Interaction Elements

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Lecture notes in this series are based on

- Ahmed Sabbir Arif. 2021. Statistical Grounding. *Intelligent Computing for Interactive System Design: Statistics, Digital Signal Processing, and Machine Learning in Practice*, ACM
- Ann Blandford, Dominic Furniss, Stephann Makri. 2016. Qualitative HCI Research: Going Behind the Scenes. Morgan & Claypool
- Jonathan Lazar, Jinjuan Feng, Harry Hochheiser. 2017. Research Methods in Human-Computer Interaction. Morgan Kaufmann
- I. Scott MacKenzie. 2013. Human-Computer Interaction: An Empirical Research Perspective, Morgan Kaufmann
- Interaction Design Foundation. 2022. Design Thinking
- Lecture notes of Amy Bruckman, Mark Dunlop, Niels Henze, I. Scott MacKenzie, Laura Moody, Albrecht Schmidt, Kami Vaniea

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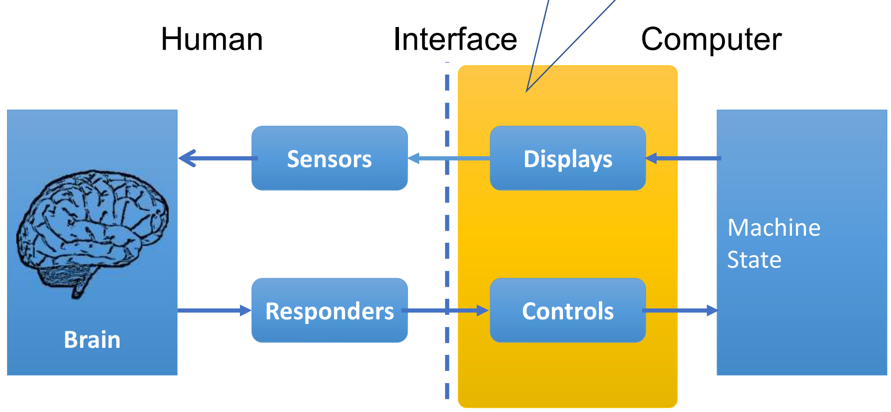
Human Factors Model

- Interaction elements
- Natural vs. learned behavior
- Mental model and metaphor
- Modes, occlusion, IMU, errors



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Interaction

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

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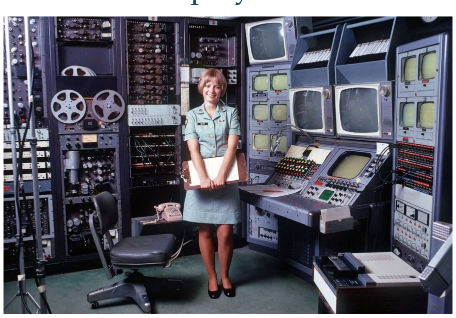
Interaction Elements

- Can be studied at many levels and in different contexts
- Early human factors research on *knobs & dials* is relevant today
  - Knobs → controls
  - Dials → display



U.S. Army audiovisual technician stands at her videotape editing station (1973)

Entergy's Chiltonville Training Center is an identical twin mock-up of the control room at the Pilgrim nuclear power plant.

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Knobs & Dials

Dieter Rams' T3 Radio design for Braun (1953)

Jonathan Ive's original iPod design for Apple (2001)

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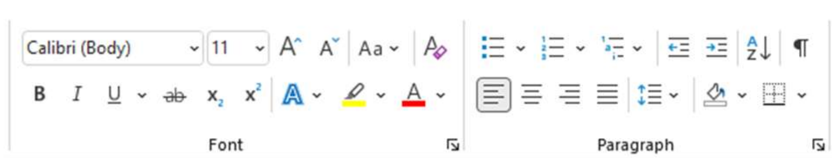
Hard & Soft Controls

- Hard controls are physical, used on single-purpose devices
- Soft controls are interfaces created in software
  - Today's graphical displays are malleable
  - Soft controls rendered on a display
  - Distinction blurred between soft controls and displays



Soft controls are also displays. Consider controls for *format*

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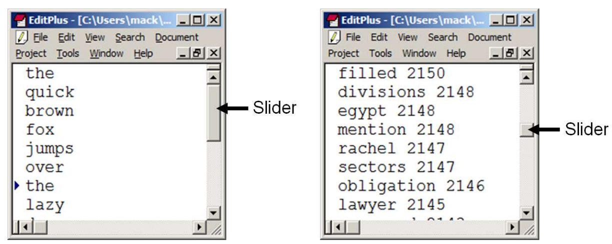
Soft Control Example: Scrollbar Slider

- Both control & display
  - Control:
    - Moved to change view in document
  - Display:
    - Size reveals view size relative to entire document
    - Position reveals view location in document



Check out *Evolution of the Scrollbar,* https://scrollbars.matoseb.com

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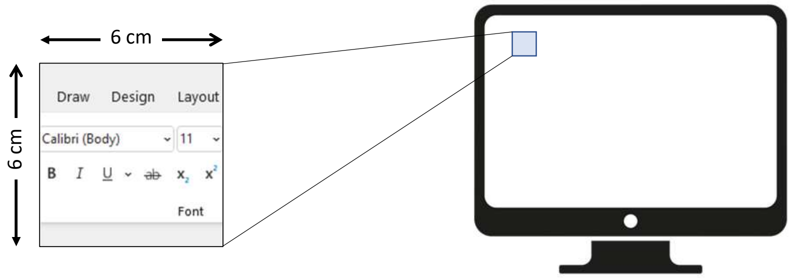
Interface Malleability

- Below is a 36 cm^2 view into a GUI
- More than 10 soft controls
  - Not all are displays
- Clicking a button morphs the space into a completely different set of soft controls & displays



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Control-Display Relationships

