Topics in Pen-Based User Interfaces

Lecture #1: Introduction

Fall 2007

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Instructor

Professor – **Joseph J. LaViola Jr.**

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Office Hours – Tues. 4:30pm – 6:30pm

Wed. 5:45pm – 6:45pm

Office is Harris 321

Website will have all required info
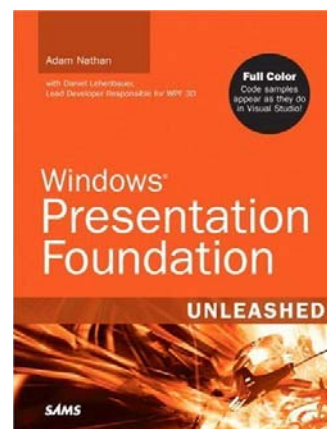
www.eecs.ucf.edu/courses/cap5937/fall2007

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
  - Advanced Visual Interfaces 2008
  - Sketch-based Interfaces and Modeling 2008
  - User Interface Software and Technology 2008
  - SIGGRAPH 2008

Reference Books

The Definitive Collection of Solutions and Examples

C# Cookbook

O'REILLY   Stephen Teilhet & Jay Hilyard

Adam Nathan
with Daniel Lehenbauer, Lead Developer Responsible for WPF 3D

Full Color
Code samples appear as they do in Visual Studio!

Windows Presentation Foundation
UNLEASHED

SAMS

Recommended   Required

Grading

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

Final Projects

- Encourage 2 person teams
- 6000 level students must have research component
- Everyone must write and get approved a project proposal
- Final Project write up required
- DEMO DAY!!!! – December 10, 2007
- More on Wednesday – August 22nd

Class Structure (see syllabus for details)

- **Lectures**
  - Fundamentals of pen computing
  - sketch-based interfaces
- **Paper discussions**
  - 3 or 4 papers
  - students must write 1-2 page reviews
- **Student paper presentation**
  - 20 minute presentation
- **Final project update sessions**

Tools

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

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
  - Paper reviews – by 4:30pm on day of discussion

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
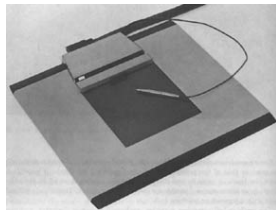- Inference and ambiguity
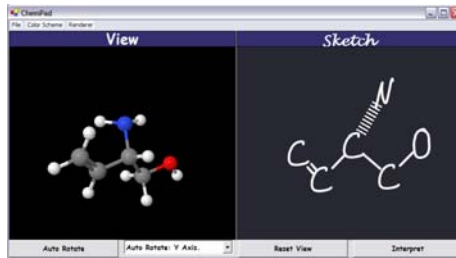
(ChemPad 2007)

Historical Perspective (60s and 70s)

SketchPad (Sutherland 1963)
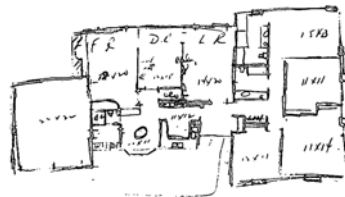
Architecture-By-Yourself
(Weinzapfel & Negroponte 1976)

HUNCH
(Herot 1976)

Logic Diagrams
(Sutherland 1966)

Math Reco (Anderson 1967)

Historical Perspective (80s and 90s)

Wang Freestyle (1988)   GRIDPad (1989)   PenWindows (1991)   GO +PenPoint (1991)
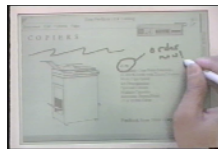
Slate (1992)

Anoto (1999)

Newton (1993)   Palm Pilot's Graffiti (1994)   CrossPad (1999)

RIP – (adapted from Bill Buxton)

✝ Freestyle   ✝ Grid   ✝ Pen for Windows   ✝ GO

✝ Slate   ✝ Newton   ✝ Crosspad

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!)

A Sketch Input Continuum

Number of Strokes per Operation (N to 1)

- 2D/3D Gestural Shape Recognition And Modeling
- Mathematical Sketching
- Complete Sketch Understanding Systems
- Sketching 3D Geometry
- Domain Specific Gestural Commands
- Real-Time Mathematical Expression recognition

