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

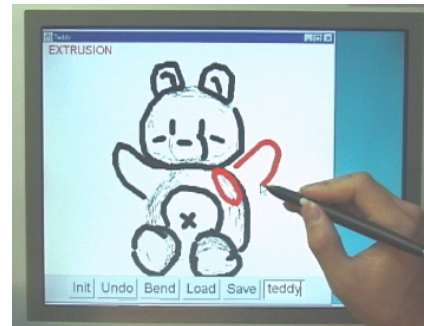Single stroke gesture

Multi-stroke gesture

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

www-ui.is.s.u-tokyo.ac.jp/~takeo/research/teddy/teddy.htm
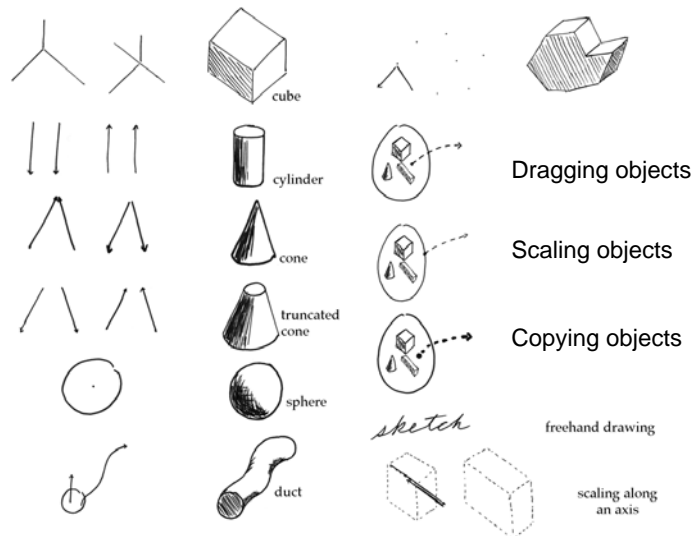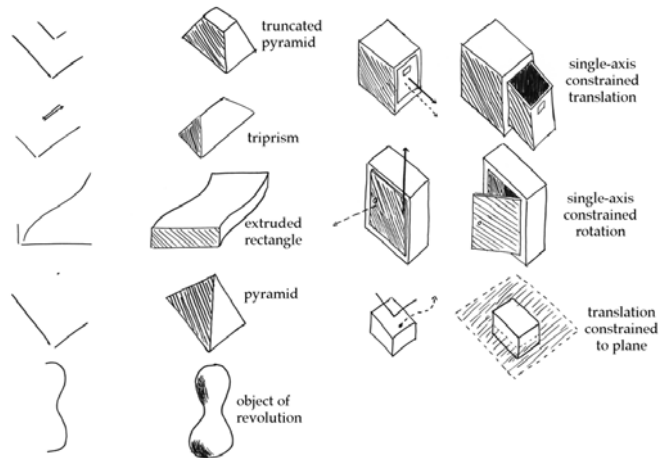
SKETCH

- 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
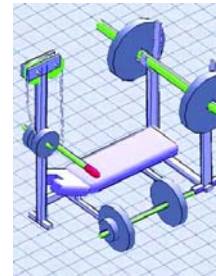
SKETCH Gesture Set (1)

Dragging objects

Scaling objects

Copying objects

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
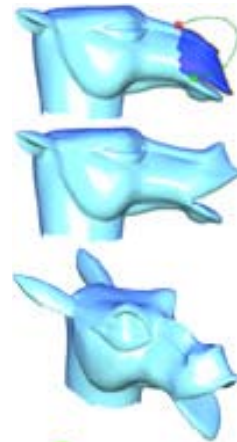

Smooth Teddy

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

Nealen et al. (2005)

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
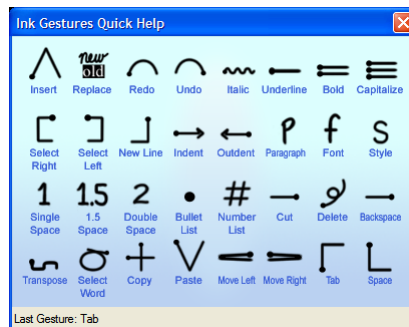 - mathematical apps
  - etc…

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
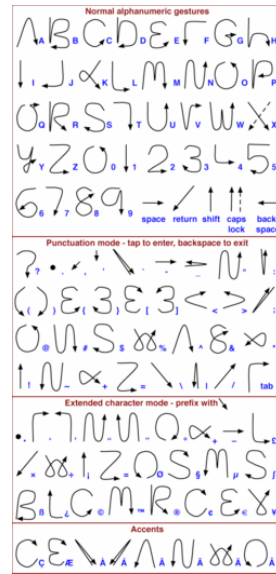
Text Editing

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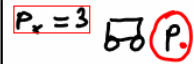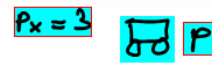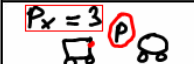
www.jumpingminds.com

