most noticeable at faster speeds.

The most significant improvement in TTD with compression was using the phone line (Table 2). There was a 70.8%, 80.9%, and 65.5% decrease in the TTD with compression in the overall average, the CR average, and the cross-sectional average, respectively. The range of the TTD over the phone line was six minutes, 40 seconds to 10 minutes, 11 seconds with an average of 8 minutes and 11 seconds without compression and 34 seconds to 3 minutes, 48 seconds with an average of 2 minutes, 23.4 seconds.

Although no formal analysis of the images was performed, there seems to be no significant difference in the appearance of the images that were compressed versus those noncompressed (Fig 1). A

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Table 1. TTD (seconds) Information for the Various Configurations Connected by Ethernet, Both With and Without Compression

	Overall Without Compression	Overall With Compression	CR Without Compression	CR With Compression	Cross-sectional Without Compression	Cross-sectional With Compression
200-32	38.9	38.2	51.3	52.3	30.1	28.1
200-64	16.1	14.0	14.6	12.7	17.2	15.0
200-96	16.4	14.5	14.8	13.1	17.6	15.5
266-128	9.5	7.3	8.0	5.0	10.6	9.0
300-64	11.3	8.8	12.3	7.8	10.6	9.6
300-128	8.8	8.5	8.2	7.2	9.3	9.4
300-192	8.4	9.2	8.3	7.8	8.5	10.2
300-256	8.8	8.1	8.4	6.6	9.1	9.2
400-64	12.9	12.3	15.4	8.5	11.2	15.0
400-128	7.3	7.4	6.8	5.2	7.6	9.0
400-196	7.3	8.8	6.7	5.3	7.7	11.2
400-256	7.1	6.9	6.6	5.2	7.4	8.2

NOTE. Overall averages, CR averages, and cross-sectional averages are included.

Table 2. TTD (seconds) Information for the Remote Site Connected by 28.8K Modem Pool

	Overall Without Compression	Overall With Compression	CR Without Compression	CR With Compression	Cross-sectional Without Compression	Cross-sectional With Compression
28.8-KB telephone	491.0	143.4	407.4	78.0	551.1	190.1

NOTE. Overall averages, CR averages, and cross-sectional averages are included.

radiologist judged the images as no degradation at the compression rates used.

DISCUSSION

With more traffic over the network, web-based display times will be prolonged. It will be helpful to optimize the images for transmission. Compression

is a method to reduce the size of the images and therefore increase the speed of transmission. Compression can be one of several types, both lossless (no decrease in information) and lossy (some decrease in information). Lossy compression can be of varying degrees. Compression may be of various methods including wavelet and JPEG. It is

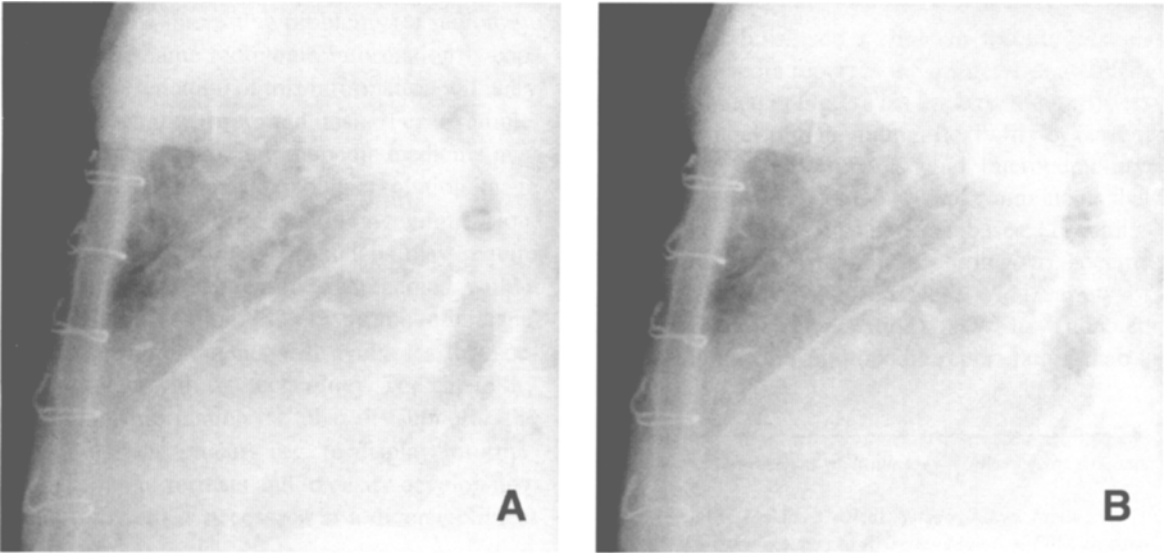


Fig 1. Coned lateral image of the chest showing the anterior clear space, without compression (A) and with compression (B). Difference in details is imperceptible.

unclear whether compression will have an advantageous effect at high-speed networks. The question also rises whether the process speed will effect the TTD because of calculation required to uncompress the image.

Our data showed that absolute decrease in TTD is small, only 2.2 seconds. This did represent a 23.2% decrease, but the TTD were initially small. It did not seem to be a significant difference, although in viewing many images this may add up. The degradation of the image is imperceptible and viewing all images with compression is a reasonable course.

There was, however, an interesting phenomenon in the faster central processing unit (CPU) machines. This was the decrease in the TTD improvement, particularly with cross-sectional images. In fact, it takes longer to display images with compression. This phenomenon is difficult to explain. One theory is that the faster CPU/high RAM configuration is near optimal for displaying over ethernet lines and the decompressing of the images actually takes more time.

The effects of compression are dramatic when accessing images at much slower speed of phone line connection (almost 1/350 the speed of direct

ethernet connection). This is undoubtedly the result of transmitting the small images over very slow lines. Test of remote sites with faster speeds such as 56K modem pools, integrated services digital network (ISDN) lines, and possibly cable modems are needed.

Additional testing is necessary to evaluate the effects of varying amounts of compression. We are currently in the process of evaluating different degrees of compression. Image quality will be a major factor of evaluation as images become more compressed.

CONCLUSION

We found that compression offers some improvement in TTD overall, but it is not a significant improvement with ethernet. We also found that image quality does not suffer with lossy compression at a quality factor of 65% to 75% and usually has no disadvantages. We recommend using compression routinely if CR images are being viewed. However, compression should not be used for viewing cross-sectional images particularly with faster processors. Compression is certainly useful when viewing images at a remote site with a slow connection.