Looking Back …

• Humans
  – Understanding them needs knowledge from many fields
  – Processing information by humans can be modelled
  – Human physiology plays an important role for designing systems
  – Vision
    • eye tracking, eyes can be tricked, preattentive processing
    • Gestalt psychology
  – Hearing
    • audibility, pain threshold, spatial hearing
  – Touch
    • input and output
  – Memory
    • sensorial, short term (working), and long term memory
    • short term memory: 7 ± 2 chunks
    • long term memory: episodic and structural memory
    • generate new information: deduction, induction, abduction
Looking Back ...

• Affordances
  – Attractive things ‘work’ better (i.e. are often perceived as easier to use)
  – Perceived affordance is the perceived possibility for action
    • not only bc learned by conventions, feedback, etc.

• Intuitiveness
  – Do not rely on something to be intuitive, especially with regard to virtual interfaces
  – Providing clear perceived affordances and constraints can help the user
  – Use previous knowledge, e.g. metaphors for interaction

• Signifiers
  – Indicators in the physical or social world that can be interpreted meaningfully
  – Help to make possible actions and states visible
  – Often unconsciously / unintentionally (e.g. are still people waiting for the bus?) but can be applied intentionally (show a scrollbar to indicate length)
Mensch-Maschine-Interaktion 1

Chapter 7 (July 8, 2010, 9am-12pm):
Basic HCI Models
Basic HCI Models

- Predictive Models for Interaction: Fitts’ / Steering Law
- Descriptive Models for Interaction: GOMS / KLM
Fitts’ Law – Introduction

• Robust model of human psychomotor behavior
• Predicts movement time for rapid, aimed pointing tasks
  – Clicking on buttons, touching icons, etc.
  – Not suitable for drawing or writing
• Developed by Paul Fitts in 1954
• Describes movement time in terms of distance+size of target and device
• Rediscovered for HCI in 1978
• Subsequently heavily used and discussed


Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a CRT.
Fitts’ Law – History

- **Paul M. Fitts** was an American psychologist and one of the pioneers in improving aviation safety. He went on to lead the Psychology Branch of Air Force Research Laboratory – later renamed, in his honor, to Fitts Human Engineering Division.

- Fitts’ Law was his most famous work. It was first mentioned in a publication in 1954, and first applied to Human-Computer Interaction in 1978.

- Fitts’ discovery "was a major factor leading to the mouse's commercial introduction by Xerox“ [Stuart Card]

- Initially derived from a theorem for analogue information transmission

http://fww.few.vu.nl/hci/interactive/fitts/

Derivation from Signal Transmission

\[ C = B \log_2 \left( 1 + \frac{S}{N} \right) \]

- Shannon-Hartley Theorem
- \( C \) is the channel capacity (bits / second)
- \( B \) is the bandwidth of the channel (Hertz)
- \( S \) is the total signal power over the bandwidth (Volt)
- \( N \) is the total noise power over the bandwidth (Volt)
- \( S/N \) is the signal-to-noise ratio (SNR) of the communication signal to the Gaussian noise interference (as linear power ratio – \( \text{SNR}(\text{dB}) = 10\log_{10}(S/N) \))

Fitts’ Law – Formula

- The time to acquire a target is a function of the **distance** to and **size** of the target and depends on the particular pointing **system**

\[ MT = a + b \log_2 \left(1 + \frac{D}{W}\right) \]

- **MT**: movement time
- **a and b**: constants dependent on the pointing system
- **D**: distance to the target area
- **W**: width of the target
Fitts’ Law – Index of Difficulty

\[ MT = a + b \log_2 \left(1 + \frac{D}{W}\right) \]

- Index of Difficulty, \( ID = \log_2 \left(1 + \frac{D}{W}\right) \)
  - \( MT = a + b \cdot ID \)
  - \( ID \) describes the difficulty of the task independent of the device / method

- Units
  - Constant \( a \) measured in seconds
  - Constant \( b \) measured in seconds / bit
  - Index of Difficulty, \( ID \) measured in bits
Fitts’ Law – Advanced Topics

