Pen-Based User Interfaces

Lecture #1: Introduction
Fall 2010
Joseph J. LaViola Jr.

Instructor

Professor – **Joseph J. LaViola Jr.**
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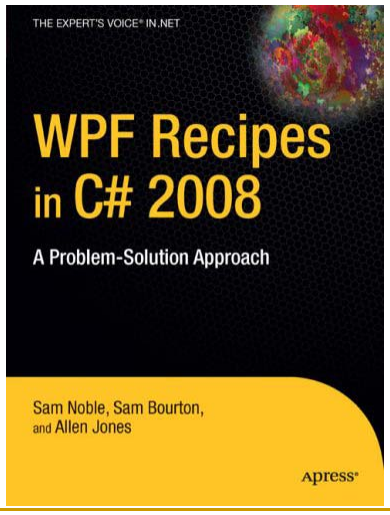
Office Hours – Tues. 4:00pm – 5:30pm
Wed. 6:00pm – 7:00pm
Office is Harris 321

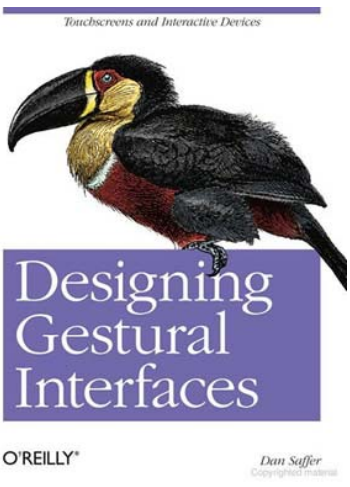
Website will have all required info
www.eecs.ucf.edu/courses/cap6105/fall2010/

Class Goals

- Provide foundation for pen-based user interface research and development
- Learn to critique research papers
- Speaking and presentation skills
- Start of master's projects and PhD dissertations
- Possible publications
  - Intelligent User Interfaces 2011
  - Sketch-based Interfaces and Modeling 2011
  - User Interface Software and Technology 2011
  - SIGGRAPH 2011

Reference Books





Grading

Assignment 1	10%
Assignment 2	10%
Assignment 3	10%
Assignment 4	10%
Paper discussion	5%
Paper presentations	5%
Final Project	50%

Final Projects

- Encourage 2 person teams
- Must have research component
- Everyone must write and get approved a project proposal
- Final Project write up required
- DEMO DAY!!!! – December 13, 2010
- More on Wednesday – August 25th

Class Structure (see syllabus for details)

- Lectures
  - fundamentals of pen computing
  - sketch-based interfaces
- Paper discussions
  - 3 or 4 papers
  - students lead discussion
- Student paper presentation
  - 25 minute presentation
- Final project update sessions

Tools

- Tablet PC lab – Harris 208
  - will meet there sometimes
  - 12 HP Tablet PCs
    - 1.83 GHz Dual Core
    - 2GB memory
    - Windows 7
  - key access to room
- Visual Studio 2008
  - C#
  - Windows Presentation Foundation

starPad SDK

www.starpad.org

Collaboration and Late Policy

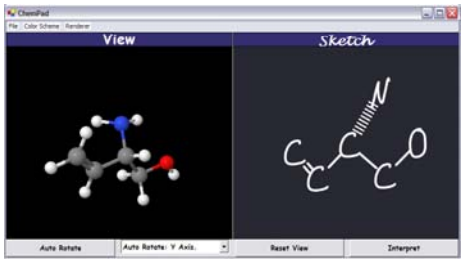
- Collaboration encouraged
  - do your own work on assignments
  - cheating = BAD!!!
- All assignments must be handed in on time
  - assignments – by 11:59pm on due date

Sketching and Gestures

- What is Sketching?
  - to make a hasty or undetailed drawing or painting often made as a preliminary study (dictionary)
- What is a Gesture?
  - the act of moving the limbs or body as an expression of thought or emphasis (dictionary)
    - not focusing on this type of gesture
    - interested in 2D pen, finger, and mouse-based gestures
- Gestures are like simple sketches

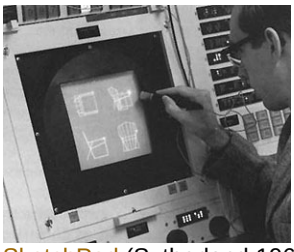
Pen-Based Interfaces

- Interaction stylus (2D) or finger
- Strokes for the computer to interpret
  - commands (gestural UI)
  - drawings
  - symbols, words, mathematics
- Mimic pencil and paper
- Inference and ambiguity

