The Leeds Teaching Hospitals NHS
NHS Trust

Point of Use QA: Digital Pathology Slides

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Outline

- Building on existing work in X-ray imaging, will illustrate the need of point of use QA as an adjunct to component QA.
- To present early stage design considerations specifically for digital pathology.
- Propose possible solution to quantify image integrity.

What's the problem?

- Analogue:

  Acquisition and display are linked proving image context or ‘frame of reference’.

- Digital:

  Acquisition and display are unlinked removing context; There is no ‘digital frame of reference’. This is compounded by the potential for unlimited post acquisition processing.

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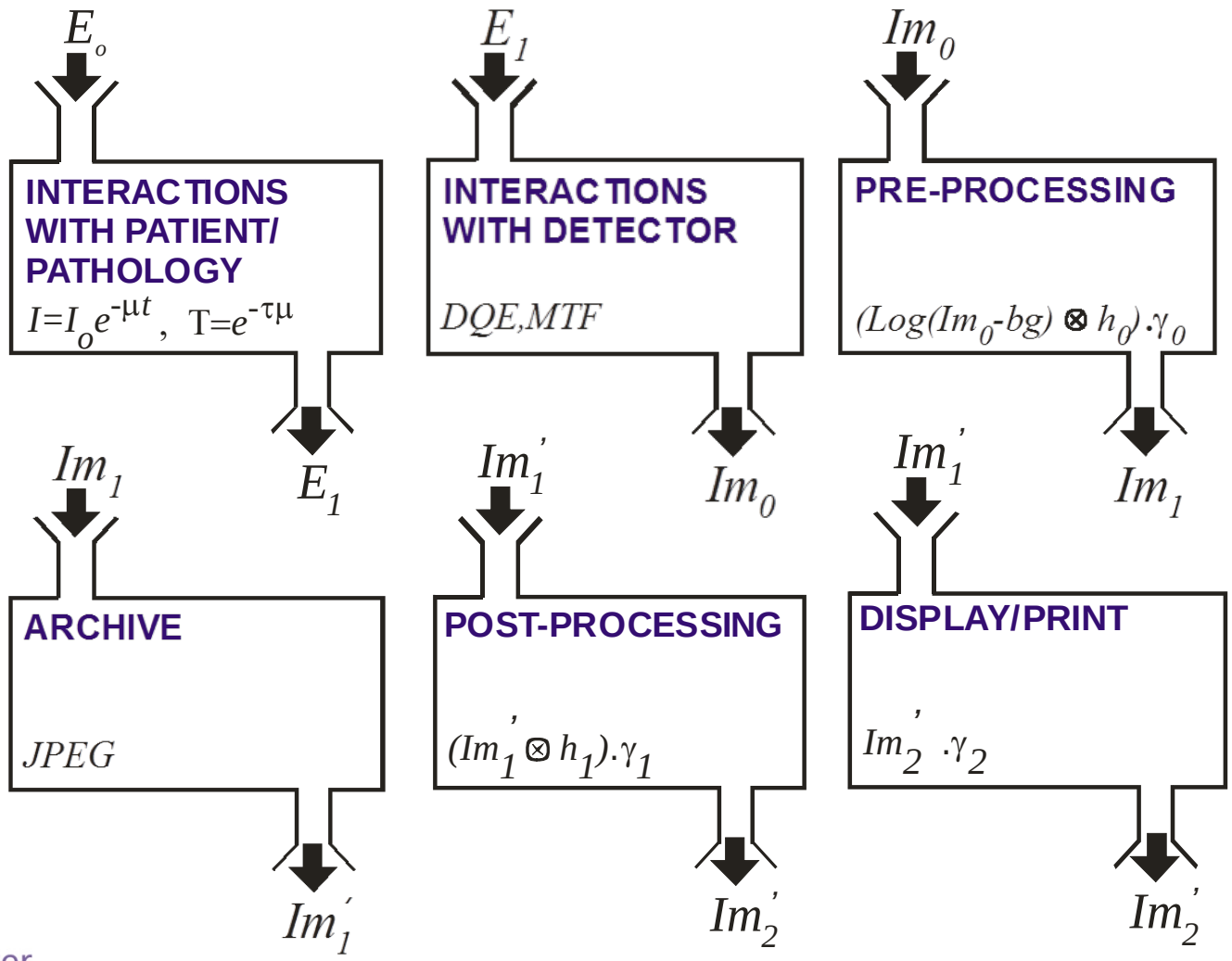
The Digital Image Chain