Ambiguity Level (Low to High)
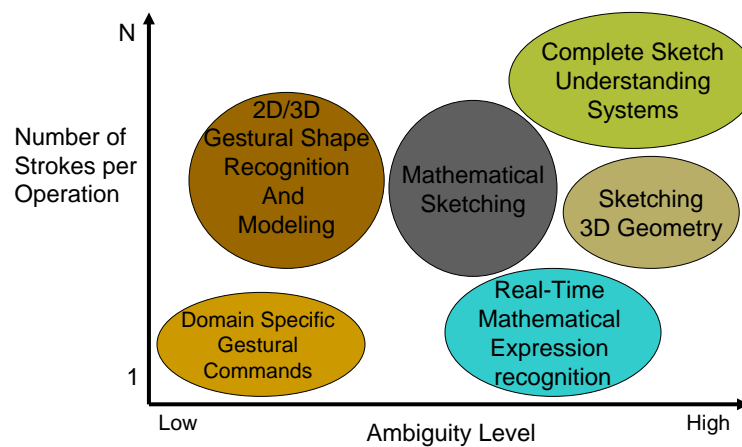
Ambiguity level refers to sketch interpretation difficulty and domain generality
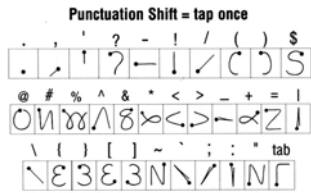
Pen-Based Applications

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

Conceptual 2D Design
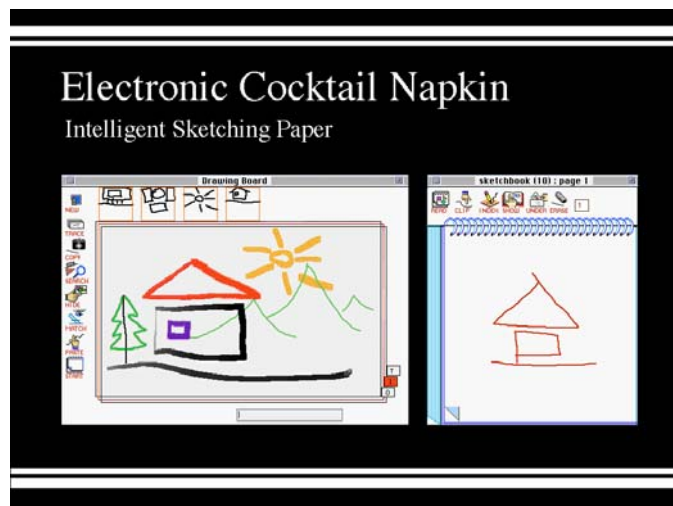
(Gross 1994)

Character and Mathematical Expression Recognition

$$\lambda(\kappa,\lambda) = \sqrt{(2\ell+1)^2 + (2\kappa+1)^2}$$

$$A_{(\kappa,\lambda)}(x,y) = \frac{\sin((2\ell+1)\pi x)\,\sin((2\kappa+1)\pi y)}{(2\ell+1)(2\kappa+1)}$$

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

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

$$X(t) = 2\sin(t^{\lambda})$$

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

3D Modeling

SKETCH
(Zeleznik et al. 1996)
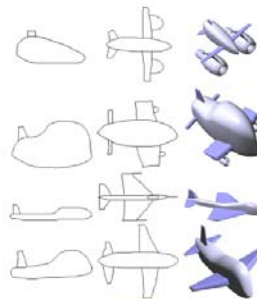
Parameterized Object Sketching
(Yang et al. 2005)
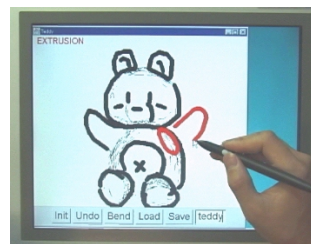
TEDDY
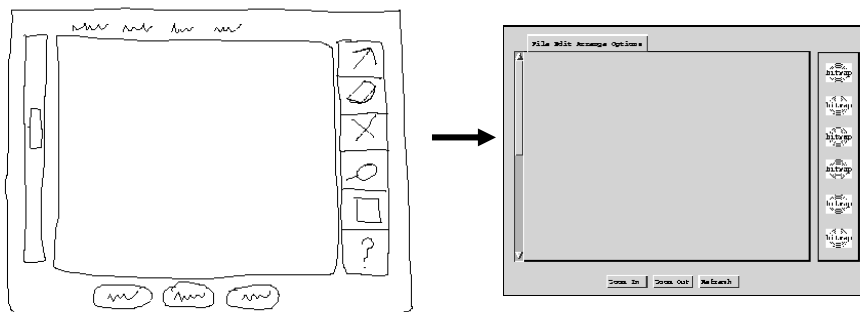(Igarashi et al. 1999)

