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Does the choice of display system influence perception and visibility of clinically relevant features in digital pathology images?

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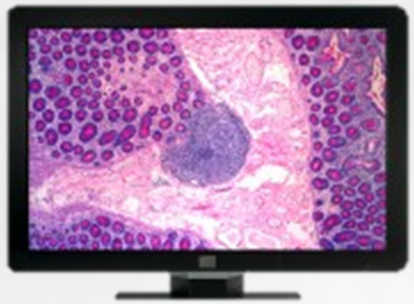

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Outline

We study the impact of the display on perception and visibility of clinically relevant features in digital pathology

- Quantify the difference of display systems
- Study the difference of display systems in clinical performance

Agenda:

- Background
- Methods
- Results
- Conclusions and future work

Background: Digital pathology systems

- Digital pathology systems typically consist of
  - **Slide scanner**
  - **Processing and visualization/rendering software**
  - **A medical display**

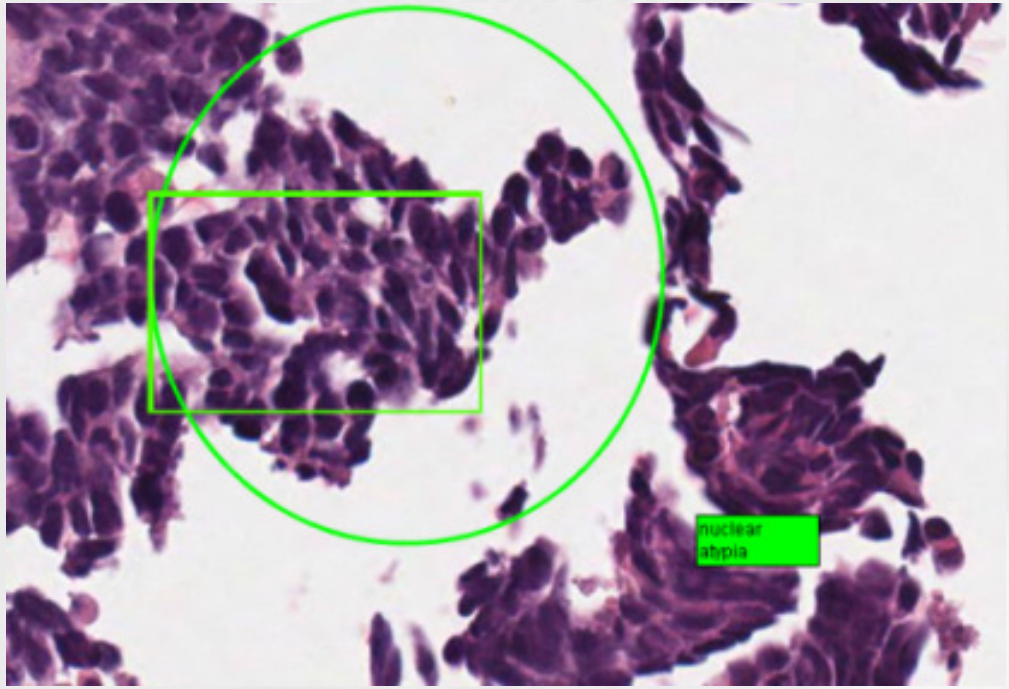
- The display is a very important component since it presents the final images to the pathologist

Background: State-of-the-art medical color displays

- Clinical use of color medical images is low in comparison to gray scale images
- Today's state-of-the-art medical color display systems don't yet fully address [1; 2]
  - **Whitepoint variations between displays and over time**
  - **Color gamut variations between displays and over time**
  - **Color non-uniformity throughout the display**
  - **Optimal rendering of colors** (maximizing color discrimination)
- Research is ongoing to define and standardize a color calibration target [3] for medical color displays that guarantees optimal visualization of medical color images

Methods: Clinically Relavent Features

- Four digital pathology images of different subspecialties were selected, and clinically relevant features were marked by a pathologist



muscle core biopsy involved by Ewing sarcoma (image: Core14)

