

# Pen-Based User Interfaces

Lecture #1: Introduction

Fall 2015

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

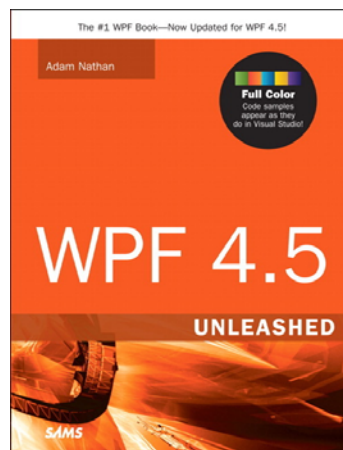
Website will have all required info

[www.cs.ucf.edu/courses/cap6105/fall2015](http://www.cs.ucf.edu/courses/cap6105/fall2015)

## 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
  - Graphics Interface 2016
  - Expressive 2016
  - User Interface Software and Technology 2016
  - SIGGRAPH 2016

## 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
- DEMO DAY!!!! – December 14, 2015
- More on Wednesday – August 26th

## 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
  - 7 HP Tablet PCs
  - 4 Windows Surface Pro 3
  - keycard access to room
- Visual Studio 2013
  - C#
  - Windows Presentation Foundation 4.5



## starPad SDK



[www.starpad.org](http://www.starpad.org)

## Collaboration and Late Policy

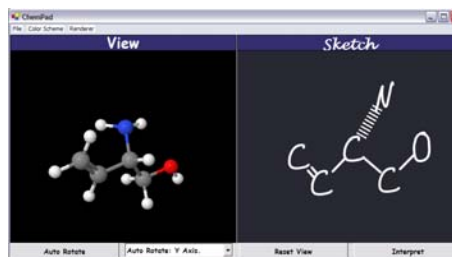
- Collaboration encouraged
  - do your own work on assignments
  - cheating = BAD!!!
- All assignments must be handed in on time
  - assignments – by 11:59pm on due date

## 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

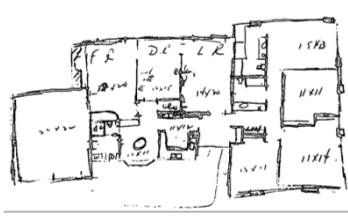


[\(ChemPad 2007\)](#)

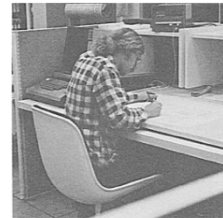
## Historical Perspective (60s and 70s)



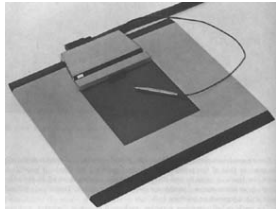
**SketchPad** (Sutherland 1963)



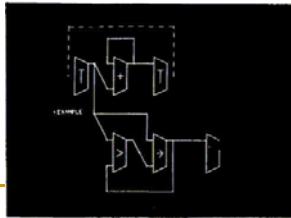
**Architecture-By-Yourself**  
(Weinzapfel & Negroponce 1976)



**HUNCH**  
(Herot 1976)



**Math Reco** (Anderson 1967)



**Logic Diagrams**  
(Sutherland 1966)

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## Historical Perspective (80s and 90s)



**Wang Freestyle** (1988)



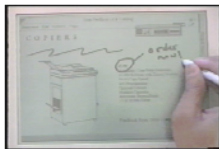
**GRIDPad** (1989)



**PenWindows** (1991)



**GO +PenPoint**  
(1991)



**Slate** (1992)



**Anoto**  
(1999)



**Newton** (1993)



**Palm Pilot's  
Graffiti** (1994)



**CrossPad** (1999)

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## RIP – (adapted from Bill Buxton)

+

Freestyle

+

Grid

+

Pen for Windows

+

GO

+

Slate

+

Newton



ABCDE  
FGHIJ  
Palm Pilot's  
Graffiti (1994)

+

Crosspad



Anoto  
(1999)

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## Today

- Much improved hardware support
  - Tablet PC
  - Digitizers
    - Wacom Cintiq
    - Perspective Pixel
  - Smartphones
- Much improved software support
  - Windows 10 SDK
    - handwriting recognition
    - speech recognition
  - character recognizers
- Better recognition algorithms
  - machine learning (use those cycles!)



