Interaction Elements

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Overview

Sources

- Mackenzie, Chapter 3, **Interaction Elements**, Human Computer Interaction: An Empirical Research Perspective, 1st ed. (2013)

Control-display relationships

- **Control-display relationships** describe the mappings between **control** and **display**
- The mouse/cursor example describes a **spatial** relationship. There are also **dynamic** relationships, describing how a controller affects the speed of the response, and **physical** relationships, describing whether the response is to a movement or a force in the controller

Spatial relationships

- The mapping is **congruent** in left figure, while in right figure, you move the mouse forward which indicates up (fortunately, human can learn this relationship quite naturally)

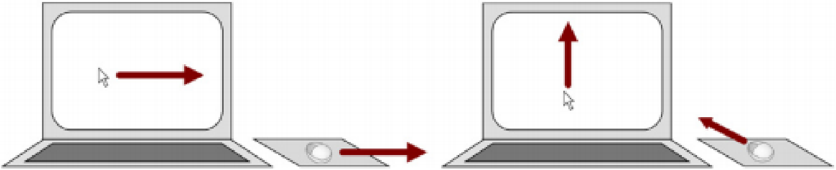

Figure: Source: Figure 3.4 (Mackenzie)

Definitions

- **Control space** (a) depicts the possible movement of the input device
- **Display space** (b) depicts the corresponding display (e.g., cursor) movements
- **Control-display mappings** for a mouse and cursor (c)
- The y-axis cursor motion is an example of a **transformed spatial mapping**. In this case, it is a 90 deg transformation along the y-z plane

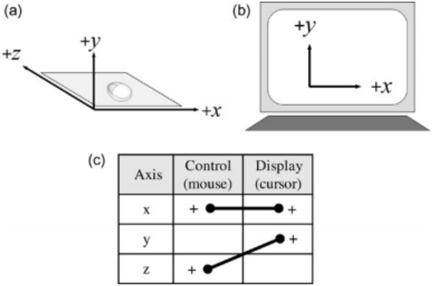

Figure: Source: Figure 3.5 (Mackenzie)

Scrolling

- Consider **scrolling** the view of an image or document. Interaction involves manipulating a physical controller, such as a **mouse** (a hard control), to **move a pointer** to the slider (a soft control), **acquiring** it with a button-down action, then **drag** to change view.
- In this case, the hard control has a **proportional** relationship with the soft control, while having a **reverse** relationship with the display.

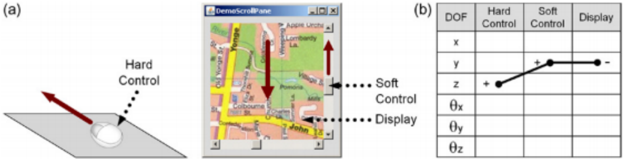

Figure: Source: Figure 3.6 (Mackenzie)

Rotations

- Let's consider another possible transformation: **rotations**
- theta (θ) designate angle, whereas positive direction corresponds to clockwise movement
- **Degree of freedom** refers to the degree in which each parameter may be manipulated independently of the others
- For a 3D object, six parameters are required: three for the object's position in space (x, y, z), and three for object's orientation in space (θ_x, θ_y, θ_z).

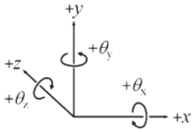

Figure: Source: Figure 3.7 (Mackenzie)

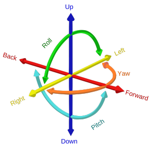

Figure: Source: Wikipedia

Rotations

An example of exact congruence in 3D space

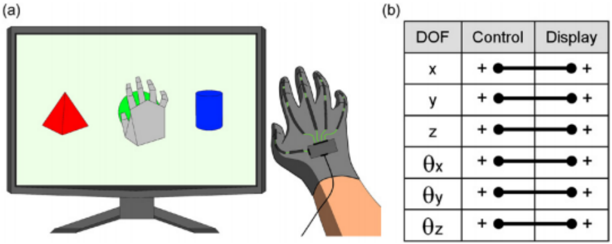

Figure: Source: Figure 3.8 (Mackenzie)

Rotations

- **Panning**: drag the mouse where linear movement of the mouse in x-axis (left-right) rotates the display along the y-axis, a linear movement of the z-axis (forward-backward) rotates the scene along the x-axis
- **Zooming**: clicking on + and - soft controls, or use the middle-wheel of a mouse. The middle wheel is a spatially congruent control-display mapping but the problem is its jerkiness (non-continuous). A better way is to use z-axis movement but oops...