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

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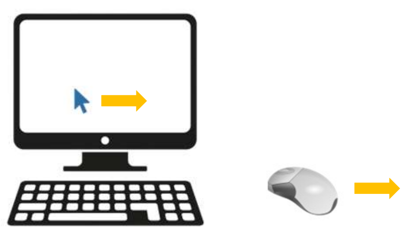
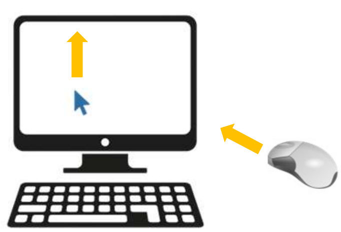
Spatial Relationships



Natural

Spatial congruence
Control *Right*
Display *Right*



Learned

Spatial transformation
Control *Forward*
Display *Up*

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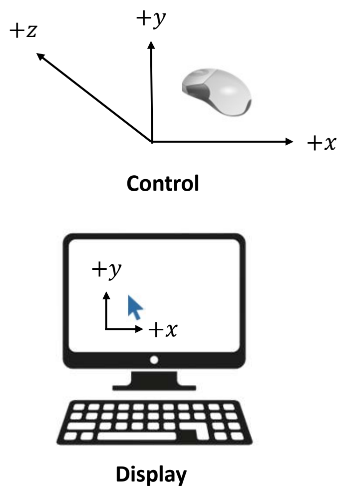
Spatial Relationships: Axis Labeling



Axis	Control (Mouse)	Display (Cursor)
x	+	+
y		+
z	+	

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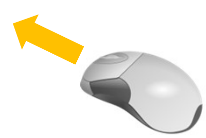
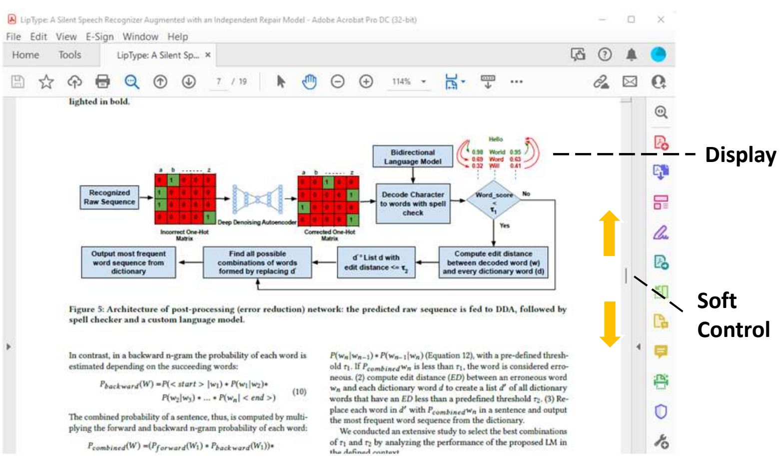
Spatial Relationships: Third Tier



Hard Control



Axis	Hard Control	Soft Control	Display (Cursor)
x	+		
y		−	+
z	+		
θ_x			
θ_y			
θ_z			

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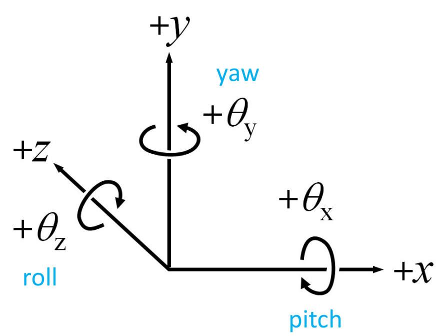
Spatial Relationship: 3D

- In 3D there are 6 degrees of freedom (DOF)
  - 3 DOF for position (x, y, z)
  - 3 DOF for orientation $(\theta_x, \theta_y, \theta_z)$



In aeronautics

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3D: Spatial Congruence

Cat Explorer - Leap Motion Gallery

Axis	Control	Display
x	+	+
y	+	+
z	+	+
θ_x	+	+
θ_y	+	+
θ_z	+	+

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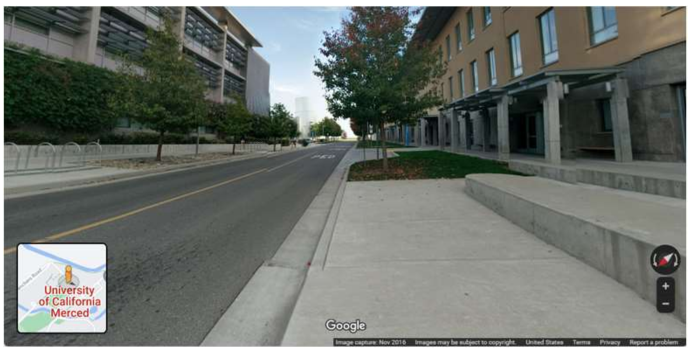
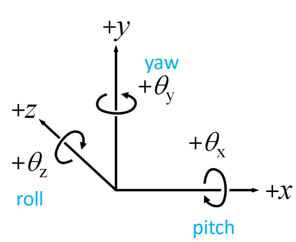
3D: In Interactive Systems

- Usually a subset of the 6 DOF are supported
- Spatial transformations are present and must be learned



Google Street View

3D: Panning in Google Street View



Axis	Control	Display
x	+	+
y		+
z	+	+
θ_x		−
θ_y		−
θ_z		+

Control $+x$ Display $-\theta_y$

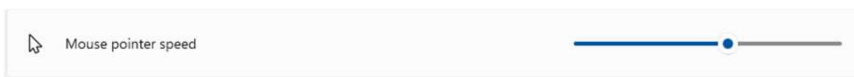
Control $+z$ Display $-\theta_x$

CD (Control-Display) Gain

- Quantifies the amount of display movement for a given amount of controller movement
  - Sometimes specified as a ratio (C:D ratio)

$CD_{gain} = \frac{V_{pointer}}{V_{device}}$, *where* $V_{pointer}$ *is velocity of* *cursor* *and* V_{device} *is velocity of* *input device*

$CD_{gain} = 1$ *when the mouse moves 1 cm, the cursor also moves 1 cm*
$CD_{gain} < 1$ *the cursor moves slower than the mouse*
$CD_{gain} > 1$ *the cursor moves faster than the mouse*



