REAL-TIME COLLABORATION TOOLS FOR DIGITAL INK

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INTRODUCTION

• Mathematics lab: problem-solving session
  – Group collaboration leads to active learning
  – Sketching requires formulas and diagrams

• Old-fashioned tools: paper and/or board
  – Advantages: high bandwidth and interactivity
  – Disadvantages: working remotely; saving info.

• Explored using tablet computers instead
  – Summer 2006 Cascade Mentoring program
BACKGROUND

• Collaboration requirements
  – Provide real-time (duplex) communication

• Persistence requirements
  – Provide long-term (organized) storage

• Purpose of interaction: convey mental models
  – Spatial: using a pen to draw ink and annotate
  – Temporal: using one’s voice for oral explanation
REAL-TIME COLLABORATION

• Communication can be defined as the transfer or conveyance of information through space:

  HERE  duplex  THERE

  ➔ simultaneous  ➠

• handwritten sketching is low bandwidth:
  – AT&T: it could fit underneath the spoken audio

• The more critical issue is latency in order to preserve interactivity between participants.
LONG-TERM PERSISTENCE

- Storage can be defined as the transfer or retention of information through time:
  \[ \text{NOW} \rightarrow \text{store} \rightarrow \text{THEN} \]
  \[ \leftarrow \text{lookup} \leftarrow \]

- Raw data rate \(~100\) samples per second
- High compression ratio (strokes are very predictable) means very low storage needed
- Purpose is retention between sessions
PAPER

• Still popular since it combines both long-term persistence and real-time collaboration, i.e.
  – annotate a document, carry it from place to place, work jointly with someone else on same piece
  – retains a record of that information interaction

• However, without additional technology there is no remote collaboration or shared copies

• Editing is cumbersome, e.g. moving, erasing
SIMULTANEITY IN SPACE AND TIME

• **Deixis**: explaining an idea by simultaneously speaking about it and pointing to it
  – Establishes information correspondence between temporal (voice) and spatial (pen).

• Critical to STEM education and presentations
  – Math professors need lots of board space
  – Importance of pointers during technical presentations
PRIOR WORK

• HP Omnishare allowed two parties to speak and share ink over an ordinary telephone line:
  – full-duplex; real-time; dual floating cursors
• Failed due to high price and poor penetration
• Could save and organize screen images using a clever pile of papers metaphor
HARDWARE

• Use tablet monitor instead of graphics tablet
  – Sony’s PCV-LX920 desktop tablet computer
    • Integrated proprietary pen-tablet monitor
    • Windows XP (ordinary, not Tablet PC version)
  – Hewlett-Packard TC1000/1100
    • XP Tablet PC
    • hybrid
    • wireless
    • portable
SOFTWARE for instructor

• Interaction is usually simplex: one-way
• Must allow for persistent inking (annotations)
  – Ink should be stored in actual file, not as overlay

• Presentations: Microsoft Office PowerPoint
  – without Tablet PC, can only ink actual slide show
• Handouts: Microsoft Office Document Imaging
  – any document can be annotated with a pen, etc.
SOFTWARE for students

• Interaction should be duplex: two-way
• Must allow for collaboration (in real-time)
  – simultaneous inking of same file

• OneNote (optional part of Microsoft Office)
• DyKnow (server-based classroom solution)
• NetMeeting (little known part of Windows XP)
OneNote

- strong organizational features and an intuitive interface

- used disappearing ink instead of cursors
DyKnow

- Well-implemented student privileges good for teacher run collaborative sessions
- Limited organizing capability
- Cursors had high latency
NetMeeting

- Shared whiteboard
- Includes voice communication
- Hand pointers (buggy)
- No longer supported
FINDINGS

• Students’ preferred modes of interaction:
  – sitting side-by-side at one monitor (with two pens)
  – face-to-face monitors attached to same computer
• Why? Removed biggest problem – dual deixis
  – In simplex applications (giving a presentation, annotating a document by oneself) the cursor suffices for spatiotemporal reference (deixis).
  – But for pointing in duplex collaboration, there is a desperate need for dual cursor support!
<table>
<thead>
<tr>
<th>Pros of PC</th>
<th>Pros of Paper</th>
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</thead>
<tbody>
<tr>
<td>✓ Neater and cleaner</td>
<td>✓ More viewing space as opposed to a computer screen</td>
</tr>
<tr>
<td>✓ Faster text and image editing</td>
<td>✓ Does not experience lag or system errors</td>
</tr>
<tr>
<td>✓ Easier to organize and manage</td>
<td>✓ No software bugs</td>
</tr>
<tr>
<td>✓ Multiple users can write on a single page simultaneously</td>
<td>✓ Easily transportable</td>
</tr>
<tr>
<td>✓ Allows collaboration between physically disparate locations</td>
<td>✓ Increased lifespan of information</td>
</tr>
<tr>
<td>✓ Easily searchable</td>
<td>✓ Little necessary hardware</td>
</tr>
</tbody>
</table>
CONCLUSIONS

• Electronic collaboration on technically sophisticated STEM problems requires specialized tablet hardware, and software for simultaneous inking into same file.

• While several applications support this, their biggest shortcomings were in dual pointing:
  – Disappearing ink (OneNote)
  – High latency (DyKnow)
  – NetMeeting (buggy pointers)
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