Figure: Source: Figure 3.9 (Mackenzie)

CD gain

- **CD gain** refers to the amount of movement in a display object (e.g., cursor), for a given amount of movement in a control.
- For example, if a mouse is moved three cm, the cursor moves six cm, then the CD gain is $6/3 = 2$

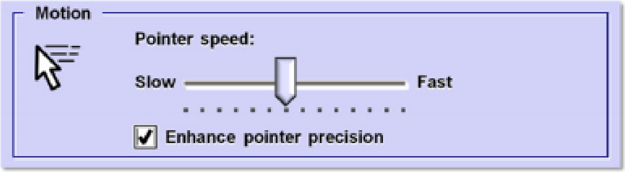

Figure: Source: Figure 3.10 (Mackenzie)

CD gain

- Follows a **power function** - enables by "*Enhance pointer precision*". If the mouse moves quickly, CD gain increases. Vice versa.
- Lowering the CD gain for slow controller movements is useful to enhance the precision of target selection at the end

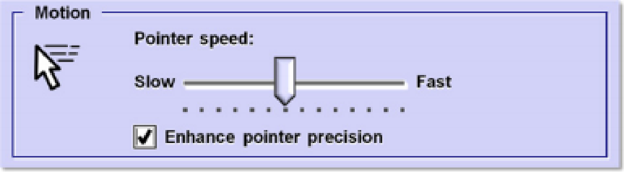

Figure: Source: Figure 3.10 (Mackenzie)

CD gain

- Research on CD gain dates back to at least 1940s
- Varying CD gain evokes a tradeoff between **gross positioning time** (getting to the target) and **fine positioning time** (final acquisition).
- CD gain research is still ongoing, although the focus is often in **different settings** - very large displays, very small displays, remote pointing, accessible computing, 3D interaction

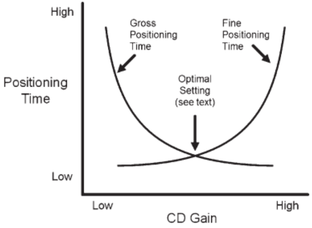

Figure: Source: Figure 3.11 (Mackenzie)

Latency

- Not surprisingly, human performance and the interaction experience are adversely affected when feedback is delayed. The delay between an input action and the corresponding response on a display is called **latency** or **lag**.
- Latency is crucial in **remote manipulation** and **virtual reality**, etc.

Latency

- MacKenzie and Ware (1993) systematically introduced latency in a system and measured the effect on human performance in simple point-select tasks. With **75ms** latency, movement time increased by 16 percent and **error rate by 36 percent.** At **225ms** the effect was dramatic, with movement time increasing by 64 percent and error rate by **214 percent**

Property sensed

- The input controller senses the interaction and coverts a **property sensed** into data that are transmitted to the host computer for processing.
- For pointing devices, the most common properties sensed are **position**, **displacement**, and **force**.
  - With a **pen**, the property sensed is the **position** of a stylus
  - With **finger**, the property sensed is the **absolute coordinate** at the point of contact along the x and z axis
  - **Mouse** is different and uses **displacement** instead which is **relative** to previous movement.
  - **Joystick** also uses **displacement**
  - **Thinkpad trackpoint** uses **force**

Isotonic

- Isotonic joysticks are called **displacement** joysticks. The output signal represents the position of the stick as the amount of displacement (i.e., rotation) from the neutral or home position, about the x- and z-axes. Good for **position**.

