EECS 4441 Human-Computer Interaction

Topic #3a: The Interaction

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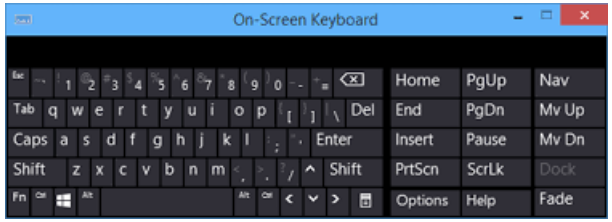
Topics

- Soft Controls
- Control-Display Relationships
- Mental Models
- Modes
- Multi-Degree of Freedom Input Devices
- Touch UIs

Soft Controls

- Traditionally, hard, physical controls for system/devices

- Prevalence of computer displays has led to dynamic, on-screen controls, created by software (i.e., soft controls)



Control-Display Relationships

- Spatial
  - Movement of a device affects movement of a response
- Dynamic
  - Movement of a device affects speed of a response
- Physical
  - Whether movement or force affects a response

Spatial Relationships

- Movement of a control device results in a movement response (e.g., movement of a mouse)

- Latency
  - Time delay between action and response
  - Delays of about 150 millisecond in VOIP calls is tolerable
  - Latency of about 100 ms in online games is tolerable
  - Latency in VR >20 ms typically leads to motion sickness
    - 60 Hz frame rate (60 fps) = a minimum delay of 17 ms

https://www.pubnub.com/blog/2015-02-09-how-fast-is-realtime-human-perception-and-technology/

http://www.chioka.in/what-is-motion-to-photon-latency/

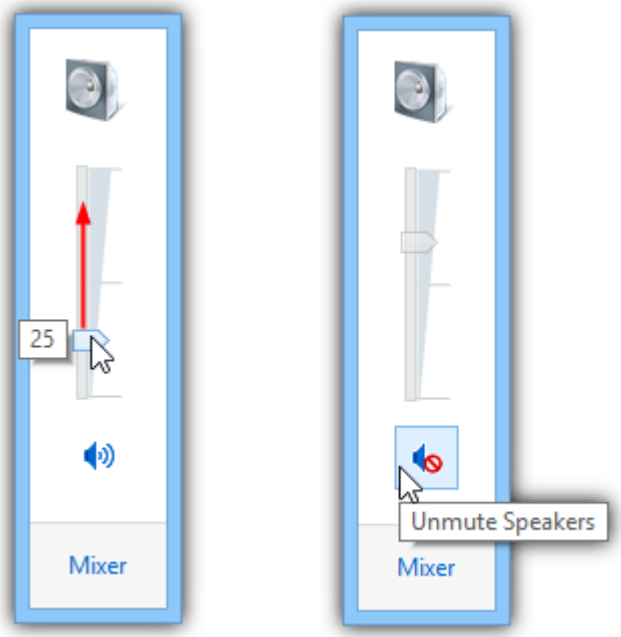
https://www.wareable.com/vr/vr-headset-motion-sickness-solution-777

Natural vs. Learned

- Is there a natural relationship between the control and the response or is it (easily) learned?
  - Does it matter?
  - If it is learned, is it cultural or universal?

- For learned interactions there is often a spatial congruence (mapping) of device motion to response motion

Natural?



Learned (Cultural)

