Input

Scott Klemmer

HCI Design with materials from Bjoern Hartmann, Stu Card, Pat Hanrahan
Quiz 4

- Do not start until instructed
- 10 minutes (timer below)
- Loose piece of paper is for after the quiz
Fitts' Law Exercise

1)

2)

3)
A7 Examples
Shuming Cao,
Changtong Qiu,
Xinyuan Zhang
Braxton Fitts, Dennis Ku, Todd Tang
Input
Input

- How do these devices work for getting information into the computer?
- Some Frameworks:
  - How do input devices effect the nature of the interaction?
  - What’s coming next?
Key cap
Top conductive layer
Bottom conductive layer
Separating layer (with hole)
Key cap

Top conductive layer

Bottom conductive layer

Separating layer (with hole)
Keyboard Encoder
Row/Column Scanning

9 lines

20 keys
Closeup
One Key Down
One Key Down
3 Keys Down
3 Keys Down

C1

R1

C2

R2
Keys → Scan Codes

Make (onPress) and Break (onRelease) codes

http://www.computer-engineering.org/ps2keyboard/
Keys (Scan Codes) !=

- Special keys - interpreted by the OS or App
  - F1, ..., F12
  - Insert, Delete, Home, ...
- Duplicated keys
  - Numbers on keypad vs. keyboard
  - Left-shift, Right-shift, Left-cmd, Right-cmd
Layered Model of Input

- Keyboard
- Characters
- Scan Codes
- Switches
- Keys

Diagram:

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

User action

Keyboard:
- G
- 59h 34h
- F0h
- 59h F0h
- F12
- b7a2 b1a6
- SHIFT g
But we can do much better
The real problem: ASYMMETRY OF OUTPUT TO INPUT

Typewriter limits input speed (and expressibility)
Input Device

Whirlwind (MIT, 1951)
Big Idea:
INPUT ON OUTPUT
Input on Output

SAGE
HUMAN-MACHINE SYMBIOSIS:

“The hope is that in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain ever thought.”
Graphical Direct Manipulation

SKETCHPAD (1963)
- Direct Manipulation
- Tiled windows
- File icons
- Menus

TX-2 (MIT, 1959)

Changing visual element part of interaction loop
Lightpen
Point and Click, Hypertext

NLS (SRI, 1968)

- Mouse
- Point & Click editing
- Hypertext
- Rapid interaction
- Text/graphic integration

Clickable Text

Command Chordset

Mouse

Video
The Mouse: Small, Cheap, Fast, Small Targets
Mouse. Engelbart and English ~1964

Graphical UI, Windows

- Digital Mouse
- Ball mouse
- Bitmapped CRT
- Overlapped windows
- Desktop metaphor
- Object-oriented UI
- Pull-down menus
- Cut & Paste
- Icons
- Typography
Independent information

Alto (Xerox, 1974)

Smalltalk (Xerox, 1976)
slotted wheel (between emitter & detector)
Sensing: Rotary Encoder
Sensing: Fwd Rotation
Sensing: Backwd Rotation

Low

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

Low
High
Sensing: Rotary Encoder

Coding:
HH-> LH: dx = 1
HH-> HL: dx = -1
Transformation

c_{x_t} = \max(0, \min( sw, c_{x_{t-1}} + dx \times cd ))

c_{y_t} = ...

c_{x_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
Optical Mouse

Move, DoubleClick, etc
Screen cursor Position
Quadrature Encoding
Rotary Encoder
Mover x,y
What about optical mice?

Source: http://spritesmods.com/?art=mouseeye
A design space of input

Table I. Physical Properties Used by Input Devices

<table>
<thead>
<tr>
<th></th>
<th>Linear</th>
<th>Rotary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute</td>
<td>Position $\mathbf{P}$</td>
<td>Rotation $\mathbf{R}$</td>
</tr>
<tr>
<td>Relative</td>
<td>Movement $\mathbf{dP}$</td>
<td>Delta rotation $\mathbf{dR}$</td>
</tr>
<tr>
<td><strong>Force</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute</td>
<td>Force $\mathbf{F}$</td>
<td>Torque $\mathbf{T}$</td>
</tr>
<tr>
<td>Relative</td>
<td>Delta force $\mathbf{dF}$</td>
<td>Delta torque $\mathbf{dT}$</td>
</tr>
</tbody>
</table>

How about People?
Can we model human performance?
Principles of Operation

- Fitts’ Law
  - Time $T_{pos}$ to move the hand to target size $S$ which is distance $D$ away is given by:
    - $T_{pos} = a + b \log_2 \left( \frac{\text{Distance}}{\text{Size}} + 1 \right)$
    - The log part is the “index of difficulty” of the target; it’s units are bits
  - summary
    - time to move the hand depends only on the relative precision required
What does Fitts’ law really model?

