
Microsoft® Research
Faculty Summit
10
YEAR ANNIVERSARY

Microsoft Research

The Promise of Pen- and Touch-Computing

Andy van Dam

Brown University

Microsoft Research

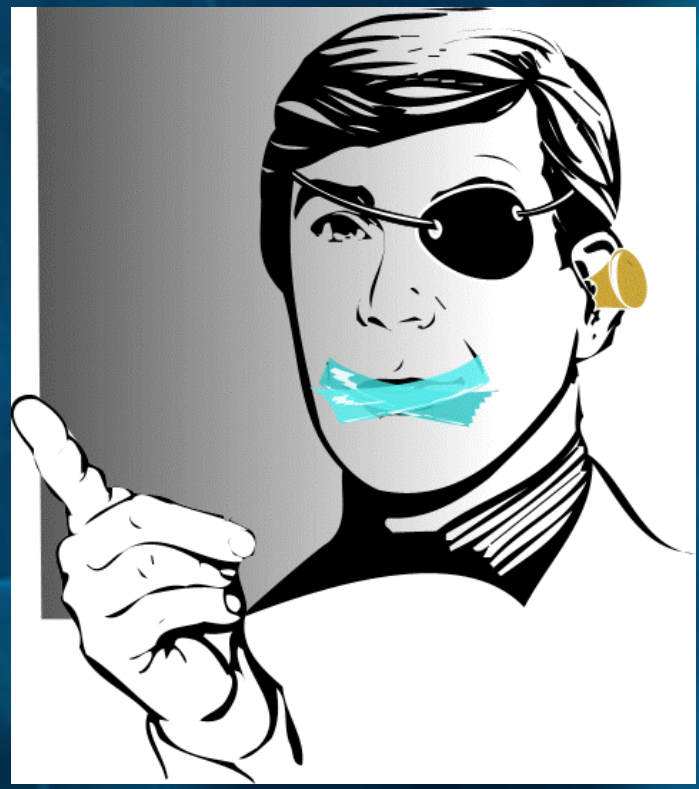
WIMP GUIs – impedance – matching limitations

video

WIMP GUIs – impedance – matching limitations

Microsoft Research

- Limited vision (flat, 2D)
- No speech
- Limited audio
- No gestures
- One-handed interaction
- Limited tactile feedback
- System unaware of user
- Pre-cursor to NUIs, Natal…
- We work on interaction, especially gestural, for 2D and (immersive) 3D