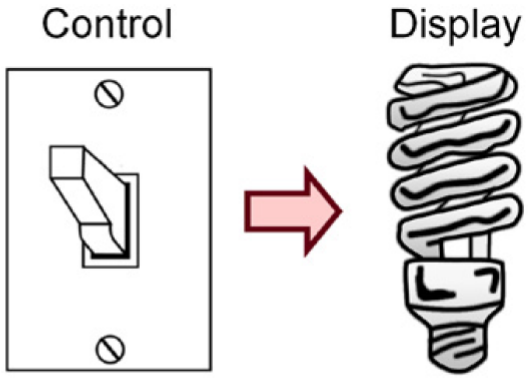
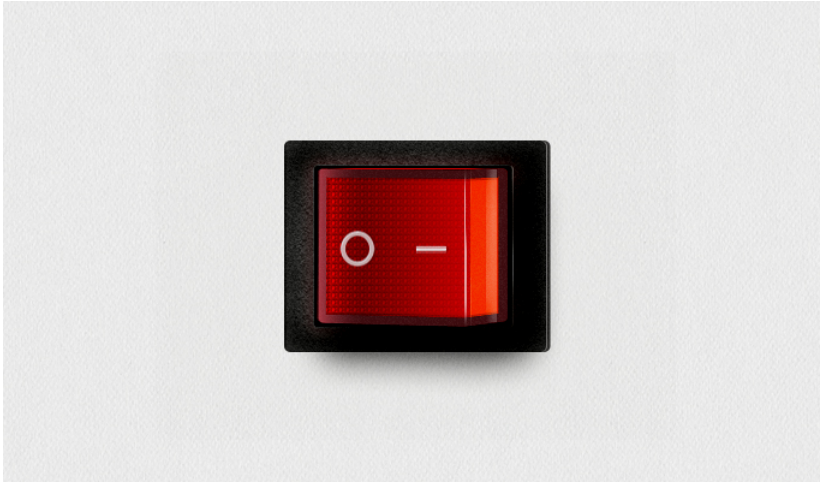


FIGURE 3.17

Culture plays a role. Is the display on or off?



Mapping

- Movement in 3D space can occur along the three linear axes, and also the three rotational axes

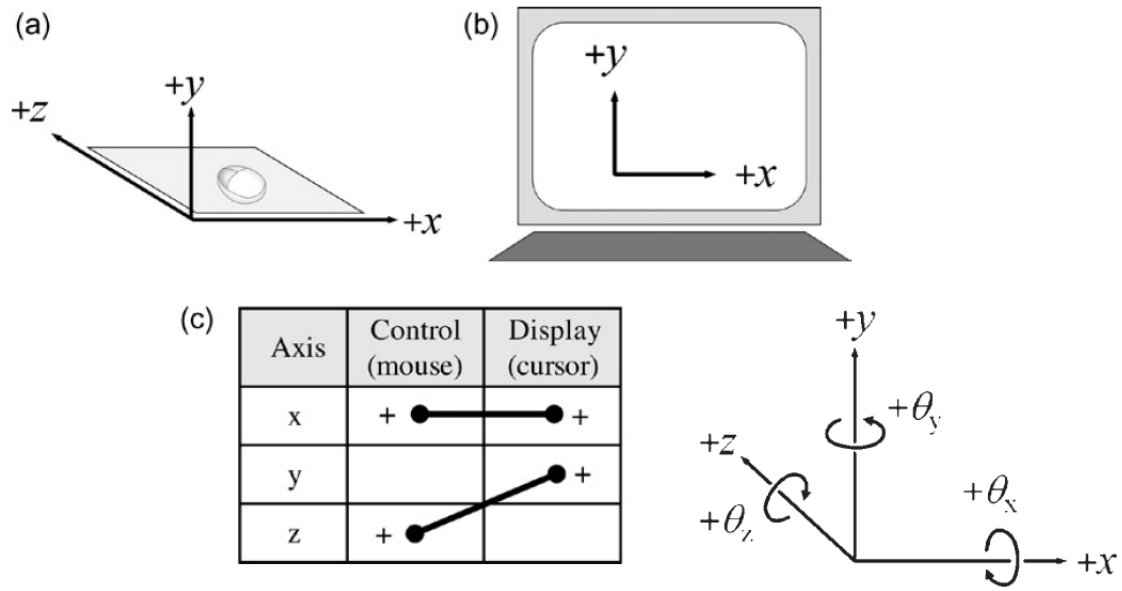


FIGURE 3.5

Axis labels. (a) Control space. (b) Display space. (c) Control-display mapping for a mouse and cursor.

