The Leeds virtual pathology project

Darren Treanor BSc (Computing) MB BCh FRCPath
Leeds Teaching Hospitals Trust & Leeds Institute of Molecular Medicine
Chicago
October 2012

darrentreanor@nhs.net
www.virtualpathology.leeds.ac.uk
@LeedsPathology
Summary

• Overview
• Some of our other projects
  – 3D pathology
  – Tracking with virtual slides
• The Leeds Powerwall and digital pathology workstation projects
Summary

• Overview

• Some of our other projects
  – 3D pathology
  – Tracking with virtual slides

• The Leeds Powerwall and digital pathology workstation projects
Context

- Leeds Teaching Hospitals NHS Trust
  - Fully sub-specialised department for 15+ years now
  - Single site, all subspecialties covered
  - 38 FTE consultant/attending pathologists
  - 30 trainees
  - ~250,000 H&E slides/year in "histopathology" (ie surgical pathology excluding cytopathology)
- Leeds Institute of Molecular Medicine on same site
Leeds digital pathology project

- Scanning since 2003
- 4 x Aperio scanners
  - 2AT – 380 slides at a time
  - 2 CS – 5 slides at a time
- Scan 2000 - 5000 slides per month for teaching, education and research
- 160,000 slides scanned
- 80 TB of images
All available online, free at

www.virtualpathology.leeds.ac.uk

• EQA
• Slide library (5,000 cases)
• Undergraduate teaching
• Postgraduate teaching
• FRCPath examinations
• Clinical trials
Summary

- Overview
- Some of our other projects
  - 3D pathology
  - Tracking with virtual slides
- The Leeds Powerwall and digital pathology workstation projects
3D histopathology with virtual slides

Nicholas Roberts,* Derek Magee,† Yi Song,† Keeran Brabazon,† Mike Shires,* Doreen Crellin,* Nicolas M. Orsi,* Richard Quirke,* Philip Quirke,* and Darren Treanor‡, Toward Routine Use of 3D Histopathology as a Research Tool, Am J Pathol, May 2012.
Summary

• Overview
• Some of our other projects
  – 3D pathology
  – Tracking with virtual slides
• The Leeds Powerwall and digital pathology workstation projects
Tracking to study different types of diagnostic tasks

Systematic (exhaustive) search

Feature finding
Tracking to study expert vs. trainee behaviour

Summary

• Overview
• Some of our other projects
  – 3D pathology
  – Tracking with virtual slides
• The Leeds Powerwall and digital pathology workstation projects
The Leeds digital pathology workstation project

• ‘The Powerwall project’

• NHS National institute for Health Research (NIHR) funded project (2009-2012) to develop:
  – Multi-user Powerwall for teaching/ training/ collaboration
  – Single-user workstation for diagnostic work

• Multi-disciplinary team with expertise in pathology, computer graphics, software engineering, HCI, psychology

• Aim: To develop a virtual slide workstation as fast as, or faster than, the conventional microscope
Leeds “Powerwall” project

Leeds Powerwall

- Collaboration, teaching, discussion

Leeds digital pathology workstation

- Diagnosis (single user)
The powerwall:
44 megapixels, 3.5m wide
Background: What’s wrong with digital pathology?

**Poor acceptability**

- Majority of pathologists feel virtual slides are not suitable for clinical diagnosis

**Poor efficiency**

- 60% less efficient than the microscope
Task by task breakdown shows where digital pathology is slowest

Tasks

1. Make a simple diagnosis
2. Make a decision about a lymph node
3. Make a measurement
4. Find a needle in a haystack
5. Score a tissue microarray
6. Navigate to a specific point on a slide
7. Attempt a very difficult diagnosis

Treanor D, Quirke P. The virtual slide and conventional microscope – a direct comparison of their diagnostic efficiency. J. Pathol. 2007;213(S1):1A–65A.
Why are virtual slide viewers less efficient than the microscope?

- Display resolution
- Software performance (moving pixels)
- Software design
  - GUI design adopted from photo editing software
- Lack of training and experience
- Other factors
  - Lower image quality than microscope, at both image capture and display stages
Why are virtual slides less efficient? The effect of display resolution

17” xga monitor shows 14% of the viewable area of the microscope field at 40x
Project overview

To make a digital microscope as fast as, or faster than, a conventional microscope

Study work practices and workflow

Develop a digital microscope

Evaluate the system with pathologists

Leeds Institute of Molecular Medicine
Pathology and Tumour Biology
What we’ve done

- Studied work in pathology
  - Quantitative
    - Workload metrics
    - Quantification of range of task types performed with the microscope
  - Qualitative
    - Observations, interviews
    - Videos of work in the office, using the microscope
  - Experimental
    - Evaluation of workstation efficiency, utility
    - Evaluation of specific UI questions

Theoretical classification of task type and navigation patterns

Aim - to identify **common themes** and **determine user requirements**:
- Type of movement
- Diagnostic aims
- Information gathered
Breakdown of time spent in the office

Chart Title

- Viewing slide: 54%
- Dictation: 10%
- Other: 4%
- Computer: 3%
- Notes: 3%
- Annotating: 2%
- Book: 2%
- Paperwork: 2%
- Filling forms: 1%

Randell R, Ruddle RA, Quirke P, Thomas RG, Treanor D. “Working at the microscope: analysis of the activities involved in diagnostic pathology”. Histopathology 2011
How time was spent - timelines

- 3 cases, 5 slides
- Mix of activities
Workflow in the office: “long” and “short” cases
Doing more than one thing at a time...