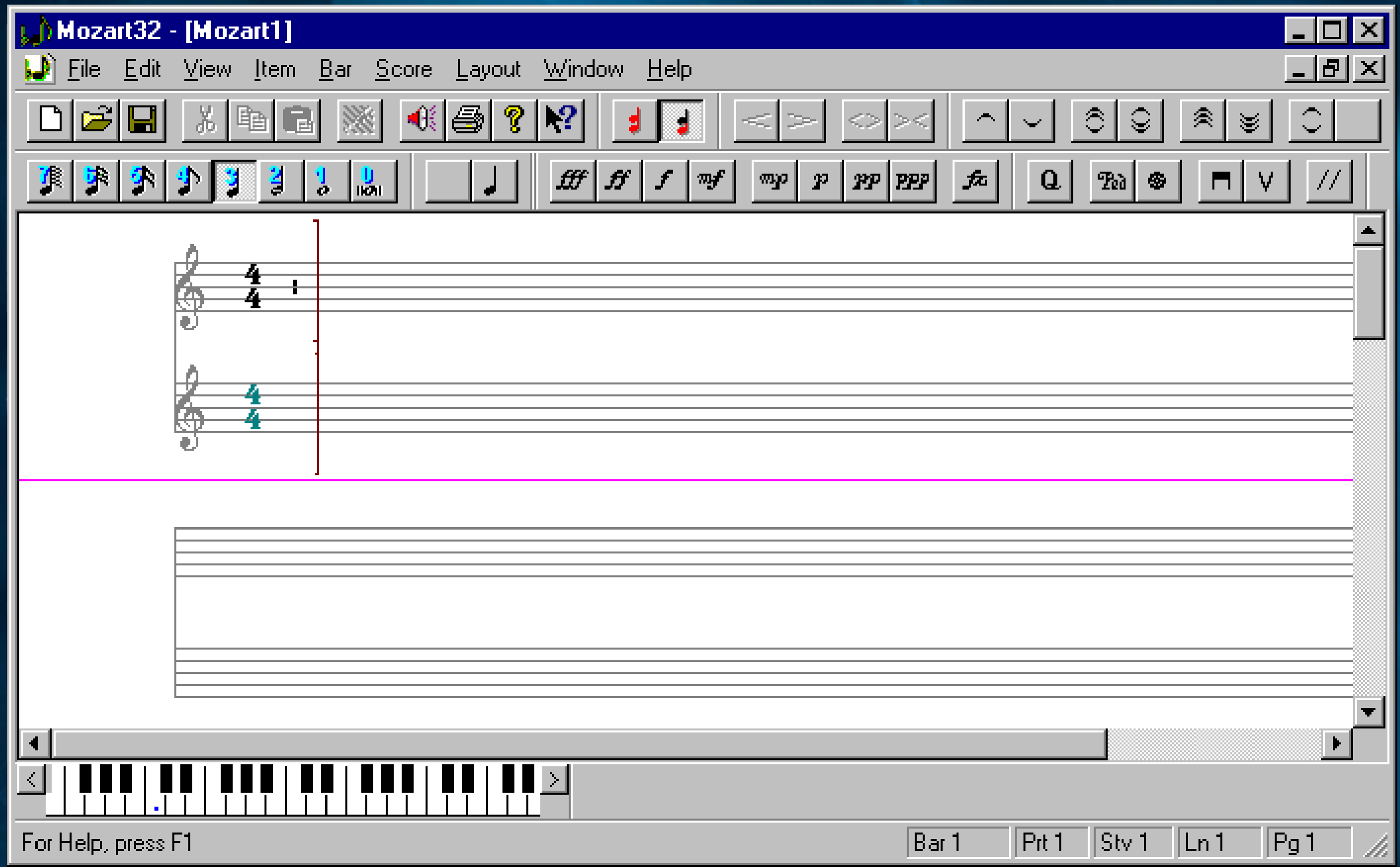


Microsoft Research

Music Notepad

video

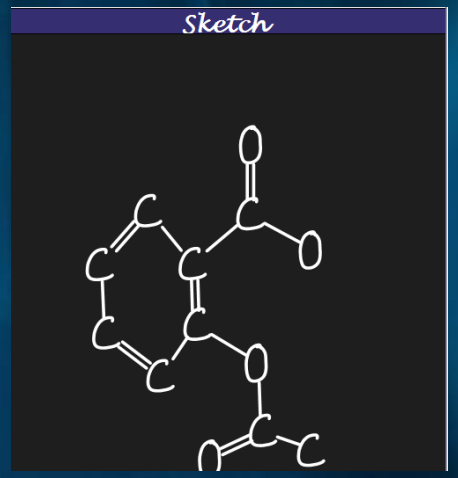
Brown University


Mozart32 - [Mozart1]
File Edit View Item Bar Score Layout Window Help
For Help, press F1
Bar 1
Prt 1
Stv 1
Ln 1
Pg 1

Where pens make sense

Microsoft Research

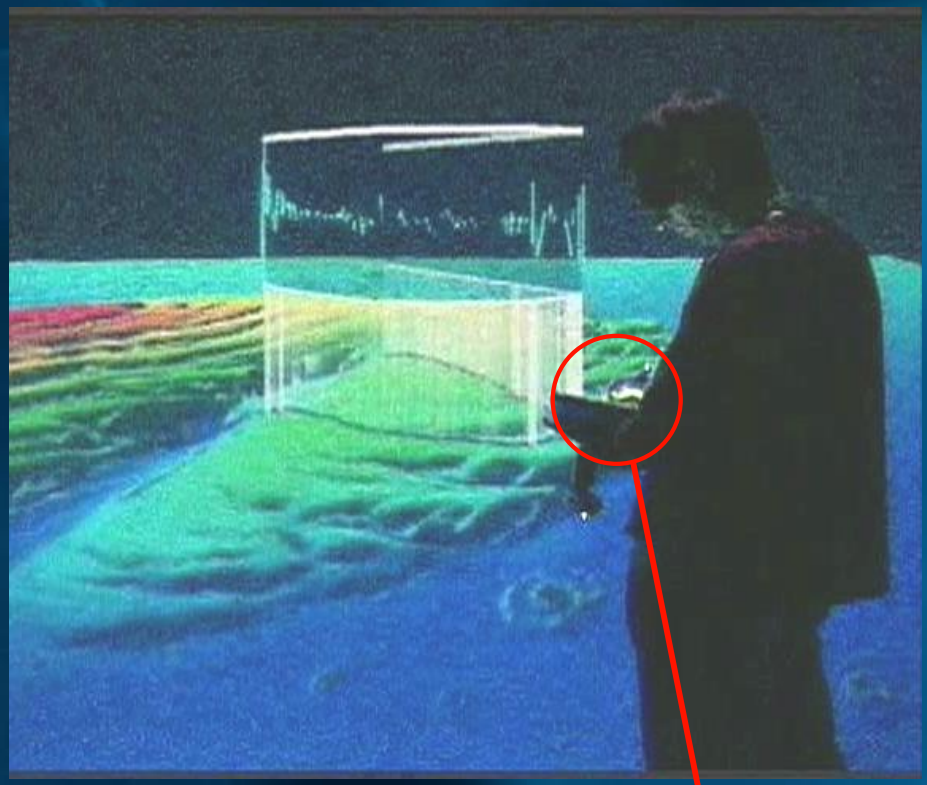
- Sketching
  - preliminary and conceptual design
  - artistic expression
- 2D visual languages
  - music, circuit diagrams, chemistry, …
- Ultra mobile platforms
  - PDAs
  - small tablets

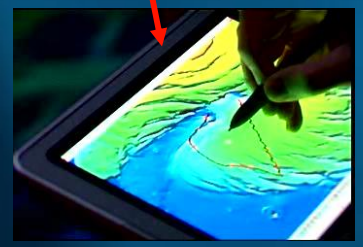


Where pens make sense

Microsoft Research

- Sketching
  - preliminary and conceptual design
  - artistic expression
- 2D visual languages
  - music, circuit diagrams, chemistry, …
- Ultra mobile platforms
  - PDAs
  - small tablets
- Keyboardless environments such as IVR





First wave (60s and 70s) Research (1/3)