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## Moving Forward

- Multi-touch is here
  - large screens
  - laptops (Windows 10)
  - iPad
- Interesting questions
  - killer app?
  - what is multi-touch good for?
  - how to integrate pen and multi-touch together?

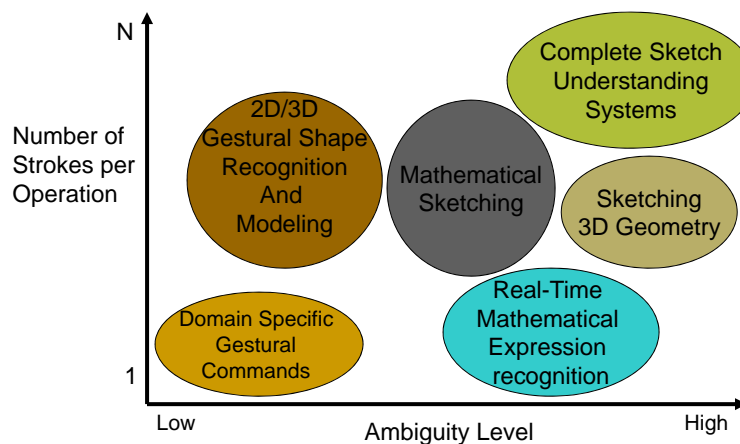


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## A Sketch Input Continuum



Ambiguity level refers to sketch interpretation difficulty and domain generality

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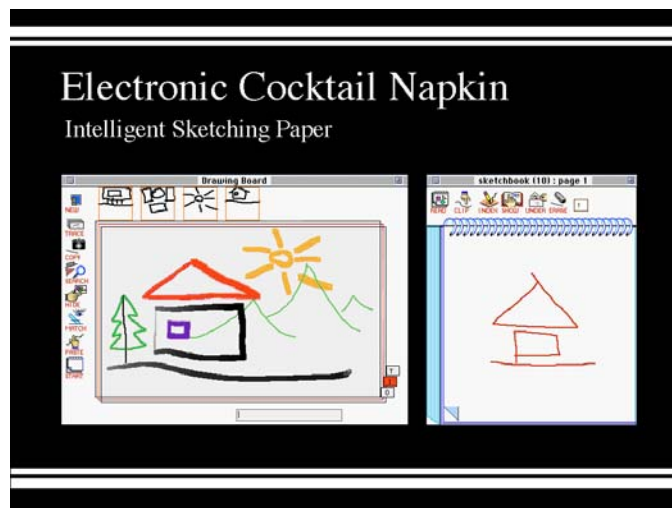
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## Pen-Based Applications

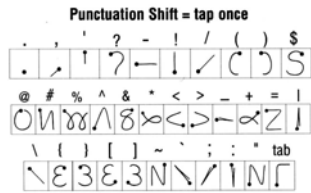
- 2D/3D Graphics
- UI Prototyping
- Animation
- Note Taking/Annotation
- Symbol/Word/Math Recognition
- Mathematical Sketching
- Etc...

## Conceptual 2D Design



(Gross 1994)

# Character and Mathematical Expression Recognition



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

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

$$u(x,y,t) \cong \frac{1}{\pi^2} \sum_{k=0}^{y_0} \sum_{l=0}^{x_0} A_{(k,l)}(x,y) e^{-\lambda^2(k,l)t}$$

