Input
Announcements

Reading responses:
Posted to Wiki by class time.

Change in schedule:
John Tang (MSR) to visit on Wed 9/7

Office Hours:
Thursday 1-2:30pm, 125 Cory

Lab:
Thursday 5:30-7pm, 125 Cory
Announcements

Discussant Assignments: Out by Friday
Due Today

Reading responses (by Wed 9am)
Mackenzie, Input Models
Grossman, Bubble Cursor (2005)

Create a Wiki Account (by Wed 9am)

Course Petition (by Wed 9am)
Today

Functional Dissection of Mouse, Keyboard
Design Space of Input Devices
Fitts’ Law
Input Research
Homework
Discussion
Anatomy of Input Devices
slotted wheel (between emitter & detector)
Sensing: Rotary Encoder
Sensing: Fwd Rotation
Sensing: Backwd Rotation

Oops!
Solution: Use two out-of-phase detectors
Sensing: Rotary Encoder
Sensing: Rotary Encoder

Coding:
HH-> LH: \( dx = 1 \)
HH-> HL: \( dx = -1 \)
Transformation

\[ cx_t = \max(0, \min(\text{sw}, cx_{t-1} + dx*cd)) \]

\[ cy_t = \ldots \]

cx_t: cursor x position in screen coordinates at time t
dx: mouse x movement delta in mouse coordinates
sw: screen width
cd: control-display ratio
Device Abstraction

Click, DoubleClick, MouseUp, MouseDown, MouseMove

...
What about optical mice?

Source: http://spritesmods.com/?art=mouseeye
Source: http://spritesmods.com/?art=mouseeye
Separating layer (with hole)

Key cap
Top conductive layer
Bottom conductive layer
Key cap
Top conductive layer
Bottom conductive layer

Separating layer (with hole)
Row/Column Scanning

9 lines

20 keys
Closeup
One Key Down
One Key Down

R1

C1

C2

R2
3 Keys Down

C1

C2

R1

R2
3 Keys Down

R1

R2

C1

C2
Input Devices Are Like Onions

- device abstraction
- transformation
- signal coding
- sensing
- physical properties

user action
The Pointing Device Zoo
Frankenmice

Rockin’Mouse (Balakrishnan, CHI’97):
http://www.autodeskresearch.com/publications/rockinmouse
Soap.
P. Baudisch, UIST2006
http://patrickbaudisch.com/projects/soap/
A Design Space of Input Devices

Table I. Physical Properties Used by Input Devices

<table>
<thead>
<tr>
<th>Linear</th>
<th>Rotary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Position</strong></td>
<td></td>
</tr>
<tr>
<td>Absolute</td>
<td>Position ( P )</td>
</tr>
<tr>
<td>Relative</td>
<td>Movement ( dP )</td>
</tr>
<tr>
<td><strong>Force</strong></td>
<td></td>
</tr>
<tr>
<td>Absolute</td>
<td>Force ( F )</td>
</tr>
<tr>
<td>Relative</td>
<td>Delta force ( dF )</td>
</tr>
<tr>
<td></td>
<td>Rotation ( R )</td>
</tr>
<tr>
<td></td>
<td>Delta rotation ( dR )</td>
</tr>
</tbody>
</table>

A morphological analysis of the design space of input devices.  
Which is better? Faster?
Which is faster?

Engelbart

Experiment:
Mice are fastest!

Fitts’ Law

Time $T_{\text{pos}}$ to move the hand to target size $S$ which is distance $D$ away is given by:

$$T_{\text{pos}} = a + b \log_2 \left( \frac{D}{S} + 1 \right)$$

*Index of Difficulty (ID)*

Only relative precision matters.
Fitts’ Law

Time $T_{\text{pos}}$ to move the hand to target size $S$ which is distance $D$ away is given by:

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Device Characteristics
(bandwidth of human muscle group & of device)

$a$: start/stop time

$b$: speed
Shannon-Hartley Theorem

The effective information capacity $C$ of a communication channel of bandwidth $B$:

$$C = B \log_2(S/N + 1)$$

$C$: capacity (bits/s)
$B$: bandwidth (Hz = 1/s)
$S$: signal power (watts)
$N$: noise power (watts)
Fitts’ Analogy

The human motor system is like a communications channel.

<table>
<thead>
<tr>
<th>Communication</th>
<th>Human Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>Amplitude of movement</td>
</tr>
<tr>
<td>Noise</td>
<td>Spatial Accuracy/Error</td>
</tr>
</tbody>
</table>
Across Disciplines...

Channel Capacity → Human Movement → Target Acquisition with Input Device

Fitts
Card, English, Burr
Input Research

**Path 1**: develop and verify new models

**Path 2**: assume standard* I/O configuration
- propose & evaluate new techniques that improve on status quo (for a given **task**)

**Path 3**: propose, implement & evaluate new input devices

* may be desktop, large display, mobile, stylus input, etc. But device is off-the-shelf
Examples of Path 2

Bubble Cursor (Grossman)

Drag and Pop (Baudisch)


Occlusion-aware interfaces

http://www.youtube.com/watch?v=4sOmlhEJ2ac
Baudisch et al., NanoTouch
Homework 1
Assignment is out today - on the class wiki.

Re-implement the Bubble Cursor

Record a screencast of your project

Submit source and video on the wiki.

If you feel rusty: lab hours this week: schedule?
Thu 5:30pm, 125 Cory Hall
Discussion: Drew