A Study of Digital Ink in Lecture Presentation

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Steve Wolfman presenting
http://www.cs.washington.edu/research/edtech/

Outline
• Background & Motivation
• Study
• Attentional Marks & Hand Gestures
• Ephemerality & Persistence
• Conclusions & Future Directions

Research History

Distance & Large Class Studies
Presenter [SIGCSE'04]
Classroom Feedback System [ICCE 05]
Ink Study
Student Interaction Systems [ITiCSE'04]
Retro/Prospective Feedback Patterns [CHI'03]

Expected Use of Ink

Common Use of Ink

code
Example:
let true = ([parent] is bool {true: trueBlock = {trueBlock value}})
let false = ([falseBlock value, falseBlock])
is true? [true] false? [false]
Ink Study
Interpretive analysis [Erickson] of 3 courses:
- Distance courses (\vdash, A / V and ink archives)
- “Slideware-style”
- Experienced instructors

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Time</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof A.</td>
<td>4</td>
<td>6 hrs</td>
</tr>
<tr>
<td>Prof B.</td>
<td>8</td>
<td>20 hrs</td>
</tr>
<tr>
<td>Prof C.</td>
<td>10</td>
<td>23 hrs</td>
</tr>
</tbody>
</table>

Prevalence of Attentional Marks
Segmented strokes from six hours of lecture into coherent episodes and coded into four categories:

<table>
<thead>
<tr>
<th>% of strokes</th>
<th>% of episodes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Attentional</td>
<td>49</td>
</tr>
<tr>
<td>Diagram</td>
<td>9</td>
</tr>
<tr>
<td>Writing</td>
<td>41</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
</tbody>
</table>

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Understanding Attentional Marks
Properties:
- brief, simple markings
- occur with speech
- augment meaning of speech
- ad hoc form

Is there a linguistic context in which to understand these marks?

Spontaneous Hand Gestures
Spontaneous Hand gestures [McNeill]:
- are synchronous w/speech
- are co-expressive w/speech
- lack standard of form

Attentional marks share these properties.

Gesture Types: Iconic
- Starts with magic number (0xCAFEBABE)
- Constant pool - symbolic information
  - String constants
  - Class and interface names
  - Field names
  - All other operands and references in the class file are referenced via a constant pool offset
Gesture Types: Deictic & Cohesive

Example: \( w = w^{2}x^{y}z^{2} \).

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Persistent Representation vs. Ephemeral Meaning

Design Recommendations

• Separate strokes w/non-homogenous color

• Show co-occurrence/ordering w/age cues

• Show process w/incremental rendering

“Whiteboard” Effect [Prince]
Steve Wolfman
A Study of Digital Ink in Lecture Presentation

Conclusions

• Identified important ink use pattern: Attentional Marks
• Established gestural framework for understanding/analyzing Attentional Marks
• Demonstrated tension between ephemeral meaning and persistent representation
• Generated design recommendations to resolve tension
• Characterized instructors' parsimonious use of UI features

Future Directions

• Alternate ink renderings
• Augmented transcripts
  – Keyframing
  – Deixis resolution for blind students
• Improved recognition
  – Auto-captioning
  – Link time/speech to slide locations
• Further analysis

URLs for More Info

UW CS&E Education & Ed. Tech. Group:
http://www.cs.washington.edu/research/edtech/
Classroom Presenter:
http://www.cs.washington.edu/education/dl/presenter/

Surprising Use of Attentional Marks (1 of 3)

8.10 Phantoms

• Problems when using 2PL with inserts and deletes

<table>
<thead>
<tr>
<th>Accounts</th>
<th>Asset</th>
<th>Location</th>
<th>Balance</th>
<th>Location</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seattle</td>
<td>400</td>
<td>Seattle</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tacoma</td>
<td>200</td>
<td>Tacoma</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tacoma</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T1: Read Accounts [1, 2, and 3]
T2: Insert Accounts [4, Tacoma, 100]
T3: Read Assets[Tacoma], returns 500
T4: Write Assets[Tacoma, 600]
T5: Read Assets[Tacoma], returns 600
T6: Commit

EXTRA SLIDES: NEW SURPRISING USE
**Surprising Use of Attentional Marks** (2 of 3)

8.10 Phantoms

- Problems when using 2PL with inserts and deletes

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<tr>
<td>3</td>
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<tr>
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**Surprising Use of Attentional Marks** (3 of 3)

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- Problems when using 2PL with inserts and deletes

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**EXTRA SLIDES:** MOTIVATING PROBLEMS

**Language Model (LM)**

- Probabilistic finite state machine: a (almost fully)
- connected directed graph:
  - joint probability is estimated for
  - program model by starting at START
  - and multiplying the probabilities of the arcs that are traversed for a given
  - sentence/phrase

  \[ P(\text{attack of the killer tomato}) = P(\text{attack}) P(\text{of}) P(\text{attack}) P(\text{of}) P(\text{killer}) P(\text{for}) P(\text{the}) P(\text{tomato}) P(\text{killer}) \]

**“Sticky” Colors**

Semantic Interpretation

- Our goal: translate sentences into a logical form.
- But: sentences convey more than true-false: it will rain in Seattle tomorrow.
- Will it rain in Seattle tomorrow?
- A sentence can be analyzed by:
  - propositional content, and
  - speech act (tell, ask, request, deny, suggest)

**“Feature Recovery” Problem**

Top-Down Induction of Decision Trees

Main steps:
1. A → the “true” decision attribute for root node
2. Assign a decision attribute for each
3. Pair each value of A, create a description of nodes
4. Test training examples to find node
5. If training examples perfectly classified, then
6. IF NOT then go to next step and nodes

Ways algorithm can go:
- backtracking
- backtracking to a state-space search problem?
EXTRA SLIDES: GESTURE TYPES

Gesture Types: Metaphoric

Gesture Types: Beats

Viterbi Algorithm

```plaintext
Viterbi Algorithm

States

1) +

V(t) = V(t-1) + λ(t)

Backtrack

Backtrack from the last state to the first state.

λ(t) = log P(Y(t) | X(t))
```