Control panel to adjust CD gain in Windows 11

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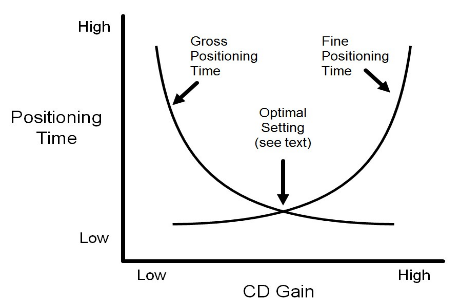
CD Gain: User Performance

- For non-linear gains, the term *transfer function* is used
  - Many available in the literature
  - Adjusted to optimize user performance with an input device
- Tricky to adjust CD gain to optimize user performance
  - Speed accuracy trade-off (reducing positioning time tends to increase errors)
  - Opposing relationship between gross and fine positioning times



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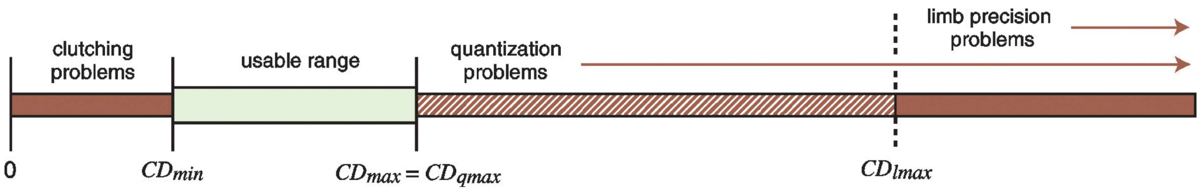
CD Gain: Range of Usable Gains

Quantization is the motion of the mouse pointer by discrete (usually single-pixel) increments



Géry Casiez, Daniel Vogel, Ravin Balakrishnan, Andy Cockburn. 2008. The Impact of Control-Display Gain on User Performance in Pointing Tasks. Human–Computer Interaction, 23:3, 215-250.

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Latency

- *Latency* or *lag* is the delay between an input action and the corresponding response on a display
- Usually negligible on interactive systems
  - Cursor positioning, editing, etc.
- Can be noticeable in some settings
  - Television remote, virtual reality, web applications, etc.

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Property Sensed & Order of Control

Position & Velocity Control

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Property Sensed vs. Order of Control

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

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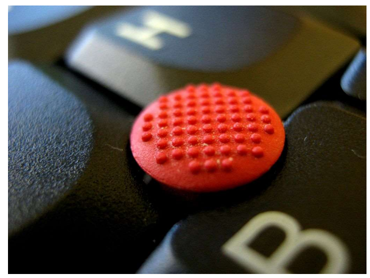
Controls: Joysticks

1. *Isotonic joysticks* sense displacement of stick
2. *Isometric joysticks* sense force applied to stick

Isotonic joystick: Kraft Systems' **Premium II** joystick (1987)



Isometric joystick: Pointing stick on an IBM/Lenovo ThinkPad (1992)

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Joysticks: Mapping

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

Property Sensed \ Property	Position	Velocity
Position	✓	
Force		✓

- Isotonic devices (e.g., mouse) appropriate for position control
- Elastic/isometric devices (e.g., joystick) appropriate for rate (velocity) control

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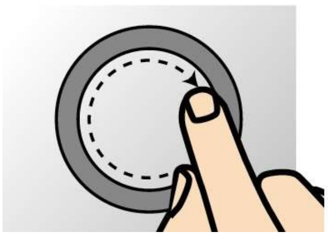
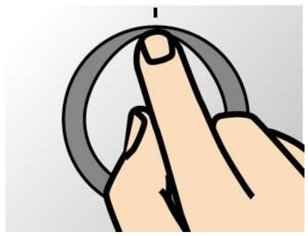
Joysticks: Mixed Control

- Increasing the input space of a trackpad by combining position and rate control



Position control



Velocity control

https://youtu.be/kucTPG_zTik

Géry Casiez, Daniel Vogel, Qing Pan, Christophe Chaillou. 2007. RubberEdge: Reducing Clutching by Combining Position and Rate Control with Elastic Feedback. In Proceedings of the 20th annual ACM symposium on User interface software and technology (UIST '07). ACM, NY, USA, 129–138.

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Natural vs. Learned Relationships

Mental model and metaphor

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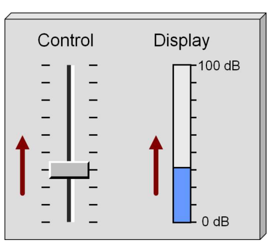
Natural vs. Learned Relationships

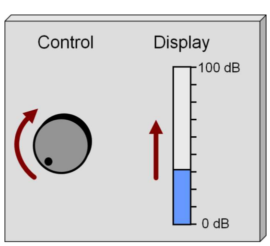
- Natural relationships are spatially congruent
- Learned relationships require spatial transformation
  - Relationship must be learned

Natural vs. Learned Relationships



Natural Relationship

Axis	Control	Display
x		
y	+	+
z		
θ_x		
θ_y		
θ_z		



Learned Relationship

Axis	Control	Display
x		
y		+
z		
θ_x		
θ_y		
θ_z	+	

Learned Relationship

- Learned relationships seem natural if they lead to a population stereotype or cultural standard
  - There could be culture effects

- Is the display on or off?
  - *Off* in the U.S. and Canada
  - *On* in the U.K.