Mapping (2)

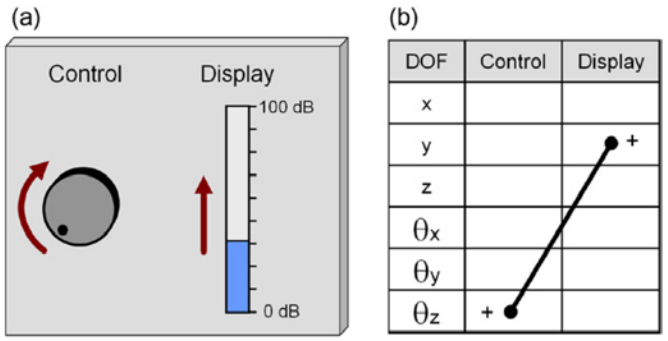


FIGURE 3.15

A control-display relationship. Learned or natural?

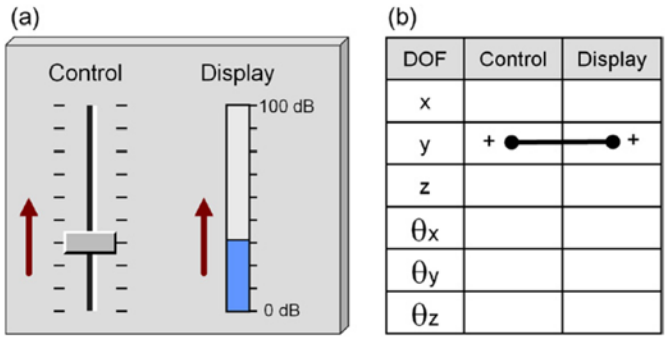
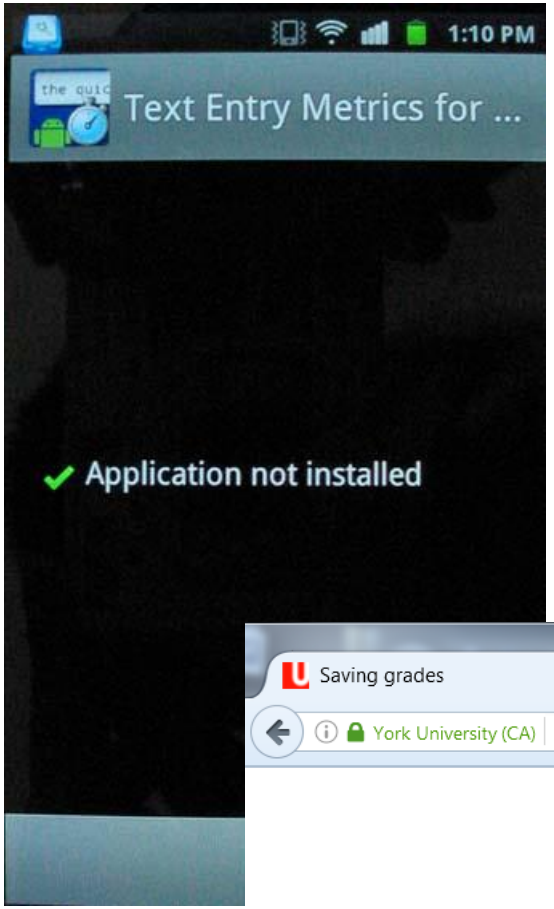
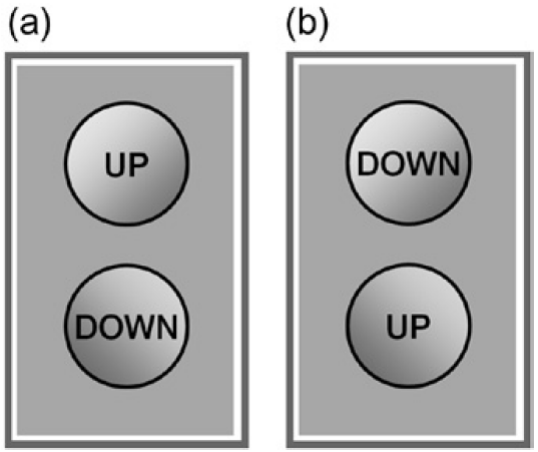