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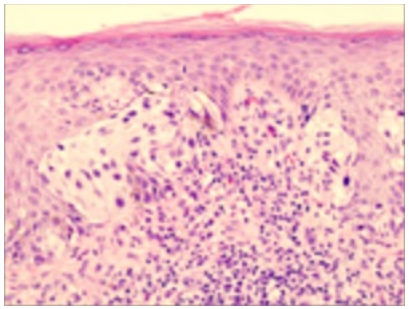
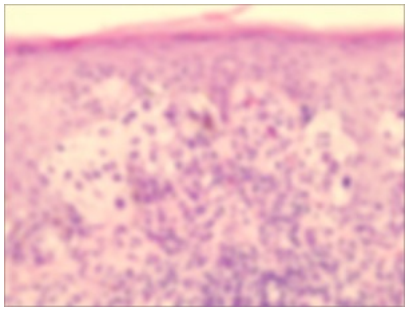
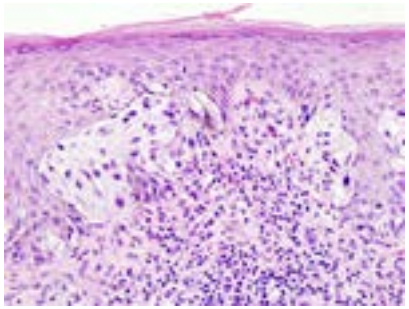
The Digital Image Chain



Transmission

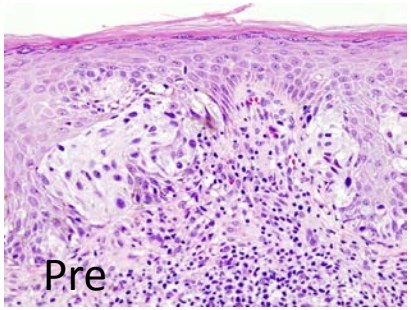


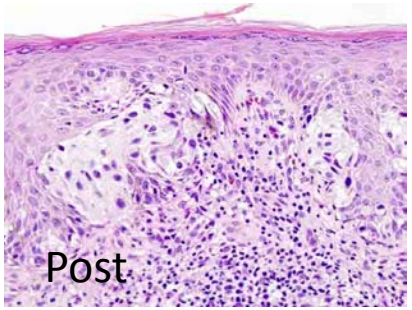
Detection

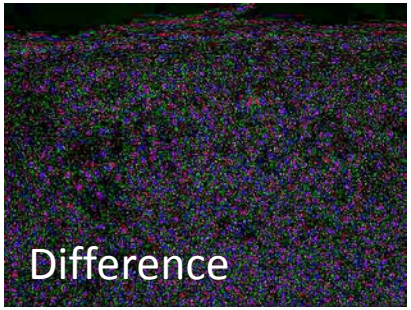


Pre-processing

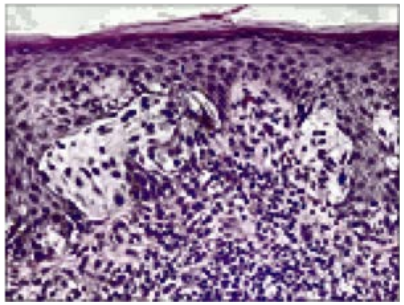
Compression

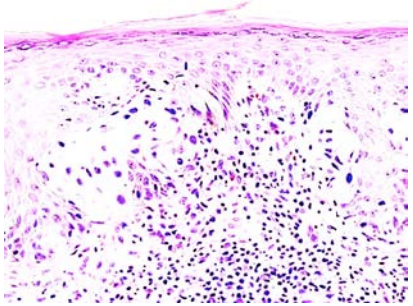


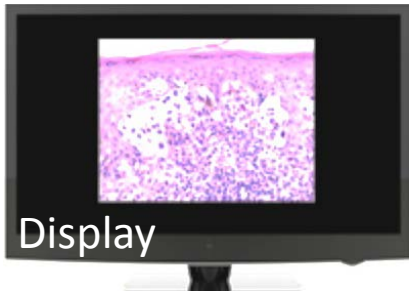




Post-processing







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Pre-processing gone wrong

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Pre-processing gone wrong

Stitching artefact

Corrected Algorithm

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Post Processing gone wrong: Recurrent Caries?

Original

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Post Processing gone wrong: Recurrent Caries?

Original

Processed,
but mimicking pathology

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Post Processing gone wrong: Recurrent Caries?

Original

Processed,
but mimicking pathology

Real Pathology

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Brettle D. S and Carmichael F.
The impact of digital image processing artefacts mimicking pathological features associated with restorations.
British Dental Journal (2011). 211(4), 167–170.

The ‘So what?’ factor - Local context

- Local experience can compensate for factors affecting the image chain. *“So what!..That doesn't bother me, we see that on all the images ”*.

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The ‘So what?’ factor - Local context

- Local experience can compensate for factors affecting the image chain. *“So what!..That doesn't bother me, we see that on all the images”*.

BUT

- If the image becomes orphaned from the host institution this local knowledge and ‘compensation’ is missing.
- A system can be within specification but still apply deliberate processes that may compromise an image.

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Concept Solution

An embedded environment in the image that is responsive to all the processes applied to the image, from acquisition to display, and allows assessment of integrity at any time or point in the image life.

General Design Criteria

- Responsive to image generation factors.
- Non-intrusive in the image.
- Responsive to essential image components: frequency, contrast, color and image processing.
- Allows quantification of the degradation of the image and subjective assessment.
- Accessible at all stages in the image life-cycle.
- Allows image ‘correction’.