Control

Display

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Mental Model

Conceptual Model

System Model

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Mental Model

- A mental model is a psychological representation of a real, hypothetical, or imaginary situation
- The concept comes from Kenneth Craik's book The Nature of Explanation (1943):

> *The mind constructs "small-scale models" of reality that it uses to anticipate events, to reason, and to underlie explanation.*

- Their structure corresponds to the structure of what they represent

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Mental Model

- Users acquire mental model through
  1. Interaction
  2. Explanation
- Two types of mental models
  1. Functional
     - Knowing *what* to do but not *why*
       - For example, closing the browser before shutting down the computer
  2. Structural
     - Understanding the components and their relationships (*why*)
     - Allows us to solve problems

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Mental Model

- A mental model is based on **belief**, not **facts**
  - A model of what users know *or think they know* about a system
  - Users base their predictions about the system on their mental models and plan their future actions based on how that model predicts the appropriate course
- A key goal for designers is to make user interfaces communicate a system's basic nature well enough that users form reasonably accurate mental models

Jakob Nielsen. 2010. Mental Models, https://www.nngroup.com/articles/mental-models

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Mental Model

- Individual users each have their own mental model
  - Different users might construct different mental models of the same user interface
- The gap between designers' & users' models is a usability dilemmas
  - As designers know too much, they form ideal mental models of their creations, believing that all features are easy to understand
  - Users' mental models are usually more deficient, thus likely for them to find the design more *difficult* use, thus make *mistakes*
- Facilitate the creation of ideal mental model by
  - Training ("learning by using" is preferred)
  - Proper documentation and suggestive feedback
  - Iteration with system

Jakob Nielsen. 2010. Mental Models, https://www.nngroup.com/articles/mental-models

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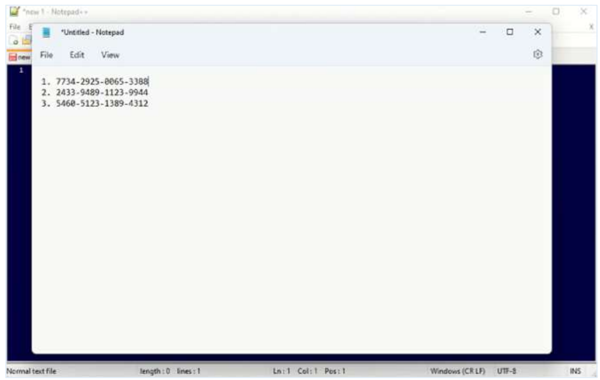
Mental Model: Example

- How would you copy-paste the 1st and the 3rd entry from the front document to the document in the back?



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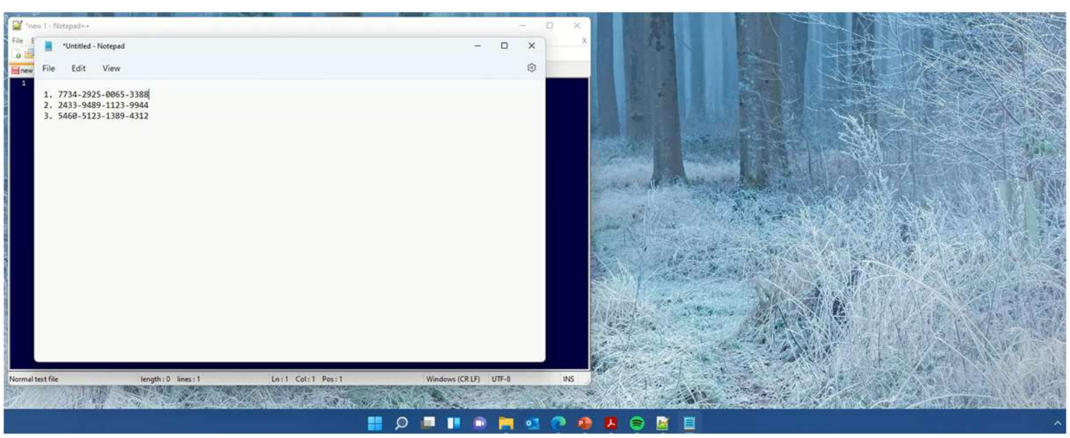
Mental Model: Example Model 1



Copy > Minimize window > Paste > Maximize window > Repeat …

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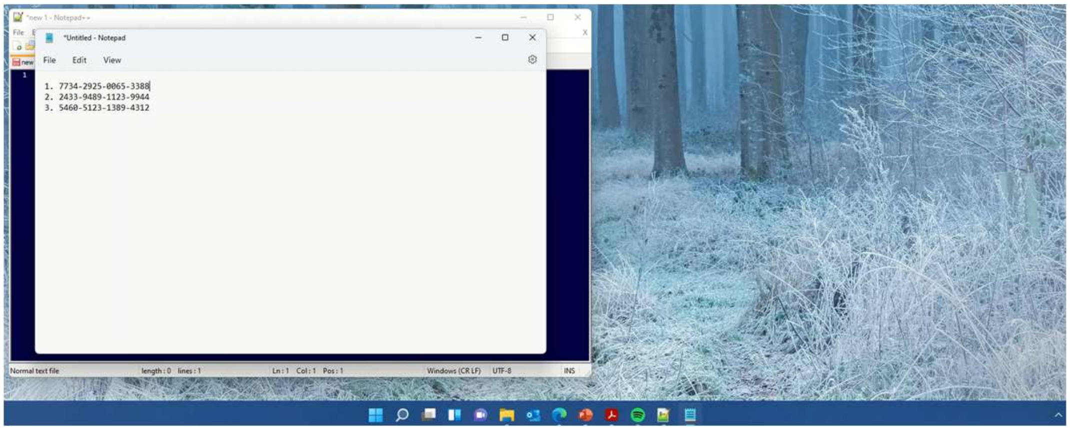
Mental Model: Example Model 2



Place windows side-by-side > Copy > Paste > Repeat …

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Mental Model 1 & 2 Actions per Task

$$APT = a_{initiate} + (n * a_{copy\_paste}) + a_{conclude}$$

$a_{initiate}$ = actions needed initiate a task
n = total number of copy actions
a_{paste}= total actions needed to copy and paste
$a_{conclude}$ = actions needed to conclude a task

For Mental Model 1

$a_{initiate} = 0$	*none needed*
$n = 2$	*two number sequences*
$a_{copy\_paste} = 4$	*copy + minimize + paste + maximize*
$a_{conclude} = 0$	*none needed*

$$APT = 0 + 2 * 4 + 0 = 8$$

For Mental Model 2

$a_{initiate} = 1$	*place windows side by side*
$n = 2$	*two number sequences*
$a_{copy\_paste} = 2$	*copy + paste*
$a_{conclude} = 0$	*none needed*

$$APT = 0 + 2 * 2 + 0 = 4$$

Twice as many actions!

