CS@CU Distinguished Lecture Series 2018

Enabling Real Virtuality: Closing the Gap Between the Digital and the Physical

Nov. 12, 2018 (Monday)
11:40AM–12:40PM
451 Computer Science Building
(Overflow in Computer science lounge)

Daniel Wigdor
University of Toronto

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COMS W4170
Interaction Devices 4

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November 8, 2018

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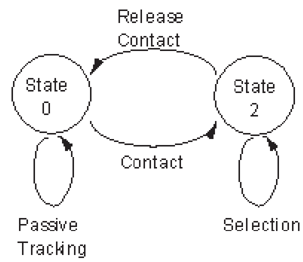
Three-State Model W. Buxton, A Three-State Model of Graphical Input. *Proc. INTERACT '90,* 449–456

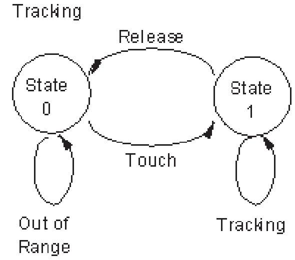
- Direct input devices (e.g., touch screen)
  - *Out of range* state 0 actually supports *passive tracking* since unsensed pointing device/finger can act as its own cursor
    - Not state 1, since system cannot sense it

- In contrast, compare with the [indirect] touch tablet/pad (in which finger on tablet/pad cannot be viewed in context of screen in state 0)
  - Same gesture, different context

Direct input device (e.g., touch screen)



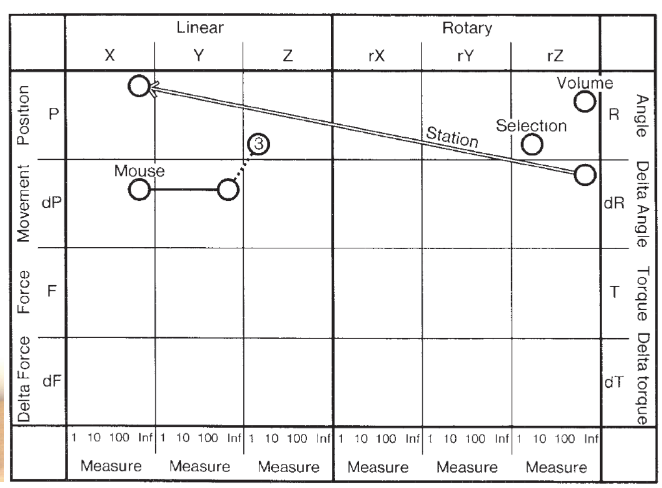
Indirect input device (e.g., touch tablet/pad)



Analyzing Input Devices S. Card, J. Mackinlay, and G. Robertson. A morphological analysis of the design space of input devices. *ACM TOIS*, 9(2), 1991, 99–122.

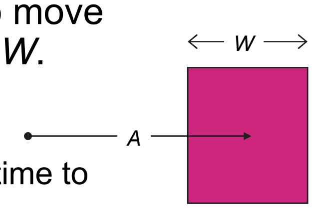
- Mouse

- Legacy AM/FM radio



Fitts's Law *P. Fitts, 1954*

- Predictive model of time *MT* to move a distance *A* to target of width *W*.
  - *MT* increases with increasing *A*, decreases with increasing *W*
  - Farther/smaller target → longer time to reach
    Closer/bigger target → shorter time to reach
  - $MT = C_1 + C_2\ ID$
    - *ID* = Index of Difficulty (function of *A* and *W*)
    - C_1 = Device/appendage-dependent constant
    - C_2 = Device/appendage-dependent constant



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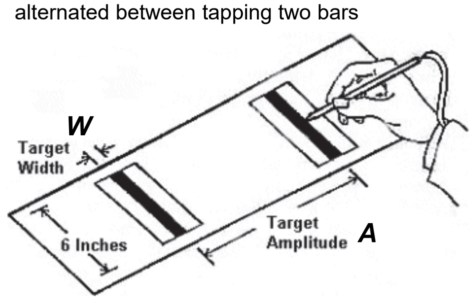
Fitts's Law *P. Fitts, 1954*

- Original task used electrical contacts
- Parameters varied from *A* = 1", *W* = 1" to *A* = 16", *W* = .25"
- $ID = \log_2 (2A / W)$
  - Conventionally measured in bits, after Shannon
- $ID = \log_2 (A / W + 1)$
  - Later formulation has slightly better fit, and assures positive *ID* (Mackenzie)

In original ***reciprocal tapping* task**, participant alternated between tapping two bars



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Fitts's Law *P. Fitts, 1954*

- $MT = C_1 + C_2\ ID$
  - where *ID* measured in bits
- C_2 measured in secs/bit, ca. .1 sec/bit (range ca. 83 msec/bit – 430 msec/bit)
  - E.g., higher for button-down dragging
- *IP* (Index of Performance) = $1 / C_2$
  - Measured in bits/sec (ca. 12 – 2.3 bits/sec)
  - Also known as *throughput* or *bandwidth*
- $MT = C_1 + ID / IP$

