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Image Visualization in Educational Multimedia Cases Through IIP (Internet Imaging Protocol)

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BACKGROUND: *Multimedia educational material aimed at self or distant learning in Pathology include histocytologic images coming from specimens, which are acquired in a variety of ways. Recent evolutions in acquisition devices allow now to obtain ver high resolution images, as well as to fully digitize whole glass slides into so-called "virtual slides". In particular, resolutions above 1800x1200 are easily reachable with regular digital cameras. However, the availability of large images poses new problems in visualization, which may become troublesome, and in networking, due to the storage needed.*

METHODS: *Recently, a communication protocol (IIP, Internet Imaging Protocol) for the distribution of multi-resolution images through the Web has been developed by a Consortium of companies (Digital Imaging Group), aimed at easily providing images suitable either for Web display (low resolution) and printing (high resolution). A companion file format, Flashpix (which statically reproduces some of the features of IIP), has been already experimented in telepathology by other research groups. An analysis of such protocol made clear that it is also suited for histopathologic images, because of the features of the protocol itself (that allows the partial transmission of rectangular areas of an image) and of the clients, usually provided with pan and scroll tools for browsing the image, which are similar to the microscope movement. Thus, we added to an already implemented educational case archive an IIP server (the open source implementation of the Digital Imaging Group) for distributing the images, with the corresponding Java client.*

RESULTS: *Accessibility of large images (i.e., greater than the monitor' screen) has been enhanced, and the multi-resolution feature of IIP closely emulates the different magnifications available with a traditional microscope, giving a greater user-friendliness to the system interface. Furthermore, the visualization of images where only a small part is significant is faster, because just the interesting part is transmitted on the network.*

CONCLUSION: *IIP may be applied in the efficient distribution of histocytologic images, and the already available client tools are adequate for their exploration. Although not tested, already available extensions of the protocol allow for voice annotation of image subparts, with interesting educational applications. Further extensions, specific for telepathology, may be studied for representing multiple focal planes of the same image.*

KEY WORDS: *Telemedicine; Telepathology, Image Visualization, Internet Imaging Protocol*

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INTRODUCTION

In the last years, digital medical images have been used in a number of applications on the World Wide Web, mainly for continuing medical education but also for diagnostic purposes. One of the fields is pathology, in which images coming from a microscope are digitised using either analog or digital cameras. Telepathology is based on the delivery of such images, with the above-mentioned aims, but also for remote image analysis and quality control.

Recent digital cameras have resolutions so high, that it becomes difficult to display them on a usual video monitor without the need for scrolling the window, and thus making the visualisation experience troublesome. Furthermore, also the storage needed for such images can be huge, although usually JPEG compression is

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accepted; this brings remarkable transfer times, whenever transfer on the Internet is requested.

A new protocol -the IIP, Internet Imaging Protocol - has been recently proposed by a Consortium of companies, for efficiently distributing multiresolution images on the WWW (Dig97). Such a protocol is primarily aimed at publishing images suitable for both visualisation and printing. Anyway, IIP is general enough to be considered for telepathology applications, as we demonstrate in the present paper.

Telepathology tools and applications

Following a classical definition, telepathology is a subspecialty of telemedicine aimed at supporting the pathologist's practice by means of telematic tools. Telepathology systems are divided into two categories: static ones, where still images are available on a store-and-forward basis, and dynamic ones, based on realtime video and sometimes on robotized microscopes. The latter are mostly used for intraoperative telediagnosis (i.e., quick diagnosis performed during surgery to guide the surgeon to further tasks), while the former almost for all applications, including continuing medical education, second opinion diagnosis, quality control, remote quantitation.

The basic source of information for the pathologist is the light microscope, with objective magnifications ranging from 2x to 100x. There are two main image exploration patterns: an overall observation of the specimen at low magnification, with deeper analysis of apparently significative clues, by means of higher magnification objectives (Tsu99).

An analog or digital camera may be connected on the microscope for digitising the images. Different features for analog and digital are available.

An analog camera (with one or three CCD chips) allows to show live images on a monitor, or in the window of the acquisition software on a computer; this way, focusing and selecting the right fields is easy, and acquisition is very fast. The maximum resolution is limited to the PAL/NTSC standards, which practically means images up to around 800x600 pixels for a 3CCD camera.

Digital cameras are currently available in two kinds: consumer cameras with usual serial interface and microscope adapters, and specifically designed cameras with fast interfaces (i.e., SCSI or proprietary). The former, with resolutions growing fast and currently set up to 1800x1200 pixels, are very cost-effective, but they do not allow live images (as they are photocameras) except for low resolution LCD display, sometimes with a video-composite output. The latter are more espensive, but have higher resolutions and also the possibility of displaying a near-live image on the computer screen. A further and less diffused category is such of photoscanners, which are acquisition devices based on a linear CCD slowly scanning the field of view, exactly as in flatbed scanners. Such devices allow for very high resolutions (6-8 millions of pixels) but are comparatively slow in acquisition, thus making their use difficult.