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Mental Model 1 & 2 Actions per Task: *"Fix"*

- Allow copying multiple sequences at once

$$APT = a_{initiate} + (n \; * a_{copy}) + a_{conclude}$$

$a_{initiate}$ = *actions needed initiate a task*
n = *total number of copy actions*
a_{paste}= *total actions needed to copy*
$a_{conclude}$ = *actions needed to conclude a task*

For Mental Model 1

$a_{initiate} = 0$	*none needed*
$n = 2$	*two number sequences*
$a_{copy} = 1$	*copy*
$a_{conclude} = 2$	*minizine, paste*

$APT = 0 + (2 * 1) + 2 = 4$

For Mental Model 2

$a_{initiate} = 1$	*place windows side by side*
$n = 2$	*two number sequences*
$a_{copy} = 1$	*copy*
$a_{conclude} = 1$	*paste*

$APT = 1 + (2 * 1) + 1 = 4$

The same number of actions!

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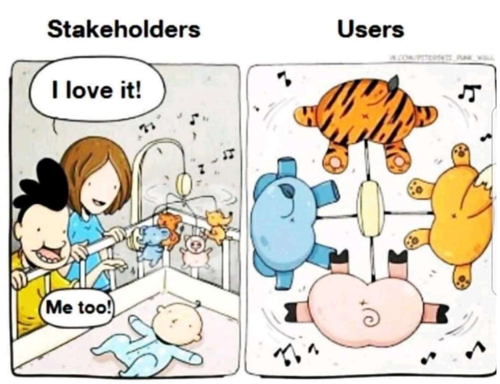
Conceptual Model

- A conceptual model is a high-level description of how a system is organized and operates
  - *The model designer wants users to have*
  - Deliberately designed with the hope to enabler users to understand & operate the user interface
  - Constructed based on prior knowledge of the target user groups
  - Communicated through the interface and interaction design



Jeff Johnson, Austin Henderson. 2002. Conceptual Models: Begin By Designing What to Design. interactions 9, 1 (January 2002), 25–32.

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System Model

- A system model represents various aspects of a system and its environment
  - Function modeling
  - Architectural modeling
- Often generated with systems modeling language
  - Unified Modeling Language (UML)
  - Systems Modeling Language (SysML)

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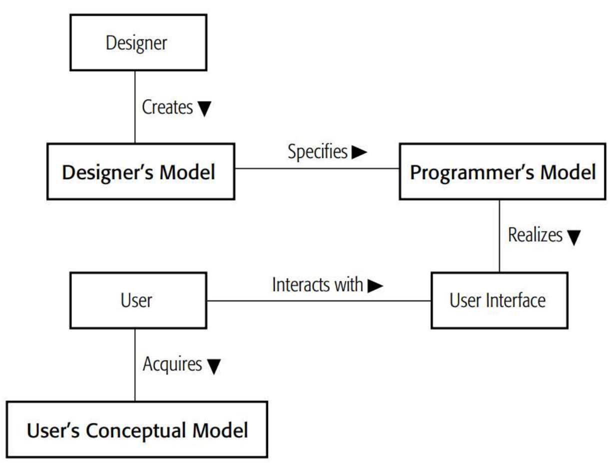
Mental vs. Conceptual vs. System Model



William Hudson. 2001. Toward Unified Models in User-Centered and Object-Oriented Design. Object Modeling and User Interface Design: Designing Interactive Systems, 313-362.

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Metaphor

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Metaphor

- A metaphor is a set of user interface controls, displays, and procedures that exploit specific knowledge that users *already have* of other domains, mainly the *physical world*
  - In other words, exploits existing conceptual models in user interfaces
    - Skill transfer
  - Good metaphors provide natural mappings
  - Metaphors are not taken literally

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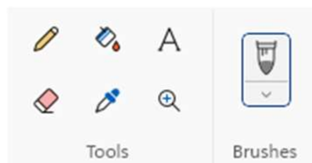
Metaphor: Popular Examples

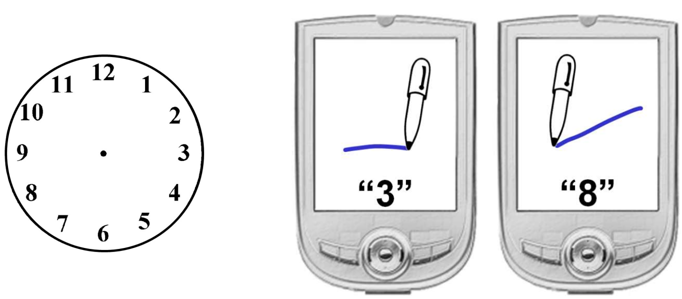
- Textual messages as e-mails in mailbox
- Data as files in folders or directories
- Deleting files as throwing it in the trash
- Programming as building objects
- Application icons attempt to leverage real-world experiences
  - Graphics and Paint Applications



Microsoft Paint 11.2110.0.0

Metaphor: Novel Examples

- Numeric entry on PDA
- Users make straight-line strokes in direction of digit on clockface



Did it stand the test of time?

J. Craig McQueen, I. Scott MacKenzie, Shawn X. Zhang. 1995. An Extended Study of Numeric Entry on Pen-Based Computers. Graphics Interface. Canadian Information Processing Society, 215-222.

Not Relevant Anymore

- Analog clocks are not as ubiquitous as before
  - Children today can't read analog clocks since they usually use their smartphones to tell time
  - Many schools are removing analogue clocks from exam halls

Jimmy Kimmel Live. Kids Can't Tell Time Anymore. May 2, 2018. https://youtu.be/PIe2auW9EMI

Camilla Turner. 2018. Many schools are removing Schools are removing analogue clocks from exam halls as teenagers 'cannot tell the time'. The Telegraph, U.K. https://www.telegraph.co.uk/education/2018/04/24/schools-removing-analogue-clocks-exam-halls-teenagers-unable 47

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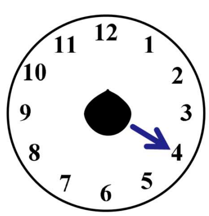
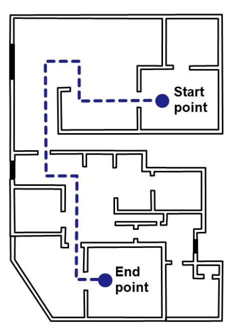
Metaphor: Novel Examples

- Blind users carry a mobile locating device
- Device provides spoken audio information about nearby objects
  - For example, *door at 3 o'clock*

Did it stand the test of time?