$t = 0 \dots 5$        $0 \leq x \leq 1$        $0 \leq y \leq 1$

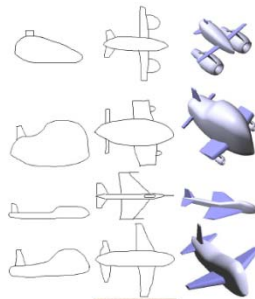
$$X(t) = 2 \sin(t^2)$$

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

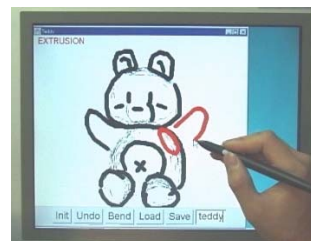
# 3D Modeling



**SKETCH**  
(Zeleznik et al. 1996)



Parameterized Object Sketching  
(Yang et al. 2005)



**TEDDY**  
(Igarashi et al. 1999)

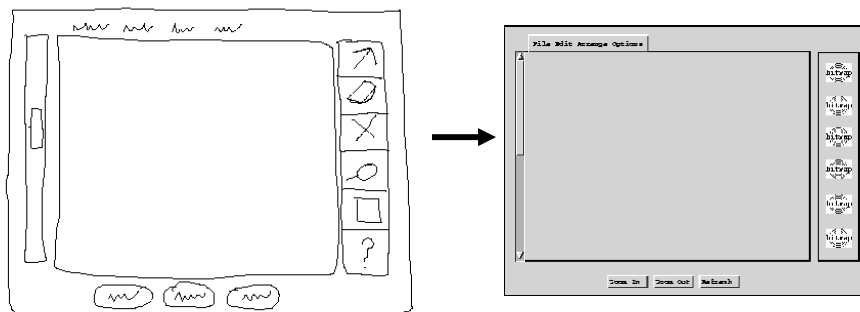
## Musical Score Creation



Music NotePad

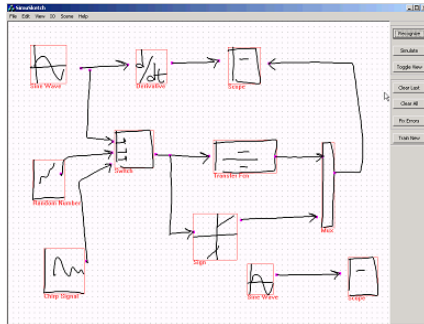
(Forsberg et al. 1998)

## User Interface Prototyping

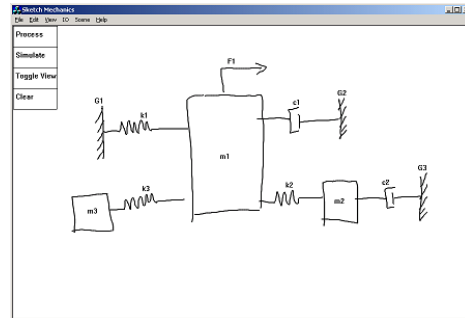


SILK (Landay and Myers 1995)

# Simulation

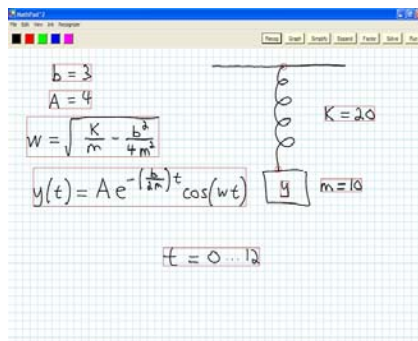


Sim-U-Sketch  
(Kara and Stahovich 2004)

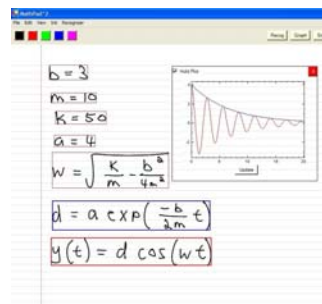


VibroSketch  
(Kara et al. 2004)

# Mathematical Sketching

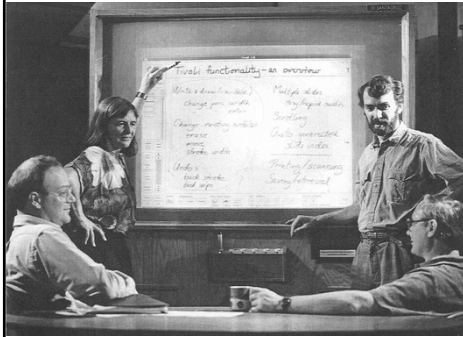


(LaViola and Zeleznik 2004)