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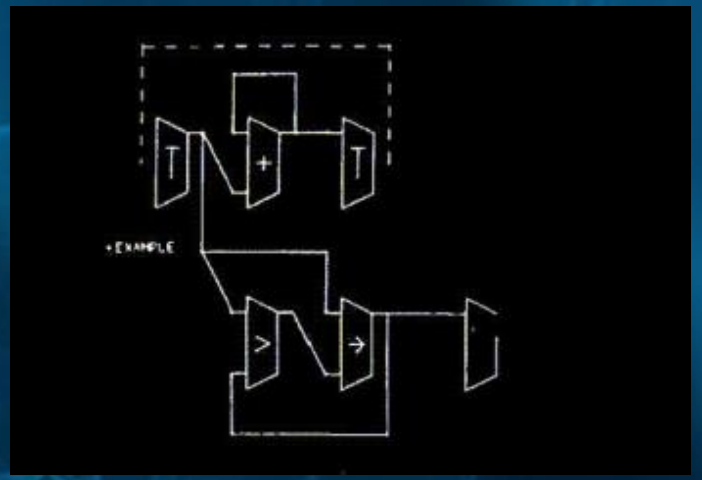
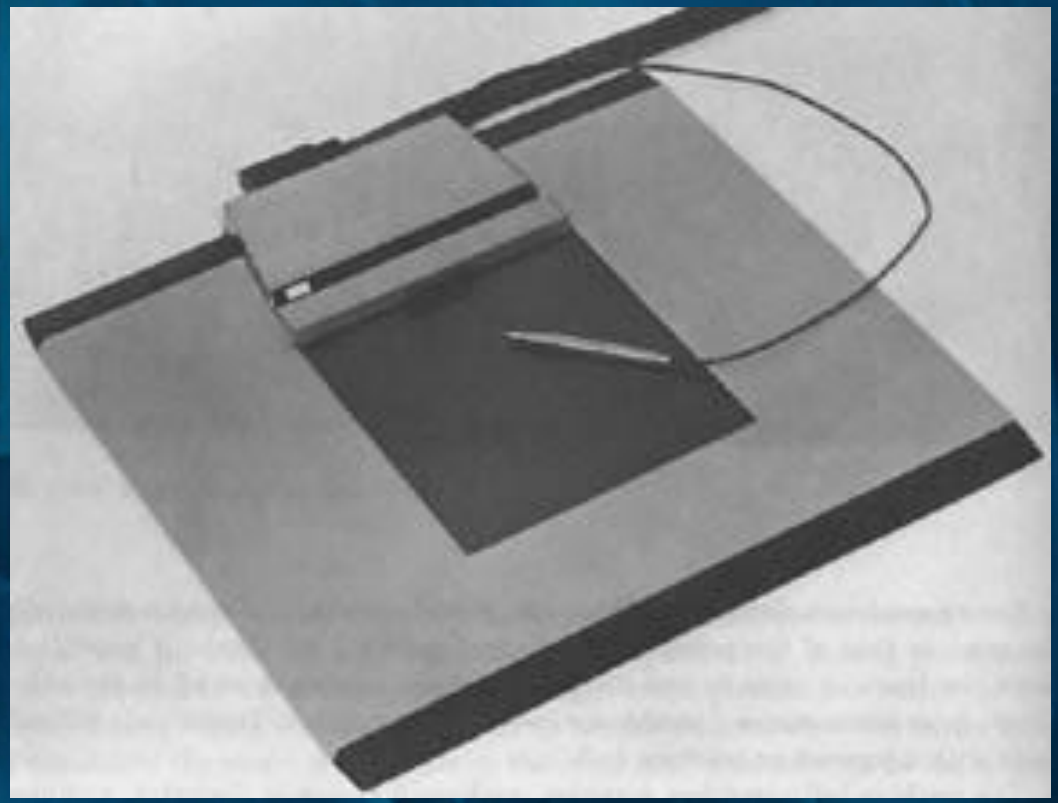
- Ivan Sutherland's Sketchpad (1963)

- Bert Sutherland's logic & circuit diagrams (1966)



First wave (60s and 70s) Research (2/3)

Microsoft Research



Robert Anderson's 2D Math Reco on Rand Tablet (1967)

Microsoft Research

First wave (60s and 70s) Research (3/3)

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Alan Kay's Dynabook (1968)

Second wave (80s and 90s)
Commercialization

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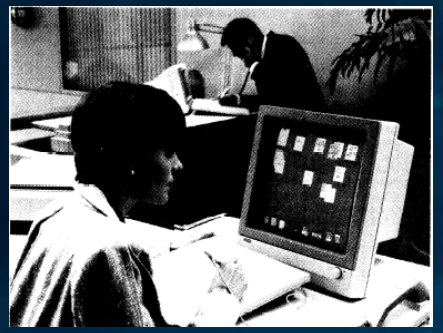
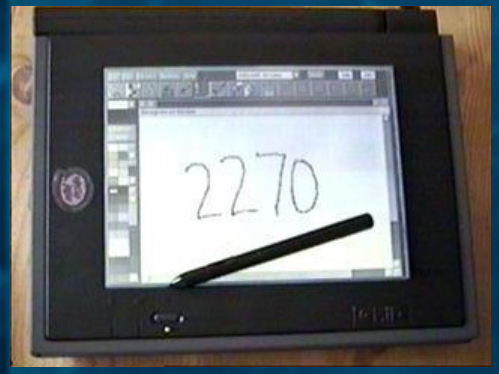
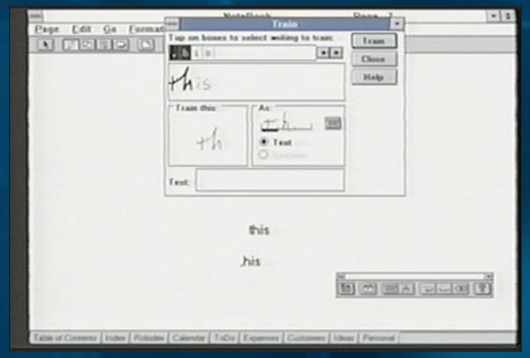


Wang Freestyle (1988)

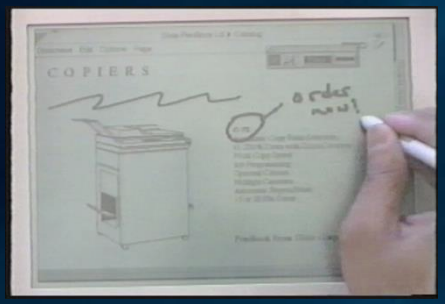


GRIDPad (1989)

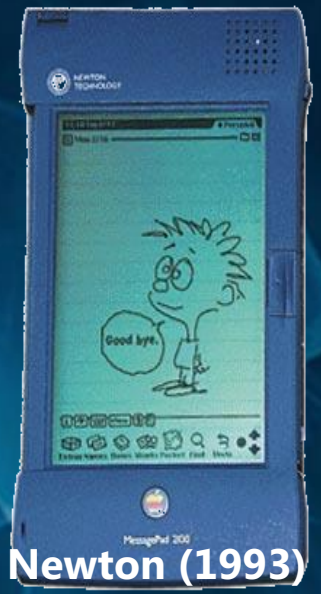


PenWindows (1991)

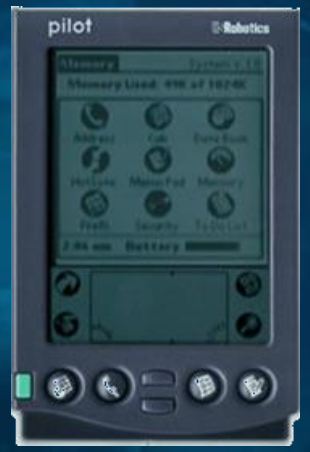
GO +PenPoint (1991)