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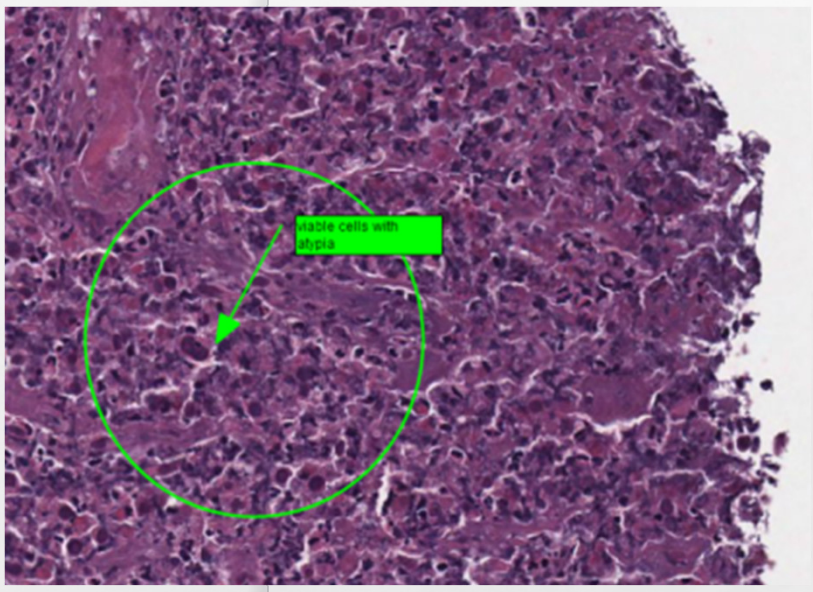
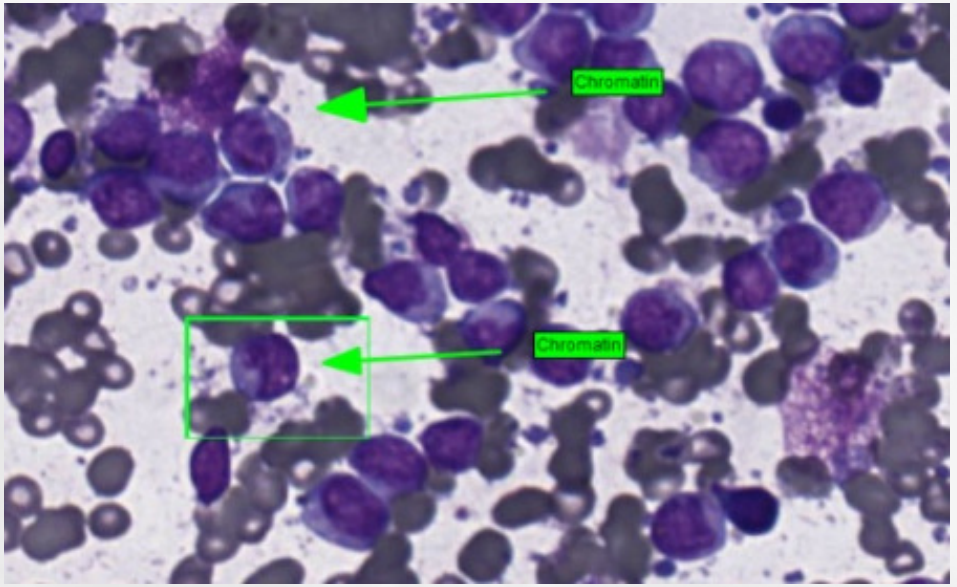
Methods: Clinically Relavent Features

