Robotic telepathology: efficacy and usability in pulmonary pathology

FJW-M. Leong, AG Nicholson, JO'D. McGee
Journal of Pathology 2002; 197: 211-2

Describes scanning and viewing slides with ZEM software.

Automated complete slide digitization: a medium for simultaneous viewing by multiple pathologists

FJW-M Leong, JO'D McGee.
Journal of Pathology 2001; 195: 508–514.

Descibes scanning and using ZEM software.

Practical applications of Internet resources for cost-effective telepathology practice

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Pathology 2001; 33: 498-503

Virtual Histological Imaging Utilising Next Generation Telepathology Technology

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A paper version of this poster was presented at the 180th meeting of the Pathological Society of Great Britain and Ireland

Abstract
The value of total histological slide digitisation has begun to be recognised by several international centres. It has application at all levels of clinical practise, and will benefit undergraduate, postgraduate and continuing education. Unfortunately, as the volume of potential data on a histologic slide represents a significant problem in terms of digitisation, storage and subsequent manipulation, the reality of virtual microscopy to date has comprised limited views at inadequate resolution.
Employing a unique combination of enhanced hardware, image capture and processing techniques designed for telepathology and using a range of histological sections, we demonstrate a prototype of how these issues may be solved and compare them with alternative methodologies. Virtual histologic imaging allows image data manipulation at a level not possible within a conventional environment. Combinations of multiple users, multiple magnifications, annotations and addition of ancilliary textual and visual data are now possible.
This demonstrates that with increased sophistication, the applications of telepathology technology should not be confined to second opinion or EQA, but has applications on a wider front.
Image acquisition
Image capture can be achieved manually, however the process is time-consuming, labour-intensive and consequently unsatisfactory for high-volume digitisation work. A robotic microscope with complete control over all microscope functions (focus, Kohler illumination, critical illumination, objective mount rotation, stage movement) is essential for full automation. We use a Nikon E1000 (Nikon UK) with a triple chip CCD camera (JVC KY-F58) Microscope control is via PC (350 Mhz Pentium II, 128M RAM, 32G harddrive, 8M graphics card, 15inch monitor), with customised software (ZEM, The Netherlands).
Results
Digitisation is performed via the client software. All features are available onscreen. In the top right-hand corner is an overview image with a marker indicating current viewing position. Below this is the 'live' window used for fine focusing and brightness adjustments. The largest window is for viewing the slide. It has has several modes – single, split (2 windows), split (4 windows) and floating. The floating window is scaleable, its size is limited only by monitor size and graphics card memory. Movement through the virtual slide is continuous – as if one was viewing an actual case. These features illustrate how increased software sophistication introduces functionality extending beyond the capabilities of a conventional microscope. Other features include the ability to annotate the image, isolate regions of interest and import images from external sources. At all times it is possible to relate the image being viewed to a location on the slide overview image.

Areas are marked out for digitisation at a given microscope objective. The system then begins scanning with the status bars in the bottom right window providing feedback.
This system stores all images viewed in a single folder which can then be archived or transmitted for viewing by anyone with the client software. We have found average case file sizes to vary up to several hundred megabytes. Client software is available for Mac OS, Windows NT4, Windows 95/98 and will be Windows 2000 compatible. It does not require any form of installation and can be saved onto a floppy disk.

New Developments in Client-server Robotic Interactive Telepathology - Application within Quality Assurance

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Abstract
The National Health Breast Cancer Quality Assurance Scheme involves over 400 designated pathologists. The concept has been introduced that telepathology may reduce problems associated with circulating slides and feedback time in QA programmes. One solution was web-based telepathology complimented by CD-ROM distribution. The images and descriptive text are delivered in an HTML document and viewed on any web-browser. This labour intensive approach limits the number of high-power fields available for examination and lacks a realistic microscope interface.
While robotic microscope control via web-browser is attractive in theory, in practise such techniques suffer the inherent shortcomings of the java programming applets used to facilitate this, namely a lack of functional efficiency. Client-server telepathology represents a more versatile and robust platform from which to conduct large-scale image serving. Unfortunately, past systems have not been designed for mass-access or cross-operating system platform compatibility. We have introduced a multi-platform system which employs image handling and processing techniques in a combination not utilised before to extend the functionality beyond that of a conventional microscope. The pathologist benefits from the ease of operability, facility for multiple simultaneous users, and multiple fields of view.

Our client software is cross-platform, compact (< 1.4 megabytes) and does not require an installation programme. It exhibits all the advantages promoted by Java-based software without the disadvantages.
The cost of a robotic telepathology system is in the range of an average histopathology consultant's annual salary. From a medium term perspective, this is not an intimidating expense for a laboratory.
System components comprise a fully robotic microscope (Nikon E1000, Nikon UK), PC (350 Mhz Pentium II, 128M RAM, 32G harddrive, 8M graphics card, 15inch monitor), server software (WinNT server), telepathology server software (ZEM, The Netherlands).
The majority of telepathology systems have been designed for consultation via telecommunications lines. This is not an option for pathologists in district general hospitals lacking internet connections and being unable to afford dedicated ISDN lines. Consequently, we have refined and modified a system (in conjunction with Nikon UK and Zem technology) for the specific purpose of application within a quality assurance and education environment. This system is scaleable and can operate in full robotic interactive mode for live consultation or store-and-forward for users without high bandwidth connections. In both instances, it retains an interface which replicates conventional microscope functionality.