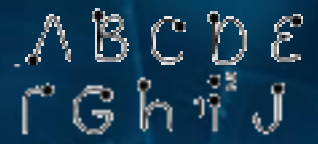


Slate (1992)



Newton (1993)





Palm Pilot's Graffiti (1994)

Anoto (1999)

RIP (adapted from Bill Buxton)

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Grid

Pen for Windows

GO

Freestyle

Palm Pilot's Graffiti (1994)

Crosspad

Slate

Newton

Anoto (1999)

Third Wave (2000 …)

Research and Deployment

Microsoft Research

- Much more powerful hardware
  - Tablet PCs
  - digitizers
    - Wacom Cintiq
    - Smartboard

- Much improved software support
  - Tablet SDK
    - handwriting recognition
    - speech recognition
  - character recognizers

- Better recognition algorithms
  - e.g. machine learning (use those cycles!)

Pen-centric computing: my definition

Microsoft Research

- Takes advantage of the pen
  - more than high resolution mouse for picking & for recording digital ink
  - interprets digital ink in appropriate context for recognition of characters/symbols, gestures, and shapes in diagram
  - best within a multi-modal interface, e.g., with speech recognition
- Uses pen, marker, finger, …,

But each has its strengths

Smartboard

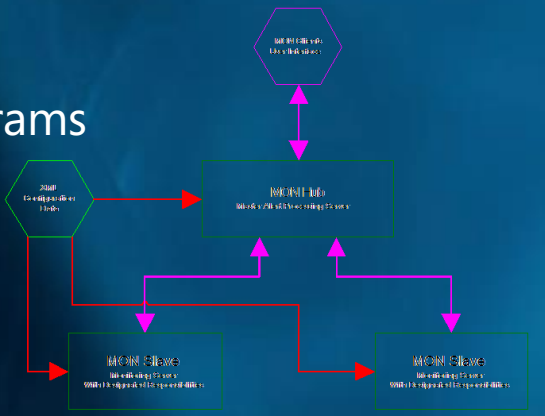
Apple iPhone

Goals

Microsoft Research

- Transparency, fluidity
  - as easy and as natural to use a pen a paper
  - but with full power of the computer for immediate or batched interpretation of input
  - transcend digital ink: interpret symbols, gestures
- Leverage pre-existing 2D notations
  - to minimize keyboard-based encoding

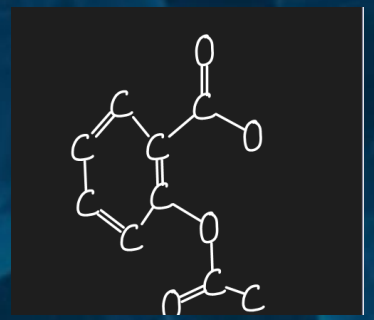
diagrams



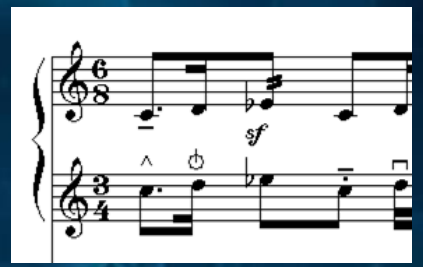
mathematics

$$y(t) = A e^{-\left(\frac{b}{2m}\right)t} \cos(wt)$$

chemistry



music

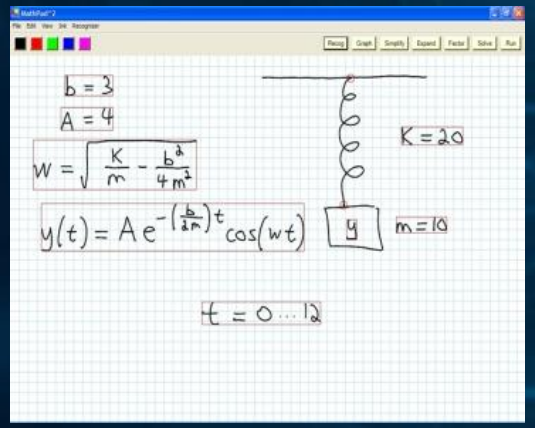


Pen applications at Brown University

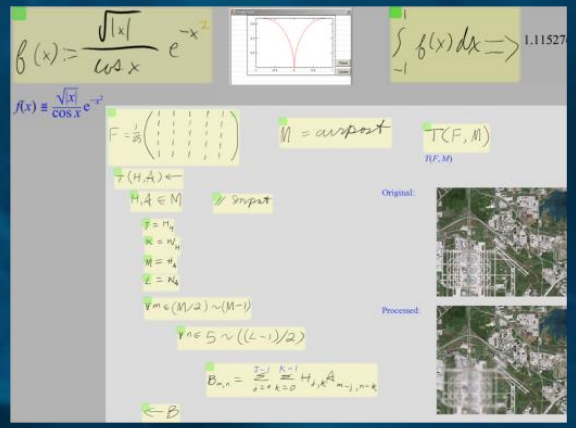
Microsoft Research

Mathematics

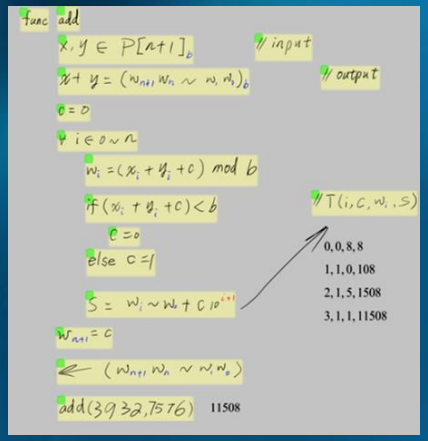
MathPad²



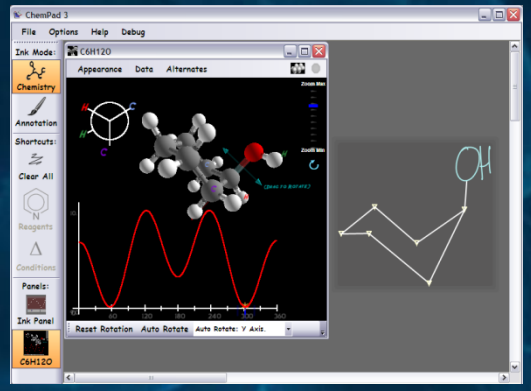
MathPaper (Brown & UCF)