Proposed solution (X-ray)

- Digital Frame of Reference ‘DFOR’
- Already proposed as a software reference
- Now a physical radiographic ‘side marker’ with responsive features.

Physical Marker

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Proposed solution

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Physical Marker

X-ray

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Proposed solution

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Physical Marker

X-ray

Processed USM

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Also ..'Image Integrity Index' (III)

- $g_{x,y} = f_{x,y} \otimes h_{x,y}$
- $G_{u,v} = F_{u,v} H_{u,v}$ (In Fourier space)
- $H_{u,v} = G_{u,v} / F_{u,v}$

- To find H need to know G and F. Normally this is not possible but with the 'Digital Frame of Reference' (DFOR) this is.
- Therefore summing H gives a net indicator of deviation from the original.
- Can be indexed to a pure digital reference or acquisition reference.

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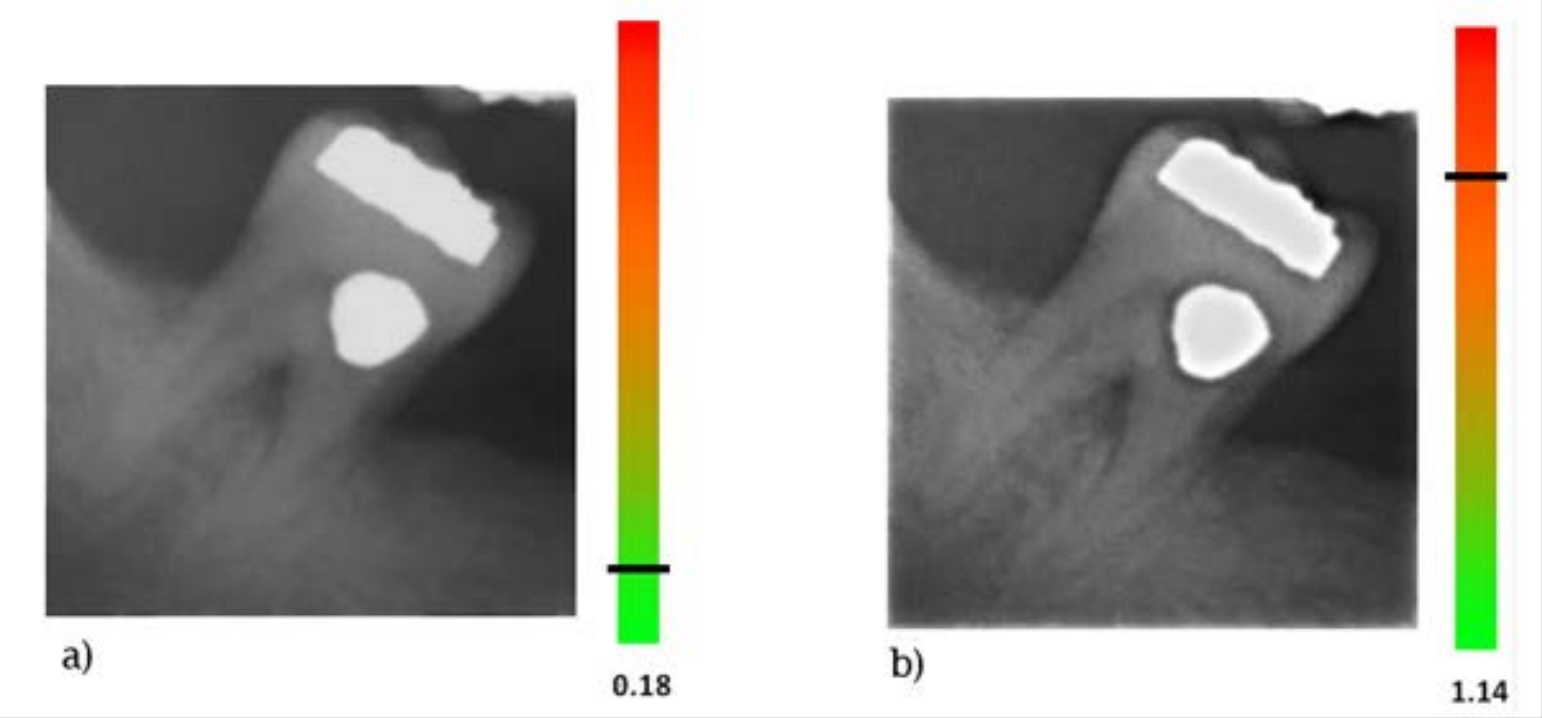
Image Integrity Index



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Digital Pathology

- There are parallels between digital X-ray imaging and digital pathology.
- Local acquisition and image generation dependencies.
- Orphan images.
- Potential clinical impact of not knowing what has happened to an image.

