

Experiments demonstrate why bench tests are required for third-party WSI viewers

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Clinical Area:
Medical Imaging

ABSTRACT

Three freely available third-party whole-slide image viewers were compared with the factory viewer on the pixel level. Experiment results show that some viewers generated excessive errors.

BACKGROUND

A whole-slide imaging (WSI) system used in digital pathology consists of the scanner, viewer, and display components. So far, only two WSI devices have been cleared by the FDA. Recently, independent WSI viewers were submitted by third-party vendors to replace the original viewer component as alternatives. However, these viewers were not adequately tested because the vendors believe that the image is just digital data and will not be altered by their software.



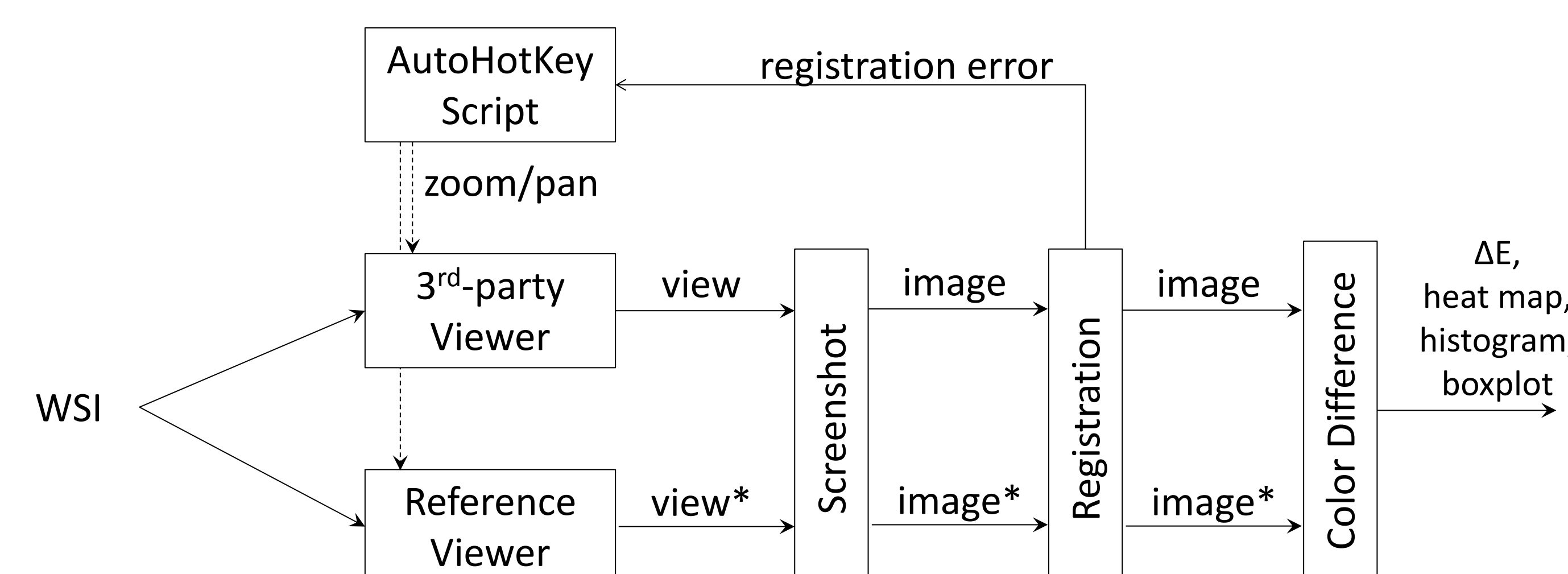
Components of a WSI system

RESEARCH QUESTION

Do different WSI viewers generate identical images for the same WSI file?