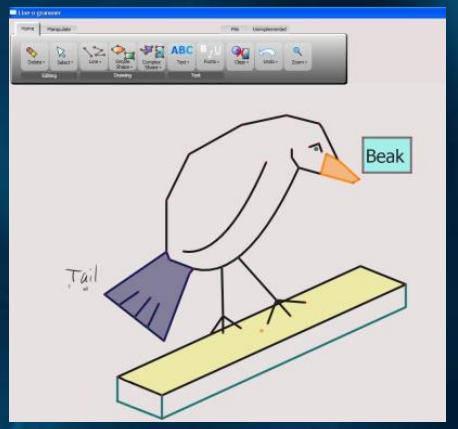
AlgoSketch



Chemistry: ChemPad



2D Diagramming



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Pen-Based Mathematics

demo

Brown University, UCF

Handwritten Math Recognition

Microsoft Research

Microsoft Research

Line-O-Grammer: Diagramming with Lines

video

Bob Zeleznik
Sr. Researcher
Brown University

Line-O-Grammer

Diagramming with Lines

Bob Zeleznik

Brown University
Microsoft Center for Pen-Centric Research

Summary of Some Research Issues

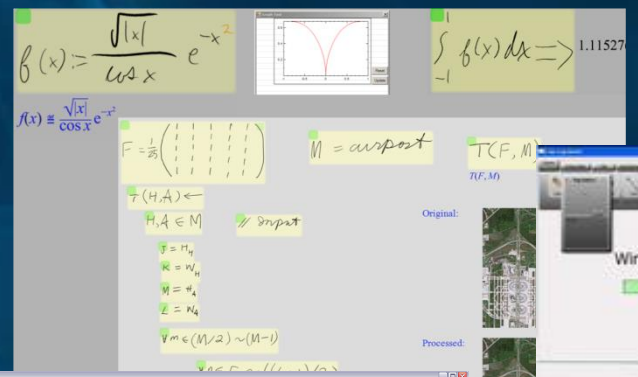
Microsoft Research

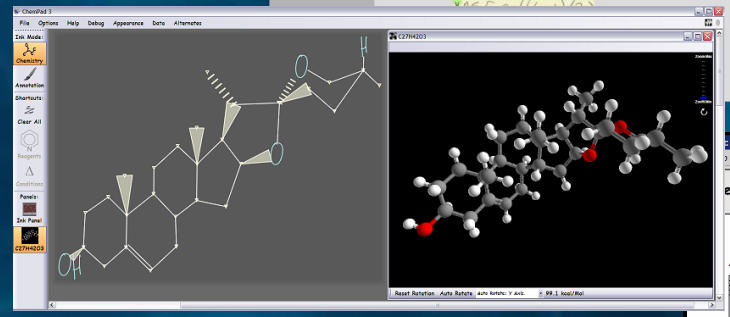
- Recognition algorithms (batch vs. real-time)
  - Segmentation; hierarchical, backtracked recognition
  - What, when, where of feedback
  - Error detection and correction (system, user)
- UI integration
  - Multi-modal (e.g., speech, multi-touch)
  - Augmentation vs. replacement
  - Discoverability and learnability of gestures (e.g., our GestureBar)
- Design of visual languages (“embrace and extend”)
- User testing (e.g., NIST for our math project)
- Seamless integration of apps in a silo’d environment

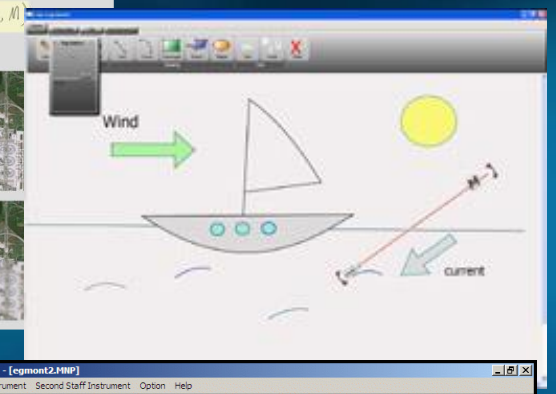
The StarPad SDK

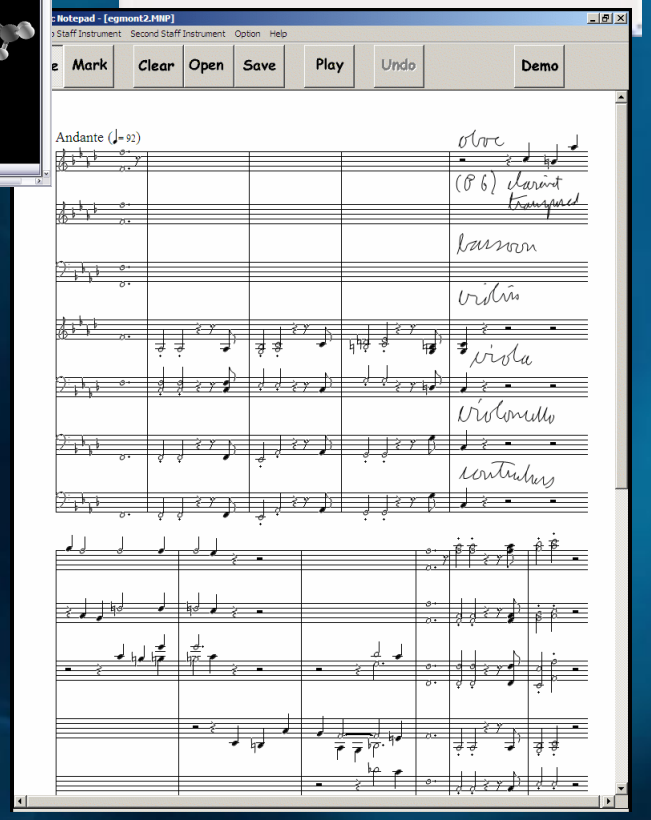
Microsoft Research

- Long-term goal: StarPad (née *Pad)
  - Seamless aggregation of post-WIMP pen-centric apps that enable computational assistance
  - e.g., Music Notepad, MathPad², ChemPad, Lineogrammer…
- Strategy: Create an SDK
  - Simplify and promote post-WIMP app creation
  - Codified our pen-centric app expertise into StarPad SDK