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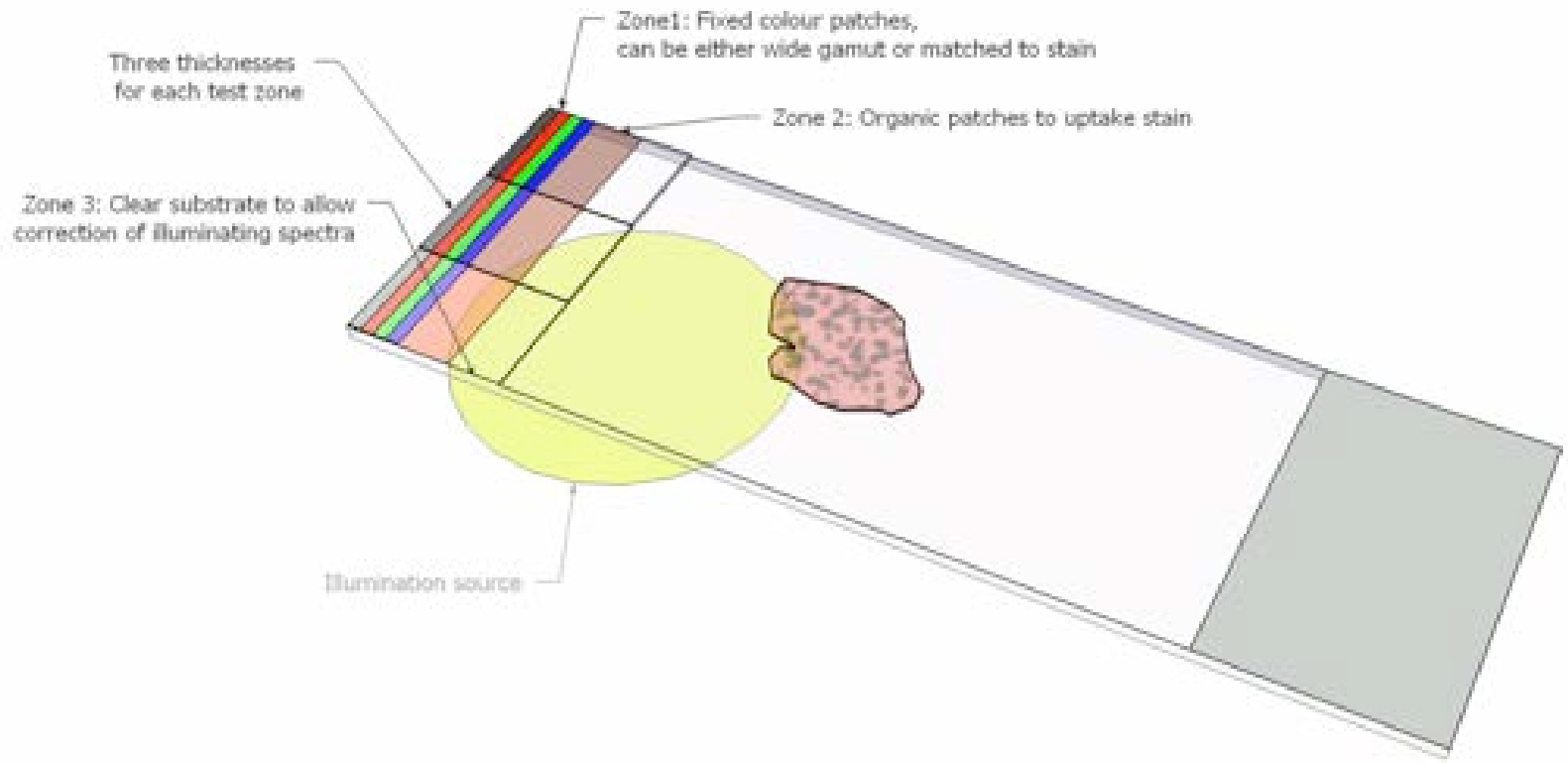
Original Concept



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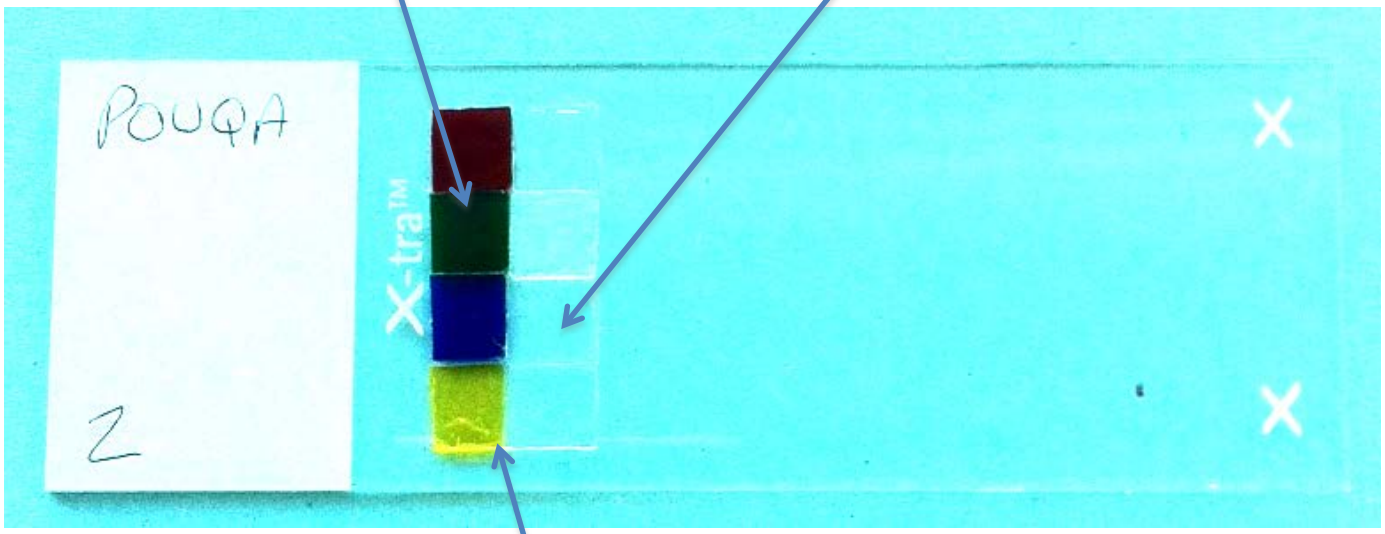
Considerations for DP POUQA