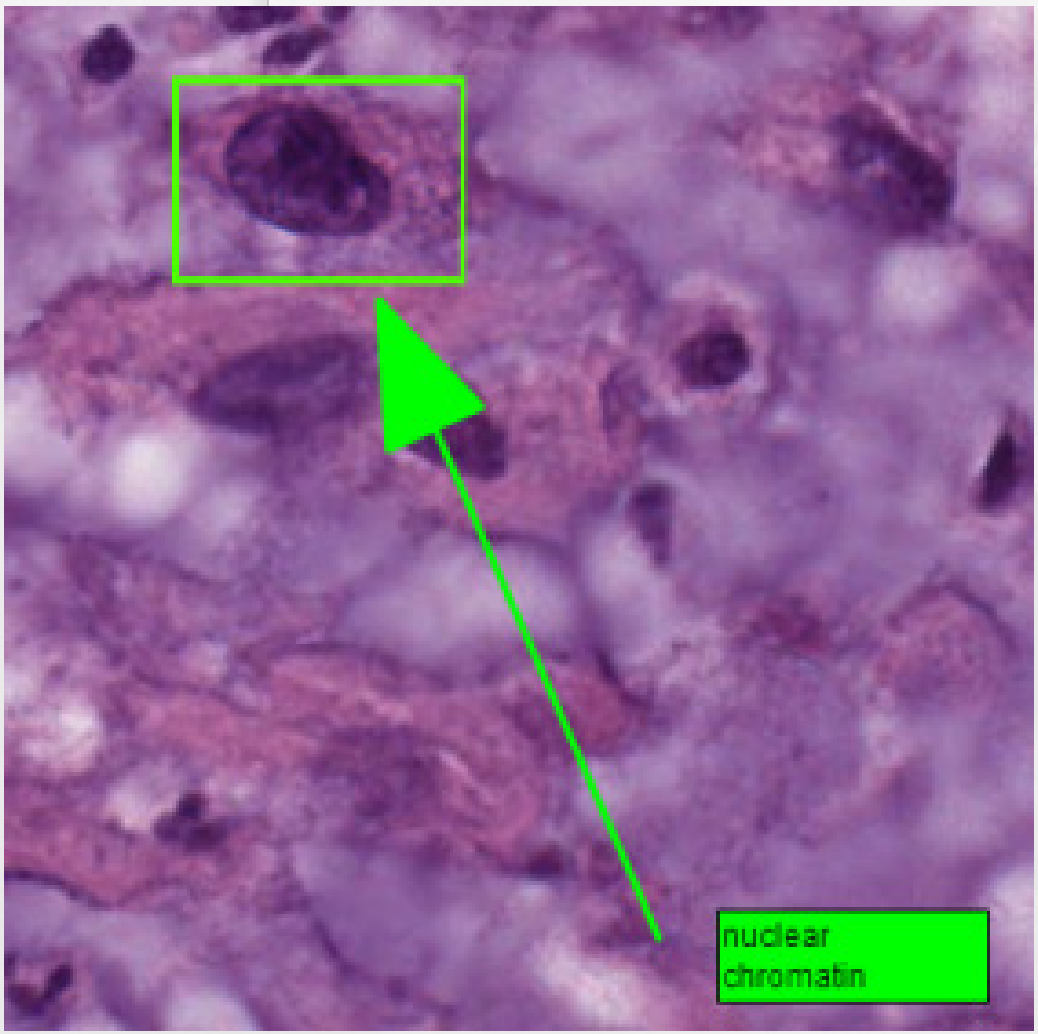


mediastinal lymph node biopsy with Hodgkin lymphoma (image:Core03)



cytology fine needle aspirate from a lymph node showing non-Hodgkin lymphoma (image: Lymph Node 124)

Methods: Clinically Relavent Features



frozen section from a bone lesion due to metastatic urothelial carcinoma (image: FS6)

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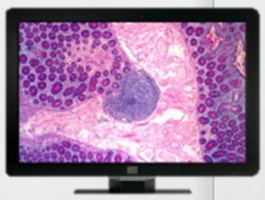
Methods: Display Systems



- Three different display systems have been compared in this study:
  - DELL 1907FP, resolution 1280 x 1024, **sRGB**, luminance 210 cd/m², contrast ratio 700:1
  - Barco MDCC-6230, resolution 3280 x 2048, **DICOM GSDF** calibrated, luminance 500 cd/m², contrast ratio 900:1
  - Barco MDCC-6230, resolution 3280 x 2048, **CSDF** calibrated, luminance 500 cd/m², contrast ratio 900:1

- The focus of the comparison was on the color behavior (rather than on other aspects such as resolution/contrast/luminance)
  - sRGB
  - DICOM GSDF (Grayscale Standard Display Function) [4]
  - a newly proposed perceptually uniform color space "CSDF" [3]

Methods: Comparison of display systems

"Do pathology images look different on different display systems?"