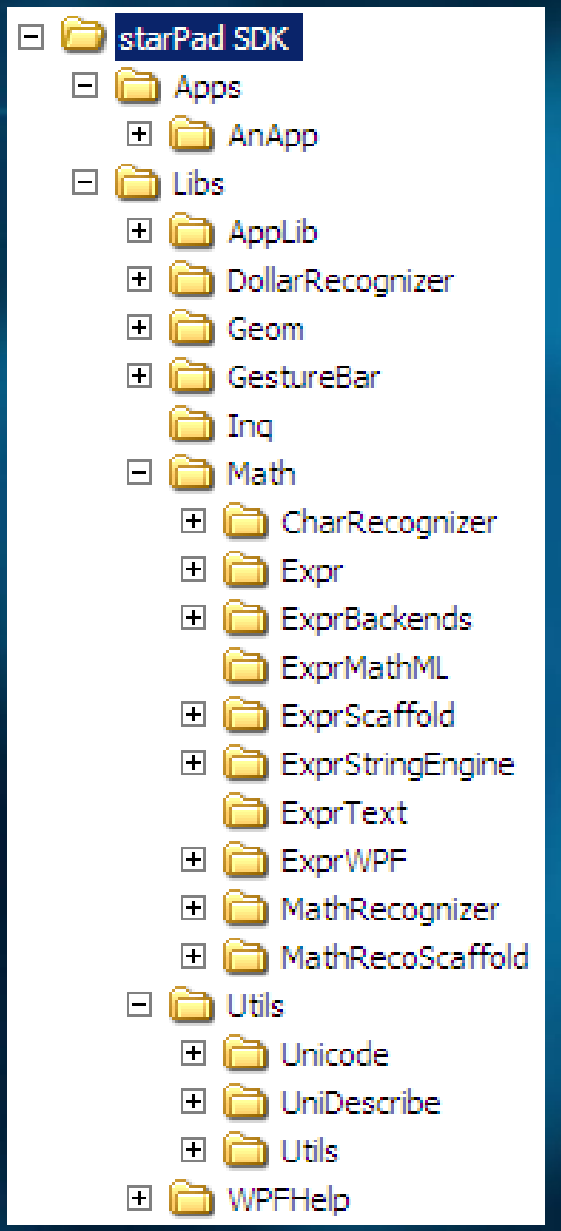




Current Pen-Based StarPad SDK

Microsoft Research

- Convenient interface to broad pen-centric functionality
- Some research functionality (no guarantees…)
- Built on .NET Framework 3.5/WPF
- Includes:
  - Convenient interface to stroke-level operations
  - Recognition library: math (Smart Graphics '08), common gestures
    - Complements MS Ink Analysis
  - App shell: selection, undo, zooming, text input, images, save/load
  - Some UI techniques, such as GestureBar (CHI '09)
- http://www.starpad.org



Research Agenda for Integrating Pen and Multi-touch

Microsoft Research

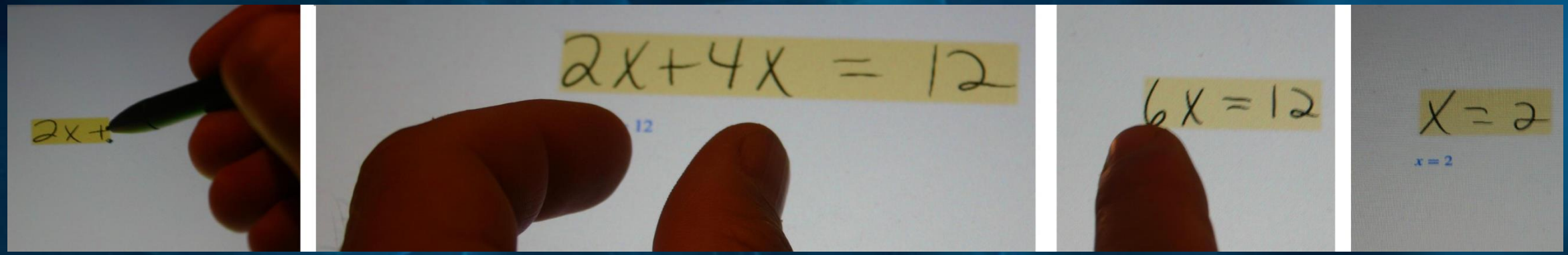
- Getting pen input to work well on the Surface
- Exploring hybrid pen and multi-touch interactions
  - Bi-manual manipulation techniques leveraging strengths of each
  - Adapt GestureBar
  - Palm rejection and alternatives
- Application to mathematical diagramming
  - Algebraic manipulations
  - Graphing
  - Simple 2D diagrams

Hands-on Math

Goals

Microsoft Research

- Port StarPad SDK math recognition layer to take advantage of Surface and bi-manual manipulation
- Make abstract manipulation of math concrete, intuitive, fun through multi-touch
  - Stackable, rearrangeable pages that respond to simulated friction, pressure
  - Using touch to interact with and manipulate ink, variables, equations
  - 360-degree, multi-user experience



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Hands-On Math

video

Brown University

Brown University

HANDS-ON MATH

I Know It When I See It (IKIWISI)

Goals

- Searching methods focus on the idea that we know what we want *a priori*
- Browsing with categories limit scope of choices given to user
- Create a Surface-centric experience using a third mechanism, "I Know It When I See It" – anticipatory, decision aid
  - Interactive recommender system
  - Users given iterative choices
  - Over 40,000 movie titles, ~100,000 reviewer profiles
  - Collaborative, multiple users