Mauricio Sáenz, Jaime Sánchez. 2009. Indoor Position and Orientation for the Blind. In International Conference on Universal Access in Human-Computer Interaction. Springer, pp. 236-245. 48

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Relevant, But Not for Long

Citizen AC2200-55E

DOT Watch

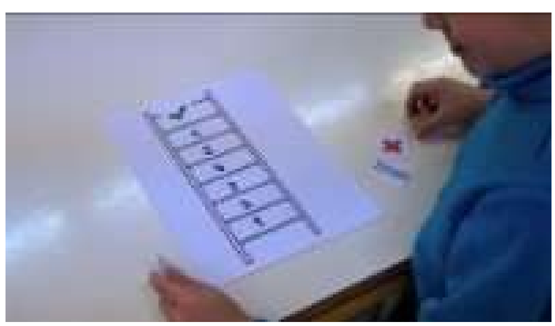
- Voice assistants & talking watches are becoming dominant

Economical Square

Amazon Alexa

Metaphor: Novel Examples

- Ladder metaphor to collect young children's feedback in studies
  - Facilitates better understanding, rating adjustments, embodiment, playfulness



https://youtu.be/Uis9F5UxBtU

Cristina Sylla, Ahmed Sabbir Arif, Elena Márquez Segura, Eva Irene Brooks. 2017. Paper Ladder: A Rating Scale to Collect Children's Opinion in User Studies. In Proceedings of the 19th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI 2017). ACM, Article 96, 8 pages.

Modes

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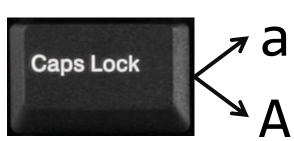
Modes

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



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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

Fields in Microsoft Word are used as placeholders for data that might change in a document, and for creating form letters and labels in mail-merge documents.

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International Keyboards

- Too many letters and symbols to fit in
- More than 1 symbols are assigned to many keys
- Users disambiguate the input by changing mode
  - Like, by pressing a modifier key
  - A modifier key is a special key that temporarily modifies the normal action of another key when pressed together

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

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International Keyboards Example: German

Alt Graph + 2 = ²

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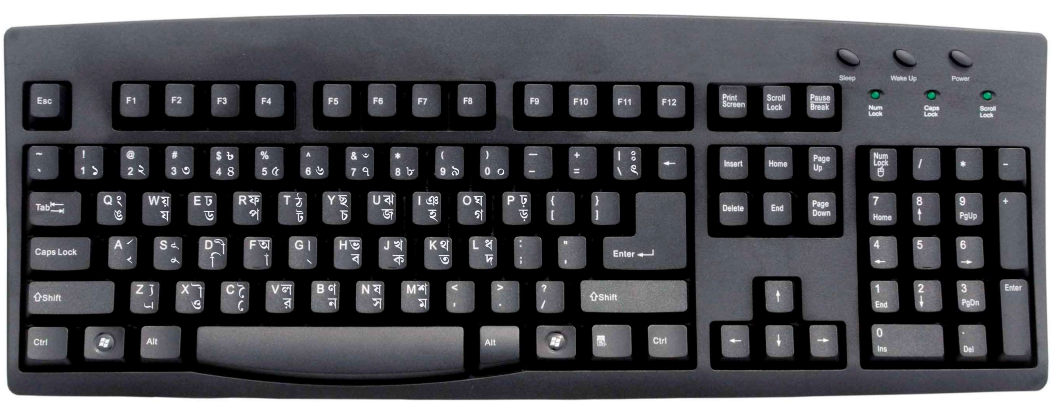
International Keyboards Example: Bangla



Bijoy Keyboard
2-4 characters per key

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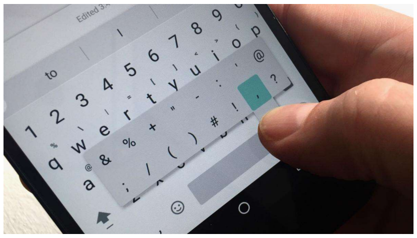
Mode Examples: Symbols in Virtual Keyboards



Google Gboard

iOS Keyboard

Ahmed Sabbir Arif, Michel Pahud, Ken Hinckley, Bill Buxton. 2014. Experimental Study of Stroke Shortcuts for a Touchscreen Keyboard with Gesture-Redundant Keys Removed. In Proceedings of Graphics Interface 2014 (GI 2014). Canadian Information Processing Society, Toronto, Ontario, Canada, 43-50. https://youtu.be/gMmH8OdW3Ng

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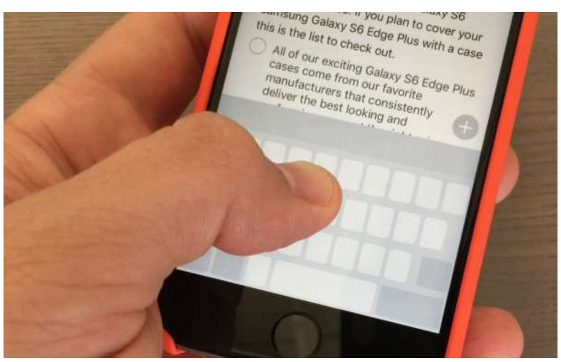
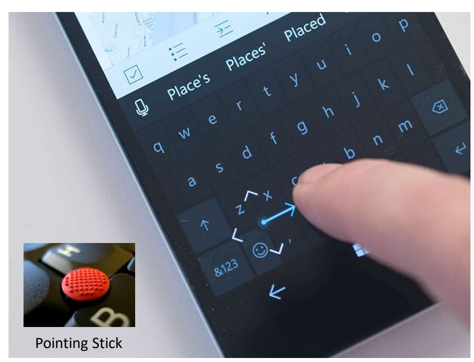
Mode Examples: Touchscreen Cursor Positioning