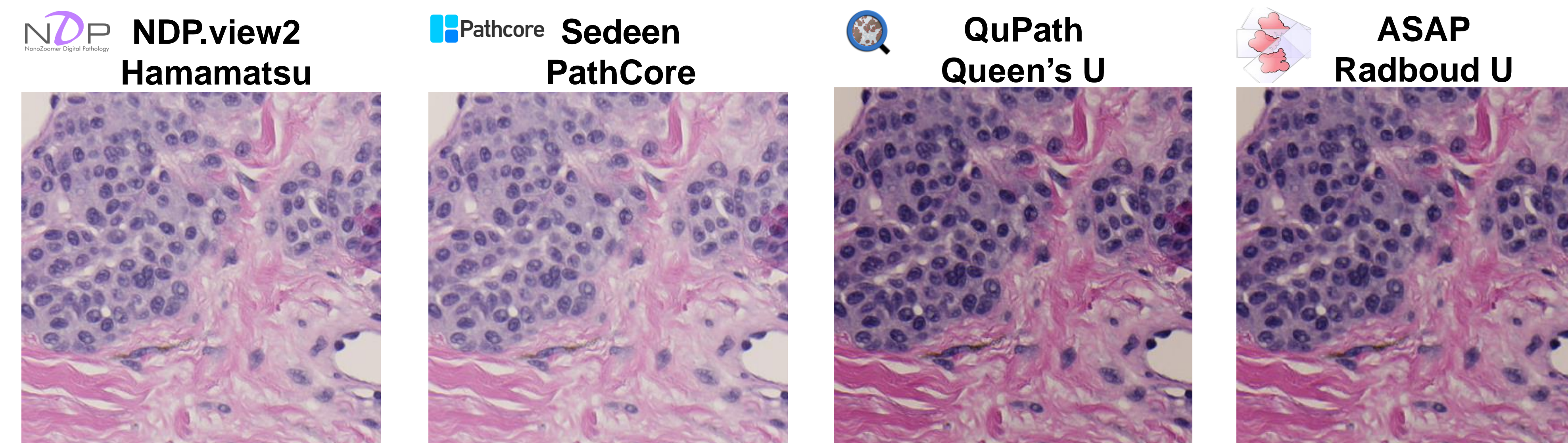
METHODOLOGY

1. Use AutoHotKey to open the same WSI file with two different viewers
2. Use AutoHotKey to generate keyboard/mouse events to select a predefined region-of-interest (ROI) in the reference viewer
3. Use AutoHotKey to select the same ROI automatically in the third-party viewer
4. Use Windows Snipping Tool to capture and save the screenshots [1]
5. Use MATLAB to check the registration accuracy; if not registered correctly, go back to Step 3
6. Use MATLAB to calculate the color difference (ΔE) for each pixel
7. Use MATLAB to report statistical and graphic results