MathPad^2
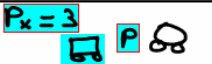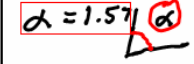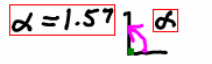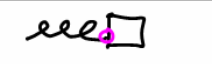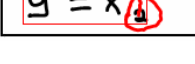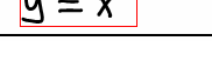
- Simple gesture set for
  - invoking operations
  - manipulating ink
- Uses notion of punctuated gestures
  - multi-stroke (gesture + punctuation)
  - makes use of context
- Why?
  - reduce number of gestures
  - overload appropriate gestures
  - reduce conflicts
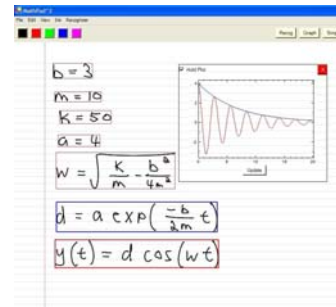
MathPad^2 Gesture Set (1)

Gesture	Result	Description
$X + y^2$ (lassoed)	$X + y^2$	Lasso and tap to recognize an expression
$X + y^2$. (scribbled)	$X + y$	Scribble and tap to delete ink
$X + y$	$x+y$	Creates a graph, line starts in recognized math, no cusps or intersections
$x(t) = t$ $a + b$	$x(t) = t$ $a + b$	Line through math and click on drawing makes association, Release makes rotation point
$y + 2 = 0$	$y + 2 = 0$ $y = -2$	Solves equation, includes simultaneous and ordinary differential equations
$\int x^2\, dx$ =	$\int x^2\, dx = \frac{x^3}{3}$	Evaluate an expression, includes intergrals,derivatives, summations, etc.

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MathPad² Gesture Set (2)

Gesture	Result	Description
$P_x = 3$	$P_x = 3$	Makes implicit association using label family 'P'
$P_x = 3$	$P_x = 3$	Makes implicit association with explicit tap on object
$\alpha = 1.57$	$\alpha = 1.57$	Implicit angle association and rectification
eee	eee	Nail two drawing elements by small circle and tap
		Group strokes
$y = x$	$y = x^2$	Lasso and drag symbol to change position

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

Gestures in top row, regular ink in bottom row.

Flick, mnemonic flick, ink

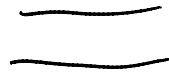| Gesture Class	Context	Gesture	Terminal	Example
Mnemonic flick	flick (/)	letter		ß saves the file
Punctuated:				
self-contained		lasso (◯), scribble (𝑀), or crop (∟)	tap or pause	𝑀 deletes ink under it
mnemonic	lasso (◯)	letter or scribble (𝑀)	tap or pause	& copies ink contained in the lasso
mimetic	lasso (◯)	stroke hook (/)	tap or pause	⬜ applies NE menu option to lasso contents

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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

Input: Strokes s_{i-1} and s_{i-2}, a bounding box threshold ϵ_{box}, and a line difference threshold ϵ_{diff}.

Output: True or false.

DETECTEQUALSIGN($s_{i-1}, s_{i-2}, \epsilon_{box}, \epsilon_{diff}$)

(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) $slen_1 \leftarrow \sum_{i=2}^{n} \|P_i - P_{i-1}\|$

(6) $slen_2 \leftarrow \sum_{i=2}^{n} \|Q_i - Q_{i-1}\|$

(7)   **if** $slen_1 > \epsilon_{box}\sqrt{Width(b_1)^2 + Height(b_1)^2}$ **or** $slen_2 > \epsilon_{box}\sqrt{Width(b_2)^2 + Height(b_2)^2}$

(8)   **return** false

(9)   **if** $Width(b_1) < Height(b_1)$ **or** $Width(b_2) < Height(b_2)$

(10)   **return** false

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

(11) $diff_1 = |X(P_1) - X(Q_1)|$

(12) $diff_2 = |X(P_n) - X(Q_n)|$

(13)   **if** $LineOverlap(P_1, P_n, Q_1, Q_n)$ **and** $diff_1 < \epsilon_{diff}$ **and** $diff_2 < \epsilon_{diff}$
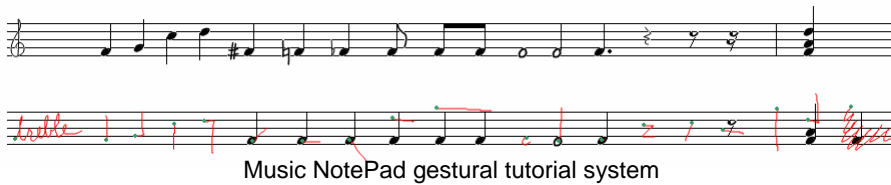
(14)   **return** true

(15)   **else**

(16)   **return** false

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

- Zeleznik, R., K. Herndon, and J. Hughes. SKETCH: An Interface for Sketching 3D Scenes. *Proceedings of SIGGRAPH'96*, ACM Press, 163-170, 1996.

- Igarashi, T., S. Matsuoka, and H. Tanaka. Teddy: A Sketching Interface for 3D Freeform Design. *Proceedings of SIGGRAPH'99*, ACM Press, 409-416, 1999.

- Robert Zeleznik and Timothy Miller. Fluid Inking: Augmenting the Medium of Free-Form Inking with Gestures. In *Graphics Interface*. Canadian Human-Computer Communications Society, p 155-162, June 2006.