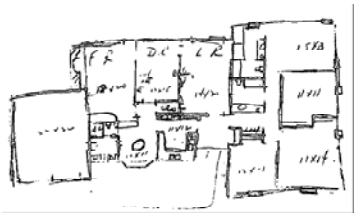


(ChemPad 2007)

Historical Perspective (60s and 70s)

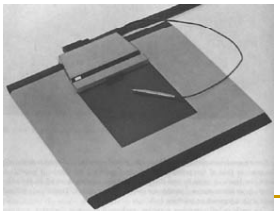


SketchPad (Sutherland 1963)

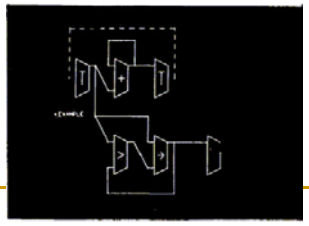


Architecture-By-Yourself
(Weinzapfel & Negroponte 1976)

HUNCH
(Herot 1976)



Math Reco (Anderson 1967)



Logic Diagrams
(Sutherland 1966)

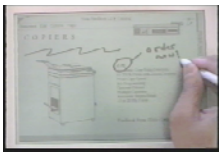
Historical Perspective (80s and 90s)

Wang Freestyle (1988)

GRIDPad (1989)

PenWindows (1991)

GO +PenPoint
(1991)



Slate (1992)

Anoto
(1999)

Newton (1993)

Palm Pilot's
Graffiti (1994)

CrossPad (1999)

RIP – (adapted from Bill Buxton)

Freestyle

Grid

Pen for Windows

GO

Crosspad

Slate

Newton

Palm Pilot's Graffiti (1994)

Anoto (1999)

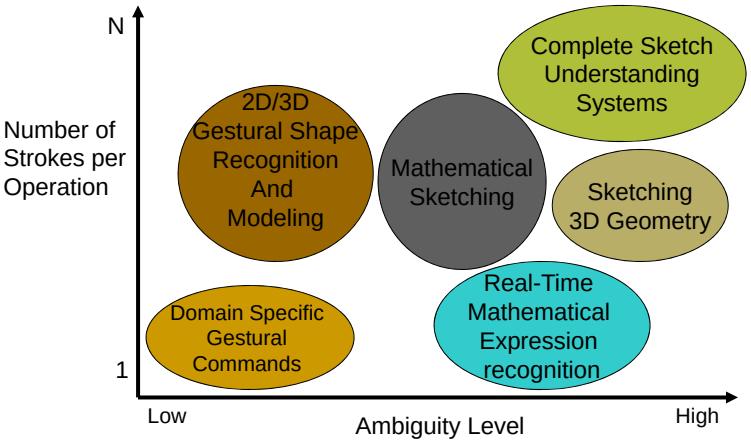
Today

- Much improved hardware support
  - Tablet PC
  - Digitizers
    - Wacom Cintiq
    - Smartboard
- Much improved software support
  - Tablet SDK
    - handwriting recognition
    - speech recognition
  - character recognizers
- Better recognition algorithms
  - machine learning (use those cycles!)

Moving Forward

- Multi-touch is now the rage
  - large screens
  - laptops (Windows 7)
  - iPad
- Interesting questions
  - killer app?
  - what is multi-touch good for?
  - how to integrate pen and multi-touch together?

A Sketch Input Continuum

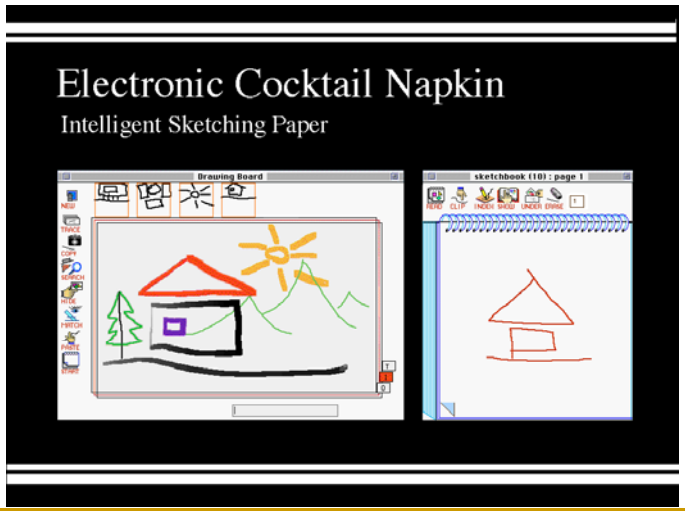


Ambiguity level refers to sketch interpretation difficulty and domain generality

Pen-Based Applications

- 2D/3D Graphics
- UI Prototyping
- Animation
- Note Taking/Annotation
- Symbol/Word/Math Recognition
- Mathematical Sketching
- Etc…