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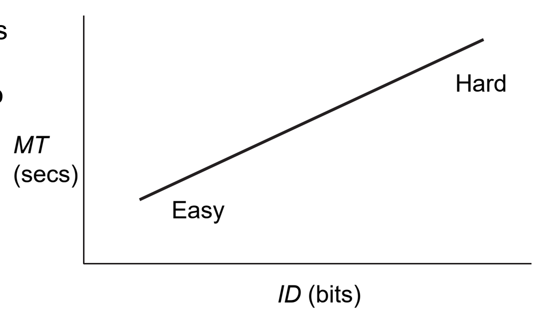
Fitts's Law *P. Fitts, 1954*

- $MT = C_1 + C_2 \log_2 (A / W + 1)$
- $MT = \ldots + C_2\ ID$
  - C_2 = slope
    - Higher C_2 means steeper curve, corresponding to lower IP ($1/C_2$)
- $MT = C_1 + C_2\ ID$
  - C_1 accounts for intercept offset from 0



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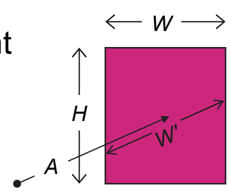
Fitts's Law *P. Fitts, 1954*

- First applied to HCI by Card, English, and Burr, 1978
- Later adapted for asymmetric targets by MacKenzie and Buxton, CHI 1992, who got better results than using *W* with two models
  - SMALLER-OF model: *W* is replaced by min (*W*, *H*)
  - *W′* model: *W* is replaced by *W′* = extent of target along approach vector



But see also Accot and Zhai, CHI 2003
It's complicated! Especially when H,W differ greatly!

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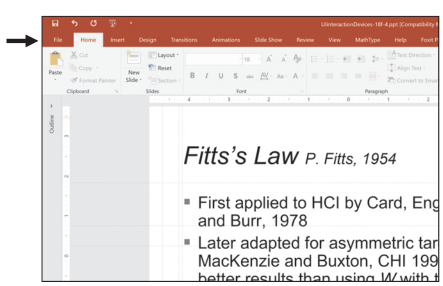
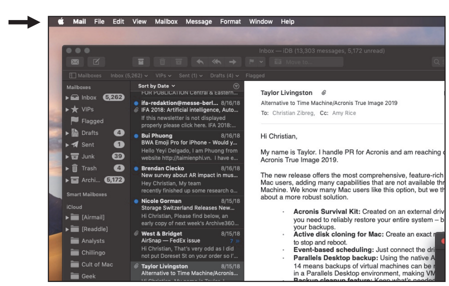
Fitts's Law *P. Fitts, 1954*

- Applied to menus in Windows vs. macOS
  - macOS menu bar is at top of screen
    - Acts as if it has infinite *H* or *W′* → Faster to target!





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Fitts's Law *P. Fitts, 1954*

- Applied to corners in macOS
  - "Hot corners" in Mission Control
    - Act as if they have infinite *H*, *W*, or *W′* → Faster to target!

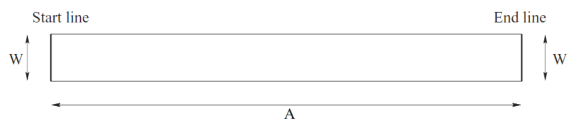
Fitts's Law *P. Fitts, 1954*

- Note complications when Fitts's Law is to be applied over a large range of
  - Distance to target
  - Angle to target
  - Size of target
  - Aspect ratio of target
  - Shape of target

Steering Law *J. Accot and S. Zhai, CHI 97*
(generalizing earlier work)

- How quickly can the user *steer* through a 2D tunnel (free-hand tracing, sketching, constrained motion)?
- Harder than a Fitts's Law task, since the cursor must remain in the tunnel!

How fast can a user move from the left to the right side of a rectangle of width W and length A, staying within the rectangle?



- $MT = a + b\,(A / W)$
  - For a straight tunnel of fixed width, where
    - A is path length
    - W is path width
    - a and b are constants
- Can be generalized for more complex tunnels (varying width, trajectory)

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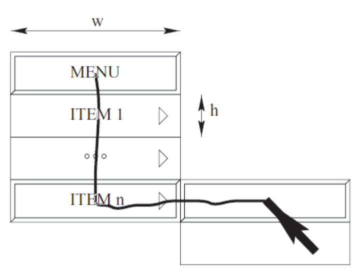
Steering Law *J. Accot and S. Zhai, CHI 97*
(generalizing earlier work)

- Modeling interacting with a hierarchical walking menu
  - Sum of vertical and horizontal steering tasks

Note: This is an approximation, assuming same coefficients *a*, *b* for horiz/vert

