Predicting Manual Motor Movement Times Using Fitts’ Law

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Materials from El-Glaly and Kuehl, Agrawala, Canny, Guimbretiere, and Hearst; and Kieras.
Major stages of human information processing:

- Perceptual
- Cognitive
- Memory
- Motor

Figure 1-9. The Model Human Processor (MHP) block diagram (adapted from Card, Moran, & Newell, 1983).
An early decomposition aimed at predicting human performance. Science permits engineering models to be constructed to predict aspects of human performance such as task execution time. Such as motor....
Motor Processor

Receive input from the cognitive processor
Execute motor programs
– Pianist: up to 16 finger movements per second
– Point of no-return for muscle action

(Agrawala et al.)
Predict the time to move a cursor or a finger distance $D$ to click on a target of size $S$. 

$X_0$ 

$D$ 

$S$
**Fitts’ Law**

\[ T = a + b \log_2(D / S + 1) \]

- \( a, b \) = constants (empirically derived)
- \( D \) = distance
- \( S \) = size

ID is Index of Difficulty = \( \log_2(D/S+1) \)

- Models well-rehearsed selection task
- \( T \) increases as the **distance** to the target increases
- \( T \) decreases as the **size** of the target increases
Considers Distance and Target Size

\[ T = a + b \log_2(D/S + 1) \]

Same ID → Same Difficulty
Considers Distance and Target Size

\[ T = a + b \log_2 (D / S + 1) \]
Considers Distance and Target Size

\[ T = a + b \log_2(D/S + 1) \]
Experimental Data

TARGET WIDTHS
- ▲ 2 in.
- ◇ 1 in.
- ● 1/2 in.
- ■ 1/4 in.

Time Per Movement (sec)

$\log_2 (D/S + .5)$ Corrected for Errors
Fitts’ Law Effects

Movement Time as a function of Distance

Time is less than linear with D

Big moves are relatively fast

(Kieras)
Movement Time as a function of Target Size
Time is worse than linear as S gets small

Very small targets are quite difficult
Implications of Fitts’ Law

- Large targets and small distances between targets are advantageous
- Screen elements should occupy as much of the available screen space as possible
- The largest Fitts-based pixel is the one under the cursor (why?)
- Screen elements should take advantage of the screen edge whenever possible
  - The edges of the screen have infinite depth and no targeting required
- Steering tasks – moving linearly in a “tunnel” of length D and size S is more difficult than pointing

(El-Glaly and Kuehl)
Toolbar Example

Microsoft Toolbars offer the user the option of displaying a label below each tool. Name at least one reason why labeled tools can be accessed faster. (Assume, for this, that the user knows the tool.)
Toolbar Example

1. The label becomes part of the target. The target is therefore bigger. Bigger targets, all else being equal, can always be accessed faster, by Fitt's Law

2. When labels are not used, the tool icons crowd together
Tool Matrix Example

You have a palette of tools in a graphics application that consists of a matrix of 16x16-pixel icons laid out as a 2x8 array that lies along the left-hand edge of the screen. Without moving the array from the left-hand side of the screen or changing the size of the icons, what steps can you take to decrease the time necessary to access the average tool?
Tool Matrix Example

1. Change the array to 1x16, so all the tools lie along the edge of the screen.

2. Ensure that the user can click on the very first row of pixels along the edge of the screen to select a tool. There should be no buffer zone.
Fitts Law - Summary

- Many aspects of human information processing and performance can be understood—and predicted—by decomposing human behavior into its component processes.
- The major components of human information processing are: perceptual, cognitive, memory, and motor.
- Fitts’ law predicts human performance for time-minimizing pointing tasks in which the target (including its boundaries) has been identified.
- Understanding Fitts’ law helps you to make better decisions for interactive designs that require pointing movements.
- Fitts’ law provides a basis for comparing the efficiency of different pointing devices or pointing techniques.
  1. Design an experiment with a range of $D$s, $S$s, and $ID$s.
  2. Bring participants to accurate and practiced performance.
  4. Plot the best-fitting (logarithmic) regressions.
  5. Compare the $a$ and $b$ coefficients across the devices or techniques.
  6. The device or technique with the lower coefficients wins.