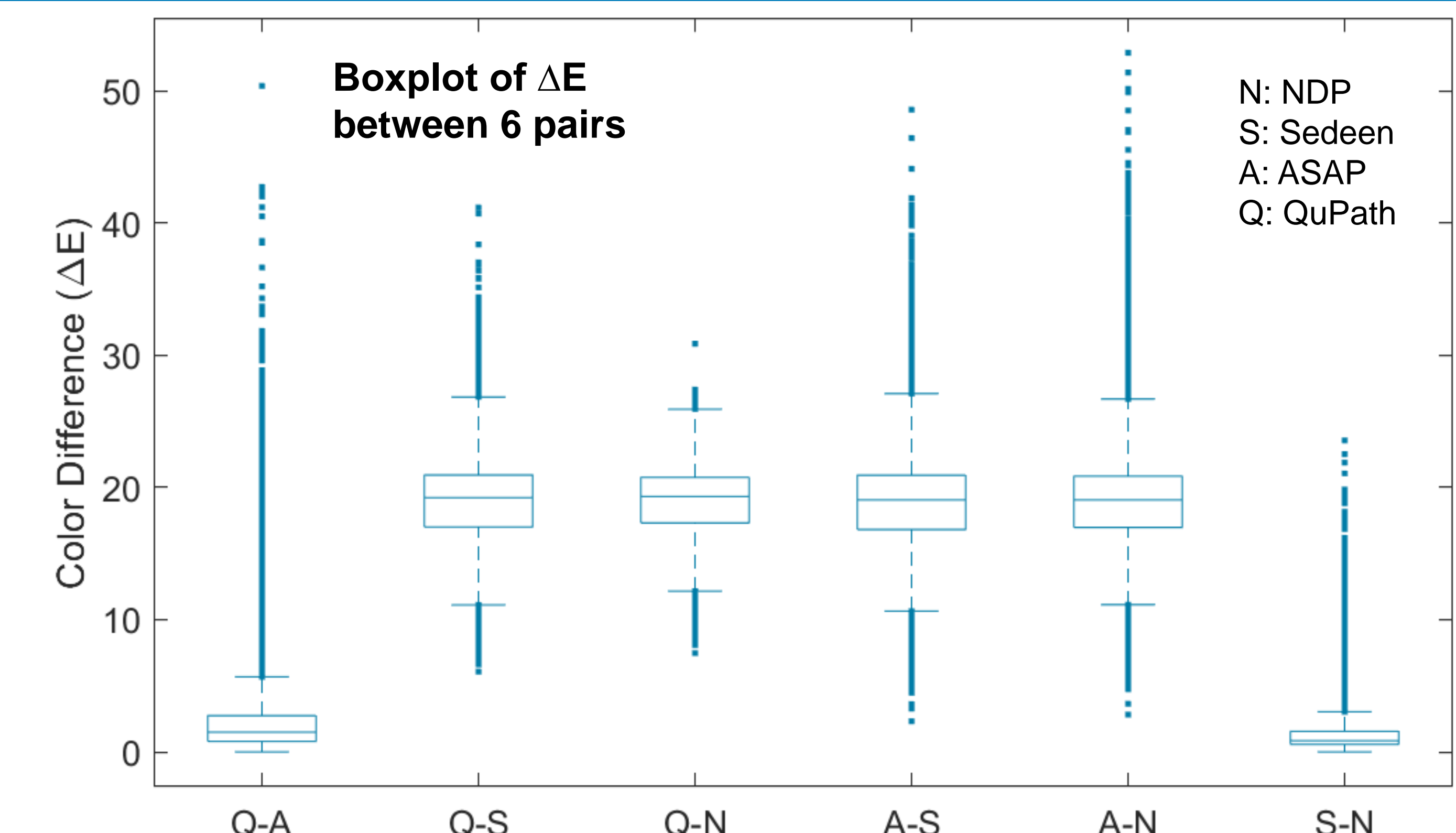
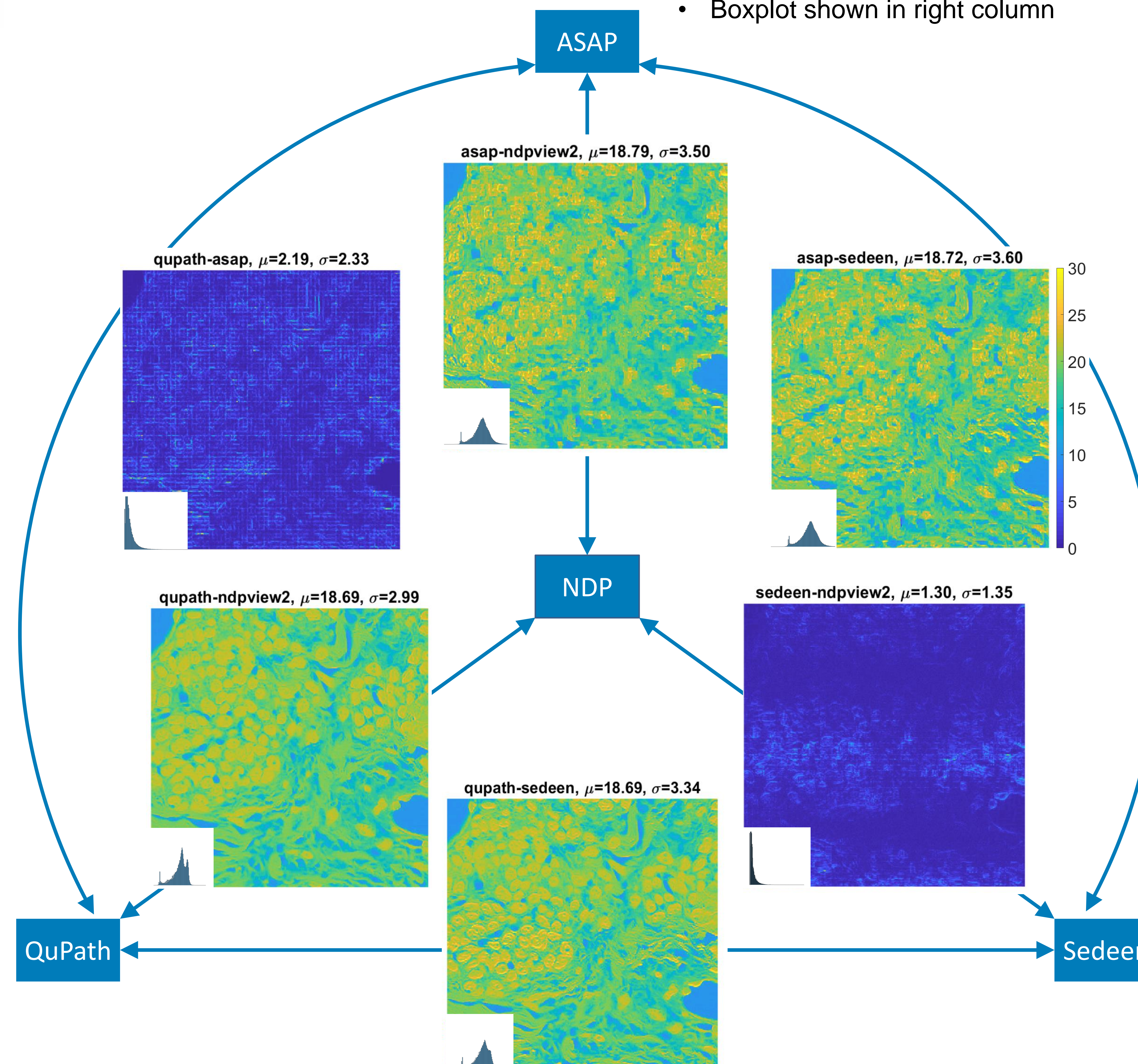
TEST SUBJECTS