Distance

Velocity

(a)

(b)

(c)

Target Width
It was inspired by information theory

- It treats acquiring a target as specifying a number of bits
- i.e., in the Fitts’ worldview, the human motor system is a noisy information channel
- Smaller target? More bits
- Further target? More bits
Experiment
Repeated Tapping
EXPERIMENT: MICE ARE
Fitts' Law for Eight Devices

log(A/W + 1) vs Duration for:
- mouse
- trackball
- trackpoint
- trackpad
- foot mouse
- tablet 1 (w/ display)
- tablet 2 (w/o display)
- joystick
WHY?

Why these results?

Time to position mouse proportional to Fitts’ Index of Difficulty $I_D$.

Proportionality constant = 10 bits/sec, same as hand.

Therefore speed limit is in the eye-hand system, not the mouse.

Therefore, mouse is a near optimal device.

$$I_D = \log_2 \left( \frac{\text{Dist}}{\text{Size} + 0.5} \right)$$
50 years of data

<table>
<thead>
<tr>
<th>Device</th>
<th>Study</th>
<th>IP (bits/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand</td>
<td>Fitts (1954)</td>
<td>10.6</td>
</tr>
<tr>
<td>Mouse</td>
<td>Card, English, &amp; Burr (1978)</td>
<td>10.4</td>
</tr>
<tr>
<td>Joystick</td>
<td>Card, English, &amp; Burr (1978)</td>
<td>5.0</td>
</tr>
<tr>
<td>Trackball</td>
<td>Epps (1986)</td>
<td>2.9</td>
</tr>
<tr>
<td>Touchpad</td>
<td>Epps (1986)</td>
<td>1.6</td>
</tr>
<tr>
<td>Eyetracker</td>
<td>Ware &amp; Mikaelian (1987)</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Reference:
EXAMPLE: ALTERNATIVE DEVICES

Headmouse: No chance to win
ATTACHING POINTING

Use transducer on high bandwidth muscles
Faster Input: Menu Selection
Faster Input: Menu Selection

Pop-up Linear Menu

<table>
<thead>
<tr>
<th>Today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
</tr>
<tr>
<td>Monday</td>
</tr>
<tr>
<td>Tuesday</td>
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<tr>
<td>Wednesday</td>
</tr>
<tr>
<td>Thursday</td>
</tr>
<tr>
<td>Friday</td>
</tr>
<tr>
<td>Saturday</td>
</tr>
</tbody>
</table>

Pop-up Pie Menu
Try to hit a target without

- You can open your eyes after each step
- Then, try it for both a mac-style and windows-style menu bar
EXAMPLE: BEATING THE MOUSE

Use transducer on high bandwidth muscles
EXAMPLE: STRUCTURING THE TASK SPACE BY PROJECTING THE MODEL
What else might we have measured?

- Time on Task -- How long does it take people to complete basic tasks? (For example, find something to buy, create a new account, and order the item.)
- Accuracy -- How many mistakes did people make? (And were they fatal or recoverable with the right information?)
- Recall -- How much does the person remember afterwards or after periods of non-use?
- Emotional Response -- How does the person feel about the tasks completed? (Confident? Stressed? Would the user recommend this system to a friend?)
New Innovation Cycle for

- Driven by
  - Small Devices
  - Big screens
  - New technologies
Radius from PolymerVision
New Input Devices
Using
INPUT ON
OUTPUT
ShapeWriter

Zhai (IBM, ShapeWriter)
ShapeWriter With Optimized Key Arrangements (ATOMIK)
Error rate ~ 1%
Average speed already > long term Graffiti and others.
QWERTY faster at first, ATOMIK faster in long run.
Experienced users can reach over 100 words/min

Shumin Zhai (IBM, ShapeWriter, Inc)
Big Idea:
INPUT ON CONTEXT
INPUT ON CONTEXT

- Typewriter:
  > Find pizza in 94304
  ==> Places for pizza near 94304
      [1] California Pizza Kitchen
      [2] Round Table Pizza Menlo Park
  > Select [1]

- Input on Output:
  > Find pizza in 94304
  <click>

- Input on Context (GPS):
  > Pizza!
  <click>
Suunto Watch

- Altitude
- Heart rate
- Calories consumed
- Lap time
- Lap number
- Accumulated oxygen deficit
- Ambient temperature
Skinput: Using body surfaces

Harrison, Tan, Morris (2010)
Proteus Ingestable

- Sensor and transmitter encapsulates pill
- Stomach acid is part of battery
- Transmits pill --> patch --> iPhone --> Internet
Some Summary Points

- Input devices are more than just peripherals. They enable classes of dialogues of information.
- Communication is asymmetric to humans: high-bandwidth in, slow bandwidth out.
- Input-on-output enables complex objects and dialogs.
- Input-on-context enables even more complex dialogs.
- Rapid evolution of input devices is expected in the immediate future.
Quiz Scores

Quiz 1: 7.9
Quiz 2: 7.7
Quiz 3: 6.9
This week’s assignment

- Develop a protocol
- Observe users using your prototype
- Compile and analyze results
- Come up with a redesign for A/B testing
Extra Credit

- Due Sunday, March 13 at 11:59pm
- Revisit inspiration
- Publicize your app
- Create a video