1. Dictating while looking at clinical details/ request form
2. Referring to LIS while filling in form to request immunohistochemistry

• They were performing more than one task 10-20% of the time
Pathologists make *hundreds of movements* when viewing a slide
  - Mean fixation time is 1.3 – 2.0 seconds
  - They follow complex paths
  - The microscope is transparent to them – they focus on the image, *the pathology*

So the workstation must support
  - Very rapid rendering of 7-10 megapixels
  - Precise control of movement
  - Rapid changes of direction
To make a digital microscope *as fast as, or faster than*, a conventional microscope

- **Study** work practices and workflow
- **Develop** a digital microscope
- **Evaluate** the system with pathologists

Leeds Institute of Molecular Medicine
Pathology and Tumour Biology
Leeds digital pathology workstation v1.0

- For viewing a single slide
- Similar physical field of view to a microscope (65 x 48 degrees)
- 12 megapixels
  - Visual angle of each pixel =~ 1 minute arc
- >40 frames per second
- Keyboard & mouse control
Leeds digital pathology workstation v1.0 - video
To make a digital microscope \textit{as fast as}, or \textit{faster than}, a conventional microscope

**Study** work practices and workflow

**Develop** a digital microscope

**Evaluate** the system with pathologists
Evaluation of v1.0 workstation

- 16 participants - 8 trainees and 8 consultants (experts)
- Separate 30 minute training session
- Viewed 3 skin and 3 GI biopsy cases on each interface
- Fully counterbalanced for task order, interface order, slide set
- Times normalised by slide

Rebecca Randell\textsuperscript{a}, Roy A. Ruddle\textsuperscript{b}, Claudia Mello-Thoms\textsuperscript{c}, Rhys G. Thomas\textsuperscript{b}, Phil Quirke\textsuperscript{a} and Darren Treanor\textsuperscript{ad}

“Virtual reality microscope versus conventional microscope on time to diagnosis: an experimental study”

Histopathology, In press, 2012
Results: Time to diagnosis

- Time was equivalent on microscope and workstation
- Mean normalised time = 0.91 vs 1.1
- $F(1, 14) = 0.87$, $p = 0.37$ (N.S.)
Results: Diagnostic confidence

- No effect of hardware on diagnostic confidence for experts
- $P = \text{N.S.}$
Results: Qualitative

- “I had no difficulty in using the workstation”
  - 8 of 16 agreed

- Comments
  - speed of panning, difficulty controlling pans (mouse sensitivity issues at high zoom)

- “Which interface felt faster to you?”
  - Experts: 5 microscope, 2 neutral, 1 workstation
  - Trainees: 2 microscope, 3 neutral, 3 workstation

- ‘faster and less cumbersome’ [than a microscope]
- ‘fun to use’
Results: Tracks

- Workstation allowed smooth anatomical tracking of tissue which would be difficult/impossible with a microscope.
Results: Tracks

• But inefficient navigation patterns from the microscope were replicated on the workstation

• Lack of training?
• Lack of appropriate software functionality?
Results: Different behaviour on the workstation

Mean magnification with error bars showing 95% confidence interval (CI) $p < .01$

Mean number of magnification changes with error bars showing 95% confidence interval (CI) $p < .05$
Project overview

To make a digital microscope *as fast as, or faster than*, a conventional microscope

- **Study** work practices and workflow
- **Develop** a digital microscope
- **Evaluate** the system with pathologists
Version 2 digital pathology workstation

- For viewing an *entire case*
- High resolution medical grade displays (Barco)
- 9MP total resolution
- Same fast pixel rendering as v1
- Main window not obstructed by bezels
- Evaluation just completed...
Leeds digital pathology workstation

Version 2
October 2012
Results of evaluation of version 2...

...to be continued at Pathology visions 2012, Baltimore
Summary of Leeds digital pathology workstation project 2009-12

• We developed an approach that is
  – Iterative
  – Multidisciplinary
  – Holistic

• We built
  – Two Powerwalls
  – Five workstations

• We gathered
  – Data from multiple experiments with ~20 pathologists

• We achieved
  – A workstation comparable in speed to the microscope
  – Equivalent diagnostic confidence to the microscope
  – A knowledge of what works, and what doesn’t

• It’s been
  – Educational
  – Surprising
  – Lots of fun
Virtual Pathology in Pathology & Tumour Biology at Leeds Institute of Molecular Medicine
- Phil Quirke
- David Turner, Martin Waterhouse, Mike Hale, Alex Wright, Fraser Lewis, Hannah Dee, Gordon Hutchins
- Nick Roberts, Richard Quirke, Mike Shires, Doreen Crellin, Nick Roberts (technical work)

Image analysis & computer vision
- Alex Wright & Andrew Bennett & Yanong Zhu, Pathology and Tumour Biology Group, Leeds Institute of Molecular Medicine, University of Leeds
- Ladislav Gubic, Jim Swainston, James Bridges, BSc students, School of Computing, University of Leeds
- Andy Bulpitt, Derek Magee, Yi Song, Yu Zhou, School of Computing, University of Leeds

Visualisation & human computer interaction
- **Roy Ruddle, Rhys Thomas**, John Hodrien School of Computing
- **Rebecca Randell**, Leeds Institute of Molecular Medicine

Collaborators/ supporters
- Claudia Mello-Thoms, University of Pittsburgh
- David Brettle, Leeds Teaching Hospitals Trust
- Barco

Funding
- Pathological Society of Great Britain and Ireland
- Department of Health
- Yorkshire Cancer Research
- National Institute for Health Research

www.virtualpathology.leeds.ac.uk