Implementation of an Electronic Teaching File Using Web Technology

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The implementation of an electronic teaching file using web technology is discussed in this article. A web client server model is used for a standard web browser capable of displaying Joint Photographic Experts Group (JPEG) compression images. Like other web-based teaching files, this teaching file in a similar way uses a database containing information. This database section of the teaching file allows flexible database querying and viewing of pages generated by hypertext markup language (HTML). Because the browser client is so flexible, images types such as video and 3D representations with virtual reality markup language (VRML) can be displayed.

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KEY WORDS: computers, imaging, teaching file.

THIS REPORT DISCUSSES the construction and use of an electronic teaching file using a web client server model. The client consists of a standard web browser able to display Joint Photographic Experts Group compression (JPEG) images. This teaching file uses an underlying relational database to hold case information in a similar manner to other web-based teaching files.^{1,2,3} The database portion of the teaching file allows flexible querying of the database and dynamic generation of hypertext markup language (HTML) pages for viewing. The flexibility of the browser client allows display of multiple image types including video and 3D representations using virtual reality markup language (VRML).

MATERIALS AND METHODS

The following criteria were used to construct the electronic teaching file: (1) open standards compatible with most web clients, (2) standard server components including HyperText Transfer Protocol (HTTP) servers and an underlying relational database, (3) low cost of hardware and software components, and (4) ease of use, maintenance, and construction.

Web base technology was used because of its ability to flexibly display various multimedia data including images,

video, and 3D representations. Also, the ability to access the teaching files using any web client provides easy and distributed access to the electronic teaching file. The use of an underlying database allows flexible queries based on specific parts of the database such as diagnosis, findings, history, organ system, and patient demographics.

Ten to one JPEG compression was used to make response time over 10 Mb Ethernet fast and to allow potential use over the Internet. This amount of compression only slightly degrades image quality and significantly improves response time.

Netscape Fast Track server (Netscape Communications, Mountain View, CA) and Livewire (Netscape) were used as the web server and interface between the web server and a relational database. Livewire allows embedding of server side Javascript (Netscape) and separate Java (SUN Microsystems, Mountain View, CA) programs in HTML documents. The server side Javascript in the HTML documents is executed before sending the HTML documents to the client. The server side Javascript allows flexible connection to the databases.

Figure 1 shows the architecture of the web-based teaching file. A HTML form is used as an entry form to query the database. Submission of the form to the server runs a SQL database query using LiveWire server extensions to the relational database (Fig 2). Imbedded server side Javascript is used to generate a HTML page with links to the matching cases. These links are again processed by Javascript and LiveWire server extensions to generate the web page with the selected case. Search criteria include diagnosis, findings, history, and organ system. Figure 4 shows a sample case from the teaching file.

Figure 3 demonstrates the structure of the underlying relational database. This structure allows up to six images per case and coded entry for certain fields such as organ system and proof of diagnosis. Free text entry is allowed for findings, diagnosis, and history. The ability of the database to sort and search any of these fields allows flexible retrieval of appropriate cases. The images themselves are referenced by case ID number and are simply stored in a separate directory and not in the relational database itself.

Cases are sent electronically to the web server using a PC-based DICOM receiver and then converted to JPEG image files. If the images are not in electronic format, these images can be scanned using laser scanners and transferred using DICOM or can be scanned using Desktop based scanners and converted to JPEG images. Using 10 to one compression, 100 cases occupy approximately 16 megabytes of disk space. These cases include mixtures of CT, MR, and plain films.

The hardware consisted of a 200 mhz Pentium Pro with 64 meg of RAM running Window NT 3.51 with 3.5 gigabyte disk drive. The cost of the hardware and software was \$5,000. Approximately 2 weeks of programming time were required to set up the relational database and embedded Javascript.

The quality of the JPEG image files viewed on a web browser with a video card using true color display is considered

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Fig 1. Teaching file logical diagram. This figure shows a diagram of the teaching file components.

adequate. Display using fewer bits per pixel result in significant degradation of image display as the browser's color palette is not optimized for gray scale display. Also the images cannot be windowed and leveled as they are reduced to 8 bit images. Cases can either be displayed with or without the diagnosis. When displaying cases without the diagnosis, the diagnosis is displayed by selecting a hyperlink.

Response over a 10 megabit Ethernet with two clients simultaneously accessing the same web server averages 4 seconds with a range from 2 seconds to 55 seconds for one case with up to six images. Response time does depend on the size of the image sets. The response time over dial up networking using a 14.4 kbs modem averaged 72 seconds per case. Over 2 months, approximately 100 cases were added to the teaching file.

FUTURE ENHANCEMENTS

Future enhancements include the ability to display annotations on the images based on users action at the client browser using Java applets or client side Javascript, ability to window and level, ability to display images in specified sequence according to users actions at the browser, and entry of cases directly from a web browser. Different types of image compression such as wavelet compression could be used to improve response time

Fig 2. Flow diagram of teaching file. The web browser sends an HTML form to the server. This form is processed by Javascript embedded in HTML pages and performs a database operation to dynamically generate the return HTML page with associated images.

Fig 3. Database diagram. Information is stored in a relational database. Most of the information is stored in the teaching table. The teaching table is linked to other tables to provide coded entry of information.

Fig 4. Example page and image from the teaching file.

and image quality. Also, future electronic teaching files need to be integrated into PAC system to provide easier and more flexible creation of cases.

Case base expert systems for radiograph diagnosis could be an easy out growth of this type of electronic teaching file. This would allow searching of large case systems as compared with present cases.

CONCLUSION

This project demonstrated that cost-effective electronic teaching files can be easily constructed from standard Internet technologies with a web server, web client, and underlying database. This technology demonstrates significant promise for construction of large and complex electronic teaching files.

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