Pen-Based Gestural User Interfaces

Lecture #6: Gestures
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What is a Pen Gesture?

- Simple ink stroke or strokes to convey an idea
  - fast to perform
  - easy to remember
- Typically disappear after they are recognized
- Supports in-band interaction
### Gesture Types

- **Single stroke**
- **Multi-stroke**
  - compound gestures
  - punctuated gestures
- **Trade-off in recognition**
  between single and multiple stroke gestures
- **Used in**
  - modeling
  - command languages
  - invoking interface widgets

### Gestures in Modeling

- **Used in 2D/3D object modeling**
- **Distinction between**
  sketch-based modeling and gestures in modeling
- **Used to**
  - create geometry
  - manipulate geometry
  - guidance for computational algorithms
SKETCH

- Seminal work by Zeleznik et al. (1996)
- Conceptual modeling
- Uses simple lines and curves to build geometric primitives
  - cubes, cylinders, pyramids, etc...
- No machine learning-based recognition used
  - simple FSA
- Does make use of modifier keys

SKETCH Gesture Set (1)

- Dragging objects
- Scaling objects
- Copying objects

Freehand drawing
Scaling along an axis
Teddy

- Seminal work by Igarashi et al. (1999)
  - did for organic modeling what Zeleznik et al. did for primitive-based modeling
- Supports
  - Object creation
  - Cutting
  - Extrusion
  - Smoothing
- No machine learning used
  - Simple FSA and geometric construction techniques
Surface/Mesh Editing

- Fine line between sketching and gestures
- Uses simple gesture as input to a surface editing algorithm
- This type of approach has been used for image processing as well
  - see work of Salesin

Gestures as Command Languages

- Gestural commands
  - replace traditional WIMP user interfaces
  - also used to invoke interface widgets
- Notion of in-band gestures
  - invoking commands and operations at the location of interaction
  - contrasts with having to move to top/side of the screen to press a button or find a menu item
- Used in
  - entering text
  - text editing
  - note taking
  - mathematical apps
  - etc…
**Graffiti**

- Language for entering text
- Maps to keyboard
- Used with Palm Pilot
- Single stroke language
  - Has prefix for some symbols
- Takes a while to learn

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**Text Editing**

- Example of a gesture set taken from real world and developed for pen computers
- Natural connection between pencil and paper and computer

www.jumpingminds.com
MathPad²

- Simple gesture set for
  - invoking operations
  - manipulating ink
- Uses notion of punctuated gestures
  - multi-stroke (gesture + punctuation)
  - makes use of context
- Why?
  - reduce number of gestures
  - overload appropriate gestures
  - reduce conflicts

MathPad² Gesture Set (1)

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Result</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x + y^2$</td>
<td>$x + y^2$</td>
<td>Lasso and tap to recognize an expression</td>
</tr>
<tr>
<td>$x + y^3$</td>
<td>$x + y$</td>
<td>Scribble and tap to delete ink</td>
</tr>
<tr>
<td>$x + y$</td>
<td>$x + y$</td>
<td>Creates a graph, line starts in recognized math, no cusps or intersections</td>
</tr>
<tr>
<td>$x(t) = \frac{t}{a + b}$</td>
<td>$x(t) = \frac{t}{a + b}$</td>
<td>Line through math and click on drawing makes association, Release makes rotation point</td>
</tr>
<tr>
<td>$\int x^2 , dx = \frac{x^3}{3}$</td>
<td>$\int x^2 , dx$</td>
<td>Evaluate an expression, includes integrals, derivatives, summations, etc.</td>
</tr>
</tbody>
</table>
### MathPad² Gesture Set (2)

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Result</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_x = 3$</td>
<td><img src="Image" alt="Gesture Image" /></td>
<td>Makes implicit association using label family $P'$</td>
</tr>
<tr>
<td>$P_x = 3$</td>
<td><img src="Image" alt="Gesture Image" /></td>
<td>Makes implicit association with explicit tap on object</td>
</tr>
<tr>
<td>$\alpha = 1.57$</td>
<td><img src="Image" alt="Gesture Image" /></td>
<td>Implicit angle association and rectification</td>
</tr>
<tr>
<td>$\epsilon = 0$</td>
<td><img src="Image" alt="Gesture Image" /></td>
<td>Merge two drawing elements by small circle and tap</td>
</tr>
<tr>
<td>$y = x$</td>
<td><img src="Image" alt="Gesture Image" /></td>
<td>Lasso and drag symbol to change position</td>
</tr>
</tbody>
</table>

### Fluid Inking (Zeleznik and Miller 2006)

- **Approach** to augment free-form inking with gestures (collection of techniques)
- **Guidelines**
  - hardware impartiality (no buttons)
  - performability (minimal targeting)
  - extensibility
  - discoverability
- **Uses**
  - terminal punctuation
  - flicks

**Example**

<table>
<thead>
<tr>
<th>Gesture Class</th>
<th>Context</th>
<th>Gesture</th>
<th>Terminal</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mnemonic flick</td>
<td>flick ()</td>
<td>letter</td>
<td>tap or pause</td>
<td>$\downarrow$ deletes ink under it; $\uparrow$ copies ink under lasso</td>
</tr>
<tr>
<td>Punctuated: self-contained mnemonic mimic</td>
<td>lasso((\bigcirc))</td>
<td>letter or scribble ((\bigcirc))</td>
<td>tap or pause</td>
<td>$\bigcirc$ applies NR menu option to lasso contents</td>
</tr>
<tr>
<td>lasso((\bigcirc))</td>
<td>stroke hook ((\bigotimes))</td>
<td>tap or pause</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figures showing gestures and examples.*

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*Footnote: ©Joseph J. LaViola Jr.*
Recognizing Gestures

- FSA’s and simple primitive operators
  - conditionals and saving state from one event trigger to another
  - Operators can be features
    - same features used in machine learning!
    - features must be excellent discriminators

- Machine learning techniques
  - SVMs, K-nearest neighbor, AdaBoost
  - more on this soon!

Anatomy of a Gesture

Detecting and equal sign

Note that as the gesture set increases the more tests you typically have to employ to avoid conflicts.
Learning Gestures

- How many gestures is too many?
- Learning strategies
  - Simple tutorials/manuals
  - Gesture practice tools
  - Color coding (useful for multi-stroke gestures)
  - Showing gestures through animations
- Techniques not proven – open research area

Music NotePad gestural tutorial system

Readings

