The virtual slide and conventional microscope - a direct comparison of their diagnostic efficiency

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Summary

- Simple experiment to test the efficiency of virtual slides
- Found that virtual slides less efficient than the conventional microscope, taking over 60% longer to perform the same tasks
- This knowledge can be used to improve the virtual slide
Background

- Virtual slides are very large computer images produced by scanning entire glass slides at high resolution.
- They are viewed using computer software with standard PC, mouse and keyboard.
- Anecdotally, pathologists report that they are more difficult to use, and less efficient than the microscope.
- This would have implications for the widespread adoption of virtual slides in diagnostic practice.
Previous studies of the efficiency of virtual slides

- Leong et al (2002) reported a dynamic (robotic) telepathology system to be 10 times slower
- Renal EQA virtual slide examination reported by participants to take 3.9x as long (Furness (2007))
- Few formal studies of efficiency of virtual slides

Furness, Histopathology, 50, 266-273
Leong, Journal of Pathology, 197, 211-7
Methods

• Within-subject comparison of efficiency of conventional microscope and virtual slide
• 4 subjects
• Timed while performing 7 diagnostic tasks chosen to represent a spectrum of work
• Recorded time taken
• Diagnostic accuracy was not tested
• User feedback on preferred method obtained
Microscope vs. virtual slide

- Leica DMRB
- 2.5x, 5x, 10x, 20x and 40x objectives
- Standard NHS PC (Pentium 4, 512MB RAM)
- Iiyama Vision Master Pro 410 CRT monitor (17”, 1024 x 768 pixels, 850 X 710 viewable area of slide)
- Virtual slides scanned at 0.23 microns per pixel with Aperio virtual slide scanner
- Slides stored on PC hard drive to avoid bias due to network latency
- Custom-made slide viewing software
Experimental design

Short (5 minutes) practice session, then 7 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
Experimental design

5. Score a tissue microarray

6. Navigate to a specific point on a slide

7. Attempt a very difficult diagnosis
## Cross over design

<table>
<thead>
<tr>
<th></th>
<th>Experiment 1</th>
<th>Experiment 2</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Virtual slide</td>
<td>Conventional microscope</td>
</tr>
<tr>
<td>B</td>
<td>Conventional microscope</td>
<td>Virtual slide</td>
</tr>
<tr>
<td>C</td>
<td>Virtual slide</td>
<td>Conventional microscope</td>
</tr>
<tr>
<td>D</td>
<td>Virtual slide</td>
<td>Conventional microscope</td>
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</table>
## Subjects

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (approximate)</strong></td>
<td>50</td>
<td>32</td>
<td>50</td>
<td>35</td>
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<tr>
<td><strong>Years of experience in histopathology</strong></td>
<td>12</td>
<td>5</td>
<td>6</td>
<td>5</td>
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<tr>
<td><strong>Qualifications</strong></td>
<td>PhD, MRCPath part 1</td>
<td>MRCPath part 1</td>
<td>MRCPath</td>
<td>MRCPath</td>
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<tr>
<td><strong>Years of experience of using computers</strong></td>
<td>10</td>
<td>10</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td><strong>Level of knowledge of computers (self assessed, out of 10)</strong></td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Number of virtual slides seen before (approximately)</strong></td>
<td>25</td>
<td>10 approx.</td>
<td>100</td>
<td>10</td>
</tr>
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</table>
Average time taken per task

93s vs. 156s
(67% longer with the virtual slide)

P = 0.03
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
Number of asbestos particles found

Median 25 vs. 7 particles
P = 0.06
User-preferred method for performing the tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make a simple diagnosis</td>
<td></td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Make a decision about a lymph node</td>
<td>A</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Make a measurement</td>
<td>B</td>
<td>A</td>
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<td>Score a tissue microarray</td>
<td></td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>A very difficult case</td>
<td></td>
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</table>

Methods: Virtual slide, No difference, Microscope
## Interpretation

<table>
<thead>
<tr>
<th></th>
<th>Mean time to perform all 7 tasks (S.E.)</th>
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<tbody>
<tr>
<td><strong>Microscope</strong></td>
<td>657 sec (91)</td>
</tr>
<tr>
<td></td>
<td>10 min 57 sec</td>
</tr>
<tr>
<td><strong>Virtual slide</strong></td>
<td>1092 sec (213)</td>
</tr>
<tr>
<td></td>
<td>18 min 12 sec</td>
</tr>
</tbody>
</table>
Summary

• Tasks took 67% more time with the virtual slide than the conventional microscope (P < 0.05)
• Virtual slide particularly less efficient at
  – Screening slides for small objects (Task 4)
  – Complex navigation tasks (Task 2)
• Pathologists preferred the microscope !
• This is knowledge which can be used as a baseline for developing improved user interfaces
Acknowledgements

- Department of Health
- Dr. Fraser Lewis, Pathology and Tumour Biology, University of Leeds
- Dr. Roy Ruddle, School of Computing, University of Leeds
- 4 Anonymous Pathologists