Chapter 3
Interaction Elements

BumpTop

- https://www.youtube.com/watch?v=M0ODskdEPnQ

Interaction

- *Interaction* occurs when a human performs a task using computing technology
- Interaction tasks with a goal:
  - Send an e-mail
  - Burn a CD
  - Program a thermostat
  - Enter a destination in a GPS device
- Interaction tasks without a goal:
  - Browse the web
  - Chat with friends on a social networking site

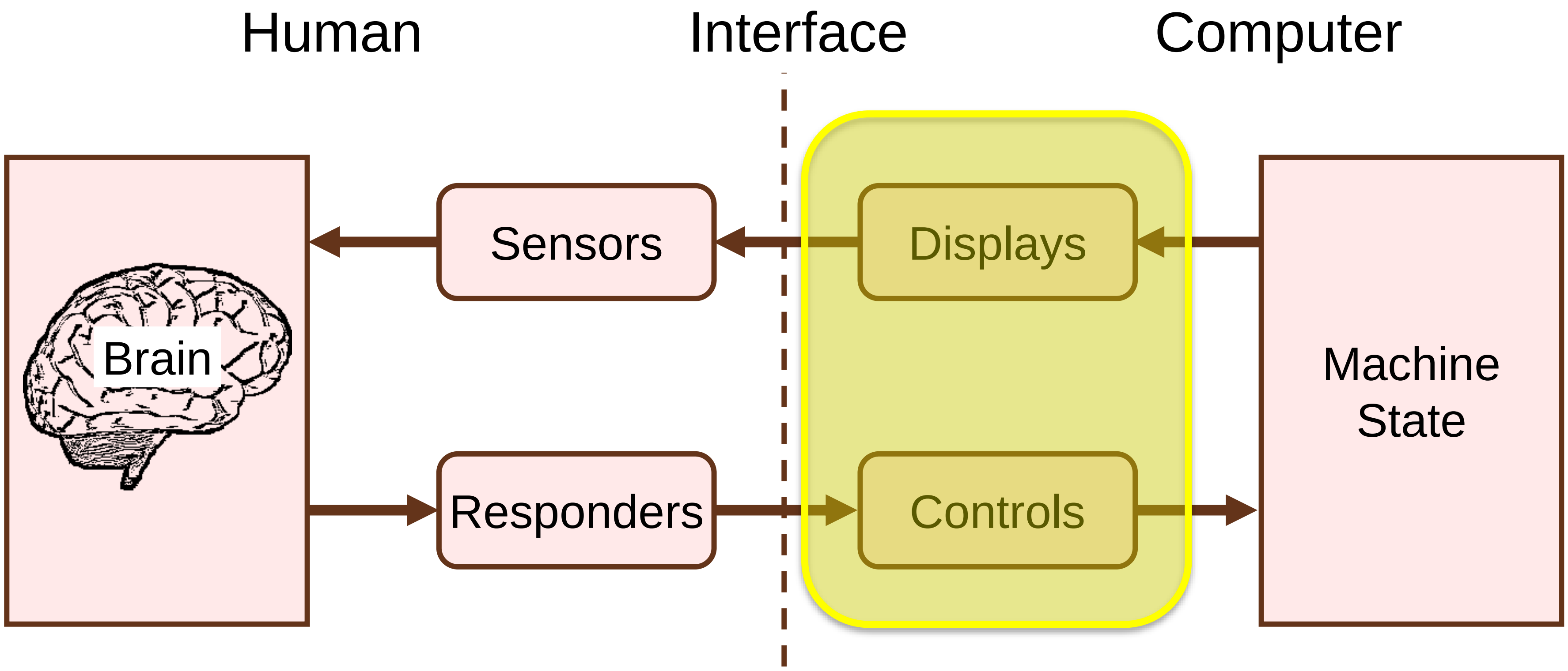
Interaction Elements

- Can be studied at many levels and in different contexts
- As presented here, the tasks are in the cognitive band of Newell's time scale of human action (see Chapter 2)
  - Deliberate acts (≈100 ms)
  - Operations (≈1 s)
  - Unit tasks (≈10 s)
- Tasks in this range are well suited to empirical research
- Experimental methodology preferred (extraneous behaviours easy to control)
- Early human factors research on "knobs and dials" is relevant today
- Knobs → "controls"; dials → "displays" (next slide)

Interaction Techniques

- The previous videos we saw introduced novel interaction techniques
  - New ways to accomplish operations and unit tasks
  - Some of the techniques moved unit tasks to simple and faster operations
    - For example, organizing files into piles or type piles using BumpTop
  - Others will make it easier for us to learn/recall how to accomplish other operations or unit tasks

Human Factors Model (revisited)



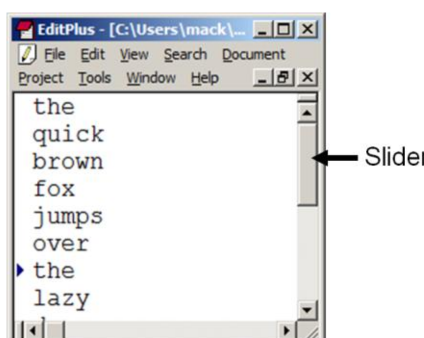
Hard Controls, Soft Controls

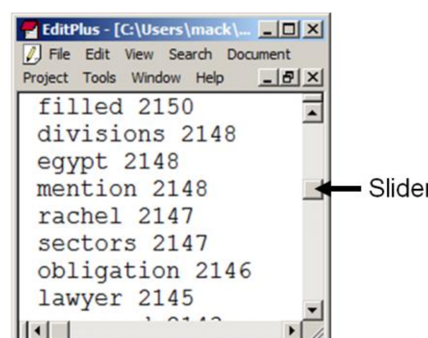
- In the past, controls were physical, single-purpose devices → *hard controls*
- Today's graphical displays are malleable
- Interfaces created in software → *soft controls*
- Soft controls rendered on a display
- Distinction blurred between soft controls and displays
- Consider controls to format *this* (see below)

Soft controls are also displays!

Scrollbar Slider

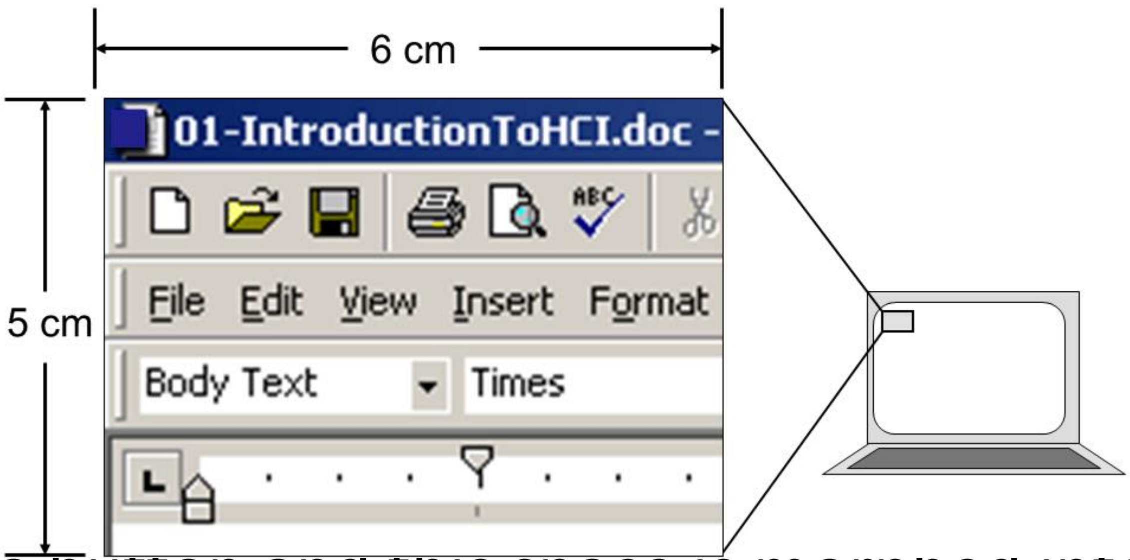
- Example of a soft control (control + display)
- As a control
  - Moved to change view in document
- As a display
  - Size reveals view size relative to entire document
  - Position reveals view location in document





GUI Malleability

- Below is a 30 cm^2 view into a GUI
- >20 soft controls (or are they displays?)

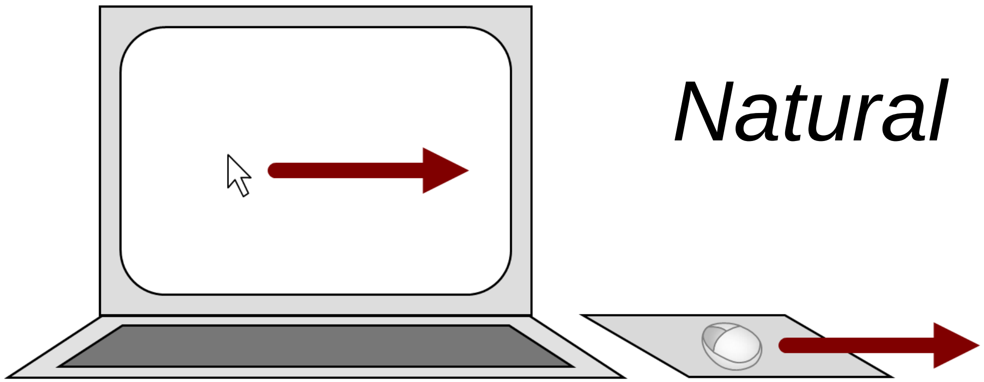


- Click a button and this space is morphed into a completely different set of soft controls/displays

Control-Display Relationships

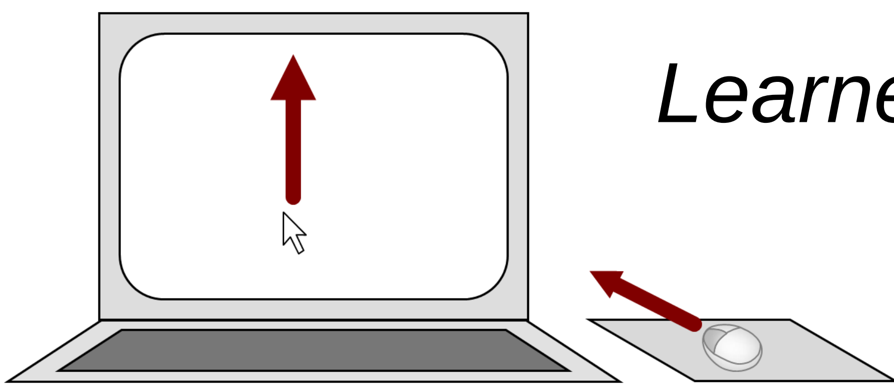
- Also called *mappings*
- Relationship between operation of a control and the effect created on a display
- At least three types:
  - Spatial relationships
  - Dynamic relationships
  - Physical relationships