Pointing Stick

In iPhone X (2017): 3D Touch on the Space activated the touchpad mode

In iPhone 11 and later: long press on the Space activates the touchpad mode

Introduced in Windows Phone 10 (2015): Swiping from a virtual pointing stick activated the touchpad mode

Whitepaper at Microsoft Research in 2012

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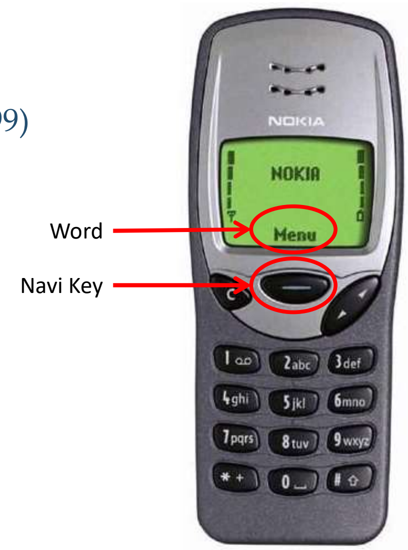
More Examples: Feature Phones

- Navi key
  - First introduced on Nokia 3210 (1999)
- Mode revealed by word above
- At least 15 interpretations:

1. Menu
2. Select
3. Answer
4. Call
5. End
6. OK
7. Options
8. Assign
9. Send
10. Read
11. Use
12. View
13. List
14. Snooze
15. Yes



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More Examples: LCD Monitor

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

- How about smart televisions?

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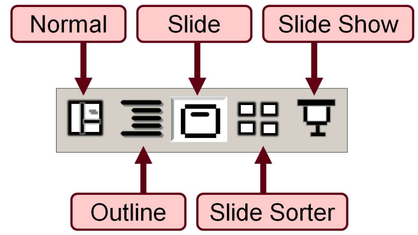
More Examples: Microsoft PowerPoint

- PowerPoint: Five view modes
- Switch modes by clicking soft button
- Current mode apparent by background shading



- Some features (like laser pointer, pen, highlighter) are available only in the Slide Show mode

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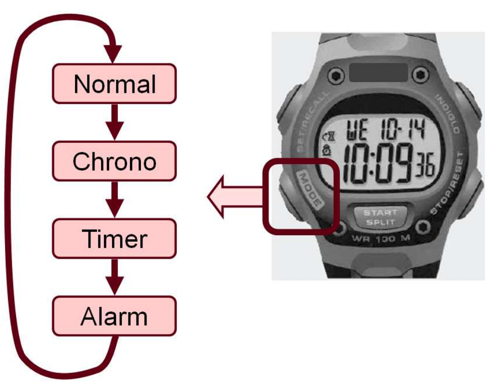
More Examples: Sports Watch

- Single button cycles through modes



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Mode Visibility

- Must provide users with feedback on the current mode, *at all times*
  - Shneiderman: *"offer information feedback"*
  - Norman: *"make things visible"*
- Not providing feedback can cause
  - Errors & stress

Ben Shneiderman, Catherine Plaisant, Maxine S. Cohen, Steven Jacobs, Niklas Elmqvist, Nicholas Diakopoulos. 2016. Designing the User Interface: Strategies for Effective Human-Computer Interaction. Pearson.
Don Norman. 1988. The Design of Everyday Things. New York: Basic Books.

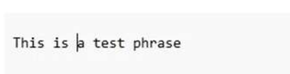
<u>Mode Visibility:</u> Examples

- Indicating *Insert* and *Overtype* modes in text editors

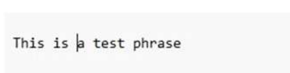
Bad Example
Microsoft Notepad 11.2112.32.0 (2022)

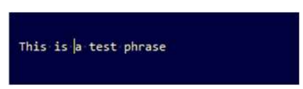
Good Example
Notepad++ 8.2.1 (2022)

Inset mode



Overtype mode





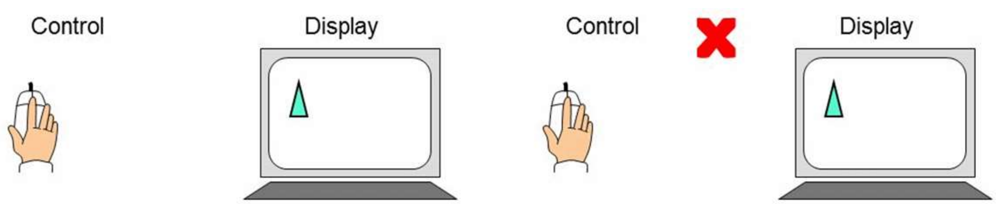
Modes & Degrees of Freedom

Modes & 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)

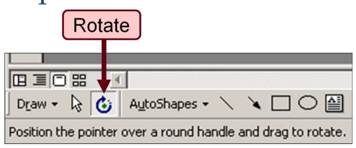
***x-y* control**
No problem

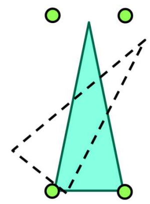
Rotation
Problem



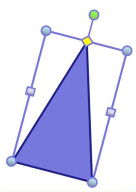
Modes & Degrees of Freedom: Soft Solution

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





  - Embedded rotate mode:



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Modes & Degrees of Freedom: Hard Solution

The 4 DOF Rockin' Mouse

Ravin Balakrishnan, Thomas Baudel, Gordon Kurtenbach, George Fitzmaurice. 1997. [The Rockin'Mouse: Integral 3D Manipulation on a Plane](). In Proceedings of the ACM SIGCHI Conference on Human factors in computing systems (CHI '97). ACM, NY, USA, 311–318.

