What is a good pen based application?
- The windows desktop and browser are NOT good pen based apps!

What is a good UI? How do you measure it?

Mechanical Properties

Keystroke level model
- Analyze task by summing individual operation times

<table>
<thead>
<tr>
<th>Operation</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving hand to mouse</td>
<td>360 ms</td>
</tr>
<tr>
<td>Pointing to a new line with mouse</td>
<td>1500 ms</td>
</tr>
<tr>
<td>Clicking the mouse</td>
<td>230 ms</td>
</tr>
<tr>
<td>Moving hand to keyboard</td>
<td>360 ms</td>
</tr>
<tr>
<td>Total</td>
<td>2450 ms</td>
</tr>
</tbody>
</table>

Targeting
- Fundamental operation
  - Moving a cursor to a specific location
  - Pointing and selection
**Experiment: measure time to move cursor to target**

- \( T(A, W) \) Targeting time for amplitude \( A \) and width \( W \)

**Index of difficulty**

- How does \( T \) behave as a function of \( A \) (\( W \) fixed)?

- How does \( T \) behave as a function of \( W \) (\( A \) fixed)?

**Fitts’ Law**

- A task’s movement difficulty is given by \( \text{ID} = \log_2(A / W) \)
  - ID – index of difficulty
  - \( A \) – amplitude of the move
  - \( W \) – width of the target region
  - \( T = a + b \text{ID} \)

**Interpretation of Fitt’s Law**

- Scale invariance
  - Dependence on \( A/W \)
  - Exponential targeting
  - Log factor – as in binary search

**Menu design**

- What can you say about the cost of accessing items in the following menu
  - Cursor is at the top of the menu

**Low level mechanisms**

- State machine model
  - Registers
    - \( X, Y, \) Pressure
  - Pen state
    - Down, Hover, Out-of-range
  - Pen button
    - Up, Down
  - Polling model
Control primitives
- Hover
- Tap
- Double Tap
- Press-and-hold
- Hold-through
- Drag
- Hold-drag

Mode Problem
- Cognitive difficulties in remembering / keeping track of modes
  - Which mode?
  - Remapping operations
  - Retaining mode across context switch
- But modes are very useful
  - Efficient use of limited input controls
- Not all modes are the same
  - Shift key vs. Caps Lock
  - Mouse move vs. mouse drag
  - Pen color

Do cars have modes?
- A system has modes if it has states where the controls have different functions.
- Do cars have modes? If so, give an example

Pen mode solutions
- Problem: How do you allow different operations with a pen
  - Ink vs. erasing
    - Explicit modes
  - Ink vs. gesture
    - Recognition of gesture overrides ink
  - Ink vs. recognition vs. control
    - Area based modes

Pen mode study
Yang Li et al., CHI 2005
- Barrel Button
- Hold
- Non-preferential hand button
- Pressure
- Eraser

Table 1. The participants’ preferences for each technique

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Barrel Button</th>
<th>Hold</th>
<th>Non-preferential hand button</th>
<th>Pressure</th>
<th>Erase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>4.9</td>
<td>3.5</td>
<td>4.7</td>
<td>3.5</td>
<td>4.2</td>
</tr>
<tr>
<td>User</td>
<td>3.7</td>
<td>2.2</td>
<td>4.1</td>
<td>3.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Accuracy</td>
<td>3.7</td>
<td>2.9</td>
<td>4.8</td>
<td>3.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Tine Time</td>
<td>4.1</td>
<td>3.5</td>
<td>4.4</td>
<td>3.9</td>
<td>4.2</td>
</tr>
<tr>
<td>Pen Tip Length</td>
<td>3.9</td>
<td>3.5</td>
<td>4.1</td>
<td>3.3</td>
<td>2.1</td>
</tr>
</tbody>
</table>
How many distinct mechanisms can you construct to select between four choices with a pen?

Assume a pen without a button.
Flow Menu

- Use movement through octants for control information

Abstract writing

- Enter text with specialized, stroke based recognition
  - Optimized for automatic recognition
  - Not human readable
  - Character based or word based

Cirrus (Georgia Tech)

- Interaction
- Education

Quikwrite [Perlin, NYU]

Write helloworld

Graffiti (Palm)
More

Graffiti
- Mostly single stroke
- Close to standard alphabet (learnability)
- Write only
- Location written for additional meaning

Selection problem
- Identify one or more graphical elements from a domain
- Mechanisms
  - Bounding Region
  - Geometric defined by stroke
  - Distance from cursor

If the red circle is a selection tool, what is selected?

Bubble cursor
- Selection radius depends on object proximity

Recognition UIs
- UIs based on attaching meaning to ink
  - Gestures
  - Diagram recognition
  - Handwriting recognition
    - Free form
    - Constrained recognition
Gestures
- Commands issued with a single stroke
- May be drawn or invisible
- Support from SDK
  - Register gestures to be recognized
- UI Issues
  - Similar to keyboard short cuts
    - Speed up for experts
    - Hard to learn / remember

Gestures
- Ambiguity
  - Distinction between gestures
  - Distinction between gesture and other ink
- Robustness
  - Handling misrecognized gestures
    - False positive
    - False negative
  - Gesture initiated actions should be undoable

Diagram recognition
- Challenges to recognition
  - Even simple shapes are hard!
  - Variation in drawing
  - Ink artifacts

Text recognition
- We will have a great lecture later in the course!
- Basic approach
  - Collect a huge amount of data
  - Use data to train neural net

Handwriting Recognition: Identify the following words

Recognition results
Recognition scenarios
- What level of error is tolerable
- How is feedback provided to the user on recognition
- How does the user specify corrections?

Other details
- Hands, obstructions, orientation

Obstructions and handedness
- Hand blocks the screen
- Accommodate left and right handedness
  - Menu direction
  - Context menus
- Difficulties at the edge of the screen

Screen orientation
- Landscape vs. Portrait mode
- Surprisingly big difference in feel of applications
- Tablet PC requires rapid orientations switch
- Many standard desktop apps not designed for portrait mode