pathologist. These numbers change to 21,7% and 32,4% if image parts without any image information are excluded from prefetching.

The possibilities to speed up the viewing process by caching and prefetching are immense. Up to 25% of the overall investigated area may be presented without long Internet dependent loading times only by use of appropriate cache memory. This value may be increased up to 33% by combination of caching and prefetching. The real possible time win depends on the characteristic of the Internet connection to the WSI server and is not simple to specify.

Conclusion

The general procedure of investigating a histological slide with respect to the type of diagnosis – second opinion - was in the focus of our paper. We could show that the safety of diagnostic on WSI is comparable to the conventional diagnostic based on glass slides. Discrepancies go back to problems with the difficulty of the diagnosis itself and not to technical problems with virtual microscopy.

The specific behaviour in the diagnostic process may be used for the improvement of the user acceptance of virtual microscopy. Strong reductions of loading times are possible by using appropriate caching and prefetching.

REFERENCES

1. Dee FR. Virtual microscopy for comparative pathology. Toxicol Pathol. 2006;34(7):966-7.
2. Ficsor L, et al. Automated virtual microscopy of gastric biopsies. Cytometry B Clin Cytom. 2006;70(6):423-31.
3. Schrader T, et al. The diagnostic path, a useful visualisation tool in virtual microscopy. Diagn Pathol; 2006;1:40.
4. DICOM, editor. Specimen Identification and Revised Pathology SOP Classes, W.G. 26. (Suppl 122). Digital Imaging and Communications in Medicine; 2007.
5. Bloodgood RA, Ogilvie RW. Trends in histology laboratory teaching in United States medical schools. Anat Rec B New Anat. 2006;289(5):169-75.
6. Schrader T, et al. Study of Efficiency of Teleconsultation: The Telepathology Consultation Service of the Professional Association of German Pathologists for the Screening Program of Breast. Verh. Dtsch Ges Path. 2005;9:211-218.

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SMALL SIZE VIRTUAL SLIDES IN PATHOLOGY

Ferrer-Roca O, Marcano F, Quintana JJ
Spain

Abstract

Small Size Virtual Slide (SSVS) is a novel technique developed by us and consistent in low power slide scan with high resolution cameras that allow digital zooming. Implemented in the TEXCAN-II® software, it allows distant diagnosis on through intranet or Internet. Complete virtual slide seen online provides a level of diagnosis comparable with regular microscopy, in a fast and reliable way, minimizing storage requirements.

In the present paper the SSVS technique was assess on fifteen cytology and pathology specimens evaluated by ten pathologists, that have never done distant diagnosis or try telepathology systems, obtaining a ROC diagnostic curve of 0.95.

Introduction

Several approaches have been proposed for an efficient distant diagnosis using static images in pathology. Among those Dynamic Robotic Telepathology (DRT)(1), Virtual Slides (VS) and recently Small-Size Virtual Slides (SSVS)(2,3).

In DRT, the remote pathologist browses and selects the slide field of views (FOV) are transmitted for diagnosis. Pathologist controls interactively the DRT microscope. Only selected FOV's are transmitted in the resolution allowed by the system, in real time.

Virtual slides provide a way for handling concurrent processes of analysis and diagnostic doing by any group of healthcare experts. Similar to DRT, pathologist can select for view a FOV's of the whole digitized slide; only this part will be transmitted. In VS there is no zoom-in and the zoom-out is handled by software.

By contrast, the novel SSVS® technique capture the slide at a low power and digitize in the highest compression possible to keep diagnostic quality of original slides. As a result of this size of the slide is 100 times smaller than VS facilitating transmission and storage (4).

The SSVS is JPEG2000 (5) format, and therefore use wavelet compression (6). Apart from color standardization and wavelet compression well standardized (1,7), the SSVS established the capture technique at low power microscope objectives, producing high quality focused images (ZoomFocus®)(2) in a reduce storage space. Images are composed and compressed to allow their efficient transmission through Internet. Zoom-in of SSVS depends on the high resolution of the camera and zoom-out on a panoramic view is similar to VS.

TEXCAN-II® implements SSVS technique, providing: a) a spatial resolution that allows a extreme digital zoom; b) a high quality focused images; c) minimal requirements for diagnostic-quality images; d) remote fast consultation of slides and e) a non-expensive digital virtual microscope.

This study assesses the diagnostic capability of SSVS in cytology and pathology.

Materials and methods

High resolution camera: AVT-Oscar F-810C
Fireware IEEE1394 camera, CCD 2/3" Sony sensor, 8 Mpixels, 12 bits/pixel. The system is integrated into the TEXCAN-II®, using AVT-Allied Vision Technologies(8), CVB(9) y LeadTools(10) libraries. TEXCAN-II® controls white balance, image focus in zoom 1:1, image noise reduction, shading correction, etc.