- analyzing perceived differences between display systems

  - **calculations [5] to quantify perceived differences**
    - DeltaE2000 calculations between different display
    - The same clinically relevant area

  - **Visible Difference Predictor (VDP)/JNDMetrix like analysis [6; 7] to determine the location of perceived differences**

Methods: Comparison of display systems

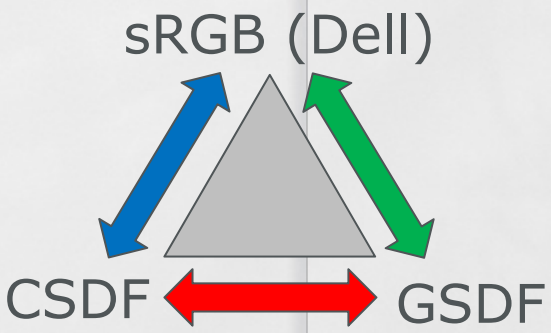
"Do differences in displays mean that there is difference in clinical performance?"

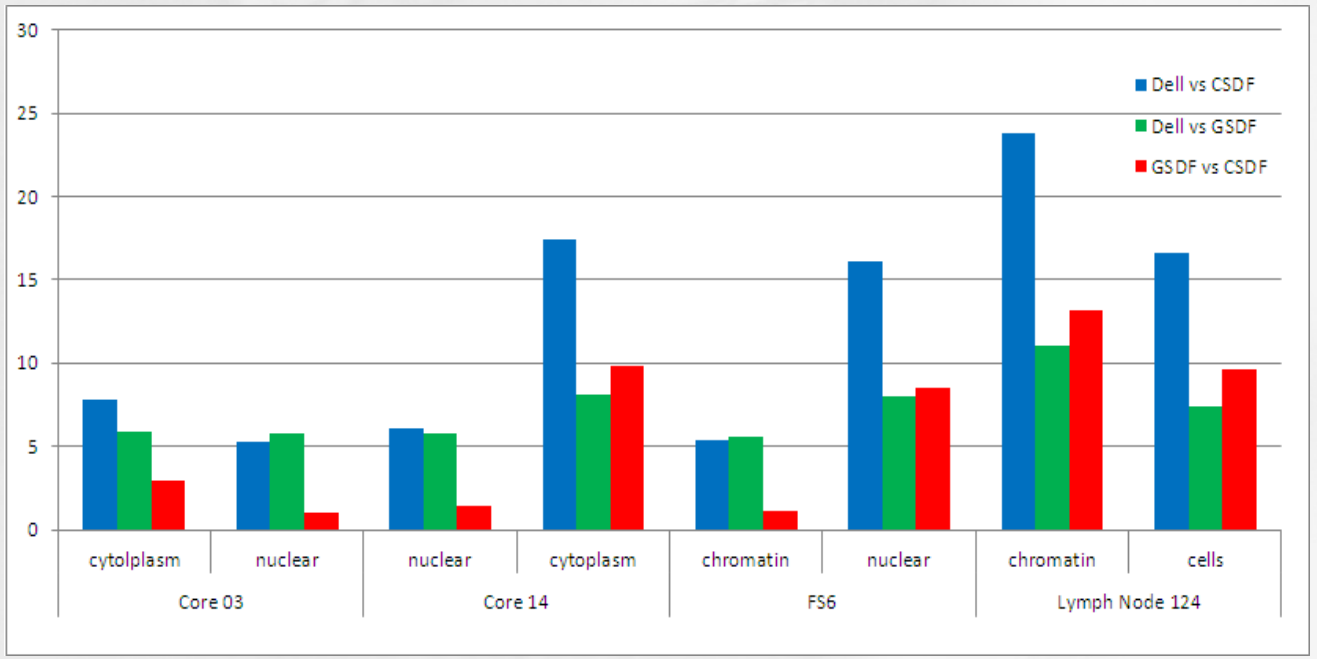
- analyzing perceived contrast of clinically relevant features
  - **DeltaE2000 calculations between the background and foreground of clinically relevant areas on the same display.**
  - **Compare the DeltaE2000 calculations of different displays**