Conceptual 2D Design



(Gross 1994)

Character and Mathematical Expression Recognition

$$\lambda(k,l) = \sqrt{(2l+1)^2 + (2k+1)^2}$$

$$A_{(k,l)}(x,y) = \frac{\sin((2l+1)\pi x)\sin((2k+1)\pi y)}{(2l+1)(2k+1)}$$

$$u(x,y,t) \cong \frac{1}{\pi^2} \sum_{k=0}^{40} \sum_{l=0}^{40} A_{(k,l)}(x,y)\, e^{-\lambda^2(k,l)\,t}$$

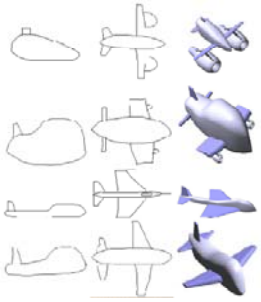
$$t = 0 \ldots 5 \qquad 0 \le x \le 1 \qquad 0 \le y \le 1$$

$$x(t) = 2\sin(t^2)$$

$$x(t) = 2\sin(t^2)$$

3D Modeling

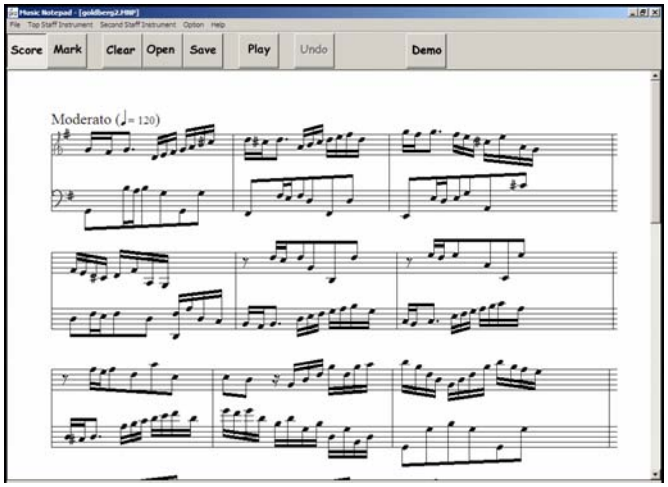
SKETCH
(Zeleznik et al. 1996)



Parameterized Object Sketching
(Yang et al. 2005)

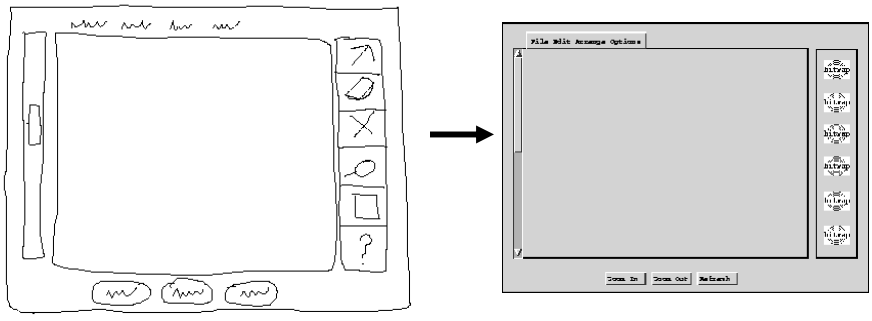
TEDDY
(Igarashi et al. 1999)

Musical Score Creation



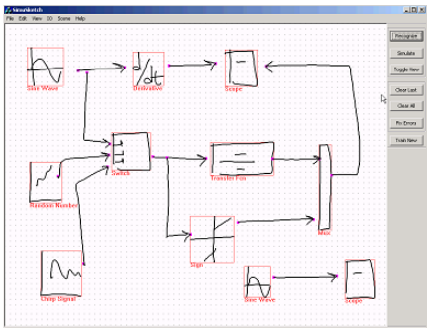
Music NotePad (Forsberg et al. 1998)