- **Staining**: Need substrate that takes up stain in a reproducible way which may need to be tailored to each stain type.
- **Scanning**: System factors can alter colour response, can even be a conscious system design criteria therefore colour reference is needed.
- **Digitisation**: The data sets for DP are huge, compression is a key factor, whereas in X-ray loss of high frequency may not be significant in DP may be profound impact.
- **Fading**: Scanning of a slide may not take place immediately, particularly with a transitional stage from analogue to digital. The substrate therefore needs to fade at the same rate at the tissue.
- **Stain variability**: Different stains interact with the tissue in different ways, therefore all staining mechanisms need to be considered.

Prototype

Absolute color reference:
4 thickneseses

Relative colour reference:
4 substrate thickneseses



Derived system information:
ESF, MTF, SNR etc

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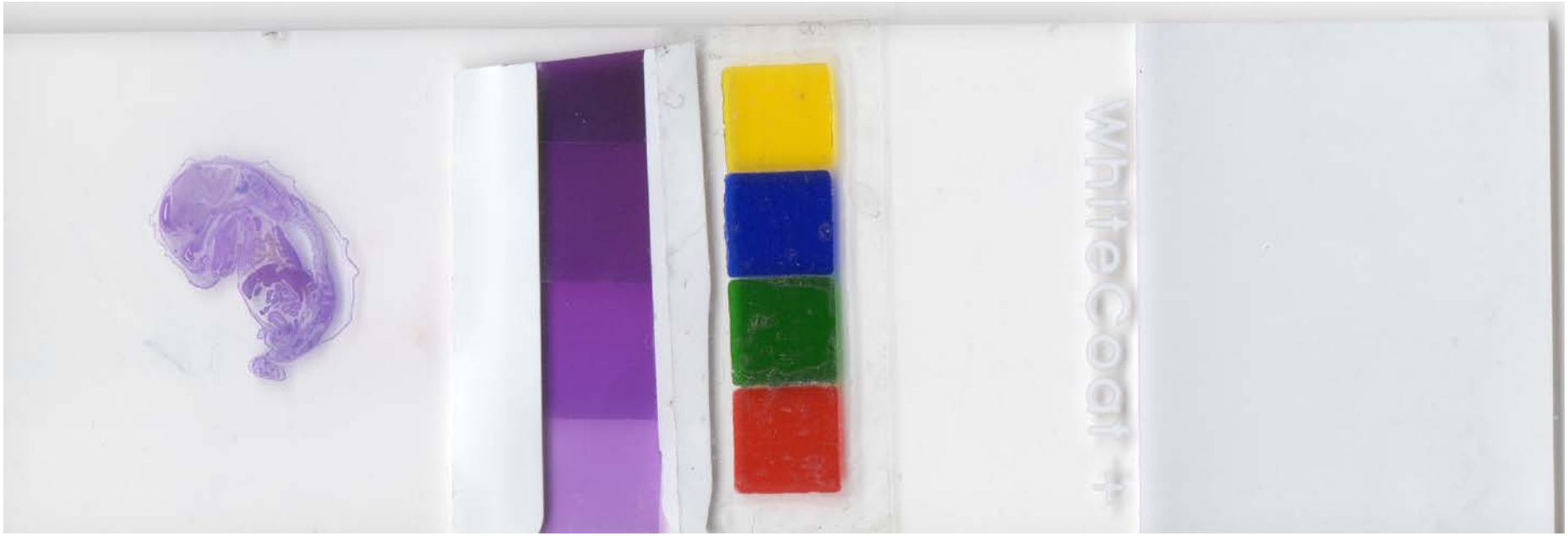
Proof of concept