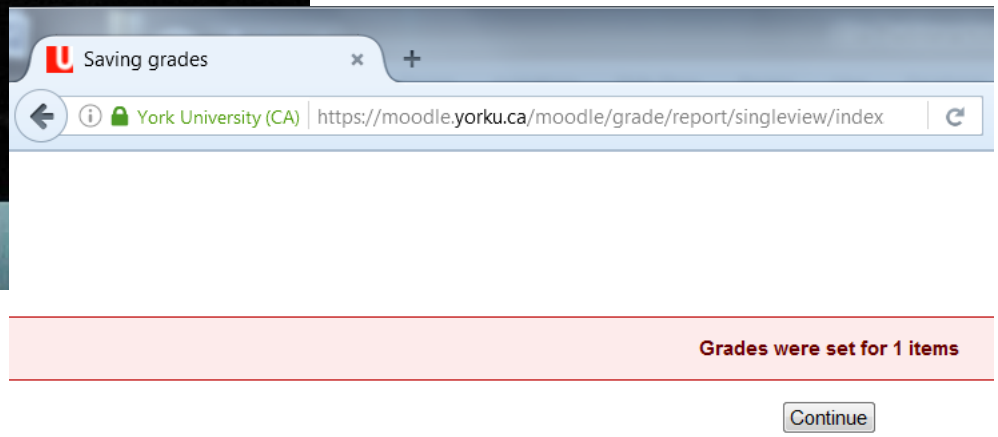
FIGURE 3.16

Spatial congruence: (a) Control and display. (b) Mapping.

Incompatible Mapping







Dynamic Relationships

- Control-display (CD) gain
  - Ratio of displayed movement (e.g., cursor) to control movement (e.g., mouse)
  - Low gain allows for more precise movement
  - High gain allows for faster movement and greater range of movement in a limited area (e.g., less need to reposition mouse)
- Non-linear (power) gain
  - The speed of moving the device (e.g., mouse) affects the CD gain and resulting movement of the pointer on screen

Physical Relationships

- Position based tracking
  - Absolute position is used as input
  - E.g.: touchscreen, digitizer, trackpads in absolute mode
- Displacement based tracking
  - Relative movement is used as input
  - E.g.: mouse, trackpad
- Force based tracking
  - Applied force is used as input
  - E.g.: Isometric joystick
- Input could control the position of movement (e.g., mouse) or velocity of movement (e.g., joystick)
  - Position control best for position tracking, velocity control best for force sensing device [Zhai, 1995]

Mental Models and Metaphor

- Mental model (conceptual model)
  - Perception of how a system works
- Metaphor
  - Mimicking system interaction using similarities to real-word interactions
  - Help facilitate mental models of interaction that are easily learned (e.g., deleting a file by putting it in the recycle bin)

- Opposite: implementation model, where interactions are imposed on the user, based on what is easiest for system implementation, rather than user interaction

Gulf of Execution and Evaluation

- Gulf of execution
  - Disparity between what the system actually provides and what the user expects it to provide
- Gulf of evaluation
  - Difficulty of the user to perceive the current state of the system
- Further description:
  - https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction/gulf-of-evaluation-and-gulf-of-execution

Modes

- Space multiplexing
  - Dedicated hardware for each control (e.g., light switch)
  - Requires the most space and hardware
  - Immediate control at any time