Spatial Relationships



Natural

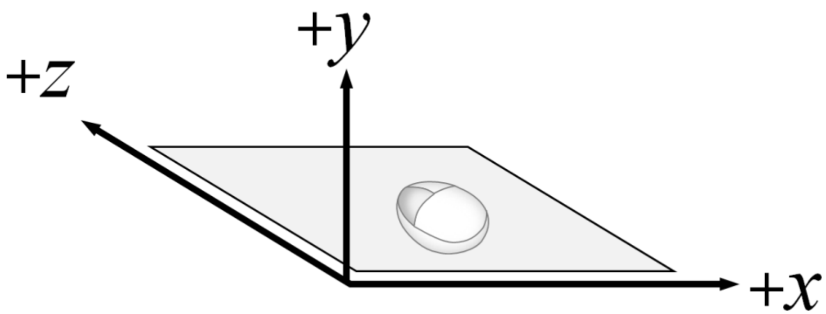
Spatial congruence
Control: right
Display: right



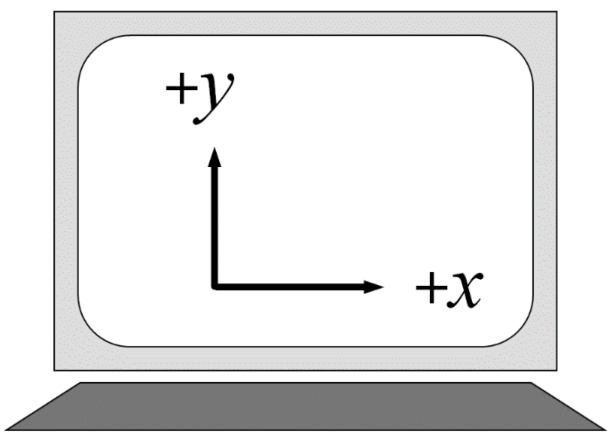
Learned

Spatial transformation
Control: forward
Display: up

Axis Labeling



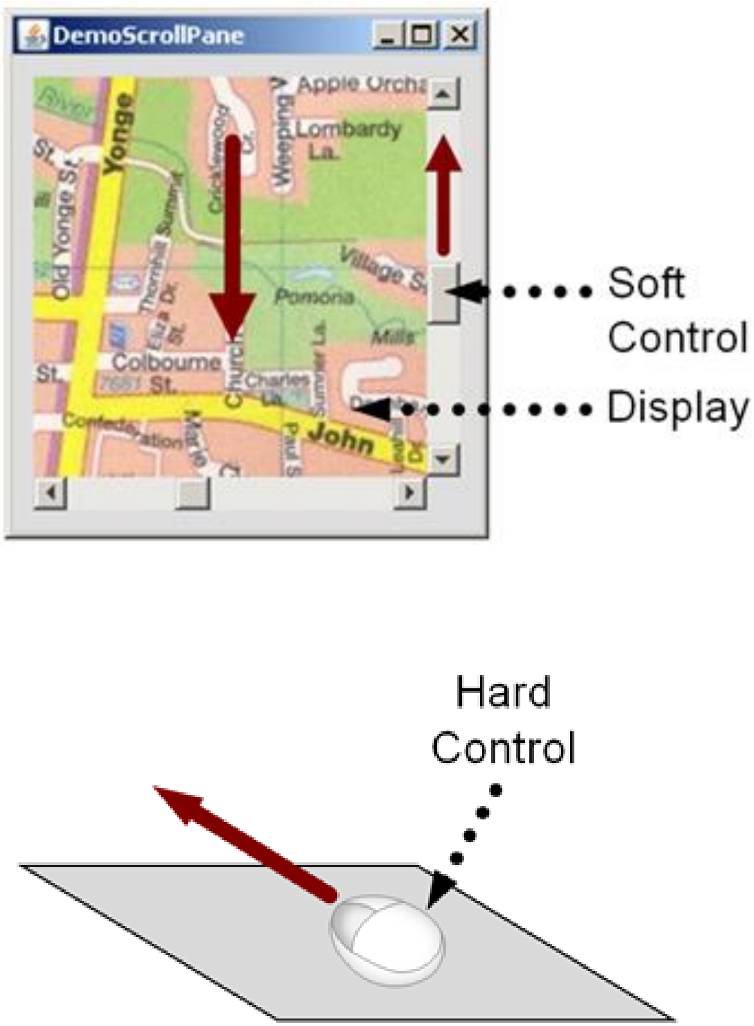
Control



Display

Axis	Control (mouse)	Display (cursor)
x	+	+
y		+
z	+	

Third Tier

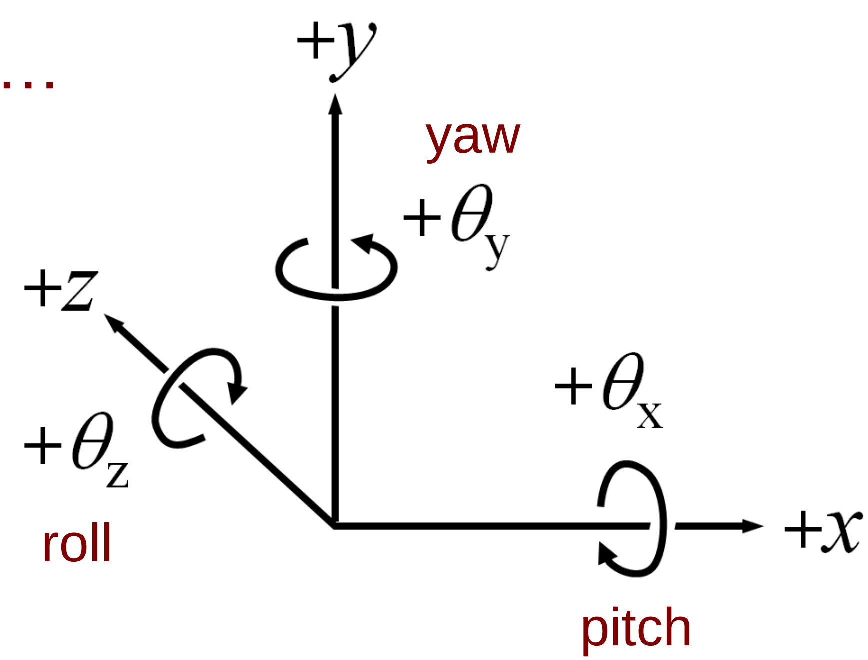


DOF	Hard Control	Soft Control	Display
x			
y		+	-
z	+		
θx			
θy			
θz			

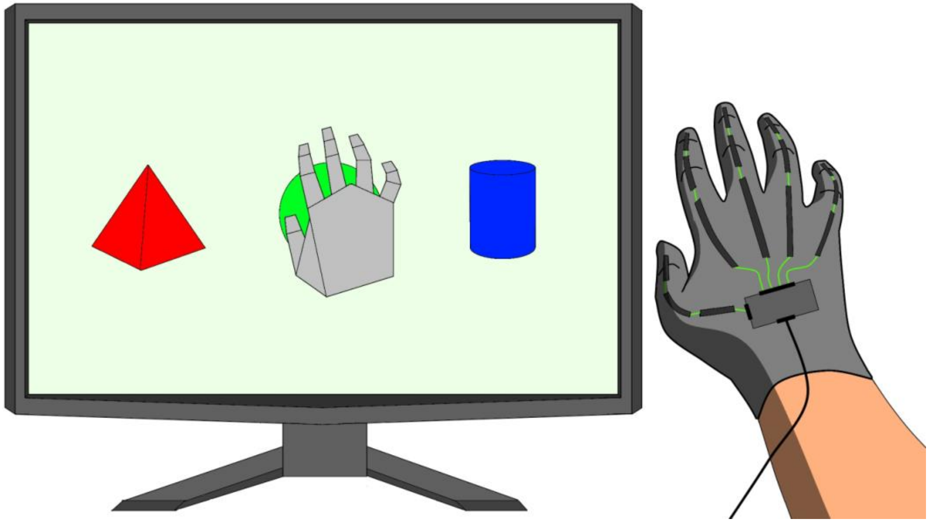
3D

- In 3D there are 6 degrees of freedom (DOF)
  - 3 DOF for position (x, y, z)
  - 3 DOF for orientation (θ_x, θ_y, θ_x)