(a)

Figure: Source: Figure 3.13a (Mackenzie)

Isometric

- With an **isometric** joystick, the stick does not move. The property sensed is the **force** applied to the stick. The output signal represents the amount of force along the x-axis and z-axis. An example is trackpoint build in many Thinkpad laptops. Good for **velocity**.

Figure: Source: Figure 3.13b (Mackenzie)

Natural versus learned relationships

- For the figure below of turning the knob, is it intuitive?
- On might argue that clockwise is the same as moving up, thus it is natural. Nevertheless, this relationship remains a **"learned"** relationship

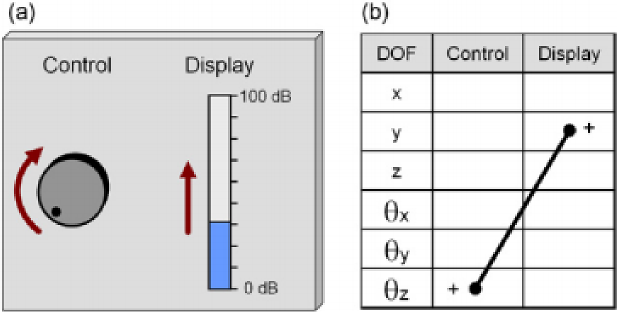

Figure: Source: Figure 3.15 (Mackenzie)

Natural versus learned relationships

- Best scenario is spatial congruence, where there is a clear 1-1 mapping.

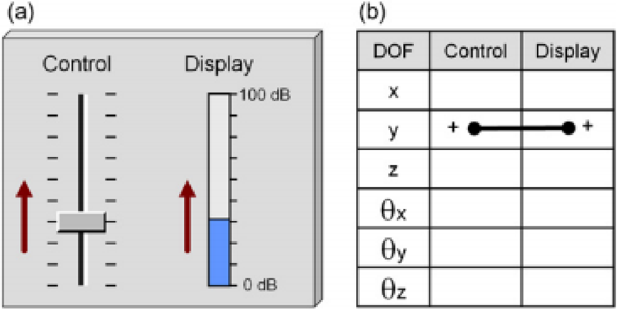

Figure: Source: Figure 3.16 (Mackenzie)

Natural versus learned relationships

- Is the switch having a spatial congruence?
- Since on/off is not something that has spatial properties, it is difficult to design a spatial congruence
- In such case, culture plays a big role. In UK, a up is off, while in US, the light is on (see how problematic it can be!)

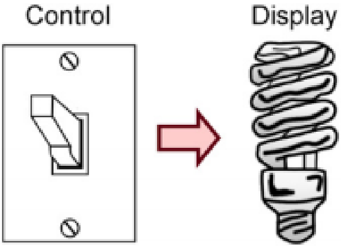

Figure: Source: Figure 3.17 (Mackenzie)

Natural versus learned relationships

- Which one is spatially congruent?

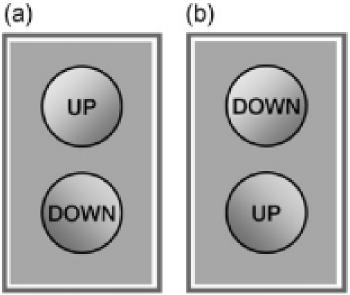

Figure: Source: Figure 3.18 (Mackenzie)

Clock as metaphor

- Most users have a ingrained understanding of a clock
- Numerous HCI research use clock as a metaphor to help users do text-entry or to navigate

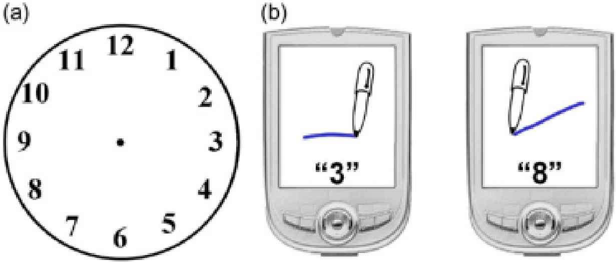

Figure: Source: Figure 3.20 (Mackenzie)

