Embedded Interface Components

Embedded Interface Design

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Learning Objectives

Students will be able to…

- Consider the mapping of human senses to computer interaction
- Contrast and apply different physical interface components
- Recognize the strengths, weaknesses, and attributes to consider when selecting interface components (and sensors)

Another foundational topic

- The elements we use to design interfaces for embedded devices are more related to UX design than to UX analysis and planning
- However, just as with our review of cognitive psychology, this is being reviewed early as these basic considerations about the building blocks for embedded devices support all phases of a UX development effort

How does a computer/device see us?

- Senses: Touch, Sight, Sound, Taste, Smell
- Also: Movement, Speech, Body, Skin Response, Heart Rate
- The drawing shown here of “how the computer sees us” [1] emphasizes how we interact with a device
- Primary interfaces
  - Touch (often with a single finger)
  - Sight
  - Some sound
- Once rare, now increasing, voice
- Almost never smell or taste
- Reference [1], [2]

Device inputs and where they're used

- Touch, press: physical controls, touchscreens
- Movement, manipulation: tangible UIs
- Speech: speech recognition
- Whole body: gesture recognition, proximity sensor
- Galvanic skin response: stress detection
- Thoughts: brain-computer interfaces
- Heart rate: determine stress, anxiety, sleep…

Device outputs and where they're used

- Seeing: LEDs, screens
- Hearing: sound, voice output
- Tactile sensing: vibration, force feedback, shape
- Smell: scent messaging
- Temperature sensing: temperature output

Typical embedded device interface elements

- Physical controls – switches, buttons, keypads, capacitive touch, etc.
- Lights – LEDs or bulbs, varying color and blink
- Screens – LCD, LED, E-Ink, etc. – some with touch capability
- Audio output – speakers, buzzers, tone generators
- Voice User Interface (VUI) – ex: Alexa, Siri, or custom applications
- Gesture Input – ex: Microsoft Kinect
- Tangible User Interface – devices reacting based on proximity or position relative to other devices
- Tactile Output – devices that change center of gravity or vibrate
- Context-sensitive – behavior based on location
- Computer vision – QR codes, bar codes, based on scanning an image
- Reference [2]

Strengths and weaknesses for interface elements

- Example: Physical controls
  - Strengths
    - Direct and fast control, fine adjustment possible, accessible for low-vision users
  - Weaknesses
    - Cannot change with firmware updates; rarely externally controlled; dexterity, force required, or use of gloves may be an issue
- Typical concerns for choice of interface elements
  - Complexity of information provided
  - Ability to be updated or modified
  - Skill to perform, complexity of input
  - Limitations of users (strength, vision, hearing)
  - Limitation by environment (noise, heat, light)
  - User perception and reaction to interactions
- Reference [2]

Physical Controls

- Examples
  - Switches, buttons, slides, keypads, selectors, joysticks, programmable display switches, knobs, thumbwheels, capacitive touch (vs. resistive vs. membrane vs. mechanical), fingerprint
- Strengths
  - Direct and fast control
  - Fine adjustment allowed
  - Accessible for low-vision users (vs. a touchscreen, for instance)
- Weaknesses
  - Cannot change or develop as software changes
  - Functions and settings cannot be controlled from multiple places
  - Dexterity required may be an issue
  - Wearing bulky or rubber gloves may be a problem

Lights

- Examples
  - LEDs or bulbs with color, intensity, and blink control
- Strengths
  - Glanceable and nonintrusive information output
- Weaknesses
  - Cannot convey complex information (ex. interpreting or counting a blink pattern)
  - Cultural color selections
  - Low-vision users