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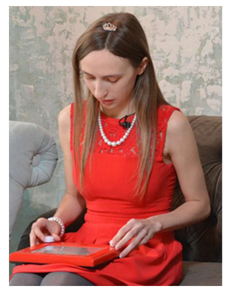
Separating the Degrees of Freedom

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

Madeline Kaufman. Feb 16, 2017. This Artist Recreates Chicago's Famous Artworks and Skyline on the Etch A Sketch: Jane Labowitch, aka Princess Etch A Sketch, Creates Intricate Artwork Using the Classic Toy. Chicago Magazine.

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Touchscreen Occlusion Problem

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Occlusion: Smartphone

- Occlusion increases the chance of errors
  - No haptic feedback
  - Vogel: The “fat-finger problem”
- Potter: Early research by on offset cursor
  - Contemporary systems use variations like offset animation

Daniel Vogel, Patrick Baudisch. 2007. Shift: A Technique for Operating Pen-Based Interfaces Using Touch. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI ’07). ACM, NY, USA, 657–666.
Richard Potter, Mitchell Berman, Ben Shneiderman. An Experimental Evaluation of Three Touch Screen Strategies Within a Hypertext Database. International Journal of Human-Computer Interaction 1, no. 1 (1989): 41-52.

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Occlusion: Smartphone

Problematic design

Better design

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Occlusion: Tablet

- Increased selection area
- Replaced buttons with *directional* sliding
  - Gestural interaction
- Enabled mode change by tapping on the virtual buttons

http://www.youtube.com/watch?v=Pw5nmLSYrvE

Tomer Moscovich. 2009. Contact Area Interaction with Sliding Widgets. In Proceedings of the 22nd annual ACM symposium on User interface software and technology (UIST '09). ACM, NY, USA, 13–22.

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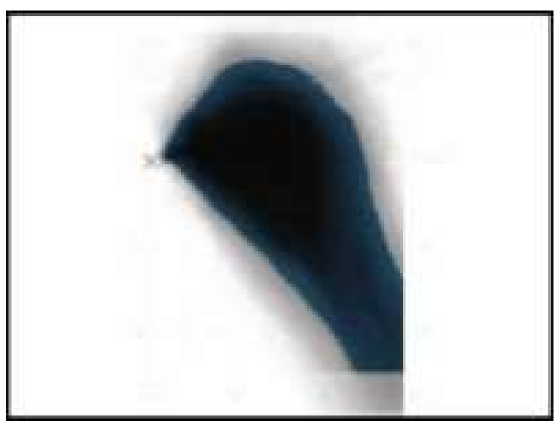
Occlusion: Large Display



https://youtu.be/j-b9q4ZjLHo

Daniel Vogel, Matthew Cudmore, Géry Casiez, Ravin Balakrishnan, Liam Keliher. 2009. Hand Occlusion with Tablet-Sized Direct Pen Input. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09). ACM, NY, USA, 557–566.

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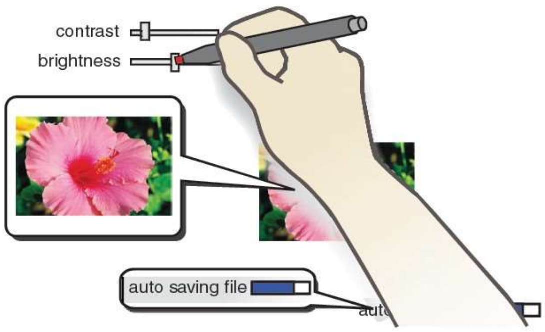
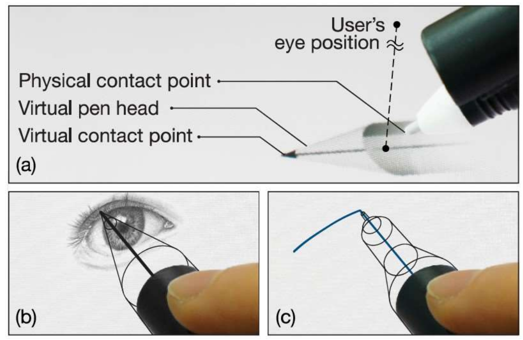
Occlusion: Large Display

Conventional Solutions



Novel Solution



David Lee, KyoungHee Son, Joon Hyub Lee, Seok-Hyung Bae. 2012. PhantomPen: Virtualization of Pen Head for Digital Drawing Free from Pen Occlusion & Visual Parallax. Proceedings of the 25th annual ACM symposium on User interface software and technology. ACM, NY, USA, 331–340.

https://youtu.be/r62wxK3Rma4

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Inertial Measurement Unit (IMU)

Accelerometers & Gyroscopes (& More…)

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Inertial Measurement Unit (IMU)

- To identify:
  - Hand posture and position
  - Mobility status of the user (seated, walking, commuting)
  - Hand gestures
  - Back-of-Device (BoD) Taps and rhythms
  - Position
- Application:
  - Spatially aware displays
  - Mode change (vertical vs. horizontal display)
  - Novel input and interaction techniques
  - Usable security

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Novel Example: Woodpecker

- Detect tapping rhythm on the back of the device
- Use a specific rhythm as password

https://youtu.be/Hu7qT2NEHN8

Satvik Kulshreshtha, Ahmed Sabbir Arif. 2020. Woodpecker: Secret Back-of-Device Tap Rhythms to Authenticate Mobile Users. In Proceedings of the 2020 IEEE International Conference on Systems, Man, and Cybernetics (SMC 2020). IEEE, Washington, DC, USA, 2727-2733.

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Reduce Interaction Errors

Revisited

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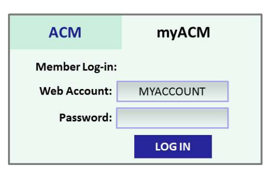
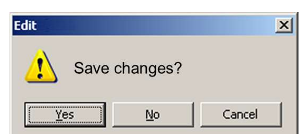
Reduce Interaction Errors

- Choose your words carefully
  - Cost of a mistake can be dire
  - What would users usually do?
- Provide continuous feedback
  - Let them catch errors earlier
  - Reduce errors in corrections
  - Correcting the error without knowing what it is

Poor



Better



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Reduce Interaction Errors

- Automate repeated/obvious tasks, *when possible*
  - Provide feedback on automation

Poor

Better

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