Pulse as metaphor

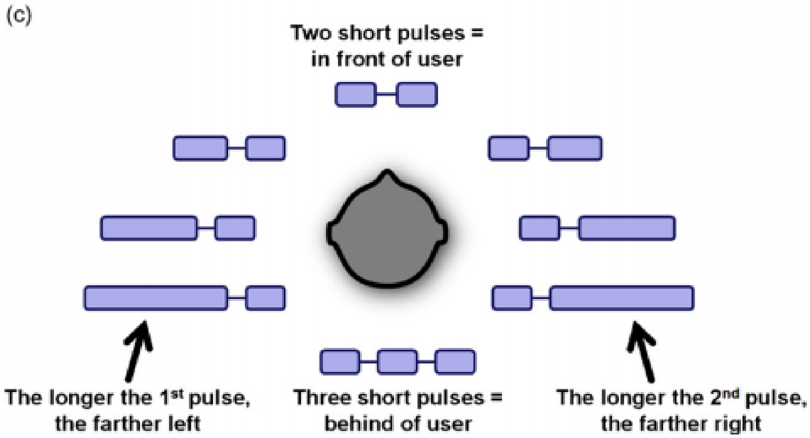

Figure: Source: Figure 3.21b (Mackenzie)

Modes

- A common and sometimes frustrating property of user interfaces is **modes**.
- Challenges with modes occur because there are **fewer controls than tasks**

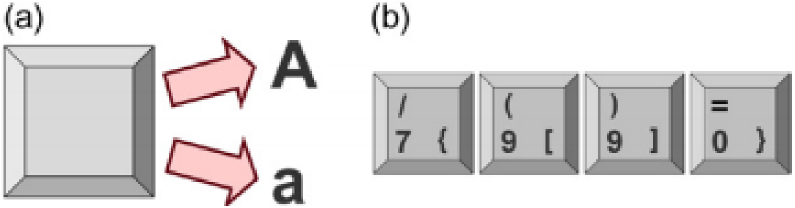

Figure: Source: Figure 3.22 (Mackenzie)

Modes

Modes exist in most interactive systems and are usually difficult to learn

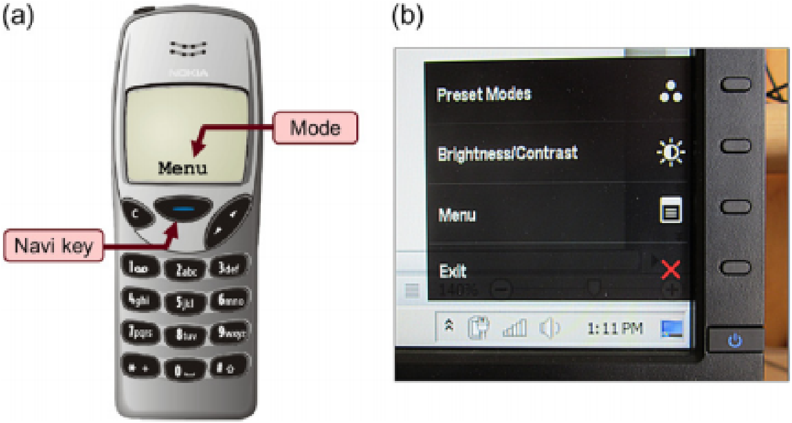

Figure: Source: Figure 3.23 (Mackenzie)

Modes

Changing mode can be easy or difficult!

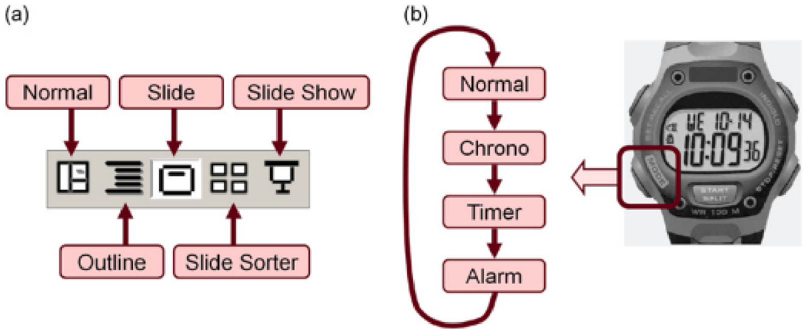

Figure: Source: Figure 3.24 (Mackenzie)