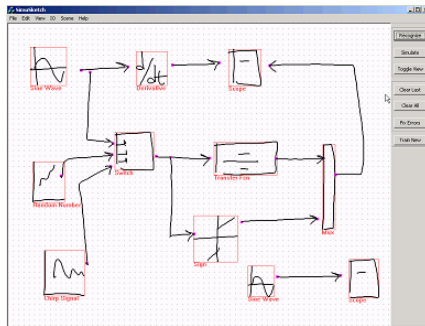# Musical Score Creation

Music NotePad   (Forsberg et al. 1998)
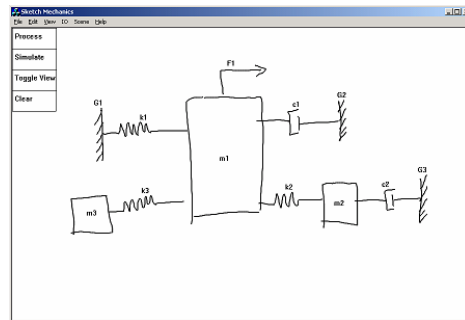
User Interface Prototyping

SILK   (Landay and Myers 1995)
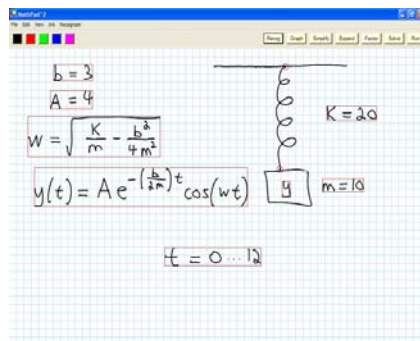
Simulation

Sim-U-Sketch
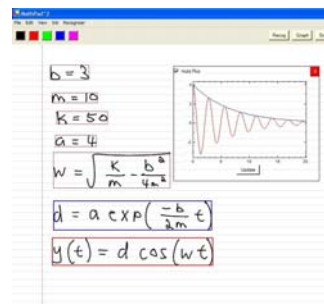(Kara and Stahovich 2004)

VibroSketch
(Kara et al. 2004)
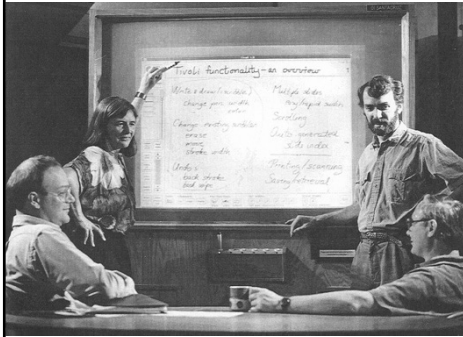
Mathematical Sketching
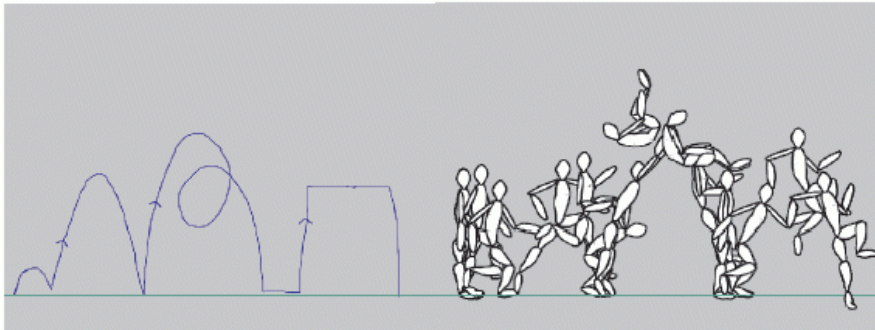

(LaViola and Zeleznik 2004)

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 Workshop 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

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Why Sketches and Gestures?

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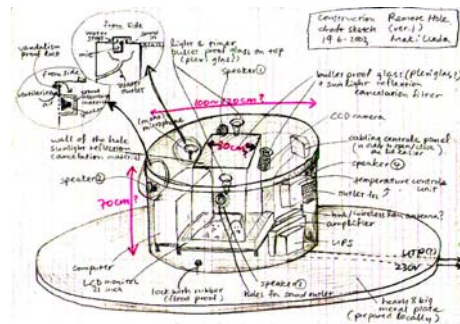 - more freedom
  - can be faster
  - non-WIMP

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

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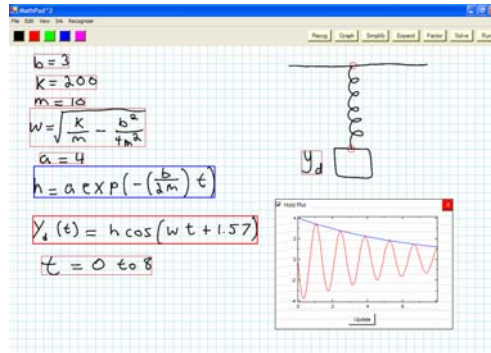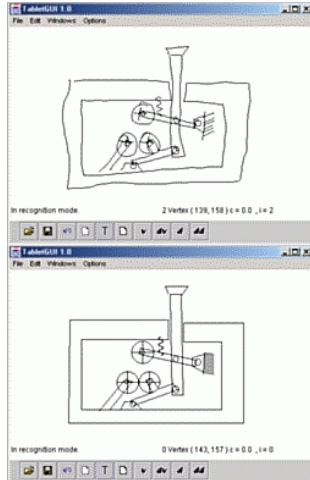 - invisible interface (mostly gestural commands)

www.ueda.nl/earth/development.html
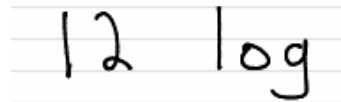
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Recognition