Optical acquisition system: Olympus BH-2 microscope
Total scan is carried out with SPlan 4x objective, 0.13 NA, relay tube lens NFK 2.5x LD of 125 and total power of 10x.

Each region of interest (ROI's) is scanned with a 0.46 NA SPlan 20x objective and total power of 50x. This includes random areas (red) or areas selected by technician (green).

SSVS samples

Fifteen cases were used, corresponding to three histological and twelve cytological samples, classified for malignancy.

SSVS generation

Individual FOVs were composed (*stitched*) by the TEXCAN-II® that integrate Panavue Image Assembler® 3.4 (11) (Figure 1).

SSVS transmission and browsing

Transmission was carried out by the TEXCAN-II® server. It contains an efficient JPEG2000 transmission protocol (JPIP) (12, 13), based on Kakadu 5.2 library(14). It is located at www.cataibreezee.ull.es:81.

Browsing is done with the TEXCAN-II® Viewer, also based on Kakadu 5.2 library.

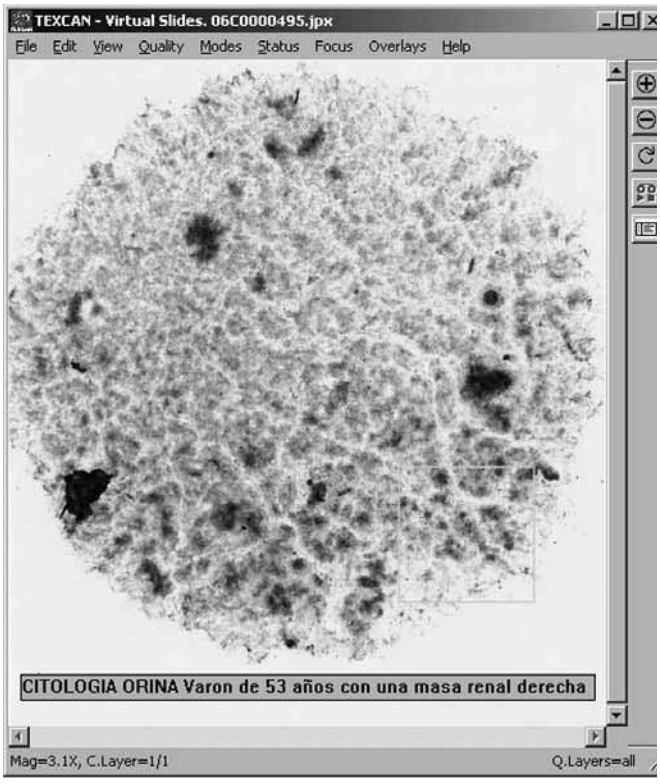
Diagnostic assessment

The diagnosis of cases are done "on line" in the TEXCAN-II® portal that can also be accessed through the TEXCAN-II® Viewer.

Diagnostic assessment was remotely performed by ten pathologists, individually and independently from each other, using the Web form shown in Figure 2. None of them have ever used a telediagnostic system.

Only malignancy was evaluated in this case according a discrete integer scale (1 to 5), being 1 – definitively negative, 2 –probably negative, 3 – with doubts, 4 –probably positive, 5 – definitively positive.

Any other comments were written in a specific box.



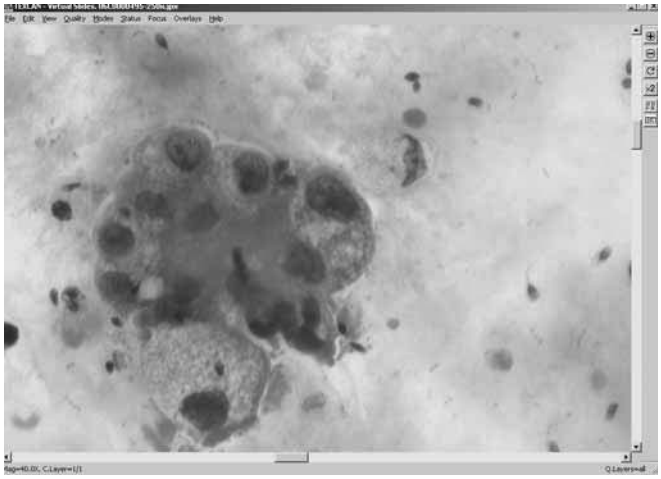


FIGURE 1. *a) Panoramic view 3.1x of a SSVS cytology. Patient data and ROI (selected by the cytotechnologist); b) B. ROI at 250x*

FIGURE 2. *TEXCAN-II® evaluation form*

ROC curves were plotted based on evaluation data provided by pathologists, using SPSS v.14.0(15) statistical software.

Results

ROC analysis applied for malignancy is seen in Figure 3, where the area under the curve reached 0.95 with a $p < 0.0001$.