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I Know It When I See It

video

Brown University

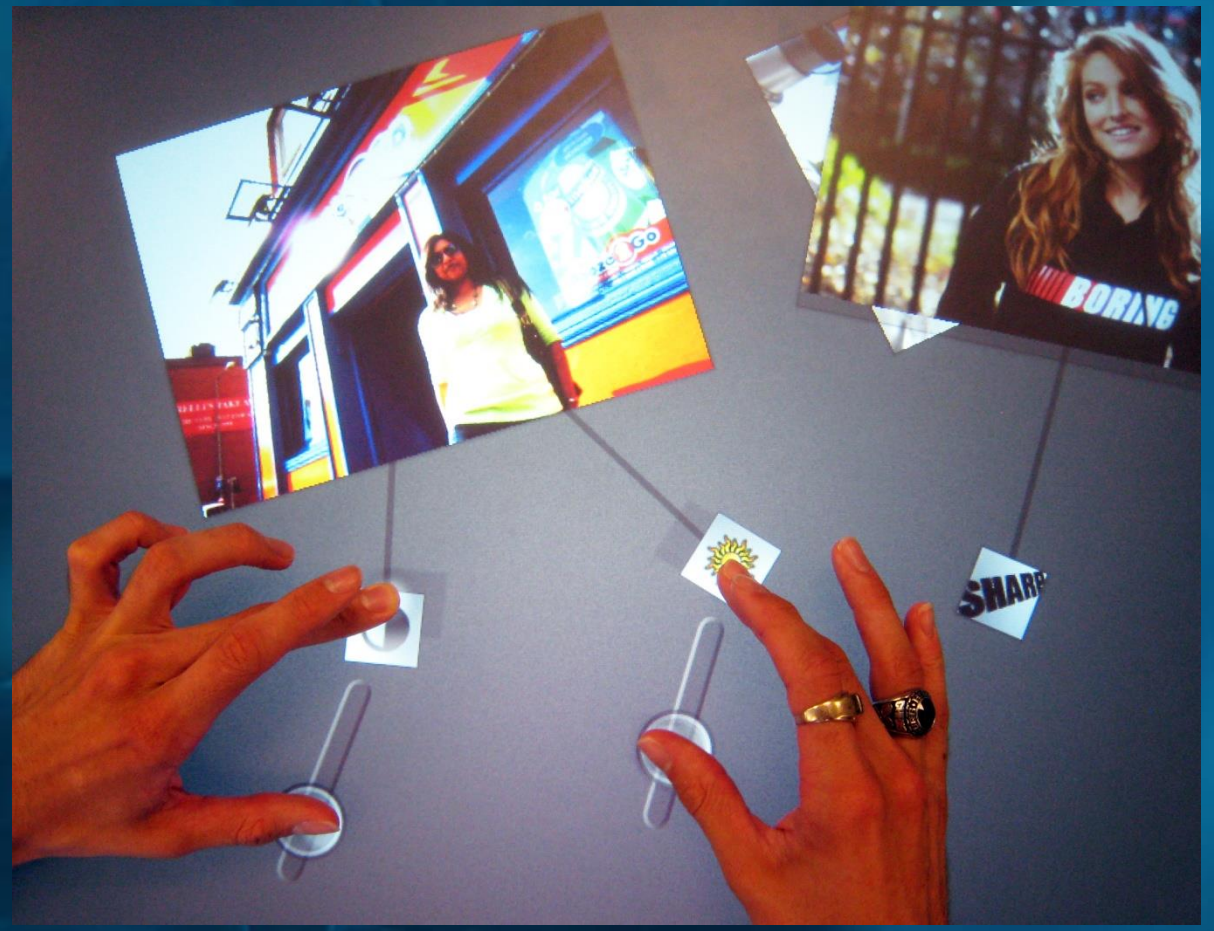
Brown University

"I KNOW IT WHEN I SEE IT" SEARCH

SurfaceShop
Goals

Microsoft Research

- Translate industry-level tasks to multi-touch environment, e.g., image manipulation
  - Assigning filters to rearrangable "tokens"
  - Gestures invoke sliders to adjust values, cropping frames, etc.
  - Proximity controls targeting
- Exploit advantages of Surface computing
  - Simultaneous touch operations
  - Multi-user environment
  - Muscle memory

