Input/Output Technology
UI Hall of Fame or Shame

![Diagram of an Xbox controller with arrows pointing to the A and U buttons.]

Here are some suggestions for the UI Hall of Fame or Shame:

- **A (1)**: Essential button for starting games and accessing menus.
- **B (2)**: Useful for selecting options and confirming actions.
- **C (3)**: Underused button that could be more prominent.
- **D (4)**: Vital for controlling in-game actions.
- **E (5)**: Critical for navigation and quick access.
- **F (6)**: Important for customization and settings.
- **G (7)**: Overlooked button that could be more accessible.
- **H (8)**: Key for in-game interactions and communication.
- **I (9)**: Essential for controlling in-game characters.
- **J (10)**: Valuable for quick access to inventory.
- **K (11)**: Necessary for accessing in-game help.
- **L (12)**: Underutilized button that could be more prominent.
- **M (13)**: Important for navigation and quick access.
- **N (14)**: Critical for customization and settings.
- **O (15)**: Overlooked button that could be more accessible.
- **P (16)**: Key for in-game interactions and communication.
- **Q (17)**: Essential for controlling in-game characters.
- **R (18)**: Valuable for quick access to inventory.
- **S (19)**: Necessary for accessing in-game help.
- **T (20)**: Underutilized button that could be more prominent.
- **U (21)**: Vital for navigation and quick access.
UI Hall of Fame or Shame
Today’s Topics

• Displays
• Pointing devices
• Keyboards
CRT vs. LCD

Cathode Ray Tube

- Picture tube
- Electron guns
- Color signals
- Electron Beams
- Shadow Mask
- Phosphor dots
- Screen

LCD

- One Pixel
- Electron Beams
- Color filter
- Common Electrode
- Liquid Crystal
- Pixel Electrode
- Polarrizer
- White (TFT Off)
- Black (TFT On)
Properties of Displays

• Diagonal size
• Pixel dimensions & aspect ratio
• Pixel density
• Refresh rate
• Color depth (# colors or grays)
• Color gamut
• Gamma
**Pixel Density**

- **Pixels per inch (ppi)**
  - CRT, LCD: 60-130 ppi
  - iPhone: 160 ppi
  - Blackberry Bold: 217 ppi
  - Laser printer: 300-1800 ppi

- **Lines per inch (lpi) for halftoning**
  - Newspaper: 85 lpi
  - Magazine: 133 lpi
  - Art book: 200 lpi
**Subpixel Rendering on LCDs**

- Ideal for text
  - kerning
  - boldface
  - italic
- But only horizontal text
Electronic Paper

- Electrophoretic display
  - charged white particles in a dark-colored oil
  - made by E Ink
  - used by Amazon Kindle & Sony Reader

- Only consumes power to change display
- Low refresh rate (1-2 Hz), low contrast
- Kindle is 167 ppi, 16 levels grayscale
Multiple Monitors and Very Wide Displays

• Multiple monitors are increasingly common
• Microsoft DSharp prototype
  – made with 3 LCD projectors = 3072 x 768 pixels
  – curved, 48” wide, 12” high, 4:1 aspect
• Problems with multiple monitors
  – losing mouse pointer
  – clutching
  – bezels & seams
  – locus of attention
Projectors

- LCD projector
  - basically LCD panel with very bright backlight
- DLP ("digital light processing")
  - uses a digital micromirror device instead of LCD
Automatic Projector Calibration

Automatic Projector Calibration with Embedded L....

Angular Robustness

Moveable Projected Displays using Projector Bas...
Today’s Topics

☑ Displays

• Pointing devices
• Keyboards
Pointing Devices

Mouse

Touchpad

Joystick

Trackball
Properties of Pointing Devices

- Direct vs. indirect
  - Direct touch on screen
  - Indirect control of mouse pointer
- Relative vs. absolute
- Throughput
- Control/display (C/D) ratio
Throughput

- Throughput
  - also called index of performance
    \[ T = a + b \log (D/S + 1) \] seconds
    \[ ID = \log (D/S + 1) \] bits
    \[ IP = \frac{1}{b} \] bits/second

- mouse: 5 bits/sec
- trackball: 3 bits/sec
- touchpad: 3 bits/sec
- joystick: 2 bits/sec
Control/Display Ratio

- **Control:** how far user’s hand moves
  - in meters
- **Display:** how far cursor moves on screen
  - in pixels
- **Direct touch:** C/D = 1
- **Mouse acceleration**

![Graph showing C-D ratio over speed with and without acceleration]
Semantic Pointing

• Adapt the C/D ratio to the targets on screen
  – Highly likely targets have high C/D ratio => pointer moves more slowly, target feels sticky
  – Less likely targets have low C/D ratio => pointer moves fast, slips over them

“Look” is unchanged

...but “feel” is different
Today’s Topics

✓ Displays
✓ Pointing devices

• Keyboards
Keyboard Layout

QWERTY

Dvorak

Alphabetical
Properties of Keyboard Layouts

• Typing speed
  – Experts
    • QWERTY: 82 wpm
    • Dvorak: 85 wpm
  – Novices
    • all layouts are about the same
    • QWERTY actually had slight benefit over alphabetical

• Finger movement distance
  – contributes to fatigue
  – Dvorak: 70% on home row
  – QWERTY: 30% on home row
Summary

• Displays
  – CRT, LCD, e-paper, projector
  – Dimensions, density, refresh rate, color depth

• Pointing devices
  – Mouse, touchpad, joystick, trackpad
  – Throughput, C/D ratio

• Keyboards
  – QWERTY, Dvorak, alphabetical
  – Typing speed, finger movement