User Interface Prototyping

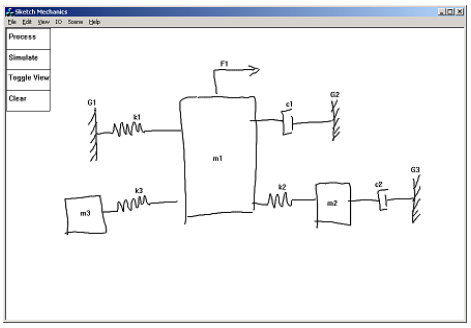


SILK (Landay and Myers 1995)

Simulation

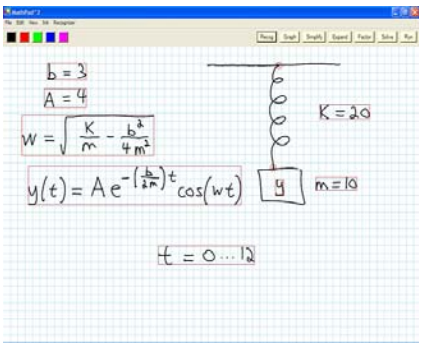


Sim-U-Sketch
(Kara and Stahovich 2004)

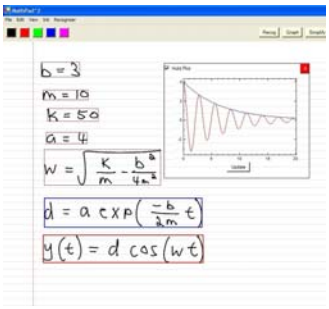


VibroSketch
(Kara et al. 2004)

Mathematical Sketching

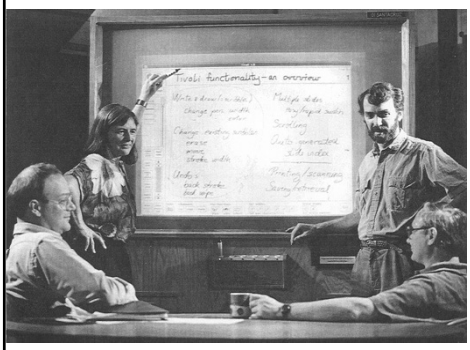


(LaViola and Zeleznik 2004)



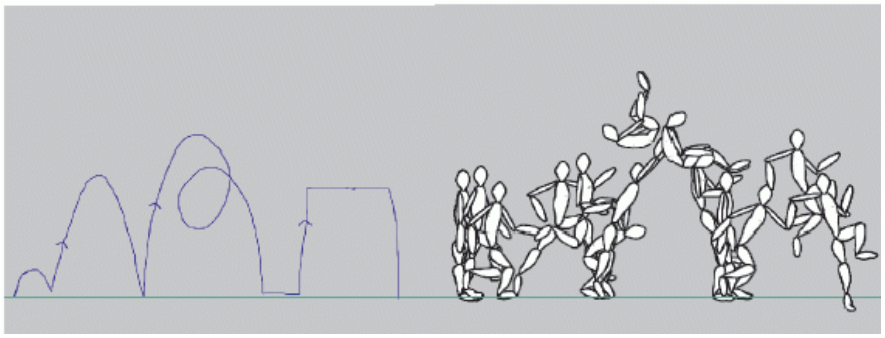
Electronic Whiteboard Systems

Tivoli
(Pedersen et al. 1993)



Flatland
(Mynatt et al. 1999)

Animation



Motion Doodles
(Thorne et al. 2004)

Pen UI Resources (1)

- Siggraph 2007 course notes
- EG Symposium on Sketch-Based Interfaces and Modeling
- Sketch-based interface project web pages
- Microsoft Center for Research on Pen-Centric Computing website
  - http://graphics.cs.brown.edu/research/pcc/home.html
- Various other conferences (UIST,CHI, SIGGRAPH)
- Check course website for links

Pen UI Resources (2)

Sketch Understanding
Papers from 2002 AAAI Spring Symposium
Randall Davis, James Landay, and Tom Stahovich, *Program Cochairs*
Technical Report SS-02-08
Published by The AAAI Press, Menlo Park, California
see http://www.aaai.org/Library/Symposia/Spring/ss02-08.php