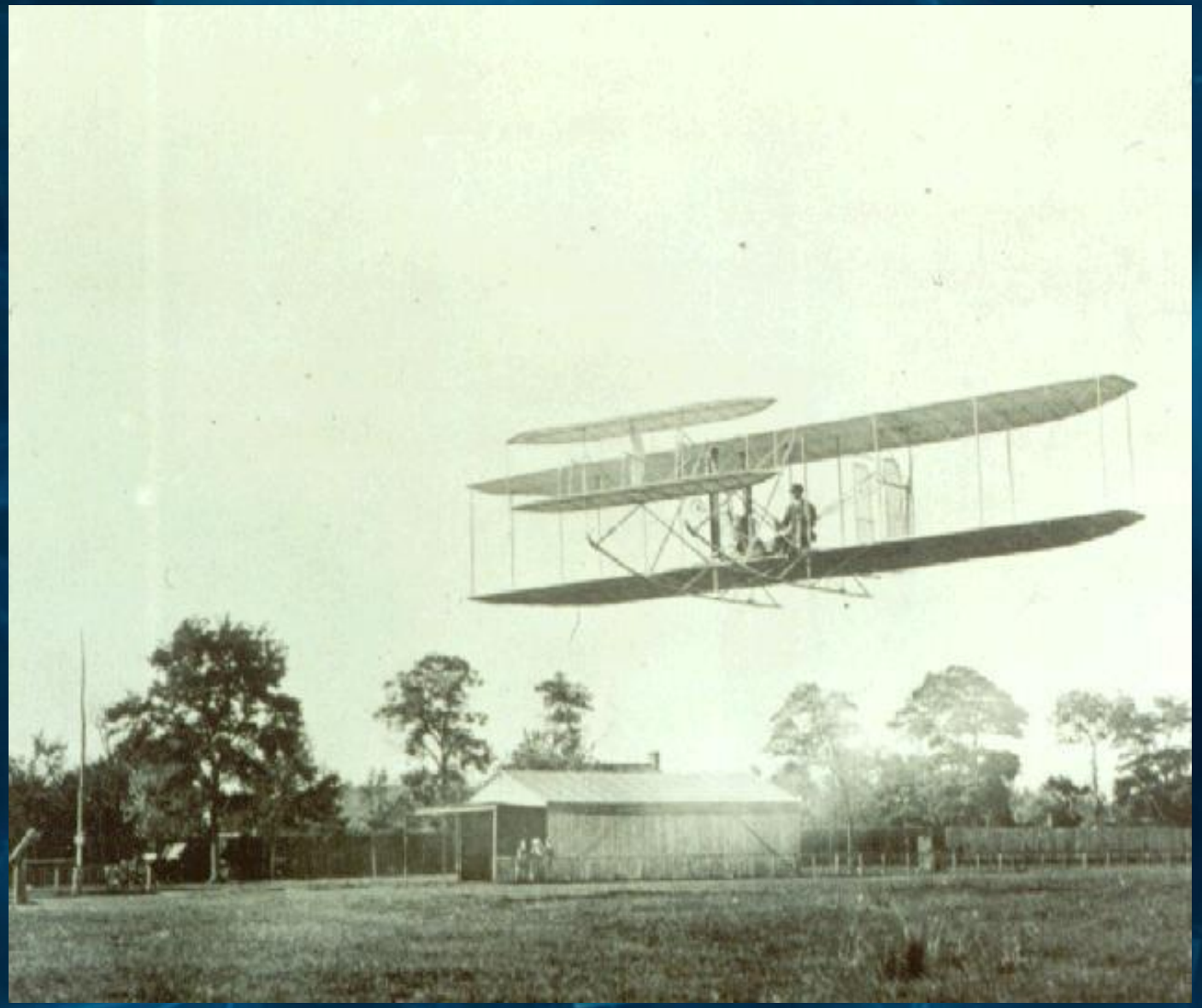


Brown University

SURFACESHOP

“To Infinity and Beyond…”

Microsoft Research



This year's R&D agenda

Microsoft Research

- Gain experience with multi-touch interaction on the Surface via “driving applications”
- Enhance Surface with pen input to provide best of both worlds simultaneously
- Enhance StarPad SDK with multi-touch functionality to allow “unification” of the two highly related interaction techniques
- Run user studies to measure effectiveness

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Your potential. Our passion.™

Research issues overview
User and user interface (1/2)

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- Users
  - conservative and quirky: conversion difficult
  - choosing design point on nice/casual user-expert continuum
  - disclosing & learning character, symbol, and gesture sets

Research issues overview
User and user interface (2/2)

Microsoft Research

- User interface
  - replacement vs. enhancement
    - enhance, e.g., with flicks, gestures, marking menus, …
  - visual feedback in human-centered forms
    - form (where)
    - content (what)
    - timing (when) – from on-the-fly to batch
  - multi-point and multi-touch techniques, multiple users
  - multi-modal integration, e.g., speech
  - experiment with time machines (display size & resolution, input devices, …)

Research issues overview
Visual language (1/2)

Microsoft Research

- Design
  - existing notations + optional enhancements
- Techniques
  - character, symbol, and simple gesture recognition
  - 2D expression parsing
    - chunking and phrasing
  - segmentation/containerization
    - defining scope for groups

Research issues overview
Visual language (2/2)

Microsoft Research

- Ambiguity resolution
  - distinguishing commands from content while avoiding modes
  - reserved gestures or areas, “punctuation”, content
  - shortcut customization

Research issues overview
Other

Microsoft Research

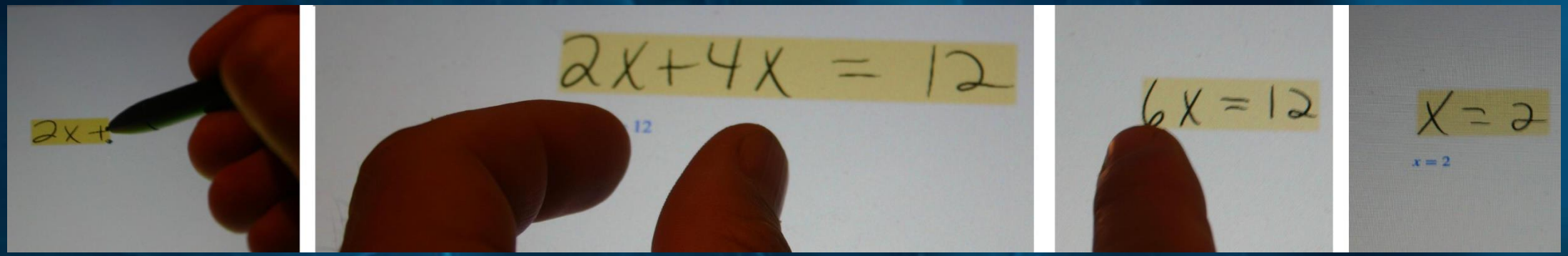
- Hardware
  - ergonomics, resolution, parallax, …
  - weight, battery life, robustness, …
  - when will we get interactive, full-color, high-resolution e-paper?
- Testing and evaluation
  - difficult and painful to do but necessary
  - who pays for it?!?
- How to move from application silos to integration…
  - e.g. E-Lab Notebook as a collection of hyperlinked "pages" of arbitrary content, a launch platform alternative to desktop

Apply SDK to Interactive Math Research

Microsoft Research

Make interactive mathematics palpable

- Recognize pen input
  - Mathematical expressions
  - Geometric diagrams
- Provide notebook metaphor for managing working sets
- Design multi-touch-driven computational interactions
  - Term simplification, rearrangement, factoring, expansion
  - Display graphs, probe geometric diagrams, solve equations
  - Explore physical simulations
  - Use Mathematica™ as a back-end *unless* Microsoft Math™ 3.0 engine is made available



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Pen-Based Mathematics: Matrices and Sketching Algorithms

Brown University
January 2008

ft search

Lineogrammer

Diagramming by Drawing

Mathpad
sketch-based interface dataflow

Microsoft Research