Pen-Based Gestural User Interfaces

Lecture #6: Gestures
Joseph J. LaViola Jr.
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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
  - frehand drawing
  - scaling along an axis
SKETCH Gesture Set (2)

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

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
MathPad\textsuperscript{2}

- 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

MathPad\textsuperscript{2} 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>$x + y^4$</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>$\frac{x(t)}{a + b}$</td>
<td>$\frac{x(t)}{a + b}$</td>
<td>Line through math and click on drawing makes association, Release makes rotation point</td>
</tr>
<tr>
<td>$y + \frac{1}{x} = 0$</td>
<td>$y = -\frac{1}{x}$</td>
<td>Solves equation, includes simultaneous and ordinary differential equations</td>
</tr>
<tr>
<td>$\int x^2 , dx$</td>
<td>$\frac{x^3}{3}$</td>
<td>Evaluate an expression, includes integrals, derivatives, summations, etc.</td>
</tr>
</tbody>
</table>
MathPad$^2$ Gesture Set (2)

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Result</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mathcal{P}x = 3$</td>
<td>$\mathcal{P}x = 3$</td>
<td>Makes implicit association using label family $\mathcal{P}$</td>
</tr>
<tr>
<td>$\mathcal{P}x = 3$</td>
<td>$\mathcal{P}x = 3$</td>
<td>Makes implicit association with explicit tap on object</td>
</tr>
<tr>
<td>$x = 1.57$</td>
<td>$x = 1.57$</td>
<td>Implicit angle association and rectification</td>
</tr>
<tr>
<td>$\text{Flick}$</td>
<td>$\text{Flick}$</td>
<td>Nail two drawing elements by small circle and tap</td>
</tr>
<tr>
<td>$y = x^4$</td>
<td>$y = x^4$</td>
<td>Lasso and drag symbol to change position</td>
</tr>
</tbody>
</table>

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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

**Gesture Class**
- Mnemonic flick
  - Punctuated: self-contained mnemonic mimic
   - lasso (\(\bigcirc\)), scribble (\(\sim\)), or crop (\(\Box\))
   - letter or scribble (\(\Theta\))
   - stroke hook (\(\bigcirc\))

<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>$\sigma$ saves the line</td>
<td></td>
</tr>
<tr>
<td>Punctuated: self-contained mnemonic mimic</td>
<td>lasso ((\bigcirc)), scribble ((\sim)), or crop ((\Box))</td>
<td>tap or pause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punctuated: self-contained mnemonic mimic</td>
<td>letter or scribble ((\Theta))</td>
<td>tap or pause</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punctuated: self-contained mnemonic mimic</td>
<td>stroke hook ((\bigcirc))</td>
<td>tap or pause</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- at deletes ink inside it
- $\bigcirc$ copies ink contained in the lasso
- $\Omega$ applies Ninja menu option to lasso contents
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

Input: Strokes $s_{i-1}$ and $s_{i-2}$, a bounding box threshold $e_{box}$, and a line difference threshold $e_{diff}$.
Output: True or false.

DetectINGEqualSign($s_{i-1}, s_{i-2}, e_{box}, e_{diff}$)

1. $P \leftarrow$ Points($s_{i-1}$)
2. $Q \leftarrow$ Points($s_{i-2}$)
3. $b_1 \leftarrow$ BoundingBox($s_{i-1}$)
4. $b_2 \leftarrow$ BoundingBox($s_{i-2}$)
5. $slen_1 \leftarrow \sum_{x \in b_1} ||P_x - P_{x-1}||$
6. $slen_2 \leftarrow \sum_{x \in b_2} ||Q_x - Q_{x-1}||$
7. if $slen_1 > e_{box} \sqrt{\text{Width}(b_1)^2 + \text{Height}(b_1)^2}$ or $slen_2 > e_{box} \sqrt{\text{Width}(b_2)^2 + \text{Height}(b_2)^2}$
   return false
8. if Width($b_1$) < Height($b_1$) or Width($b_2$) < Height($b_2$)
   return false
9. $\text{diff}_1 = |X(P_1) - X(Q_1)|$
10. $\text{diff}_2 = |X(P_2) - X(Q_2)|$
11. if LineOverlap($P_1, P_2, Q_1, Q_2$, and $\text{diff}_1 < e_{diff}$ and $\text{diff}_2 < e_{diff}$
   return true
12. else
   return false

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

Multi-Touch Gestures

http://www.flickr.com/photos/ideum/4380417382/
Readings