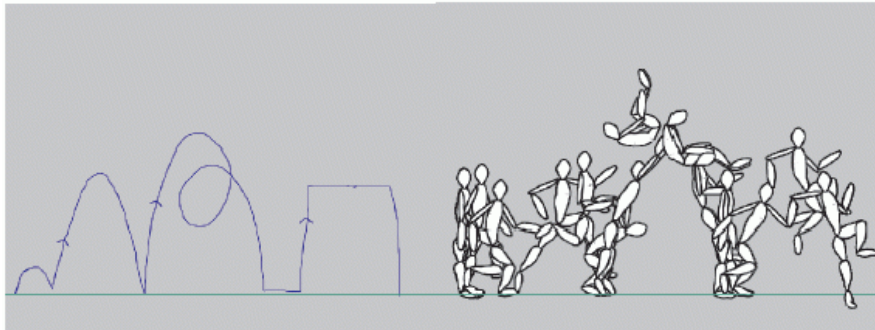
# Electronic Whiteboard Systems

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
- Zhai et al.'s 2012 Touch Gesture survey paper
- 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

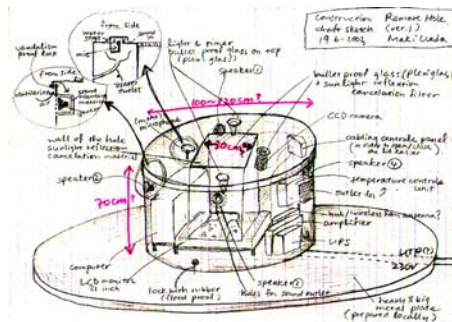
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## Key Issues – Recognition, Resolving Ambiguity, and Self-Disclosure

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



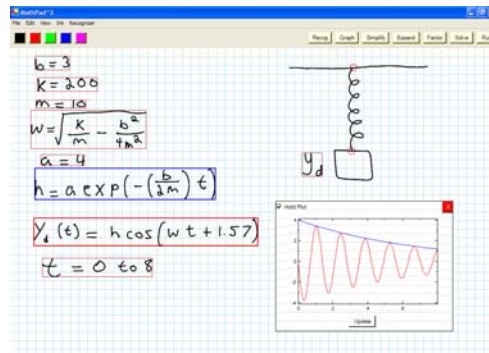
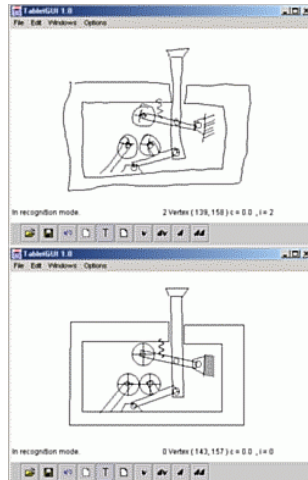
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## Recognition



MathPad<sup>2</sup>

[rationale.csail.mit.edu/project\\_earlyprocess.shtml](http://rationale.csail.mit.edu/project_earlyprocess.shtml)

## Resolving Ambiguity

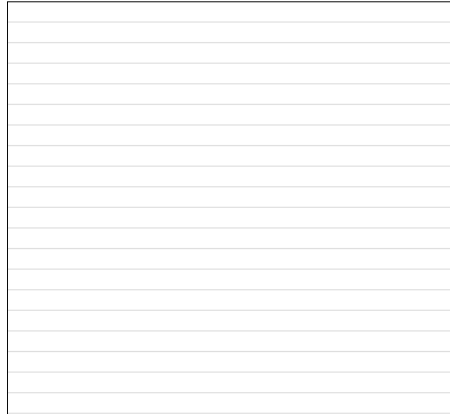
- Difficult problem
- Focal point of research
- Many approaches
  - limiting the domain
  - underlying rules and knowledge
  - suggestive interface

12 log

# Self-Disclosure

How do we interact with this application?