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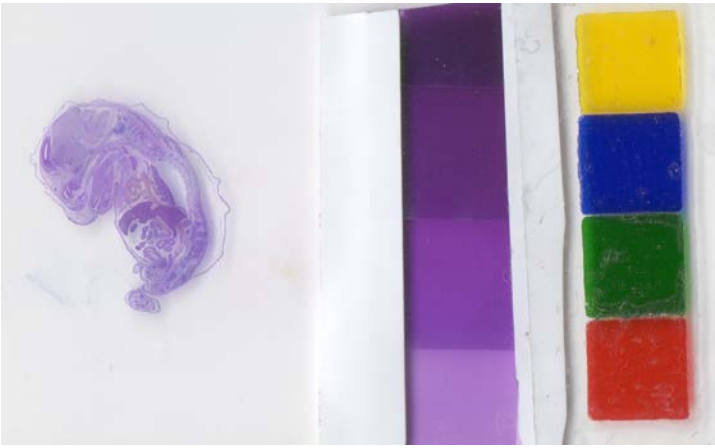
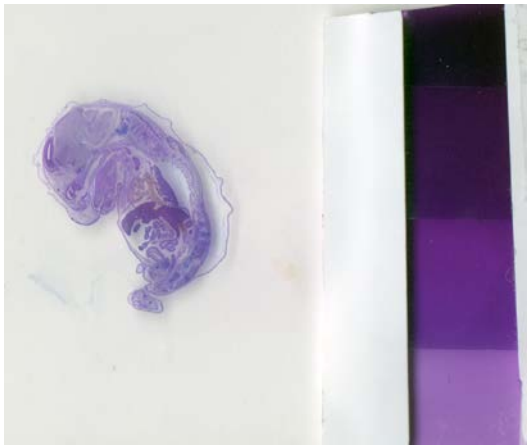
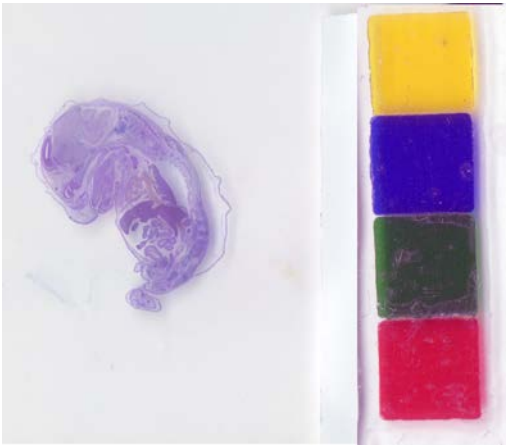
Ability to ‘optimize’ every slide



Original



Relative color re-mapping



Absolute colour re-mapping

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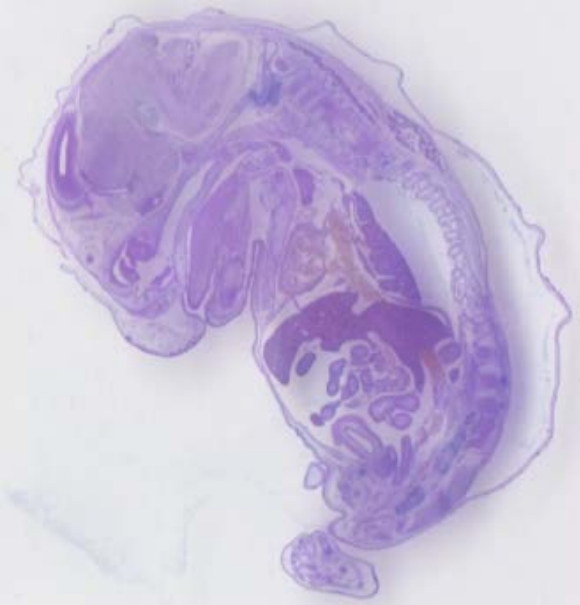
Zoomed in.