- Input WSI file: "CMU-1.ndpi" generated by a Hamamatsu scanner
- Four WSI viewers and their output images:



RESULTS

- Four images: 6 pairs to compare
- Heat maps show ΔE for each pixel
- Mean and standard deviation shown in title
- Histogram shown in inset
- Boxplot shown in right column



FINDINGS

NDP and Sedeen:

- Very close but not identical ($\mu=1.30$, $\sigma=1.35$)
- ΔE pattern does not correlate with tissue structure
- A few pixels have high ΔE (outliers)

ASAP and QuPath:

- Different from reference ($\mu=18.79$ and $\mu=18.69$)
- ΔE w.r.t. reference correlates with tissue structure -- nuclei have higher ΔE (yellow); stroma lower (green)
- Different from each other ($\mu=2.19$, $\sigma=2.33$) in macroblock patterns

ASAP vs NDP/Sedeen/QuPath

- "Pixelized" ΔE patterns similar to lossy compression

CONCLUSIONS

For the same input file, four different WSI viewers generated four different images, which confirms that it is a fallacy to assume that any WSI viewer can reproduce digital images identically. The concept of interoperability between WSI components needs to be revisited to include image integrity on the pixel level. Before a WSI file format is standardized, third-party viewer vendors should work with the scanner manufacturer instead of relying on untested free libraries. More adequate bench testing data are needed for 510(k) WSI viewer submissions.

FUTURE WORK

- Determine sources of ΔE (color profile? JPEG?)
- Repeat experiments for cleared devices (Philips, Leica)
- Develop bench test methods (software, hardware)
- Determine acceptable criteria

REFERENCE

1. Calvin Sun and Wei-Chung Cheng, *How Much Can Bad Display Calibration Cost?* 2017 FDA Summer Student Poster Day.

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