Results: perceived differences between display systems

Intra-case difference between display systems (color spaces), measured in deltaE2000

- **Important remark: <u>not</u> ranking or quality score**
- **Purely quantifying how different sRGB, GSDF, CSDF images are from each other**



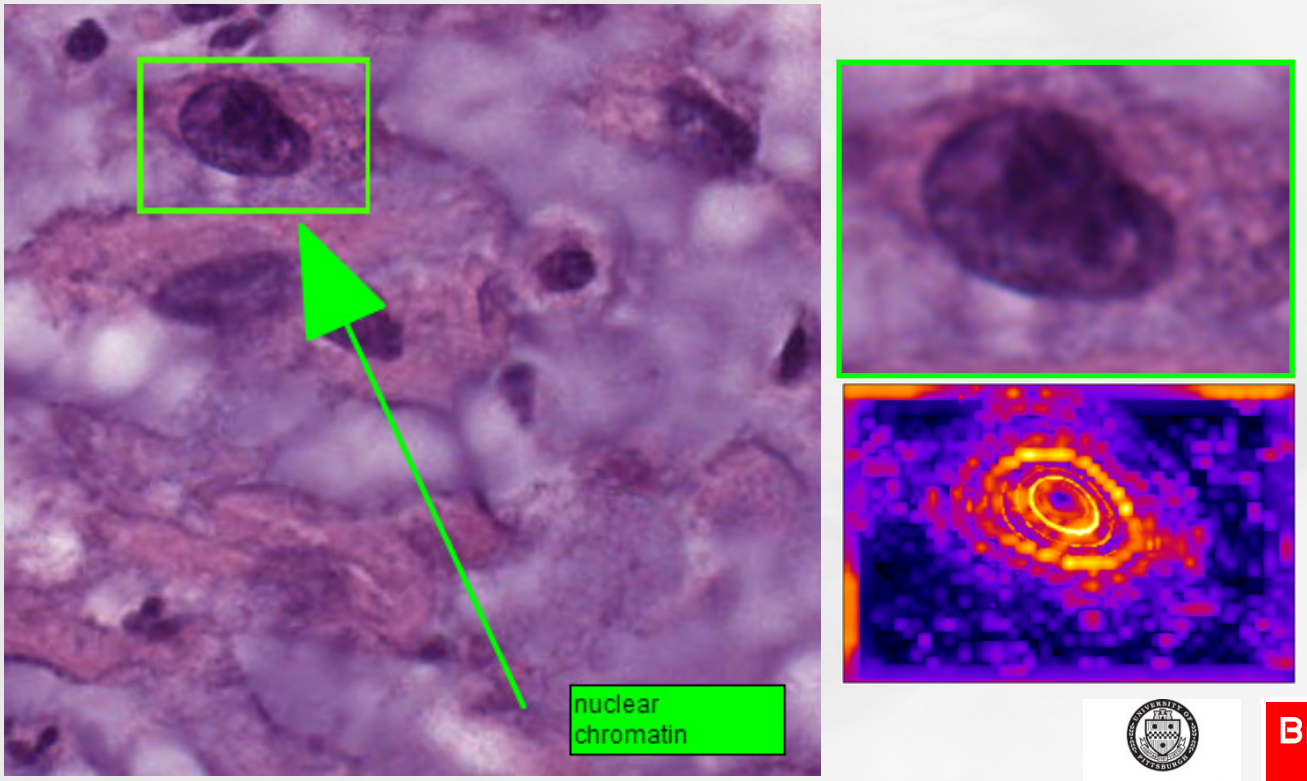


- The degree of difference depends on the subspecialty
- The choice of color target (sRGB / GSDF / CSDF) has a large impact on appearance of images