Original

Relative color re-mapping



Absolute colour re-mapping

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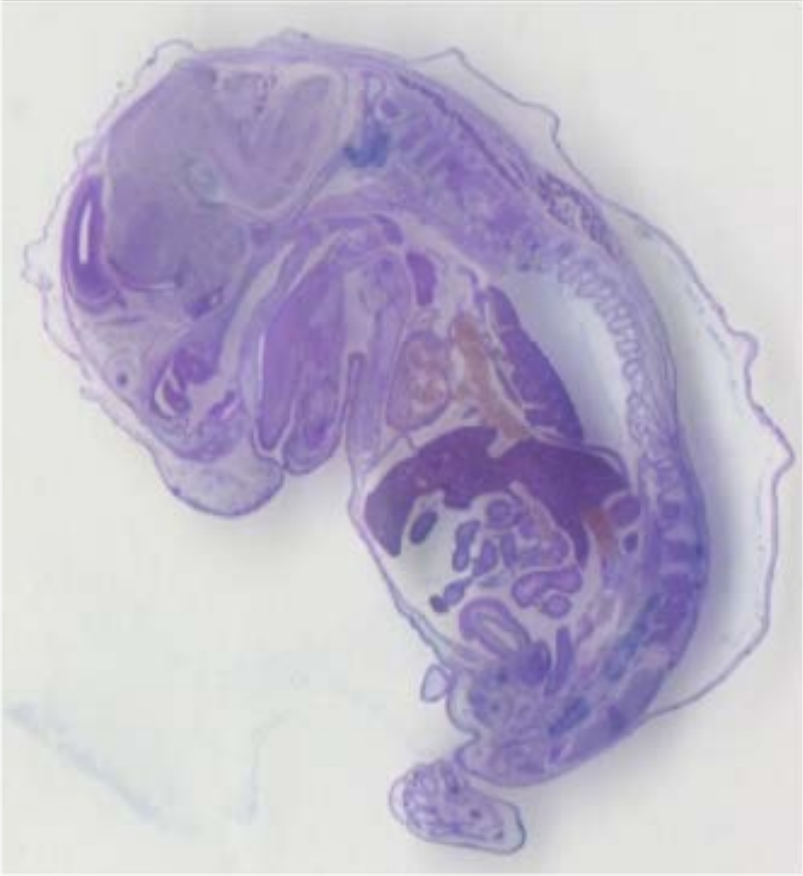
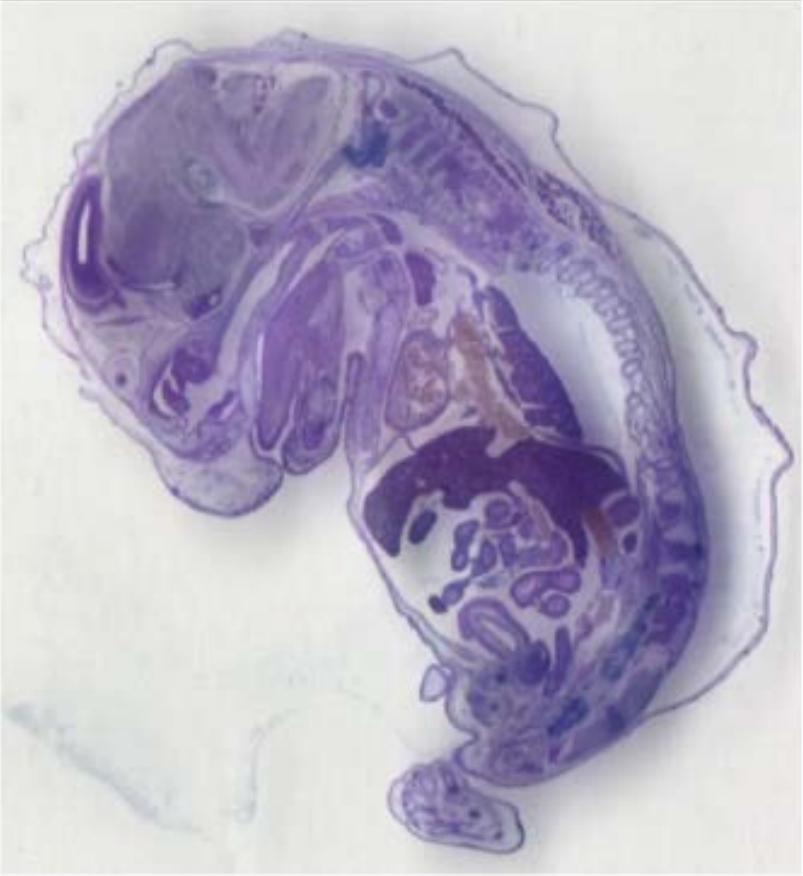
…with processing





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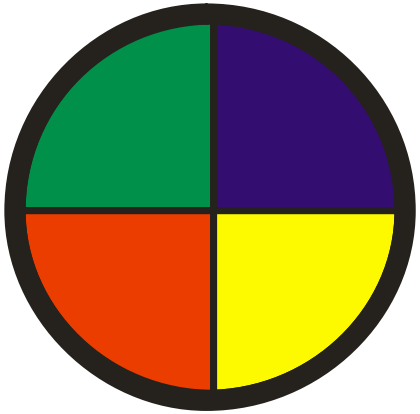
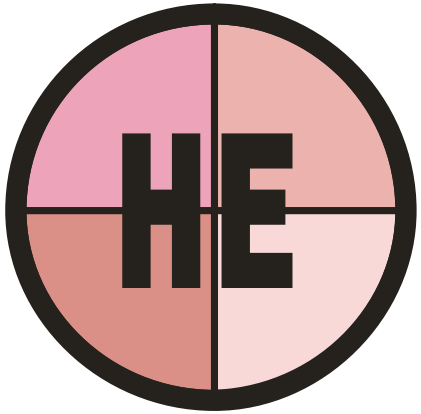
Possible solution?



Absolute Colour Reference Patch

Substrate Patch



Option: Relative Colour Reference patch

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Options

- Discrete markings on the zones will facilitate focussing. Could also be used as a LSF for MTF especially if 45º lines used giving net resolution.
- The zones could be separate stickers allowing optional/easier positioning.
- Different substrate material depending on the stain/cell structure of the sample allowing reference to the specific diagnostic task.
- And/or absolute reference colours for the stain used
- Simple 'Stain used' indicator possible.