Modes

Feedback is crucial in a mode design system

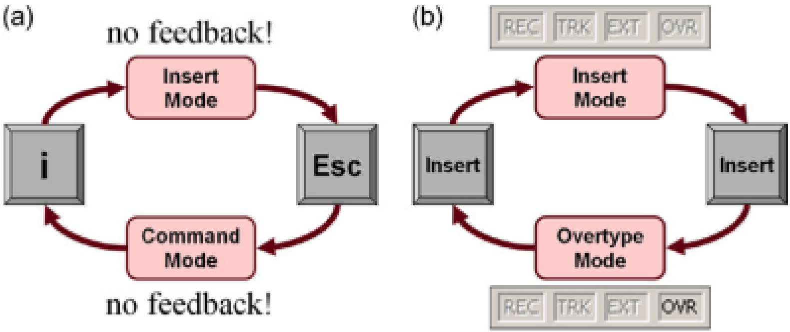

Figure: Source: Figure 3.25 (Mackenzie)

Bandwidth

- Large amount of HCI research focuses on increasing **interaction bandwidth**
- E.g., doctors performing surgery with two hands busy while using eye gestures to perform additional actions

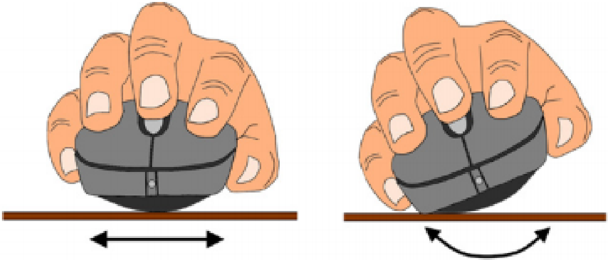

Figure: Source: Figure 3.31 (Mackenzie)

Bandwidth

- Click anywhere you want

Figure: EasySMX Ring: provides convenience but loses full-featured mouse when it comes to productivity

Bandwidth

- Chair gestures

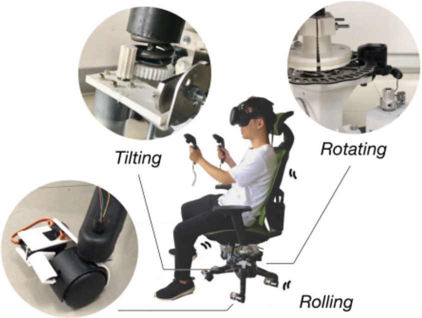

Figure 1: Aarnio modulates the resistive force of rotating, tilting and rolling an office chair for new applications.

Figure: Teng et al., **Aarnio: Passive Kinesthetic Force Output for Foreground Interactions on an Interactive Chair**, CHI 2019

Activities

Classwork

- Download **GoFitts.jar** from `http://www.yorku.ca/mack/FittsLawSoftware/`
- Perform a 1D fitts tasks with default settings (**A** = 100, 200, 400; **W** = 20, 40, 80). Other factors include **pointing speed** - *slow, medium, fast*, and **precision mode** - *on & off*. If you are NOT using Windows, instead of precision mode, use **handedness** instead (left and right hand). Set the **Number of Trials** to 5. Set **Condition Code** according to the point speed and precision mode. Leave Session Code and Group Code as default.
- Perform **four-way ANOVA** with pointing speed, precision mode, A, and W as IV and MT as DV. (you may want to first convert the long table format to wide format).
- Summarize your result in APA with graphs and submit to GC.

What's next

Read slide on **Modeling**.

- Mackenzie, Chapter 7, **Modeling Interaction**, Human Computer Interaction: An Empirical Research Perspective, 1st ed. (2013)

We will reuse this Fitts data for further modeling.

Questions