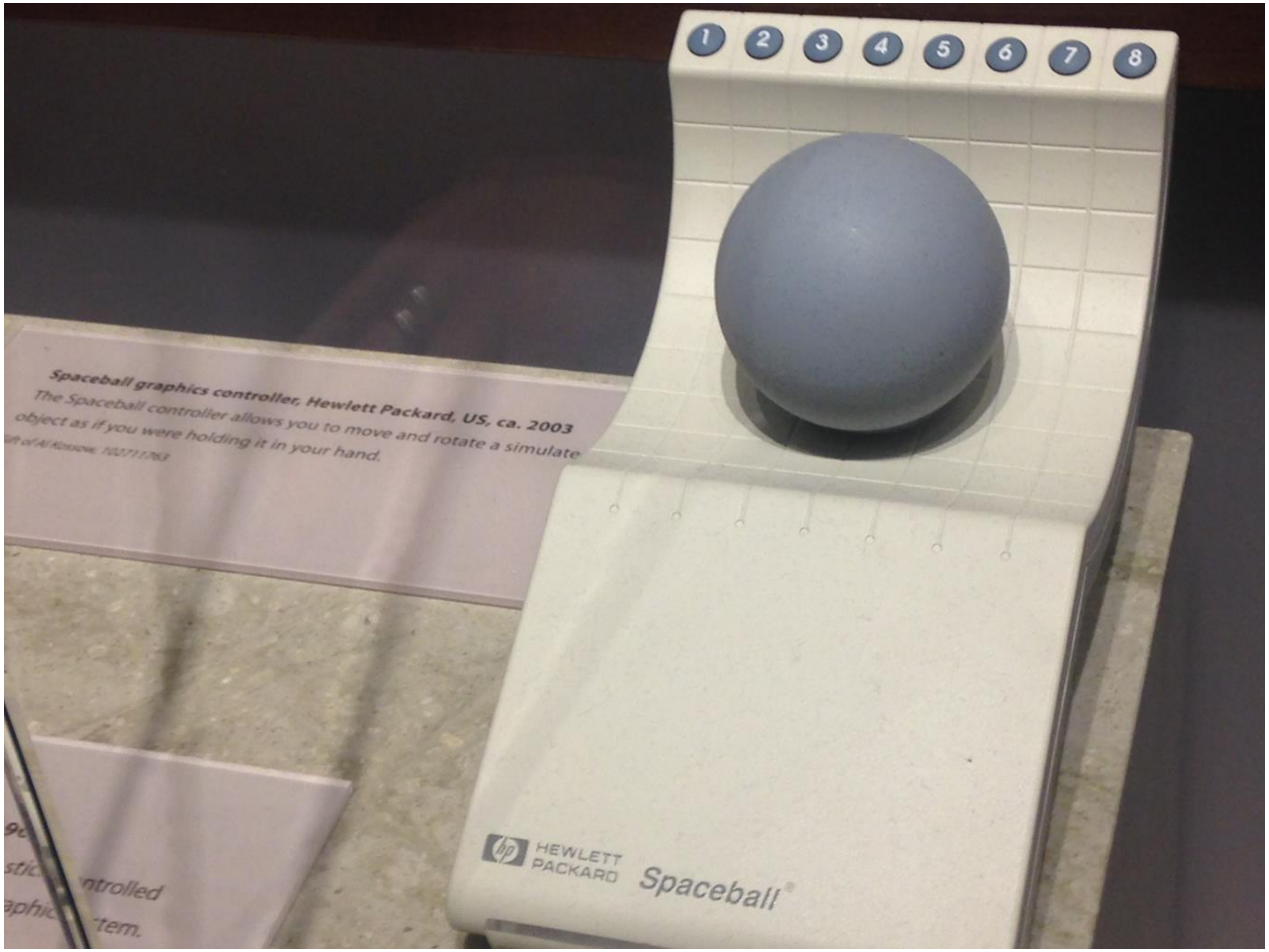
In aeronautics…



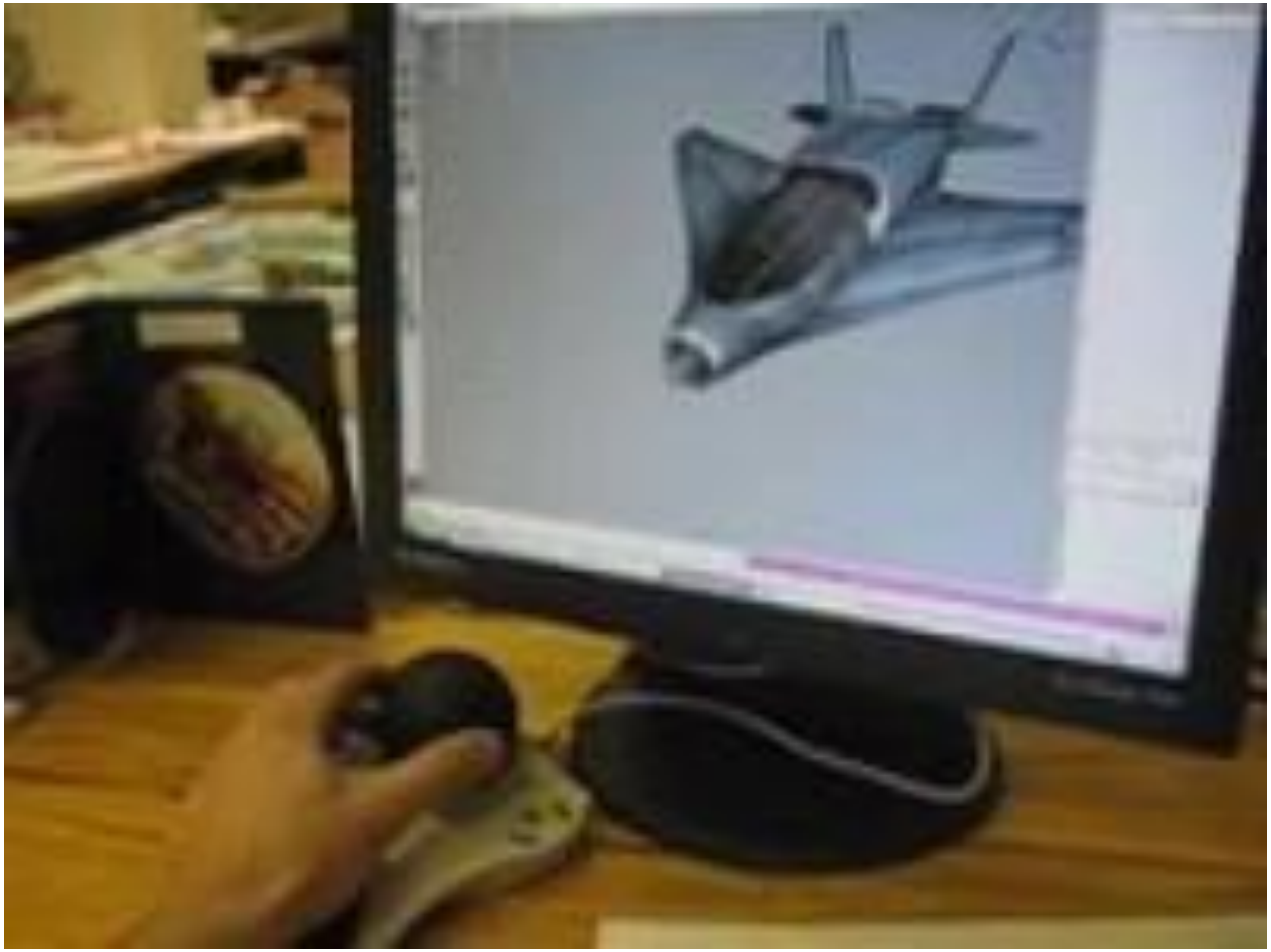
Spatial Congruence in 3D



DOF	Control	Display
x	+	+
y	+	+
z	+	+
θx	+	+
θy	+	+
θz	+	+

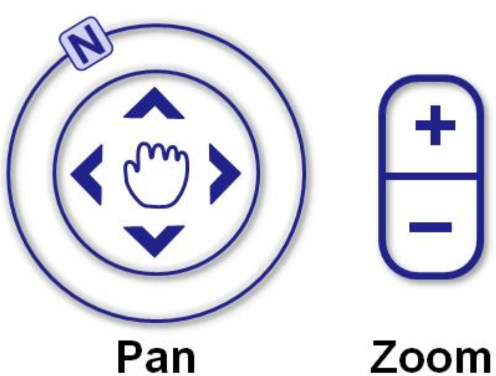


https://www.youtube.com/watch?v=yFNFI_2WYXA



3D in Interactive Systems

- Usually a subset of the 6 DOF are supported
- Spatial transformations are present and must be learned
- E.g., Google StreetView



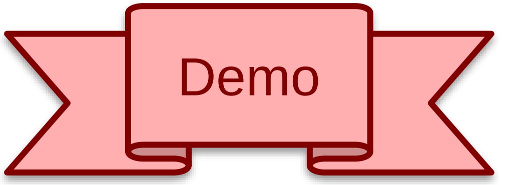
CAD Applications

- Tinkercad
- MagicaVoxel

Panning in Google StreetView

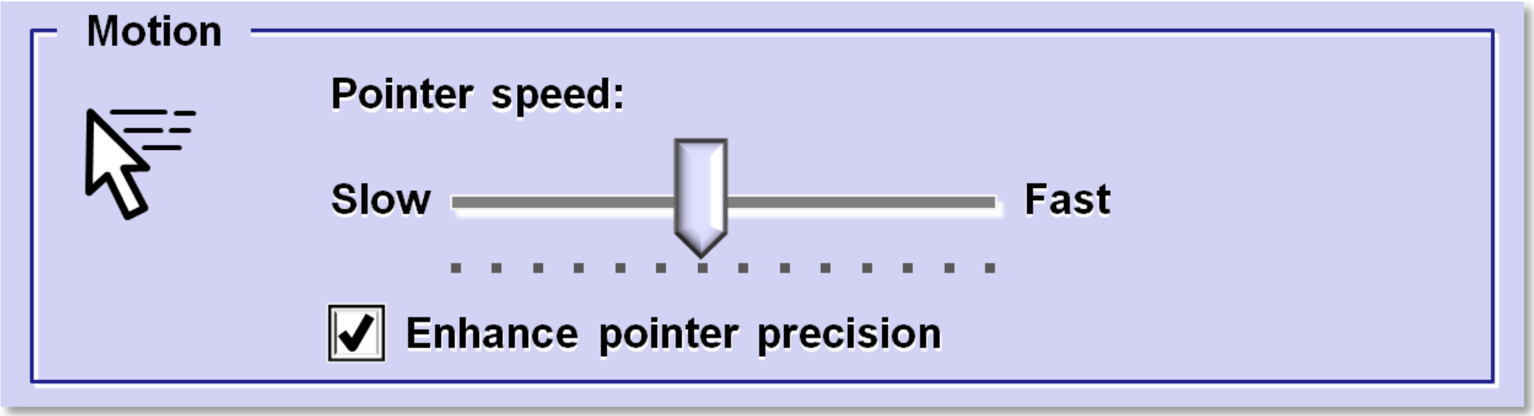
- (Switch to Google StreetView and demonstrate panning with the mouse)
- Spatial transformations:

DOF	Control	Display
x	+	
y		
z	+	
θx		+
θy		-
θz		



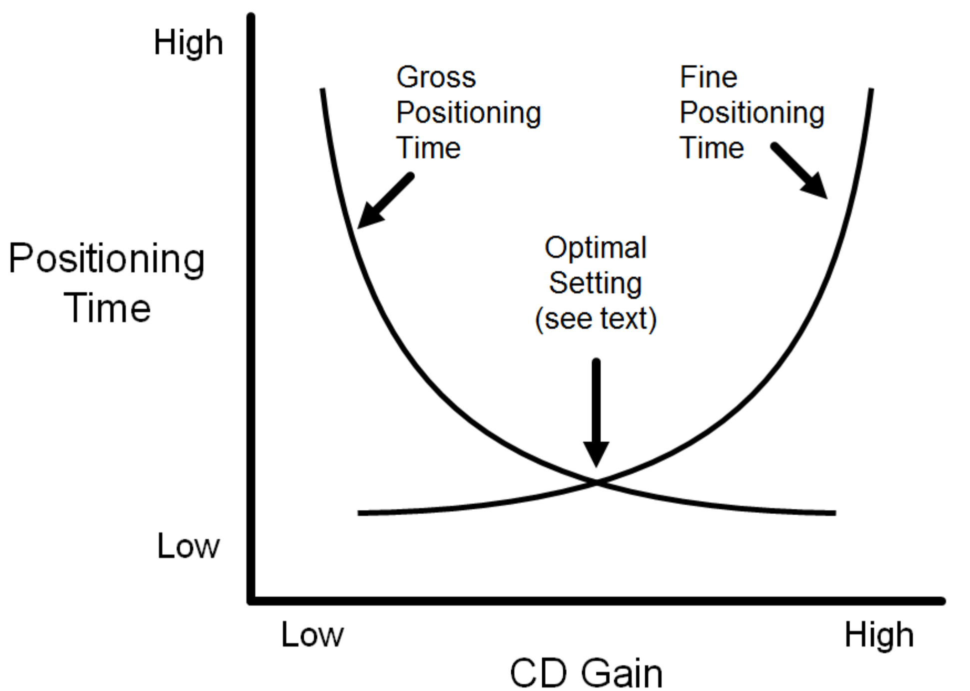
CD Gain

- Quantifies the amount of display movement for a given amount of controller movement
- E.g., CD gain = 2 implies 2 cm of controller movement yields 4 cm of display movement
- Sometimes specified as a ratio (C:D ratio)
- For non-linear gains, the term *transfer function* is used
- Typical control panel to adjust CD gain:



CD Gain and User Performance

- Tricky to adjust CD gain to optimize user performance
- Issues:
  - Speed accuracy trade-off (what reduces positioning time tends to increase errors)
  - Opposing relationship between gross and fine positioning times:



Latency

- *Latency* (aka *lag*) is the delay between an input action and the corresponding response on a display
- Usually negligible on interactive systems (e.g., cursor positioning, editing)
- May be “noticeable” in some settings; e.g.,
  - Remote manipulation
  - Internet access (and other “system” response situations)
  - Virtual reality (VR)
- Human performance issues appropriate for empirical research

VR Controllers

- 6 DOF controllers common in VR and other 3D environments
- Considerable processing requirements
- Lag often an issue
- E.g., Polhemus G^{4}™ (see below)
- Lag specified as <10 ms (which is low)
- But the user experiences the complete system

VR Controllers are now cheap!

- https://www.vive.com/us/vive-tracker/

Property Sensed, Order of Control

- Property sensed
  - Position (graphics tablet, touchpad, touchscreen)
  - Displacement (mouse, joystick)
  - Force (joystick)
- Order of control (property of display controlled)
  - Position (of cursor/object)
  - Velocity (of cursor/object)

Joystick

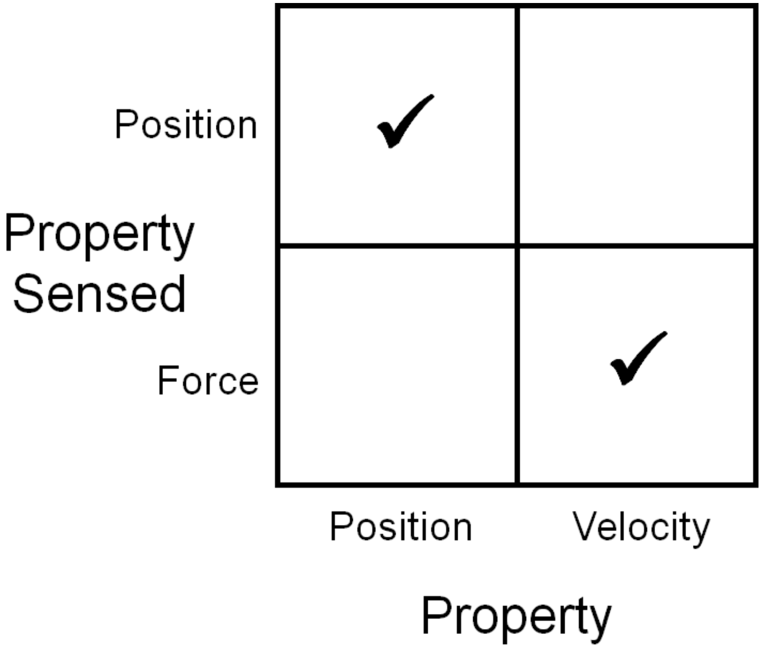
- Two types
  - Isotonic (senses displacement of stick)
  - Isometric (senses force applied to stick)

Isotonic joystick

Isometric joystick

Joysticks (2)

- Optimal mappings
  - Isotonic joystick → position control
  - Isometric joystick → velocity control

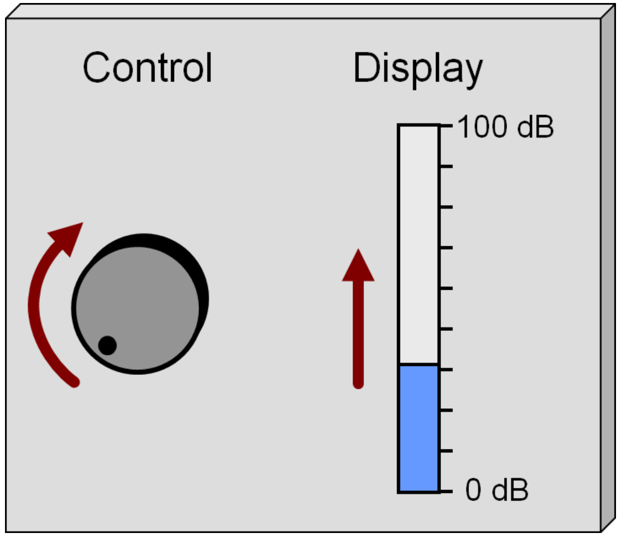


Natural vs. Learned Relationships

- Natural relationships → spatially congruent
- Learned relationships → spatial transformation (relationship must be learned)

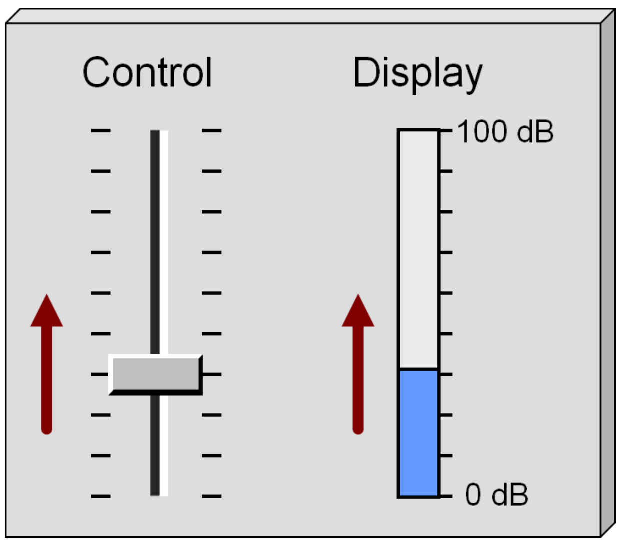
Examples

Learned relationship



DOF	Control	Display
x		
y		+
z		
θx		
θy		
θz	+	

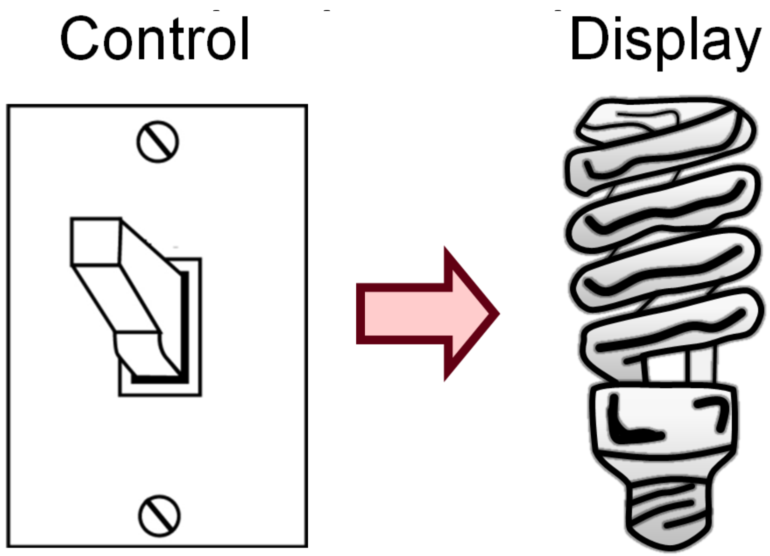
Natural relationship



DOF	Control	Display
x		
y	+	+
z		
θx		
θy		
θz		

Learned Relationships

- Learned relationships seem natural if they lead to a *population stereotype* or *cultural standard*
- A control-display relationship needn't be a



Is the display on or off?

Answer: On (in U.S., Canada)

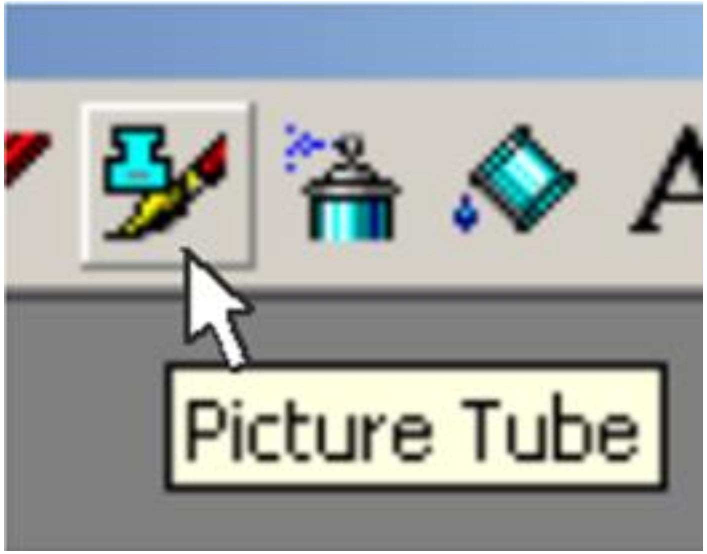
Off (in U.K.)

