Interhospital Network System Using the Worldwide Web and the Common Gateway Interface

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We constructed an interhospital network system using the worldwide web (WWW) and the Common Gateway Interface (CGI). Original clinical images are digitized and stored as a database for educational and research purposes. Personal computers (PCs) are available for data treatment and browsing. Our system is simple, as digitized images are stored into a Unix server machine. Images of important and interesting clinical cases are selected and registered into the image database using CGI. The main image format is 8- or 12-bit Joint Photographic Experts Group (JPEG) image. Original clinical images are finally stored in CD-ROM using a CD recorder. The image viewer can browse all of the images for one case at once as thumbnail pictures; image quality can be selected depending on the user's purpose. Using the network system, clinical images of interesting cases can be rapidly transmitted and discussed with other related hospitals. Data transmission from relational hospitals takes 1 to 2 minutes per 500 Kbyte of data. More distant hospitals (eg, Rakusai Hospital, Kyoto) takes 1 minute more. The mean number of accesses our image database in a recent 3-month period was 470. There is a total about 200 cases in our image database, acquired over the past 2 years. Our system is useful for communication and image treatment between hospitals and we will describe the elements of our system and image database.

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THE WORLDWIDE web (WWW) server Celebris (Digital Equipment Corp, MA) is the network system used in the Department of Radiology, and Solaris (Sun Microsystems, CA) for is the local area network system used for Kansai Medical University (KMU-LAN). Four affiliate hospitals (the Takii Otokoyama, Kori, and Rakusai Hospitals of the Kansai Medical University) are connected by telephone line. Client computers, at the Department of Radiology, are Windows (Microsoft, Redmond, WA)-based Proliant 800 (Compaq Computer Corp, Houston, TX) computers, which have Pentium II (INTEL, Santa Clara, CA) 200 Mhz CPUs, 96 Mbyte memories, video cards (Millenium II, Canada), and dual cathode ray tube (CRT) monitors, the Macintosh (Apple Computer, Cupertino, CA)-based Power Macintosh 7500/100. Imlogix has been used for high-resolution display of Digital Imaging and Communications in Medicine (DICOM) 12-bit images. The film digitizer (scan-

ner) is the Canon Film Scanner 300 (CFS300; Canon Inc, Utsunomiya, Japan). Image quality (84 to 1,000 $\mu\text{m}/\text{pixel}$) and format (DICOM, Joint Photographic Experts Group [JPEG]) can be altered using a CFS300 film digitizer console. The magnetic resonance (MR) scanner is a Siera 1.5T MRI (GE Yokokawa Medical System, Tokyo, Japan). Original image storage is performed using the Yamaha CDR400tX CD recorder (Yamaha Inc, Shizuoka, Japan). We use Thumbs Plus version 3.0J (image file manager; Village Center, Tokyo, Japan) and Osiris 32 (for DICOM) applications for image browsing for Compaq (Windows). The graphic converter, Adobe persuasion and Adobe photoshop (Adobe System Inc, Mountain View, CA), National Institutes of Health (NIH) Image version 1.55 are used for image treatment on the Macintosh. Each personal computer (PC) has Netscape Navigator (Netscape Communications, Mountain View, CA) or Internet Explorer (Microsoft) for WWW and image browsing. The server machine contains the DICOM standard program of central test node (CTN) and a program to display the image database. The four affiliate hospitals are connected using telephone line. From each hospital, image data can be transmitted using file transfer protocol (FTP) and users can browse the image database at every hospital and can access the internet.

IMAGE ACQUISITION, IMAGE STORAGE, AND IMAGE DATABASE

Images of plain x-ray, computed tomography (CT), and MR from the film scanner are transferred using FTP. Image formats are selected from the 8-bit JPEG format. Images from the MRI scanner are transferred directly to the server machine. Compressed images, such as JPEG 8-bit images,

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are used mainly for database and presentation. For measurement of density and intensity, and for detection of calcification of mammography, 12-bit images are used. Images transferred by FTP or DICOM to the server machine are stored temporarily on the hard disk drive of the server machine, Celebris. Then, all images are transferred to Compaq's hard drive using FTP and recorded as original images onto CDs using the Yamaha CDR400tX CD recorder. The CD recorder has 640 Mbyte volume per one disk, and about 1,200 slices of a 500 Kbyte image can be stored. Radiologists in our department routinely scan interesting cases and record them to the server's hard drive. The most important images are selected for the image database. We choose regions of interest (ROIs) from x-rays, CT scans, and MRI, which are reviewed using the Thumbs Plus software on Windows PC (Compaq), or using the WWW browser on Macintosh. These images are registered into the database using a WWW browser such as Netscape Navigator or Internet Explorer. With key words and text comments, ROIs are stored in the database in the server's hard drive. Although the size of the digitized film is from 500 Kbyte to 10 Mbyte, depending on the pixel size, by trimming ROI images, we have succeeded in reducing it to 20 to 50 Kbyte. Using the Common Gateway Interface (CGI) (gwpr; Canon), everyone in our department can access the database easily. The CGI defines an interface for running external applications and programs on behalf of the WWW server. We use the CGI tool (Canon Group Web), which allows a WWW server to provide information to WWW clients in a readable form known as hypertext mark-up language (HTML). The CGI tool has its own commands and allows users to write the CGI programs without knowing any particular computer languages, such as C, C++, or Pearl. Outside the Department of Radiology, image database registration can be performed using HTML.

IMAGE DATABASE AND DIGITAL TEACHING FILE

Our system is an easy to realize and high-speed database made especially for Windows NT (Compaq). Image scanning takes only 10 to 15 seconds for one film. Image review using Thumbs Plus takes only 2 seconds for one film image from the Compaq's hard drive. Within 10 minutes, everyone in our department can access one database, from

film scan to registration, with a key word and text comment. Further customization of our database is available using CGI. This mechanism enables easy operation even for users with little computer experience. We have currently stored radiographic images of approximately 500 cases. Our database for teaching and researching purpose can be accessed from any place in the university via WWW by the browsing the home page of our department, and users can search the image and information.

CONCLUSION

Recently, there have been many reports about teaching systems using computers and the WWW.¹⁻⁴ Appropriate image quality should be decided according to one's purposes. For example, primary diagnosis and first reading procedure, where the existence of the lesion is unknown, require high-quality images, while secondary diagnosis and confirmation of the first reading procedure, where the existence of the lesion is known, require relatively minimum acceptable image quality. Until now, most of image database systems have used the DICOM format for primary diagnosis. However, realization of the DICOM 12-bit image system may be difficult based on cost. Since a low-cost but high-performance PC has recently become usable, we constructed a system that provides high enough image quality for secondary diagnosis, presentation, and publication. Since, a 175 $\mu\text{m}/\text{pixel}$ image is enough for secondary diagnosis and presentation, the minimum acceptable resolution enables us to perform high-speed review using the Compaq/Windows PC system. The PC's performance and the Thumbs Plus software allow high-speed image browsing. Although we use relatively low-cost PCs and CRTs, as compared with DICOM systems, our high-quality image display system using Imlogix allows us to detect subtle intramammary calcification. High-quality images are also available for measurement of intensity for experimental MRI studies, such as measurement of the intensity of the posterior lobe of the pituitary gland. Storing the original image on CD-ROM makes it possible for us to reduce the space for stock. Regarding database construction, a customizable database can be made easily using the CGI program. Key images and key words reduce disk space and memory used. Additionally, because students and residents in our department and others can access our database

using WWW, our system may contribute to medical education and training.

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