MathPad²

rationale.csail.mit.edu/project_earlyprocess.shtml

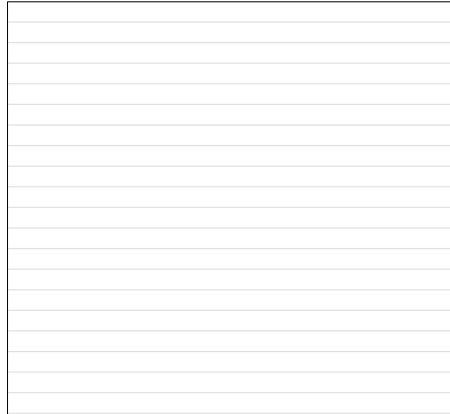
Resolving Ambiguity

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

Self-Disclosure

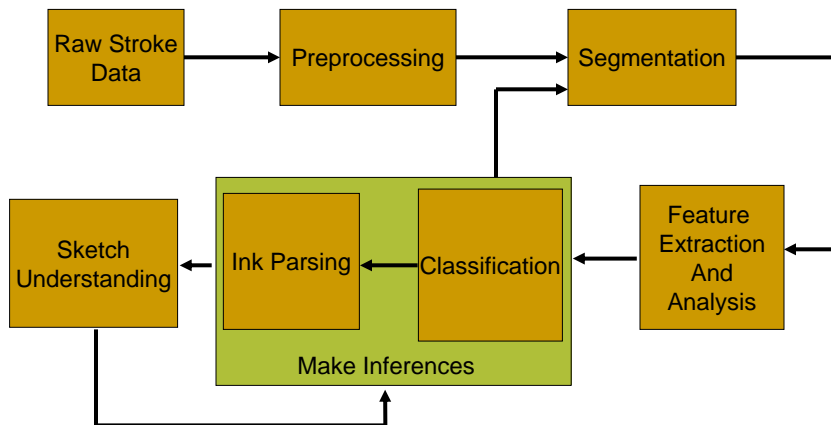How do we interact with this application?   What are the commands?

How many
commands
are there?

Where do
I begin?

Pen-Based Interface Dataflow

Raw Stroke Data → Preprocessing → Segmentation → Feature Extraction And Analysis → Classification → Ink Parsing → Sketch Understanding

Make Inferences

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
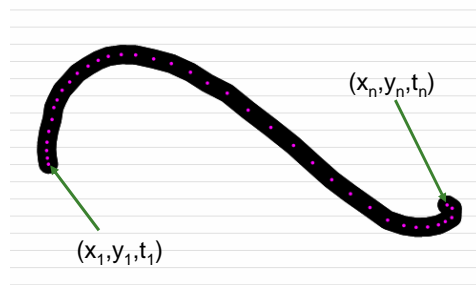
(x_n, y_n, t_n)

(x_1, y_1, t_1)

Preprocessing

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

Normal view of stroke

Beginning of Original Stroke

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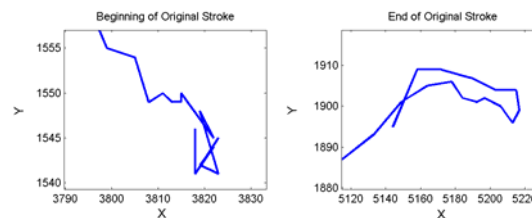
Zoomed in view of stroke showing unwanted cusps and self-intersections

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

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

$$5K$$

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…
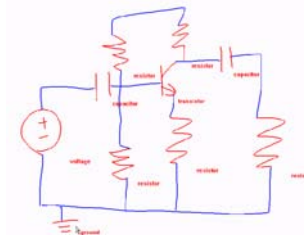- Algorithm choice dependent on problem

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

Making Inferences

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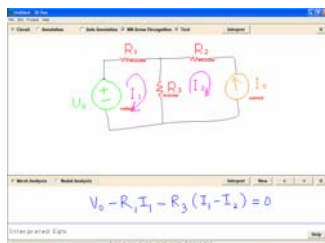 - stroke location

Sketch Understanding

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

VibroSketch Sketch Understanding
(Kara, Gennari, Stahovich 2004)

$$V_0 - R_1 I_1 - R_3 (I_1 - I_2) = 0$$

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

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.

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