Mental Models

- Related terms: *physical analogy*, *metaphor*, *conceptual models*
- Definition: a physical understanding of an interface or interaction technique based on real-world experience
- Scroll pane: slider up, view up ("up-up" is a conceptual model that helps our understanding)
- *Desktop metaphor* is most common metaphor in computing
- Other commonly exploited real-world experiences:
  – Shopping, driving a car, calendars, painting
- Icon design, in general, strives to foster mental models

Graphics and Paint Applications

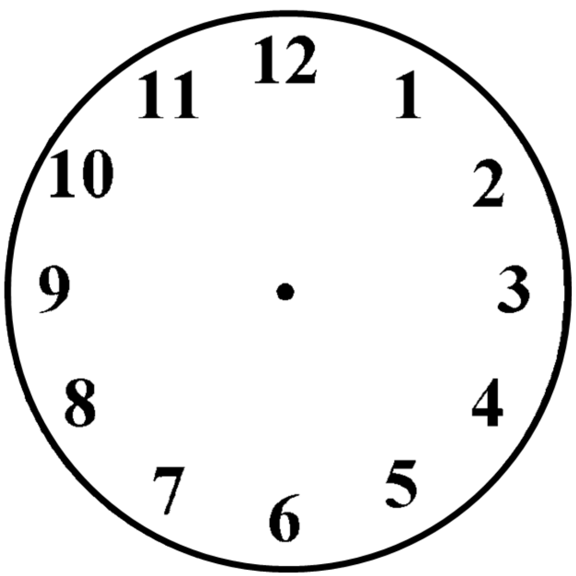
- Icons attempt to leverage real-world experiences with painting, drawing, sketching, etc.

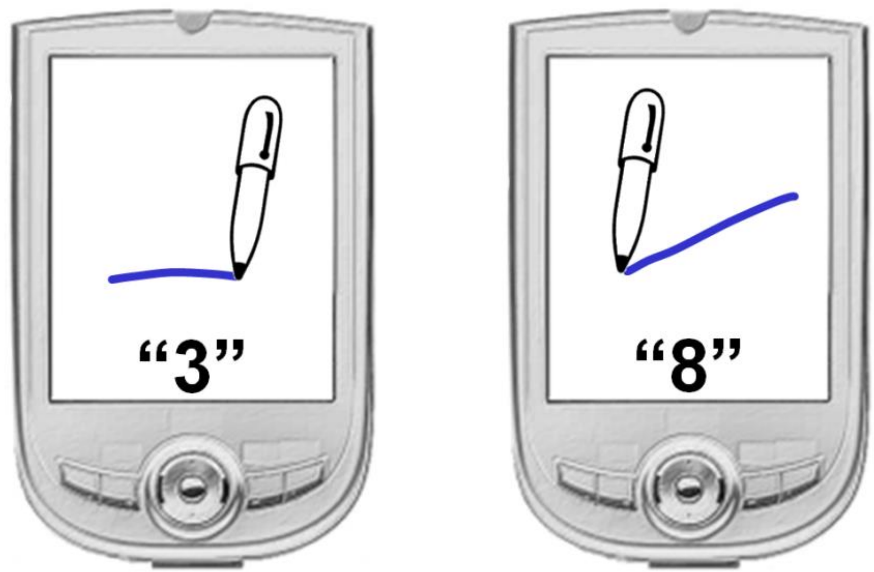


tooltips help for obscure features

Clock Metaphor

- Numeric entry on PDA[1]
- Users make straight-line strokes in direction of digit on clock face

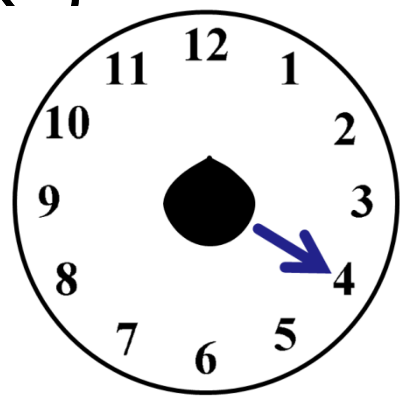


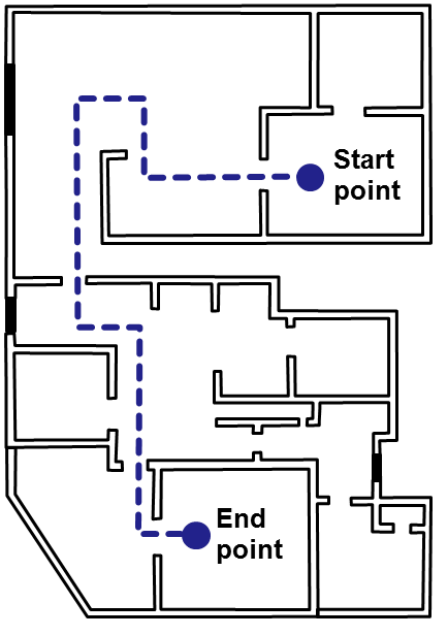


[1] McQueen, C., MacKenzie, I. S., & Zhang, S. X. (1995). An extended study of numeric entry on pen-based computers. *Proceedings of Graphics Interface '95*, 215-222, Toronto: Canadian Information Processing Society.

Clock Metaphor (2)

- Blind users carry a mobile locating device[1]
- Device provides spoken audio information about nearby objects (e.g. "door at 3 o'clock")

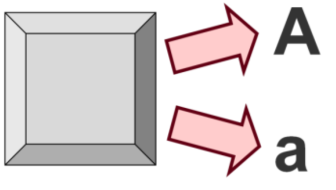




[1] Sáenz, M., & Sánchez, J. (2009). Indoor position and orientation for the blind. *Proceedings of HCI International 2007*, 236-245, Berlin: Springer.

Modes

- A *mode* is a functioning arrangement or condition
- Modes are everywhere (and in most cases are unavoidable)
- Office phone light: *on* = message waiting, *off* = no messages
- Computer keyboards have modes
  – ≈100 keys + SHIFT, CTRL, ALT ➔ ≈800 key variations



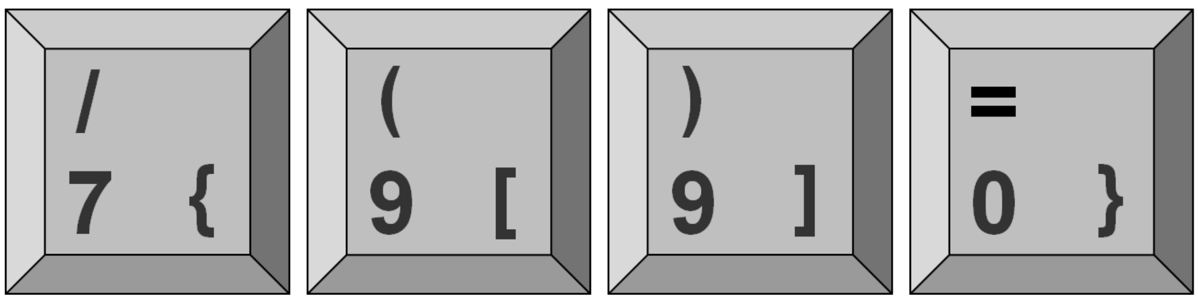
F9 – Microsoft Word (2010)

- At least six interpretations, depending on mode:

F9 →	Update selected fields
SHIFT+F9 →	Switch between a field code and its result
CTRL+F9 →	Insert an empty field
CTRL+SHIFT+F9 →	Unlink a field
ALT+F9 →	Switch between all field codes and their results
ALT+SHIFT+F9 →	Run GOTOBUTTON or MACROBUTTON from the field that displays the field results

International Keyboards

- Some keys bear three symbols
- How to access the third symbol?
- German keyboard example:



Mobile Phone Example

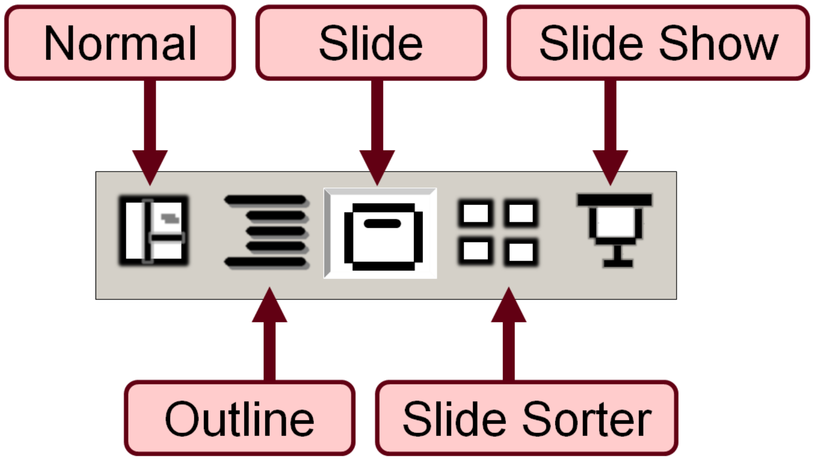
- Navi key (first introduced on Nokia *3210*)
- Mode revealed by word above
- At least 15 interpretations: Menu, Select, Answer, Call, End, OK, Options, Assign, Send, Read, Use, View, List, Snooze, Yes

Contemporary LCD Monitor

- Similar to Navi key idea
- No labels for the four buttons above power button
- Function revealed on display when button pressed
- Possibilities explode

