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INFLUENCE OF DISPLAY CHARACTERISTICS ON CLINICAL PERFORMANCE IN DIGITAL PATHOLOGY

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Introduction/ Background

Digital Pathology adoption is increasing rapidly. Recent technological advances have resulted in a steep increase in the performance and quality of digital pathology systems. Quality assurance mechanisms are being developed to ensure consistent quality of scanned slide images. However one important component that surprisingly is often overlooked is the display system. Pathologists base their diagnosis on the images presented by the display. The quality of these digital images depends on all of the components in the imaging chain, including the display itself. Even a perfectly scanned high quality image will not be useful if it is visualized on a low quality display.

Aims

The goal of this paper is to study important display characteristics and to determine what their effect is on percent correct diagnosis, reading time, diagnostic confidence and inter-pathologist-agreement. Furthermore a recommendation will be provided for minimum requirements of a digital pathology display system.

Methods

This paper combines and analyses results of several experiments that we have performed during the last two years. These studies included actual clinical studies where pathologists diagnose clinical images, reading studies where pathologists subjectively score quality of clinical images, as well as bench testing on both test and clinical images. Separately analyzing the influence of display luminance, color settings, calibration and quality assurance, stability and resolution allows us to determine a relative importance of these characteristics. It also allows recommending minimal display specifications

Results

A first clinical study analyzed the impact of luminance and color instability/aging of display systems on reading time, percent correct diagnosis, and inter pathologist agreement. 120 clinical digital pathology images were presented to pathologists. The images were scored and the diagnosis and reading time was recorded. The study shows that both luminance and color instability result into lower percent correct, lower inter pathologist agreement, and higher reading time. The results also suggest that color instability has a larger influence than luminance instability. A second study focused on color settings of a display. Three different calibration settings were compared: "sRGB", "DICOM GSDF" and a recently proposed new standard "CSDF". Bench testing and subjective reader preference analysis was performed. Results indicate that perceived contrast of clinically relevant features in digital pathology images is higher when using CSDF compared to sRGB and DICOM GSDF. A final study looked at display size, resolution, contrast and luminance and their influence on subjective quality preference, ease of reading and reading time. Based on the combination of these different results we make clear recommendations for minimum specifications for digital pathology display systems.



Percentage agreement between pathologists for: stable display, display with instable color, display with instable color and luminance

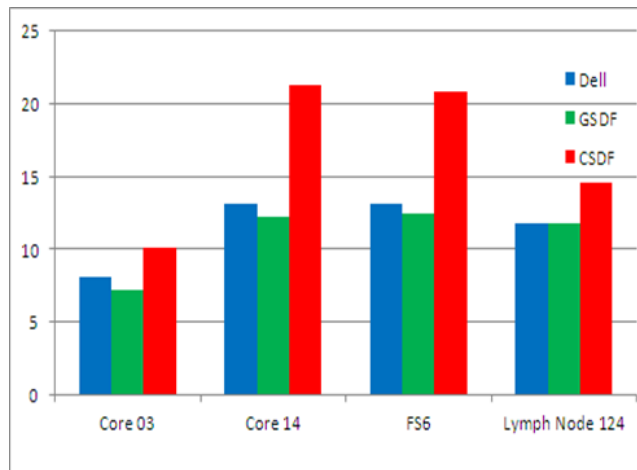
	Reader A	Reader B	two-reader aggregate
Non-aged	69.23 [53.6, 81.4]	55.26 [39.7, 69.9]	62.34 [51.2, 72.3]
Chroma aging	52.50 [37.5, 67.1]	50.00 [35.2, 64.8]	51.25 [40.5, 61.9]
Chroma+luma aging	50.00 [35.2, 64.8]	47.50 [32.9, 62.5]	48.75 [38.1, 59.5]

Average reading time for: stable display, display with instable color, display with instable color and luminance

	Reader A	Reader B
Non-aged	41.03 ± 5.38	30.79 ± 1.87
Chroma aging	49.13 ± 6.62	33.00 ± 2.13
Chroma+luma aging	51.20 ± 6.35	33.38 ± 2.26

Ease of reading for: stable display, display with instable color, display with instable color and luminance

	Reader A	Reader B
Non-aged	9.72 ± 0.19	9.74 ± 0.25
Chroma aging	8.83 ± 0.44	9.40 ± 0.31
Chroma+luma aging	8.38 ± 0.40	7.63 ± 0.59



Difference between feature foreground and background

Image	CSDF / GSDF	CSDF / sRGB
Core03	1.399	1.244
Core14	1.74	1.617
FS6	1.674	1.589
Lymph Note 124	1.24	1.239
	CSDF / GSDF	CSDF / sRGB
Average dE2000 difference between feature and background	1.513	1.422
Standard deviation of dE2000 difference between feature and background	0.235	0.209

References:

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- [3] Avanaki A., et al., Aging display's effect on interpretation of digital pathology slide, *Proc. SPIE9420, Medical Imaging 2015: Digital Pathology*, 942006.