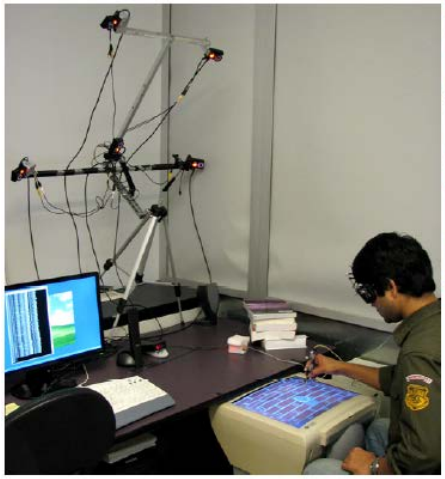
- Time multiplexing
  - Same hardware for multiple controls (e.g., keyboard)
  - Allows for more tasks than there are controls
  - Requires the lease space and hardware (i.e., less expensive)
  - Control requires a combination of actions (e.g., sequence of mode selections, or simultaneous key presses)

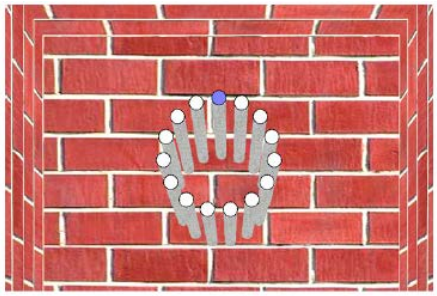
Degrees of Freedom

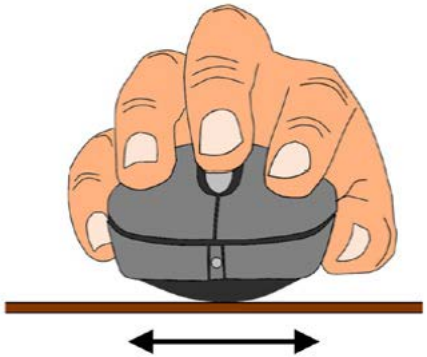
- Independently controlled parameters of motion
- Most input devices track motion on the xy-plane (2 DOF)
- Some track in 3D space along x- y- and z-axes (3 DOF)
- Others also track in the rotational axes yaw, pitch, roll (6 DOF)

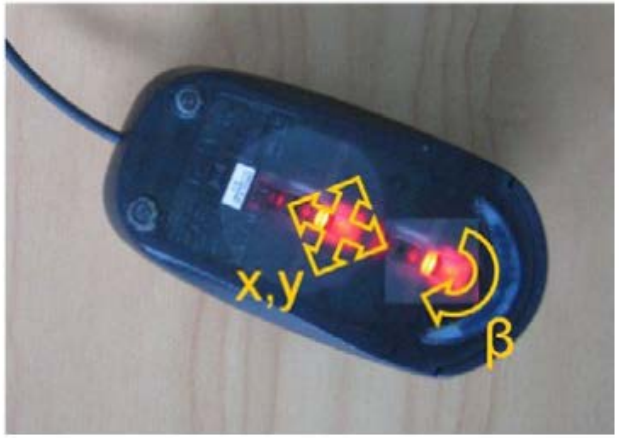
- Congruence
  - Movement in control space maps to corresponding movement is display space

Input Devices





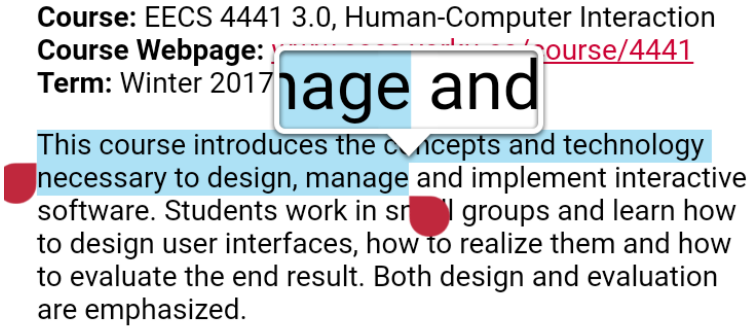




Transition to touch interfaces

- No separate input devices – your finger is the pointer
- Width of finger can lead to imprecise selection
- Interaction occludes screen

- Larger widgets (e.g., tiles instead of icons)
- Gestures (e.g., swiping, tilting)
- Magnifiers for selection



Thank You