Results: perceived differences between display systems

Visible Difference Predictor (VDP) / JNDmetrix:
perceived differences are located in clinically relevant areas

DICOM GSDF vs. CSDF



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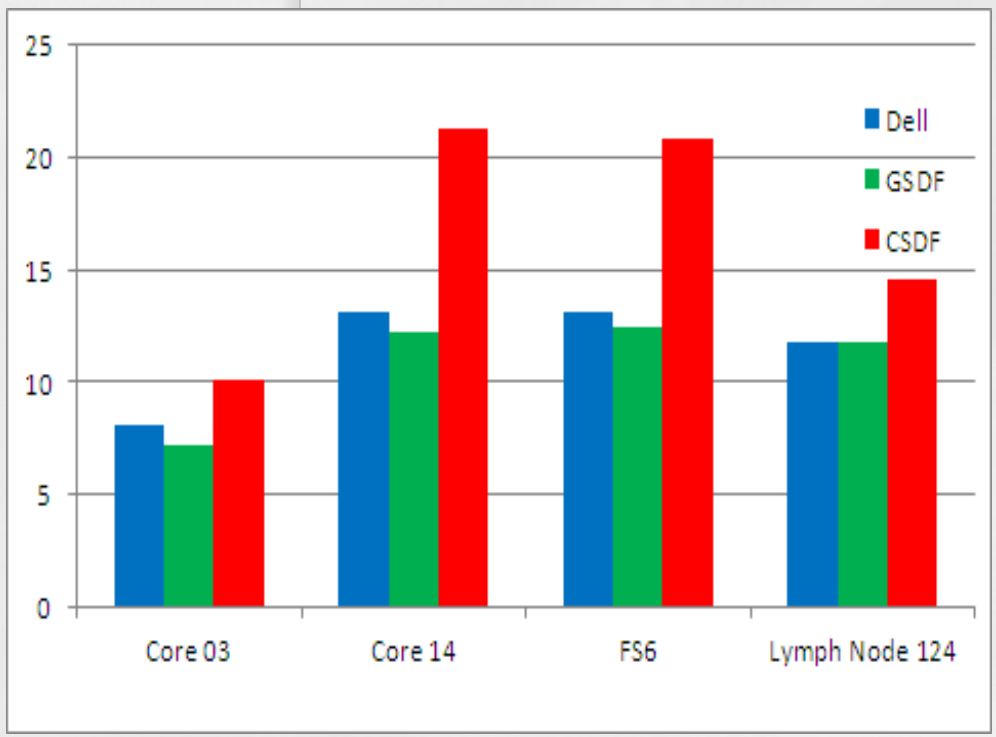
Results: perceived contrast of clinical relevant features

- GSDF and sRGB approximately offer the same perceived contrast
- CSDF always results in higher perceived contrast of clinically relevant features (on average 50% higher perceived contrast with min 25% and max 70% higher contrast)



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

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Conclusions

- The color space of the display has a significant impact on the perception of clinically relevant areas of digital pathology images
  - The degree of difference depends on the subspecialty
  - The choice of color target (sRGB / GSDF / CSDF) has a large impact on appearance of images
- A newly proposed color calibration target (CSDF) has shown to increase perceived contrast of clinically relevant features ~50%
- Future work
  - Confirmation of these findings in a clinical study
  - Working towards standardization (mRGB) [8]

References

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[2] Ali Avanaki, Kathryn Espig, Tom Kimpe, Albert Xthona, Cedric Marchessoux, Johan Rostang and Bastian Piepers, “Perceptual uniformity of commonly used color spaces”, SPIE medical imaging 2014

[3] Tom Kimpe, Ali Avanaki, Kathryn Espig, Johan Rostang, Cédric Marchessoux, Bastian Piepers and Albert Xthona, “Requirements, desired characteristics and architectural proposal for a visualization framework for digital pathology”, SPIE medical imaging 2014

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