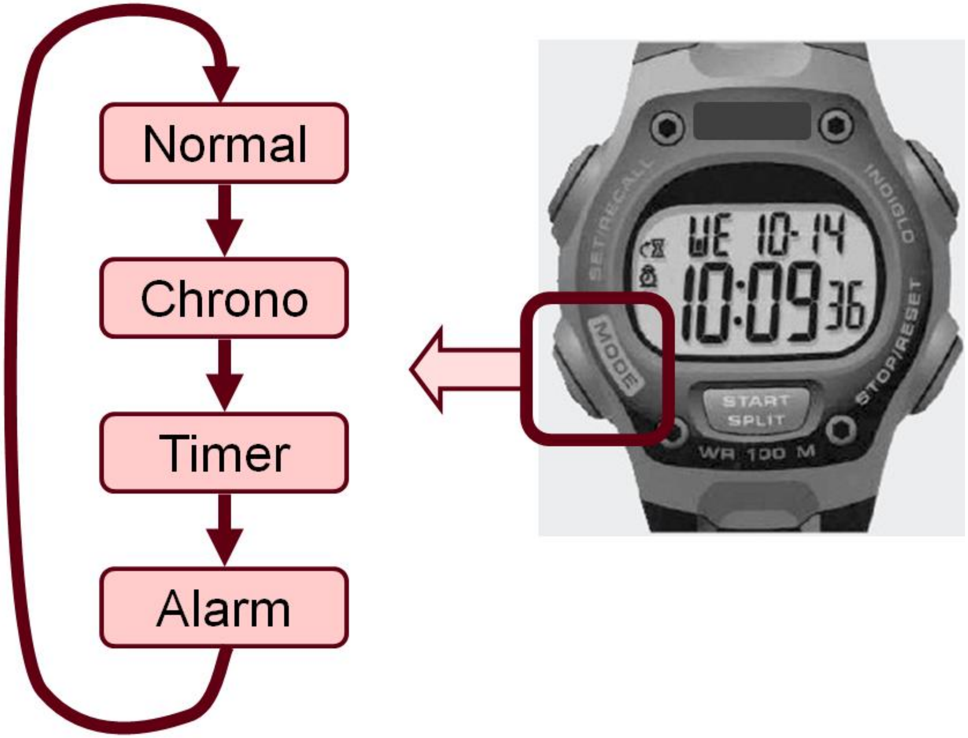
Mode Switching

- PowerPoint: Five view modes
- Switch modes by clicking soft button
- Current mode apparent by background shading
- Still problems lurk
- How to exit Slide Show mode?
  - PowerPoint → Esc
  - Firefox → ?



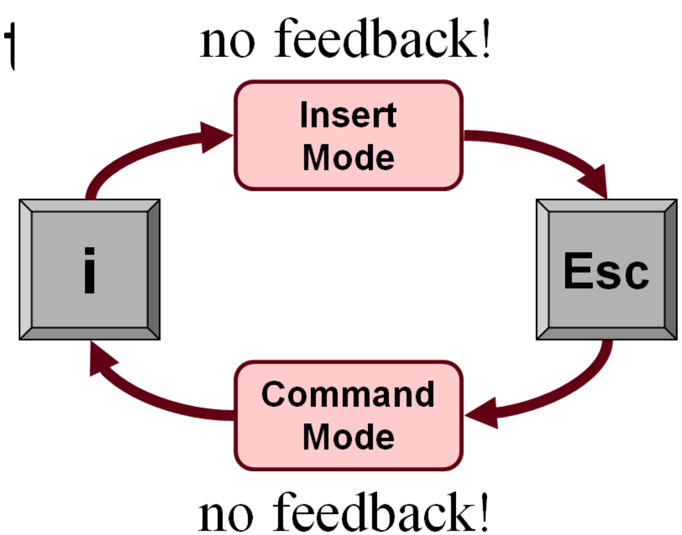
Mode Switching (2)

- Sports watch
- Single button cycles through modes



Mode Visibility

- Shneiderman: "offer information feedback"[1]
- Norman: "make things visible"[2]
- unix *vi* edit of no mode visibility:

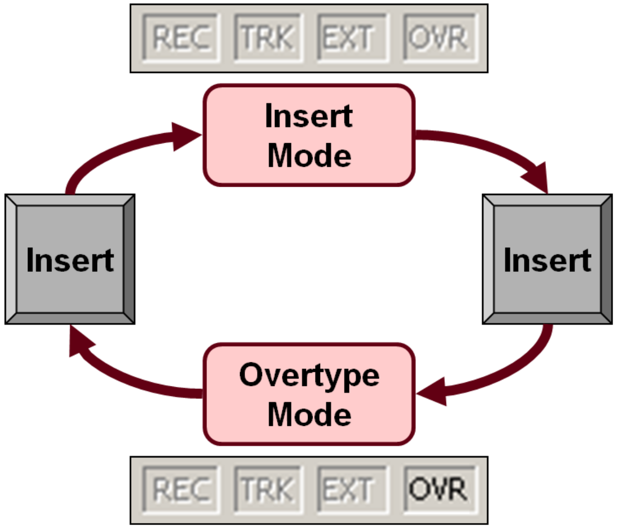


[1] Shneiderman, B., & Plaisant, C. (2005). *Designing the user interface: Strategies for effective human-computer interaction.* (4th ed.). New York: Pearson.

[2] Norman, D. A. (1988). *The design of everyday things*. New York: Basic Books.

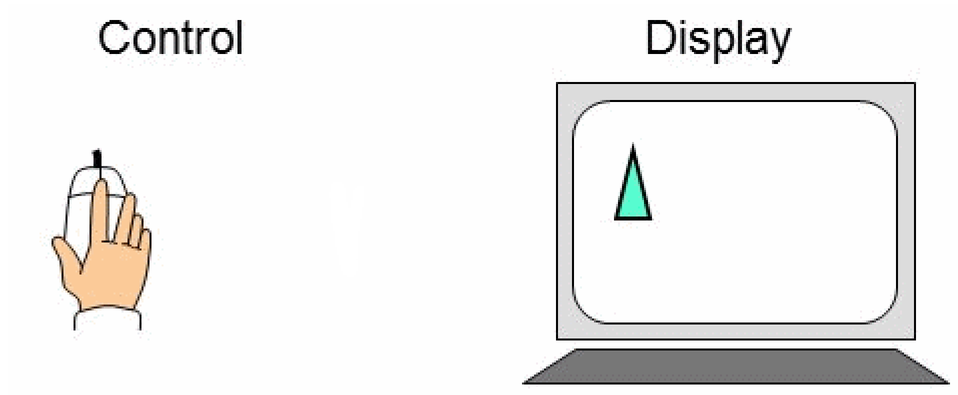
Mode Visibility (2)

- Insert vs. Overtype mode on MS/Word
- Some variation by version, but the user is in trouble most of the time



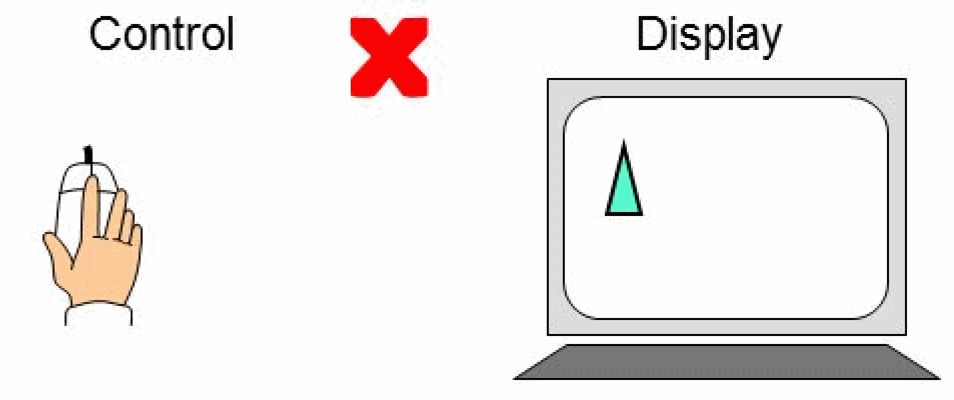
Modes and Degrees of Freedom

- If control DOF < display DOF, modes are necessary to fully access the display DOF
- Consider a mouse (2 DOF) and a desktop display (3 DOF)
- *x-y* control (no problem):



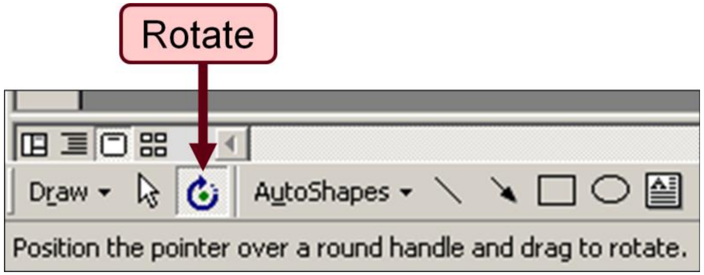
but…

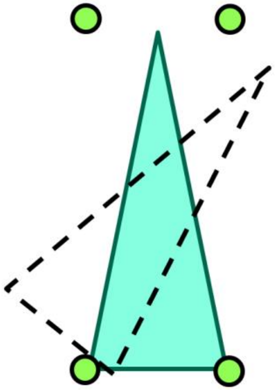
- Rotation is a problem:



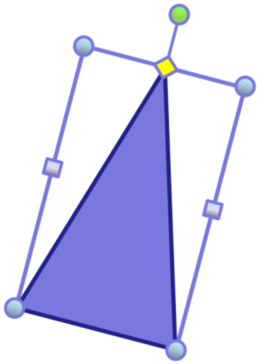
Rotate Mode

- The solution: Rotate mode
- Two approaches
  - Separate rotate mode:





  - Embedded rotate



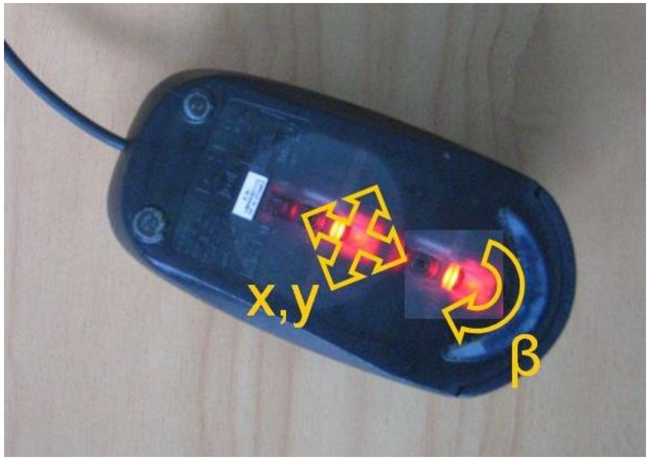
Could be avoided with…

3 DOF Mouse

- Lots of research:

1


2


3


- But no successful commercial products (yet!)