Comments of the users include the fact that would like to have more ROI areas, that security in diagnosis is higher in pathology specimens (Figures 4) than in the cytology ones (Figures 1). They were particularly impressed by the degree of zoom in pathology (Figure 4d).

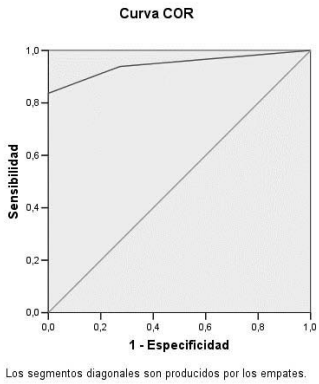


FIGURE 3. *ROC curve for malignancy. Diagnostic area 0.95; $p < 0.0001$*

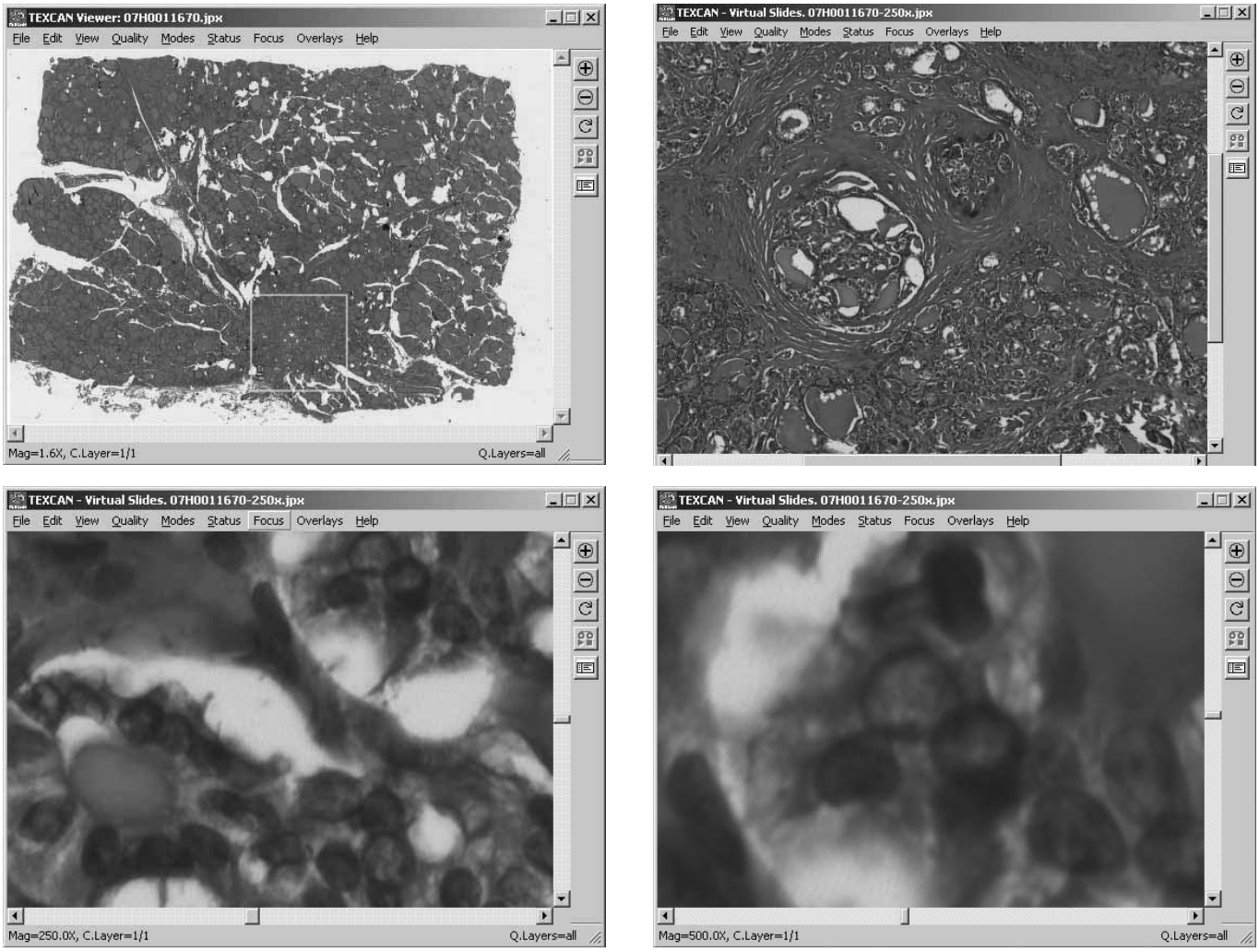


FIGURE 4. *Pathology SSVS a) 1.6x; b) ROI at 15.6x ; c) ROI at 250x (1:1 zoom) ; d) 500x digital zoom*

Discussion

The present paper evaluates the technique of the Small Size Virtual Slide (SSVS) for diagnostic purposes. This technique has been demonstrated very useful reducing the storage and transmission requirements and speed. In the present paper the diagnostic capability of the SSVS is assessed.