- $MT_n = \overbrace{a + b\,(nh / w)}^{\text{Vertical}} + \overbrace{a + b\,(w / h)}^{\text{Horizontal}}$, where
  - n is number of submenu (n^{th} submenu)
  - w is width of (sub)menu
  - h is height of (sub)menu item
- $MT_n = 2a + b\,(nh / w + w / h)$



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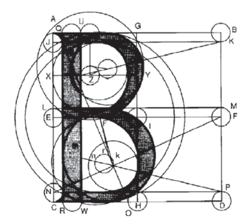
A Composite Interaction Task for Locator Devices: Snap Dragging

E. Bier and M. Stone, SIGGRAPH 86

- Extends basic idea of *grids*
- *Automatic generation* of *alignment objects*
  - *Gravity-active* points, lines, circles
- Generation based on
  - User hints
  - Heuristics about editing behavior



http://www.youtube.com/watch?v=7L8RT3M8Yeo

0:00-4:37

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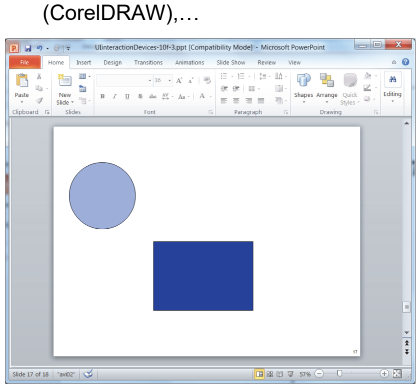
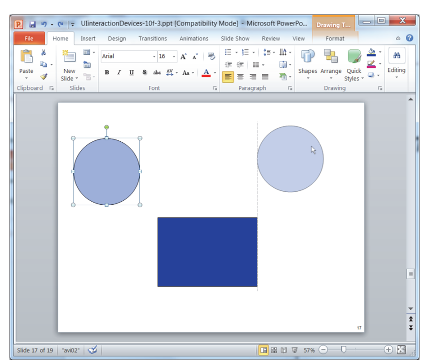
Heuristically Generated Alignment Lines in PowerPoint 2010–2016

- Dragging object (circle) creates an alignment line when its bounding box edge/center lines up with the bounding box edge/center of another object (rectangle)
- Also, smart guides (Adobe Illustrator), dynamic guides/alignment guide (CorelDRAW),…





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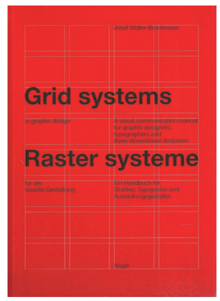
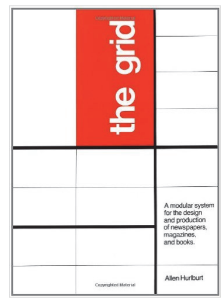
Grid (aka Design Grid)

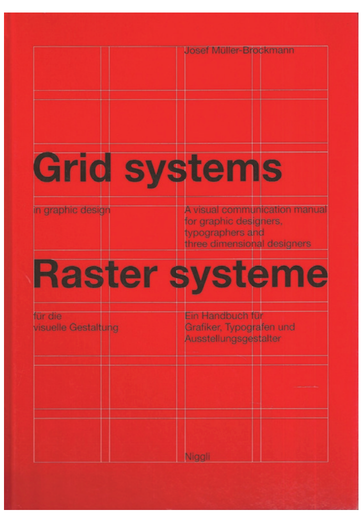
- A system of intersecting lines used to constrain position and size of content
  - Typically vertical and horizontal
  - Often arranged in repeating modules



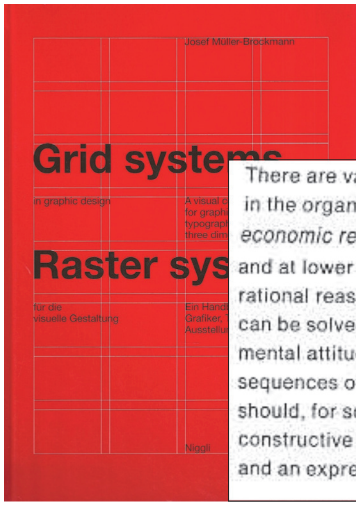


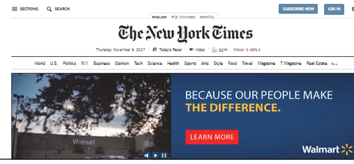
Two classic books on grids for graphic design

Grid (aka Design Grid)



Grid (aka Design Grid)





There are various reasons for using the grid as an aid in the organization of text and illustration:
economic reasons: a problem can be solved in less time and at lower cost.
rational reasons: both simple and complex problems can be solved in a uniform and characteristic style.
mental attitude: the systematic presentation of facts, of sequences of events, and of solutions to problems should, for social and educational reasons, be a constructive contribution to the cultural state of society and an expression of our sense of responsibility.