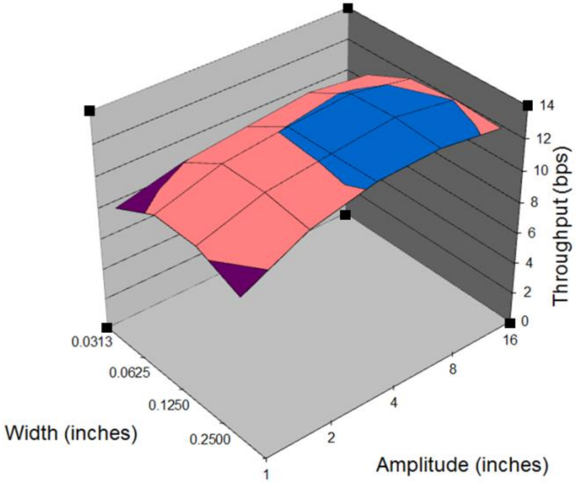
[1] Almeida, R., & Cubaud, P. (2006). Supporting 3D window manipulation with a yawing mouse. *Proc NordiCHI 2006*, 477-480, New York: ACM.

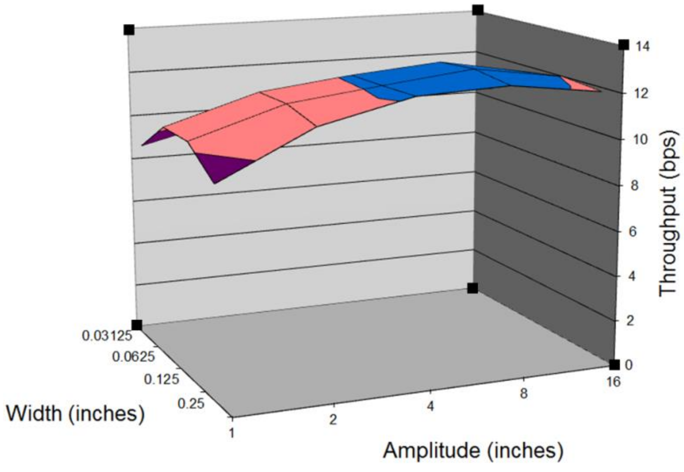
[2] MacKenzie, I. S., Soukoreff, R. W., & Pal, C. (1997). A two-ball mouse affords three degrees of freedom. *Proc CHI '97*, 303-304, New York: ACM.

[3] Hannagan, J., & Regenbrecht, H. (2008). *TwistMouse for simultaneous translation and rotation*. Tech Report. HCI Group. Information Science Department. University of Otago, Dunedin, New Zeland.

3D Rotation

- Mapping controller *x*-*y* to display θ_x-θ_y-θ_z
- Very awkward

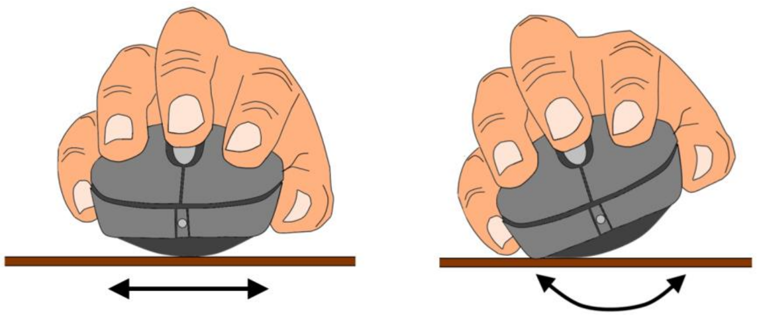




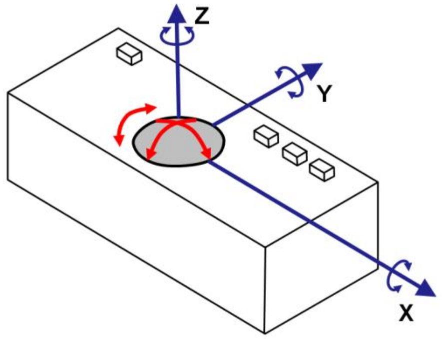
worse when combined with panning!

>2 Degrees of Freedom

- Examples in the HCI research literature
- 4 DOF *Rockin' Mouse*[1]



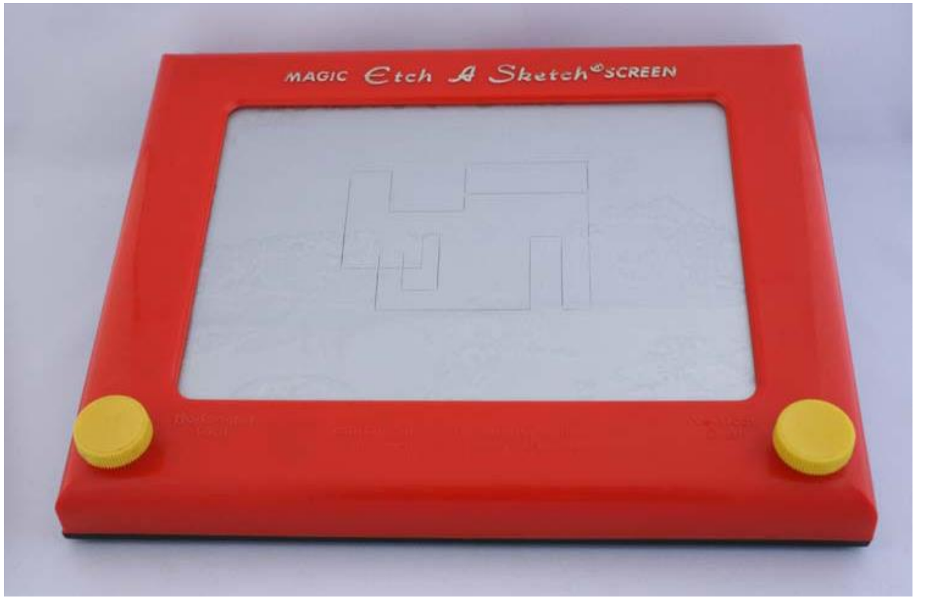
- Three-axis trackball[2]



[1] Balakrishnan, R., Baudel, T., Kurtenbach, G., & Fitzmaurice, G. (1997). The Rockin'Mouse: Integral 3D manipulation on a plane. *Proc CHI '97*, 311-318, New York: ACM.
[2] Evans, K. B., Tanner, P. P., & Wein, M. (1981). Tablet based valuators that provide one, two, or three degrees of freedom. *Computer Graphics, 15*(3), 91-97.

Separating the Degrees of Freedom

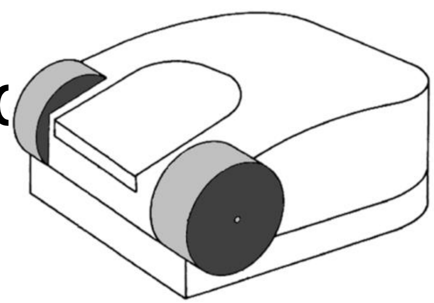
- More DOF is not necessarily better
- Must consider the context of use
- Etch-A-Sketch: separate 1 DOF *x* and *y* controllers:



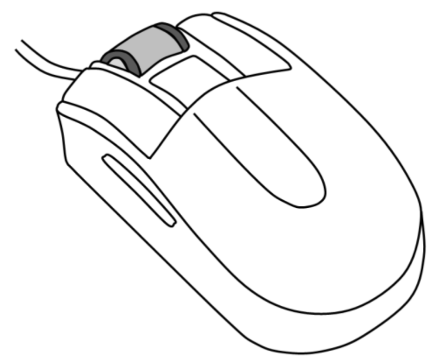
Wheel Mouse

- Separate DOF via a wheel
- Successful introduction by Microsoft in 1996 with the *IntelliMouse* →

RollerMouse[1]



ProAgio[2]

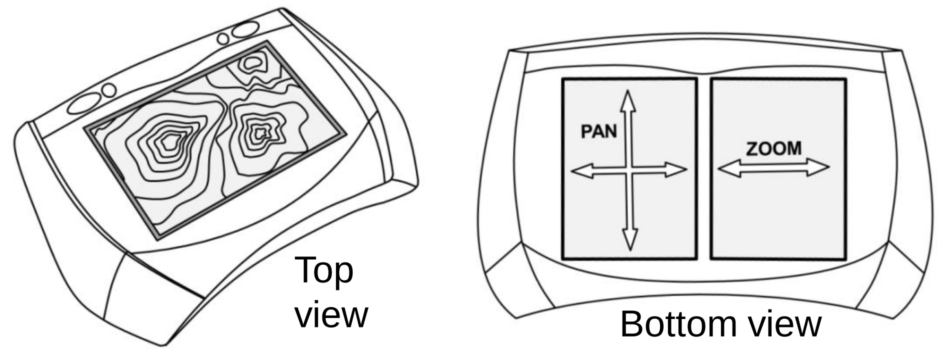


- Precedec

[1] Venolia, D. (1993). Facile 3D manipulation. *Proc CHI '93*, 31-36, New York: ACM.
[2] Gillick, W. G., & Lam, C. C. (1996). U. S. Patent No. 5,530,455.

Adding a Touch Sensor

Panning and Zooming Display[2]



[1] Balakrishnan, R., & Patel, P. (1998). The PadMouse: Facilitating selection and spatial positioning for the non-dominant hand. *Proc CHI '98* (pp. 9-16): New York: ACM.
[2] Silfverberg, M., Korhonen, P., & MacKenzie, I. S. (2003). International Patent No. WO 03/021568 A1.
[3] Villar et al. (2009). Mouse 2.0: Multi-touch meets the mouse. *Proc UIST ‘09*, 33-42, New York: ACM.