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Benefits

- Can be used to check scanner calibration.
- Allows relative stain calibration.
- Allows absolute colour calibration (if required).
- Subjective assessment of slide and image quality
- Quantitative indication of staining variability
- Secondary measurements MTF, DQE etc
- Display normalisation
- Image Integrity Index.
- Whole image life cycle QA

To Do

- Improve ‘on slide’ staining.
- Investigate other substrate/stain behaviours
- Develop Image Integrity Index and primary quality metrics

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Conclusions

- In digital imaging there are many factors that can affect image integrity.
- Component QA is important but…
- Without being able to quantify and communicate all the image degradation factors negative clinical impact is possible.
- A POUQA solution is proposed utilising a test environment embedded in every ‘mission critical’ image; e.g. X-ray, Pathology, Forensics to allow subjective and quantitative assessment of image integrity at every stage.

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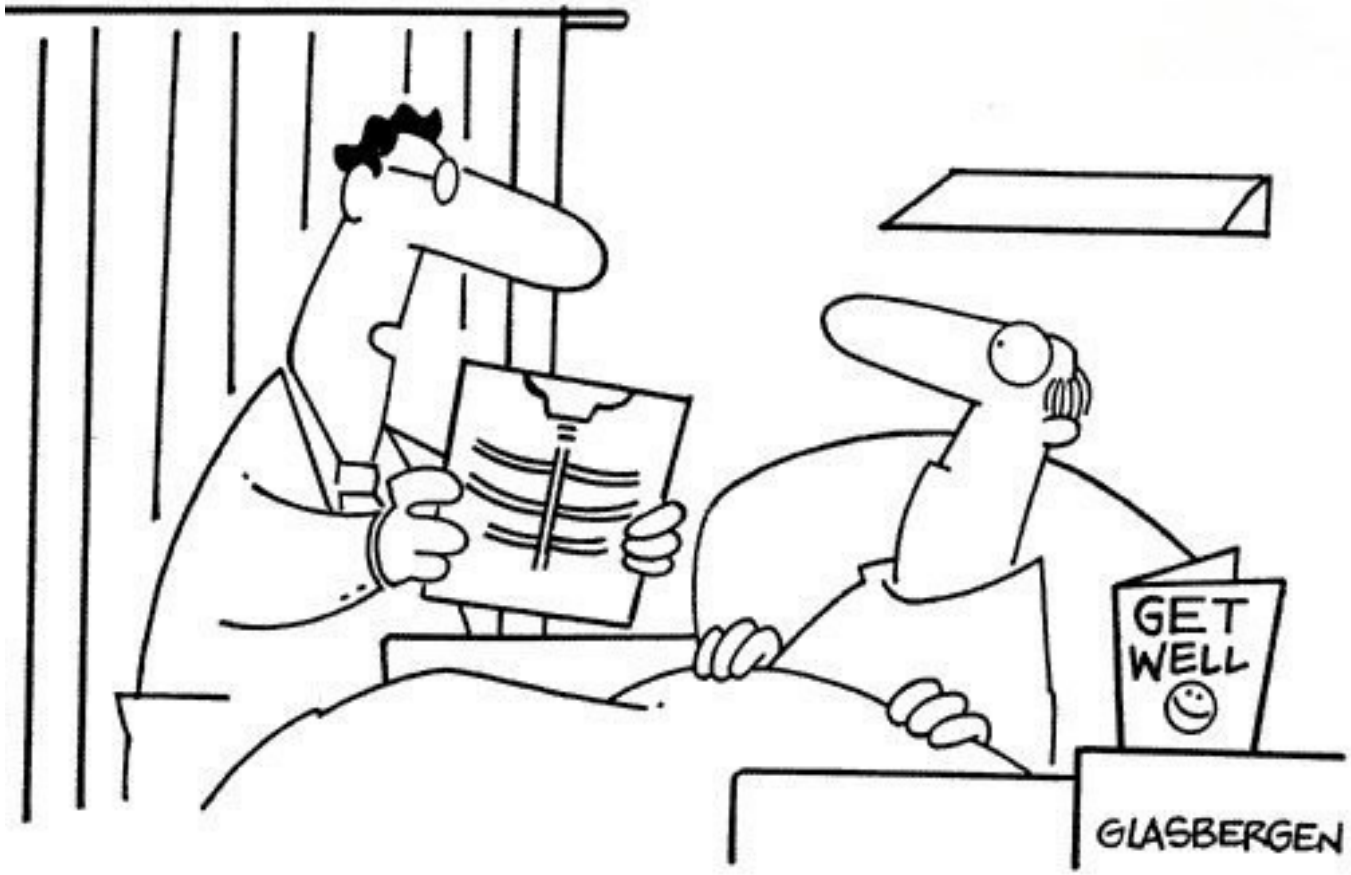
The potential is endless!



"Your x-ray showed a broken rib, but we fixed it with Photoshop."

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Contact: davidbrettle@nhs.net