One of the main drawbacks for the pathology diagnosis at distance is the sampling error if the slide is not completely digitized. In the case the slide is fully digitized the VS technique use 40x objective; as a results the image have a huge size (around 10 GB) and is difficult to handle. Not only by new compression techniques base in wavelets, but also in order to be integrated into the hospital information system which images are DICOM in format, which limit of handling is 2 GB.

The technique of the SSVS using zoom-focus and digitizing with an objective of 4x with ROIs using 20x objective has been demonstrated ideal for storage and transmission (2-4,18). In this paper we demonstrate that is also perfect for distant diagnosis.

Being tested by pathologists that have never been introduced into the distant diagnosis techniques, they found that the technique is extraordinary good for pathology slides, and it also fine for cytology assuring that the ROI is done appropriately. For this reasons they demand either good cytotechnologists for ROI selection or more random ROIs.

In summary: TEXCAN-II® is an ideal system not only for local use in the pathology lab in order to store in a limited space the slides but also to use it to share discussions in the network of the lab or at distance.

REFERENCES

1. Ferrer-Roca O. Telepathology. In Ferrer-Roca O, Sosa-Iudicissa M. Handbook of Telemedicine. Amsterdam: IOS-Press; 1998. p. 70-5.
2. Ferrer-Roca O, Marcano F, Diaz-Cardama A. Digital Zooming in Medical Images. In Ferrer-Roca O. Ed. CATAI-2006: p-health. Tenerife: CATAI Ed.; 2005. pp. 111-118. ISBN: 84-609-8648-9.
3. Ferrer-Roca O, Marcano F, Quintana, J. Small Size Virtual Slides in Cytology. In Proceedings XXIII European Congress of Cytology. Madrid (Spain); 2007
4. Marcano F, De Armas N, Díaz-Cardama A, Ferrer-Roca O. Collaborative Systems for Pathology Applications. The Open Pathology Journal. 2007;1:1-4. (cited 2007 Dic 31st). Available from: http://www.bentham-open.org/pages/gen.php?file=1TOPATJ.pdf
5. JPEG2000; 1999. (cited 2007 Dic 31st). Available from: http://stargate.ecn.purdue.edu/~ips/tutorials/j2k/

6. JPEG2000 decomposition; 2001. (cited 2007 Dic 31st). Available from: http://www.gvsu.edu/math/wavelets/student_work/EF/how-works.html
7. DICOM strategic document; 2007. (cited 2007 Dic 31st). Available from: http://medical.nema.org/dicom/geninfo/Strategy.pdf
8. AVT- Allied Vision Technologies. http://www.intek-darmstadt.de
9. CVB Common Vision Blox http://www.commonvisionblox.com
10. Leadtools Medical Image SDK; 2007. (cited 2007 Dic 31st). Available from: http://www.leadtools.com/SDK/Medical/Medical-Products-n.htm
11. Panavue Image Assembler ; 2006. (cited 2007 Dic 31st). Available from: http://www.panavue.com
12. Taubman D, Prandolini R. Architecture, philosophy and performance of JPIP: internet protocol standard for JPEG2000, International Symposium on Visual Communications and Image Processing (VCIP2003). In: Ebrahimi T, Sikora T, editors. Proceedings of SPIE (vol 5150); 2003. p. 649-663.
13. Krishnan K, Marcellin MW, Bilgin A, Nadar MS. Efficient transmission of compressed data for remote volume visualization. IEEE Trans Med Imaging. 2006;25(9):1189-1199.
14. Kakadu software; 2007. (cited 2007 Dic 31st). Available from: http://www.kakadusoftware.com
15. SPSS Statistical Software; 2007. (cited 2007 Dic 31st). Available from: http://www.spss.com
16. Ho J, Parwani AV, Jukic DM, Yagi Y, Anthony L, Gilbertson JR. Use of whole slide imaging in surgical pathology quality assurance: design and pilot validation studies. Human Pathology. 2006;37(3):322-31.
17. Bradley A, Wildermoth M, Mills P. Virtual Microscopy with Extended Depth of Field. In Proceedings of the International Conference on Digital Image Computing: Techniques and Applications, DICTA 2005. IEEE Computer Society; 2005. p. 235- 242. ISBN 0-7695-2467-2.
18. Marcano F, Ferrer-Roca O, Diaz-Cardama A. Automatic-stiching in pathology. In: Ferrer-Roca O, editor. CATAI 2007: Telemedicine standardization. Tenerife: CATAI Editions; 2006. p. 161-168.