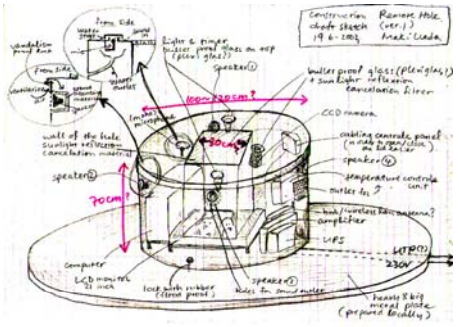
Making Pen-Based Interaction Intelligent and Natural
Papers from the 2004 AAAI Fall Symposium
Randall Davis, James Landay, Tom Stahovich, Rob Miller, and
Eric Saund *Program Cochairs*
Technical Report FS-04-06
Published by The AAAI Press, Menlo Park, California
see http://www.aaai.org/Library/Symposia/Fall/fs04-06.php

Why Sketches and Gestures?

- Mimic pencil and paper
  - direct and natural for many tasks
  - familiar affordances
- Powerful and expressive
  - more freedom
  - can be faster
  - non-WIMP

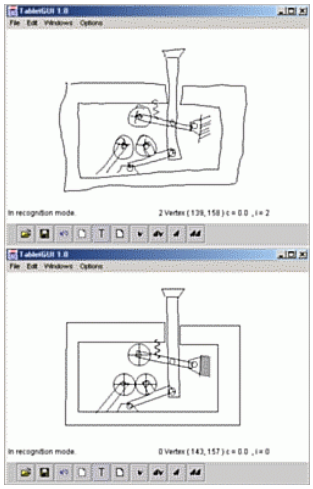
Key Issues – Recognition, Resolving Ambiguity, and Self-Disclosure

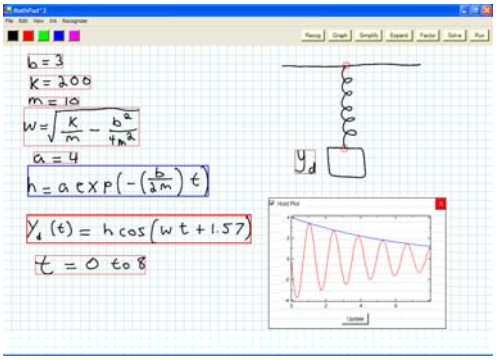
- Recognition
  - need to understand sketch components
- Ambiguity
  - deal with multiple interpretations
- Self-Disclosure
  - invisible interface (mostly gestural commands)



www.ueda.nl/earth/development.html

Recognition



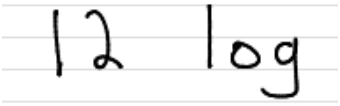


MathPad²

rationale.csail.mit.edu/project_earlyprocess.shtml

Resolving Ambiguity

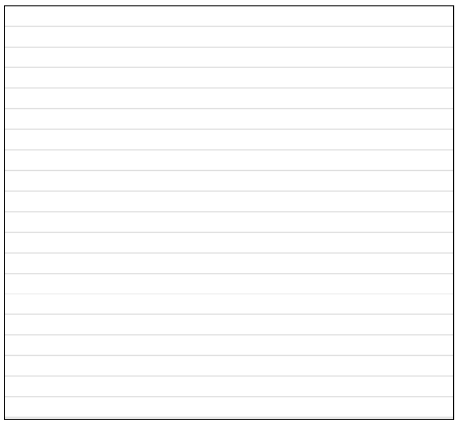
- Difficult problem
- Focal point of research
- Many approaches
  - limiting the domain
  - underlying rules and knowledge
  - suggestive interface



Self-Disclosure

How do we interact with this application?

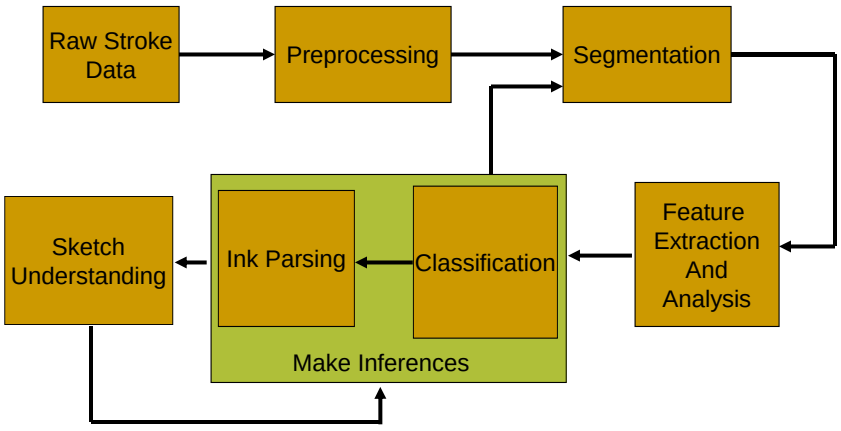
What are the commands?