Apart from analog cameras, all other devices produce images greater than the screens usually available on personal computers. However, analog cameras are still used in systems in which realtime video and fast acquisition are needed, that is, almost all dynamic telepathology systems. In the following, we focus on static telepathology, because it is often carried out on the Internet, and because it is often based on the use of digital cameras.

About the features of the microscope images, there are no established standards, but at the present time no particularly high color-sampling levels are needed (i.e., RGB with 8bits/channel is sufficient, and some Author reports even 256 colors), and JPEG compression up to 15:1 ratios is acceptable (For97, Del98).

A typical static telepathology application is centered on a specialized patient record, containing patient data useful to the specific application (e.g. a short clinical history for diagnostic use, or more accurate descriptions for education purposes) and images, mainly coming from microscope, but sometimes also macroscopic pictures of the sampled organ. Such patient record may be sent directly by a pathologist to another pathologist for second opinion consultation, or may be put on a server, to which a pathologist or a student may connect for consultation or for continuing medical education. The patient record may obviously be also intended for support to the student self-education.

While some years ago only relatively small images were available, now accessing high-resolution images within the patient record is feasible, but it introduces two weaknesses into the interface:

- the whole image may not be fully displayed on the screen, which does not easily allow for the first image exploration pattern, i.e., the overall observation;
- the accurate observation of high magnification details (second pattern) can be made only by downloading the whole image in which the details are present. As images, even compressed, occupy hundreds of Kbytes, the process become slow.

The Internet Imaging Protocol (IIP) in Pathology

The Internet Imaging Protocol was firstly proposed by Hewlett-Packard, Live Picture and Eastman Kodak, and then the Digital Imaging Group was founded, to which many other companies merged. The protocol, together with the companion Flashpix file format specification, is mainly targeted at the photographic market. The basis of the protocol is a tiled, multiresolution image representation, which allows for an efficient delivery of rectangular subsets of images at the desired resolution. Each resolution is usually a half of the immediately higher one. Other image-related information is also available via the protocol, including image technical features , author information, and descriptive notes.

The basic protocol commands are only three, and allow for requesting tiles at a specific resolution (one or more, on rectangular subsets), for requesting objects (i.e. information on images), and to set the data object storage, i.e., where to bring the information, thus allowing even extensions to the basic object model. Further details are available in the protocol specifications (Dig97).

In practice, IIP may be used to request just a section of an image at a specific resolution, by means of specified client software.

There is already server and client software available for IIP and Flashpix and, furthermore, recently the Digital Imaging group released an open-source reference implementation of both server and client, developed in Java (IIP00). Clients usually have a common set of features, for easy image exploration through pan/scroll functions (free and not limited to tile dimensions), and resolution browsing. Furthermore, caching schemes are implemented in order to avoid duplicate download of the same image tiles, although duplication occurs through different resolutions.

The main interest of IIP for pathology lies in the fact that the two interaction functions provided by IIP -pan/scroll image exploration and resolution browsing- closely resemble the two main ways the pathologist use to navigate the glass specimen at the microscope. In fact, the microscope stage movement may be emulated by the pan and scroll functions, while the change of the microscope objective may be easily put into correspondence with the multiresolution browsing, provided that the highest resolution image has been obtained by an high magnification image (e.g., 40x). Considering that many microscopes have objective magnifications one twice the other (e.g. 2.5x, 5x, 10x, 20x, 40x), lower resolutions inside an IIP-served image exactly correspond -an can be identified to- lower magnification images.

The pathologist may start the visualization of an image from the lowest resolution image, selecting details to be observed at higher resolution and requesting just the needed sections of the images. In this way, a faster interaction is provided, and the interface is more suitable for emulating the use of the microscope use, with the usual patterns of visualization.

Flashpix - the IIP companion file format - has been already tested in telepathology for educational applications (Lan00); a comparison of FPX versus other image formats is also available (Jao99). An experience on the use wavelets for multiresolution image browsing has also been reported (Wan99).

An application in the educational field

Inside the project entitled "Italian Network of Telemedicine for Research Education and Quality Control in Anatomic Pathology" (RIT00), the main network activities are: the remote expert consultation; the multimedia case archives for education and continuing education; the collaborative authoring of multimedia educational material.

The project is headed by the Institute of Pathology at the University of Udine, and currently involves five italian universities (Ancona, Bari, Ferrara, Sassari, Udine).

Among the aims of the Network, education is one of the more important.

For this, a Web-based case archive has been developed, where patient are stored for education aims. The archive was implemented on a three-tier architecture, with a SQL data base management system (currently MySQL) accessed through an independent API, an interface level base on HTML and PHP, and the client application constituted by a Java-enabled browser.

Images coming from the archive are accessible by means of two interfaces: a traditional one (i.e., by displaying the image on a web page) and another based on IIP, at the users' choice.

The latter interface has been based on the Digital Imaging Group's reference implementation, which is a Java servlet to be run in conjunction with a HTTP server. Following the latter specifications, images were stored using JPEG.