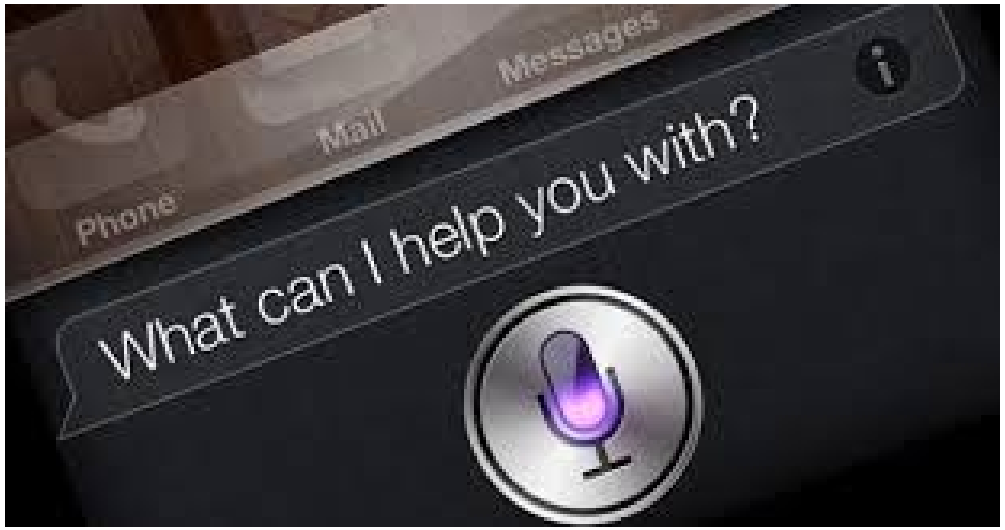
Screens

- Examples
  - Segmented LCD displays, OLED, LED or CCFL (cold cathode florescent lamp) lighting for display, E-Ink (electrophoretic), Plasma
- Strengths
  - Make a physical object dynamic
  - Keeps the product flexible
  - Allows for iterative or updated firmware/software UI changes
- Weaknesses
  - Challenging to keep the UX simple
  - Once a screen is available, maintaining simplicity becomes a challenge
  - Low-vision Users, but may be adjustable for some

Audio Output

- Examples
  - Speakers, audible buzzers or tone generators
- Strengths
  - Urgent and time critical results
  - Can give a product emotional qualities
  - Ex. “efficient” vs. “playful” sounds
- Weaknesses
  - Environment where it becomes annoying
  - Environment where it may not be heard
  - Tuning out frequent occurrences
  - Low-hearing users

Voice User Interfaces



- Examples
  - Amazon Alexa, Apple Siri, video games, etc.
- Strengths
  - Usable when other controls are not (ex. Driving)
  - Complex input and output to and from a simple device
  - Minimizes physical interface requirement
  - Allows hands-free interaction
- Weaknesses
  - Products or contexts where weak connectivity is possible
  - High noise environment
  - Difficult to pronounce or recognize commands or terms
  - Products for global markets
  - Low vocal capacity users
- More on designs later in class…

Gestural Interfaces

- Examples
  - Microsoft Kinect, Nest “wave to hush” smoke detector
- Strengths
  - Video games – increases immersion and challenge
  - Short interactions
  - When gestures are obvious
- Weaknesses
  - Precise or lengthy interaction needed
  - Serious issues with false positives
  - Time to learn
  - Low capability users

Tangible User Interfaces

- Examples
  - Devices that sense proximity of other devices, position of the device, or represent information with physical tokens
- Strengths
  - Digitally enabled experience that feels unique (not like dealing with a typical computer)
  - Educational or toy products
- Weaknesses
  - If keeping all parts is critical
  - Time to learn
  - User's level of ability to interact

Tactile Output

- Examples
  - The Bumblebee Wallet – vibrates on activity, makes it harder to open as accounts or budgets change; Mobile phones that shift center of gravity; Devices that shift shape; Vibrations in car seats for lane changes
- Strengths
  - Can reduce cognitive load
  - Can be faster feedback, but less precise
- Weaknesses
  - Mechanical frictions and wear
  - Limited lifespans
  - Limited information provided

Context-Sensitive

- Examples
  - Web interactions that differ based on your location; Options based on distance from a device or whether in the same room as a device; Device that remembers music choices based on location (Aether Cone – came and went…)
- Strengths
  - Move to levels of detail without methodical user input
  - Increasing details of information as a device is approached is an easily understood concept
- Weaknesses
  - Limiting users options may be seen as patronizing
  - Users may perceive devices negatively

Computer vision and barcode scanning

- Examples
  - QR code scanner, check scanning, etc.
  - OpenCV
- Strengths
  - Replaces cumbersome input
- Weaknesses
  - Interaction may be more cumbersome than other alternatives
  - If a QR scanner is required, users may view another option as simpler
  - Low-vision users

Sensors as input devices

- Magnetometer
- Accelerometer
- Gyro (angular velocity)
- Piezo/vibration
- Magnetic reed
- Force sensitive resistor
- PIR (pyroelectric infrared) motion detector
- Ultrasonic rangefinder
- Humidity
- Temperature
- IR emitter/receiver
- Capacitive vs. resistive touch (e.g., for touch screens)
- Photocell
- Altitude/pressure
- Flex
- Softpot (potentiometer strip)
- Strain
- Shock
- Tilt
- Current/Voltage
- Inclinometers
- Cameras
- Air quality/gas sensors
- Moisture
- Membrane or mechanical touch/buttons

Sensors/Component Design Criteria

- Functionality
- Power used
- Power management
- Interface
- Electrical and data/control
- Accuracy
- Precision
- Data rate
- Latency
- Error Rates
- False Negatives/Positives
- Range
- Cost
- Development Tools
- Reference Designs
- Availability
- Life Cycle
- Reliability (MTBF)
- Second Sources
- Physical Size
- Mounting
- Operating Environment
- Standards conformance
- Environmental impact
- Intellectual property
- Others?

- Criteria can be used, ranked, weighted, and compared in design analysis tools such as
  Pugh matrices

References

[1] Physical Computing, O'Sullivan and Igoe, 2004, Thomson
[2] Designing Connected Products, Rowland et al., 2015, O'Reilly