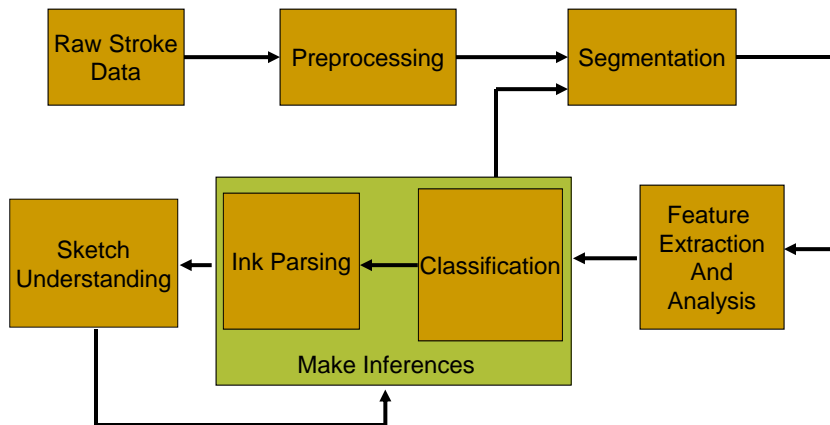
What are the commands?



How many commands are there?

Where do I begin?

# Pen-Based Interface Dataflow



## Representing Data

- Points and strokes

$$s = p_1 p_2 \dots p_n$$

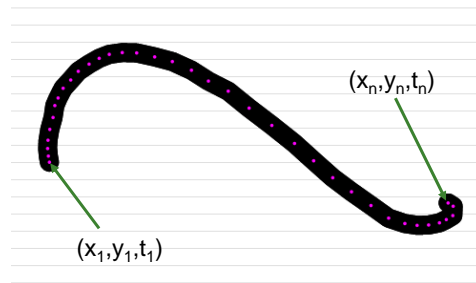
where

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

$$S = s_1 s_2 \dots s_m$$

- Image

- pixel matrix
- not as popular



## Preprocessing

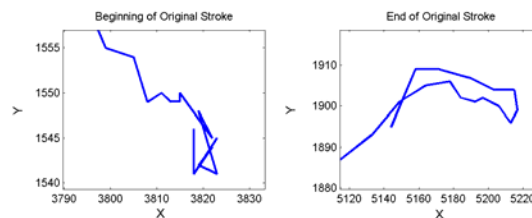
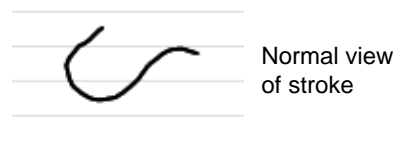
- Often required to clean raw data

- Filtering and Smoothing

- Stroke Invariance

- scale
- position
- orientation

- Dehooking



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

$$y = \frac{1}{2} x^2$$
$$y = x^2 e^{-\frac{1}{2}t}$$

5 K 

## 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...

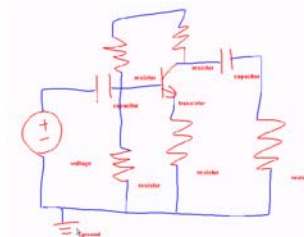
## Classification

- 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?

$$y = \begin{cases} 5t & : x < \frac{1}{2} \\ t^2 & : \text{else} \end{cases}$$



[www.engr.ucr.edu/~stahov/research/acsparc.htm](http://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

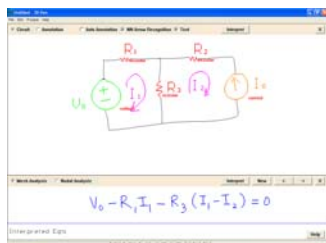
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## Sketch Understanding

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



[Kirchoff's Pen](#) (de Silva et al. 2007)



[VibroSketch](#) Sketch Understanding (Kara, Gennari, Stahovich 2004)

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## 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.