Two main educational archives are being developed:

- a continuing education archive, in which interesting cases are put by postgraduate students in Pathology and other pathologists, with the aim of giving CME material for postgraduate students as well as for specialists. Compared to the consultation cases, the latter contain more detailed clinical histories, and often also images coming from different medical fields (mostly radiographs, CT, NMR). The current archive hosts 27 cases.
- a graduate student archive, where paradigmatic cases have been stored, to be used as an educational support during regular lessons in the Pathology courses for the degree in Medicine. Such cases are less detailed at the level of patient histories, but with image descriptions (often not needed in the other archives) and with simple questions and answers, which the student should become able to respond to. At present, 5 cases are available.

Figure 1 shows a sample image displayed through the IIP interface.

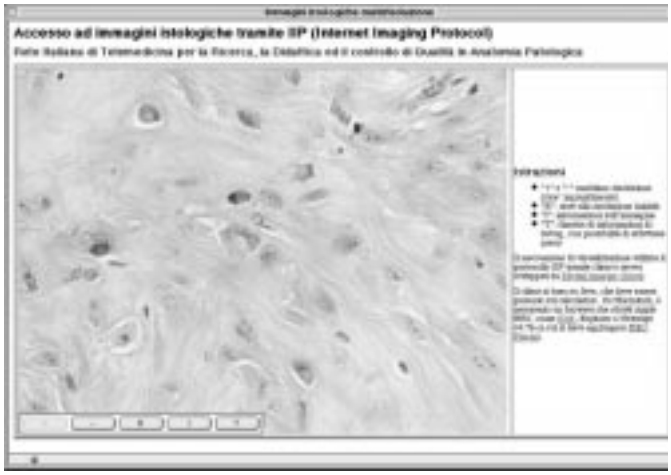

Figure 1. An histologic image displayed through the IIP client

Different browsers have been tested against portability of the client program, which revealed execution problems only on Netscape v4.7 on the Apple Macintosh (due to the Netscape implementation of the Java virtual machine, and solved in the most recent version 6.0).

DISCUSSION

The availability of refined imaging technology -namely digital cameras - has brought new problems to the user interfaces, because larger images capture diagnostic information more precisely (e.g., in microscope images), but are difficult to display using the available software -such as web browsers- which, in turn, are more and more popular in Telemedicine systems.

A quite similar problem arose in the digital photography field: higher quality images are available, higher printing devices too, but the WWW delivers more easily lower resolution images. For the latter problem, a viable solution is given by the Internet Imaging Protocol.

By analysing the features of such a protocol, its suitability for telemedicine applications is apparent. More specifically, we have proposed and applied it in the domain of Telepathology, where images come from a microscope. A direct relationship exists between the functionalities provided by the protocol and the microscope actions.

Although the visualization experience through IIP appears faster and closer to the usual pathologists' habits, further investigations should be made in order to verify whether data effectively transmitted is truly less than the highest resolution file size.

Further features of the protocol are still to be experimented. In particular, the object model accessible through the IIP may be used for adding descriptive information and even, with a recent extension (FPX00), audio data. Such objects may be of interest for educational applications, although when images are kept into a database system, support for that is already present.

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REFERENCES

1. Della Mea V, Beltrami CA. Telepathology Applications of the Internet Multimedia Electronic Mail. Medical Informatics 1998; 23:237-44.
2. Digital Imaging Group. The Internet Imaging Protocol v1.05. URL: http://members.digitalimaging.org/publicspecs/
3. Foran DJ, Meer PP, Papathomas T, Marsic I. Compression guidelines for diagnostic telepathology. IEEE Trans. on Information Technology in Biomedicine, 1997;1:55-60.
4 Digital Imaging Group. Flashpix downloads. URL: http://www.digitalimaging.org/downloads_flashpix.html
5. Hadida-Hassan M, Young SJ, Peltier ST, Wong M, Lamont S, Ellisman MH. Web-based telemicroscopy, Journal of Structural Biology 1999;125: 235-45.
6. Digital Imaging Group. IIP server and client. URL: http://www.digitalimaging.org/downloads_iip.html
7. Jao CS, Hier DB, Brint SU. The display of photographic-quality images on the Web: a comparison of two technologies. IEEE Trans Inf Technol Biomed 1999;3(1):70-3.
7. Landman A, Yagi Y, Gilbertson J, Dawson R, Marchevsky A, Becich MJ. Prototype Web-based continuing medical education using FlashPix images. Proc AMIA Symp 2000:462-6.
8. Rete Italiana di Telemedicina per la Ricerca, la Didattica ed il Controllo di Qualit‡ in Anatomia Patologica. URL: http://www.telemed.uniud.it/ritap/
9. Tsuchihashi ZY, Mazaki T, Nakasato K, Morishima M, Nagata H, Tofukuji I, et al. The basic diagnostic approaches used in robotic still-image telepathology, Journal of Telemedicine and Telecare 1999;5(S1):115-7.
10. Wang JZ, Nguyen J, Lo KK, Law C, Regula D. Multiresolution browsing of pathology images using wavelets. Proc AMIA Symp 1999:430-4.
11. Wolf G, Petersen D, Dietel M, Petersen I. Telemicroscopy via the internet. Nature 1998;391:613-4.