How many commands are there?

Where do I begin?

Pen-Based Interface Dataflow



Representing Data

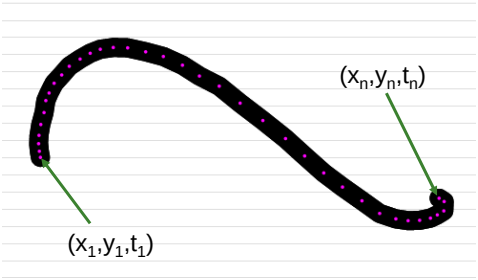
- Points and strokes

  $s = p_1 p_2 \ldots p_n$

  where

  $p_i = (x_i, y_i, t_i),\ 1 \le i \le n$

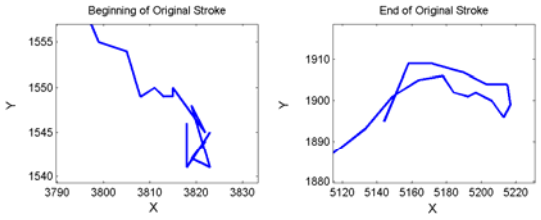
  $S = s_1 s_2 \ldots s_m$
- Image
  - pixel matrix
  - not as popular



Preprocessing

- Often required to clean raw data
- Filtering and Smoothing
- Stroke Invariance
  - scale
  - position
  - orientation
- Dehooking

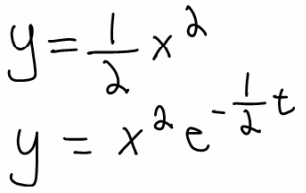
Normal view of stroke



Zoomed in view of stroke showing unwanted cusps and self-intersections

Segmentation

- Determine which strokes go together
- Determine which strokes should be apart
- Can be done in real-time or in batch
- Often uses proximity and timing information



Feature Extraction and Analysis

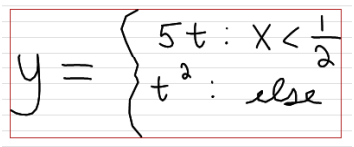
- Want to distinguish sketch components from one another
- Good features are critical
- Extract important information
  - geometrical, statistical, contextual
- Examples include
  - arc length, histograms, cusps, aspect ratio
  - self-intersections, stroke area, etc…

Classification

- Use features as input to a classification algorithm
  - recognize sketch components and gestures
- Can be simple as an FSA
- Commonly use machine learning algorithms
  - linear classifiers, neural networks, HMMs, SVMs
  - AdaBoost, K-means classifiers, etc…
- Algorithm choice dependent on problem

Sketch Parsing

- Often recognition of strokes is insufficient
  - except for gestures
- Require an understanding of spatial relationships
  - good examples are mathematical expressions
- Higher level classifications
  - is it a word or a drawing?



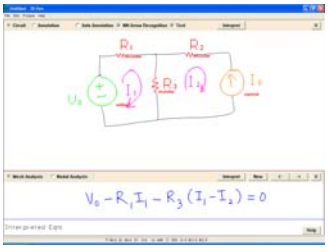
www.engr.ucr.edu/~stahov/research/acsparc.htm

Making Inferences

- Sketches are often insufficient for understanding
  - can be under- or over-constrained
- Can infer based on
  - context
  - domain knowledge
  - domain restrictions
  - stroke location

Sketch Understanding

- Understanding a sketch/recognizing a gesture is only half the battle
- What do we do with it?



Kirchhoff's Pen (de Silva et al. 2007)

VibroSketch Sketch Understanding (Kara,Gennari, Stahovich 2004)

Next Class – Discussion

- Final Project Ideas
- Readings
  - Sutherland, I. SketchPad: A Man-Machine Graphical Communication System, Proceedings of AFIPS Spring Joint Computer Conference, 329-346, 1963.
  - Blackwell, F. and R. Anderson. An on-line symbolic mathematics system using hand-printed two-dimensional notation. Proceedings of the 1969 24th National Conference, 551-557, 1969.
  - Herot, C. Graphical Input Through Machine Recognition of Sketches, Proceedings of SIGGRAPH'76, 97-102, 1976.