Accessing medical image databases on the go

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The implementation of a JPEG2000 Interactive Protocol–based communication system allows rapid access to high-resolution medical images from low-power handheld devices.

The Digital Imaging and Communications in Medicine (DICOM) standard was created to promote the distribution and viewing of medical images, such as computed tomography scans, ultrasound images, and magnetic resonance imaging files. Recently, the demand for rapid and mobile access to this medical information has risen dramatically. However, the rate of acquisition and display of high-resolution medical images is limited by the network transmission speed or the resources of handheld terminal devices. Some users may need a low-resolution image to view on a terminal device with a limited display screen, while others may be interested in viewing a specific region of the image in higher quality.

One approach is to store multiple versions of the same image on the server, but this method requires additional storage. Another is to have the server transcode the image before sending it to the client, but this wastes server computational resources. To address these problems, we present an approach based on the JPEG2000 Interactive Protocol (JPIP) to browse high-resolution medical images in a more efficient way.

The JPEG2000 image-compression standard offers many features that support interactive access to large images, including high-efficiency compression, resolution scalability, quality scalability, and spatial random access. JPIP is the interactive protocol standard for viewing JPEG2000 images in a client-server system. It uses the scalable features of the JPEG2000 code-stream, allowing the client to instantly fetch the region of interest (ROI) without directly accessing the compressed target file.

Based on JPIP, we designed and implemented an interactive-image communication system with a client-server architecture (Figure 1). The JPIP client communicates with the JPIP server through an intranet or Internet connection, and personal digital assistants (PDAs) can access the server over a wireless network.

The client sends Hypertext Transfer Protocol-GET requests to the server. The server retrieves the requested images from the picture archiving and communication system (PACS) server using a WADO (Web Access DICOM Persistent Object) protocol, stores them in a local image database, and loads the image data (DICOM header and encoded pixel data) into memory. The server then sends a precinct stream, also known as a JPP-stream, that contains a sequence of messages, with each message containing the data from a single packet. The client then parses the response stream, stores the packets in its cache, and renders the ROI. A cache model is maintained on the server side for each session, so the JPIP server can avoid sending redundant data to the client.

We used a digital radiograph image with an original size of $2048 \times 2500$ pixels to demonstrate the interactive features of this image communication system. The JPIP client requests a low-resolution image to preview, and the data transmitted from the server is 2.13% of the full compressed image. With a low-resolution image to preview, the user can choose an ROI to view at higher resolution. Figure 2 shows the resulting images at a PACS image workstation. Using empty packets to reconstruct the tile data in order to raise transmission efficiency of the tile-part stream has been proposed previously. At the client side, we used a set of empty packets to reconstruct the code-stream so that the packet transmission efficiency can be raised.

Figure 1. Architecture of the interactive-image communication system. PACS: picture archiving and communication system. JPIP: JPEG2000 Interactive Protocol. PDA: personal digital assistant.

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Figure 2. (a) The image is viewed at 25% resolution. (b) Spatial random access: Image reconstructed by the JPIP client at view-window: original file size = 2048×2500 pixels, requested file size = 512×512 pixels. The ROI in the red frame has full-resolution image quality, and the regions outside of the frame have lower resolution image quality.

Figure 3. Browsing a high-resolution image on a PDA: (a) Low-resolution image preview. (b) Reconstructed ROI image at view-window: original file size = 1024×1250 pixels, requested file size = 256×256 pixels.

...that the image information outside the ROI can also be decoded and displayed. This approach provides some navigation context in the regions outside the ROI.

In the case of browsing high-resolution medical images on a PDA, we used a DELL X51V Pocket PC connected to a wireless network. The embedded client software allows the PDA to communicate with the server. To demonstrate the protocol, we requested the previous image, this time to our PDA. First, we retrieved a low-resolution image to preview and then selected an ROI for higher resolution viewing. Figure 3 shows the resulting image on the PDA.

We also tested the performance of the server under heavy load. It ran stably and reliably when processing large quantities of requests, and the average response time to each request was acceptable.

In our interactive-image communication system, the server works as the middleware between the clients and the PACS servers. This system allows both desktop clients and wireless mobile clients to efficiently browse high-resolution medical images. This system can also be expanded and integrated into regional healthcare systems, enabling medical information to be shared across wide-area networks.

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