• Throughput
  – Also known as index of performance or bandwidth
  – Single metric for input systems
  – One definition: $TP = \frac{ID}{MT}$ (‘average’ values of ID and MT are used)
  – Another definition: $TP = \frac{1}{b}$ (equals ID / MT only if $a=0$)
  – Probably still the best approach:
    • Use regression analysis to compute $a$ and $b$
    • Use $\frac{1}{b}$ as throughput cautiously

• See detailed discussion in [Zhai 2004]

Fitts’ Law Experiment

- Extension to 2D
  - “Status Quo”: use horizontal width
  - “Sum Model”: $W = \text{width} + \text{height}$
  - “Area Model”: $W = \text{width} \times \text{height}$
  - “Smaller Of”: $W = \text{width, height}$
  - “W’ Model”: width in movement direction
- See also [MacKenzie, Buxton 1992] and [Zhai et al. 2004] who refer to

$$ID = \log_2 \left( \sqrt{\left(\frac{D}{W}\right)^2 + \eta \left(\frac{D}{H}\right)^2} + 1 \right)$$


(Simple) Linear Regression

- How to measure $a$ and $b$ for a new pointing device / menu / etc.?
  
  $MT = a + b \log_2 \left( 1 + \frac{D}{W} \right)$
  
  $ID = \log_2 \left( 1 + \frac{D}{W} \right)$

- Setup an experiment with varying $D$ and $W$ and measure $MT$

- Fit a line through the measured points: $a =$ intercept, $b =$ slope

http://fww.few.vu.nl/hci/interactive/fitts/
Implications for HCI (1)

- Bigger buttons
  - e.g. web links
  - e.g. check / radio boxes

- Proportional to amount of use?!
  - See principle (and golden rule) of consistency!

- Use current location of the cursor
  - distance is close to zero

- Use edges and corners (for examples see next slide)
  - edges of the screen have infinite height or width, respectively
  - corners have infinite height and width

Implications for HCI (1)

• Edges and corners
Implications for HCI (2)

• Compare and evaluate input devices
• Current examples
  – Behind the display cursor
  – Dynaspot


Additional Literature for Fitts’ Law


• Bibliography of Fitts’ Law Research (to get an impression about research in the HCI community): [http://www.yorku.ca/mack/RN-Fitts_bib.htm](http://www.yorku.ca/mack/RN-Fitts_bib.htm)

Steering Law

• Equally early discovery: 1959 by Nicolas Rashevsky
• For HCI rediscovered in 1997 and there sometimes called the Accot-Zhai steering law

• Models the movement time of a pointer through a 2D tunnel
• Can be seen as an extension to Fitts’ Law


Steering Law in Practice
Steering Law Equation

- The time to acquire a target through a tunnel is a function of the **length** and **width** of the tunnel and depends on the particular pointing **system**

\[ MT = a + b \frac{D}{W} \]

- **MT**: movement time
- **a** and **b**: constants dependent on the pointing system
- **D**: distance, i.e. length of the tunnel
- **W**: width of the tunnel

Adapted from Robert Miller 19
Steering Law Equation – Index of Difficulty

• The time to acquire a target through a tunnel is a function of the length and width of the tunnel and depends on the particular pointing system

\[ MT = a + b \frac{D}{W} \]

• Index of Difficulty: ID = D / W

• Index of Difficulty is now linear, not logarithmic as in Fitts’ Law
  – Steering is more difficult than pointing

Adapted from Robert Miller
Steering Law Extension to Arbitrary Tunnels

• The time to acquire a target through a tunnel is a function of the length and width of the tunnel and depends on the particular pointing system.

• The previously shown formula applies only for constant width $W$

$$MT = a + b \frac{D}{W}$$

• Let the width $W(s)$ be parameterized by $s$ running from 0 to $D$

$$MT = a + b \int_C \frac{ds}{W(s)}$$

• $C$: path characterised by $s$

• $W(s)$: width dependent on $s$
Steering Law Applied

- Early work focused on car driving scenarios and models with straight tunnels
- Various example tunnel shapes have been explored

Steering Law Applied

- Further extension to 3D e.g. virtual reality applications