Mobile Context

- Touchscreens are the full embodiment of direct manipulation
- No need for a cursor (cf. indirect input)

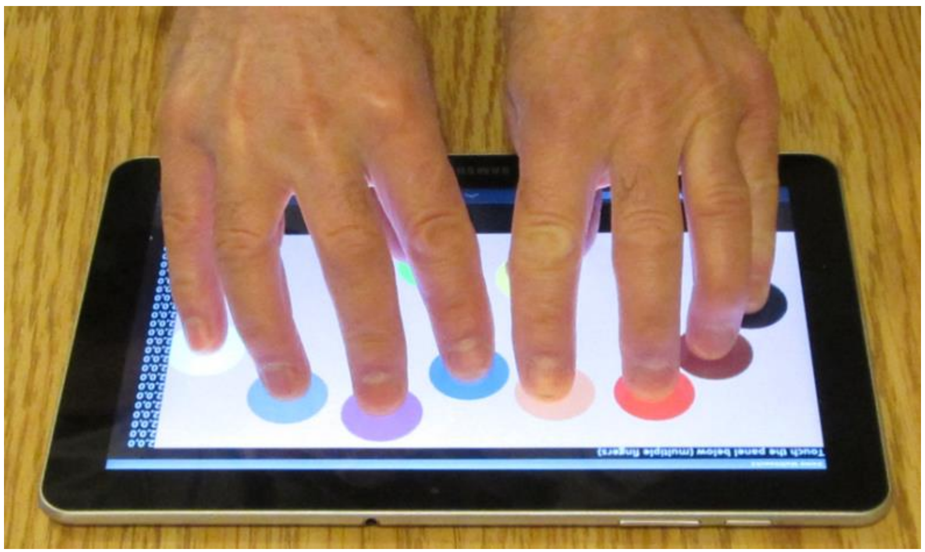
Touch Input Challenges

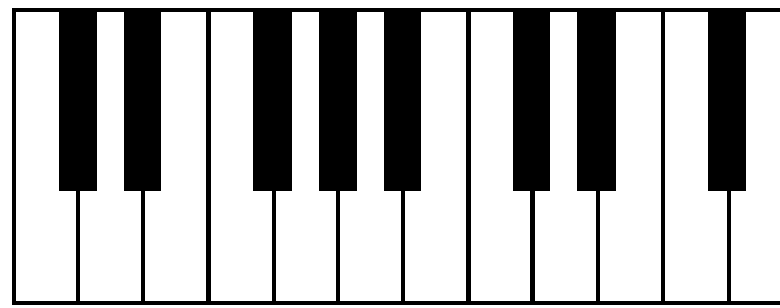
- Occlusion and accuracy ("fat finger problem")
- Early research → Offset cursor[1]
- Contemporary systems use variations: e.g.,

[1] Potter, R., Berman, M., & Shneiderman, B. (1988). An experimental evaluation of three touch screen strategies within a hypertext database. *Int J Human-Computer Interaction, 1* (1), 41-52.

Multitouch

Multitouch (>2)





Accelerometers

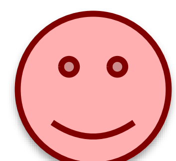
- Accelerometers enable tilt or motion as an input primitive
- Technology has matured; now common in mobile devices
- Many applications; e.g., spatially aware displays:

Interaction Errors

- Discussions above focused on physical properties of controllers and the interactions they enable
- Interaction involves the human (sensors, brain, responders) and the machine
- Interaction errors are unavoidable (and, hence, are akin to an "interaction element")
- We conclude with a look at interaction errors and their consequences
- Themes: (see **HCI:ERP** for discussion)
  - Big, bad errors are high in consequences and therefore get a lot of attention
  - Little errors are low in consequences and therefore tend to linger
  - There is a continuum
  - errors are most often due to bad design, not user error

Discard Changes

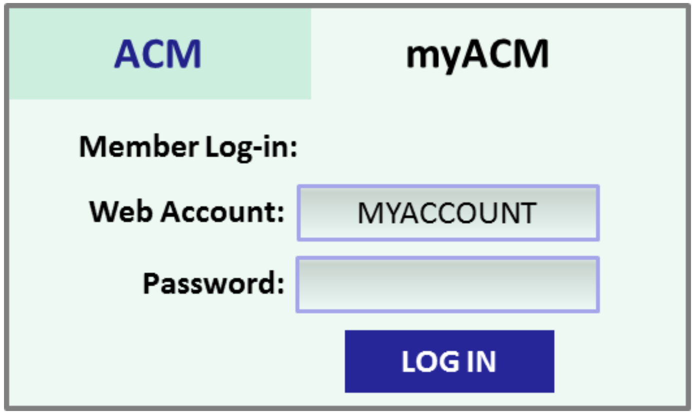
- Default dialogs to quit an application:



CAPS_LOCK

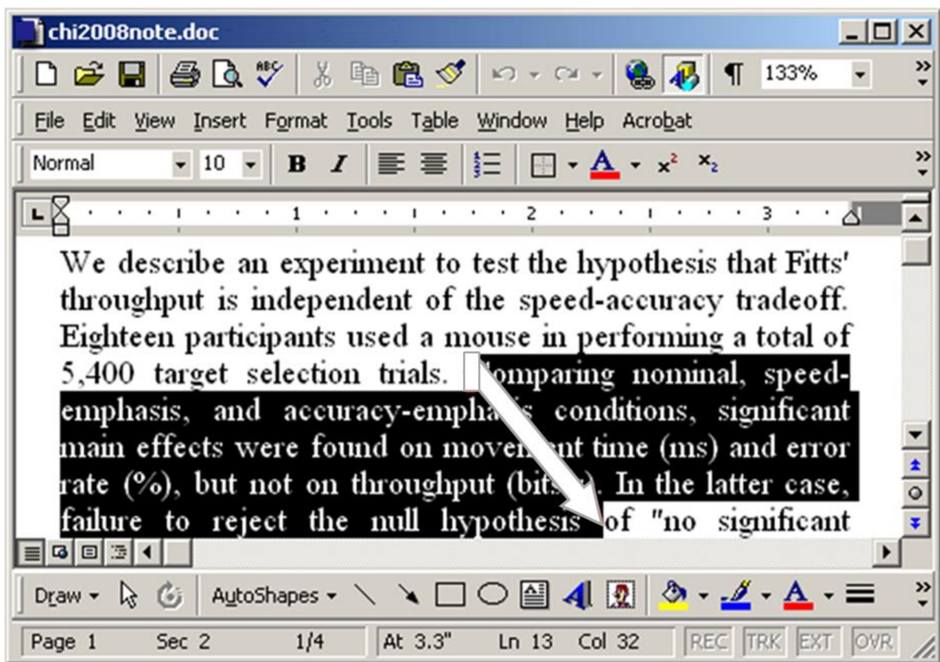
- Some log-in dialogs alert the user if CAPS_LOCK is on…

- while others do not…



Scrolling Frenzy

- Drag to select a range of text
- As the dragging extent approaches the edge of the scroll pane, the user is venturing into a difficult situation

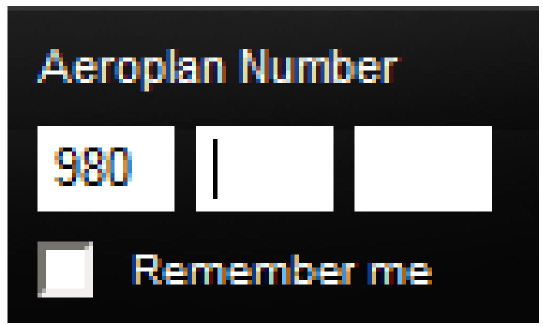


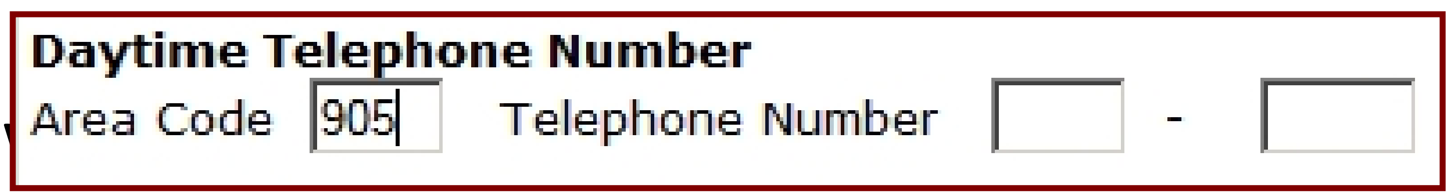
A recent (classic-style) HCI interaction technique to improve scrolling

- https://www.youtube.com/watch?v=Ym6rPM0-2jc

Focus Uncertainty

- After entering data into a fixed-length field, some interfaces advance focus the next field…





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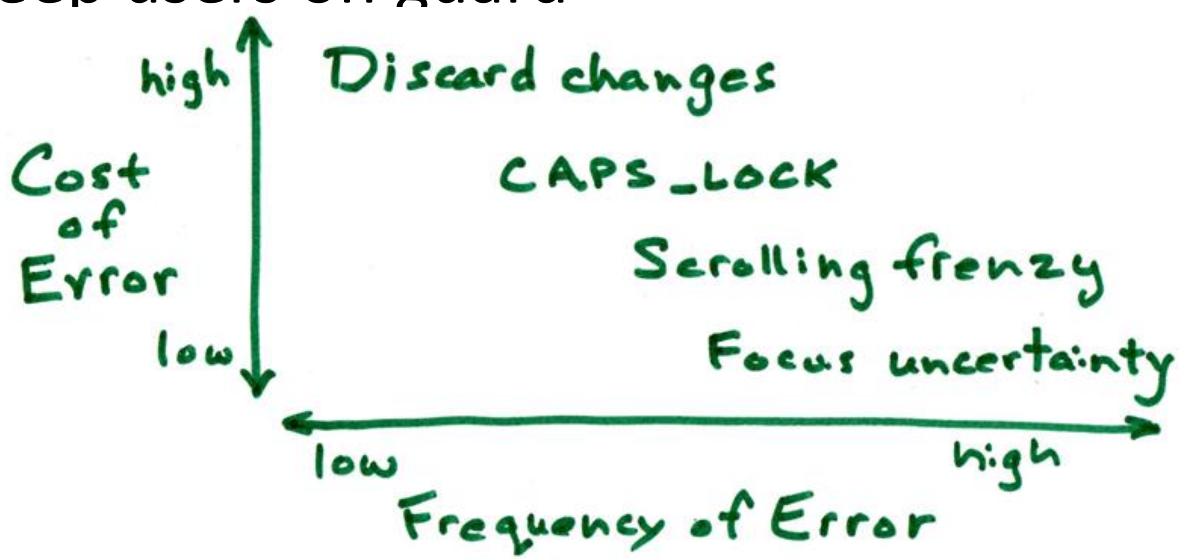
Cost vs. Frequency of Errors

- Message: High frequency / low cost errors are the most interesting
- They…
  - Have evaded the scrutiny of designers
  - Keep users on guard



funded projects available for summer/fall/etc

augmented reality, HCI/UX, performing arts (dance XR project)

Citisketch – game design UX research project

full time 1 term,
10h/week for a year

User design and HCI focus