NPTEL Course on

Human Computer Interaction - An Introduction

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Module 3:
Model-based Design

Lecture 5:
Individual Models of Human Factors - I

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Objective

- In the previous lectures, we learned about two popular models belonging to the GOMS family, namely KLM and (CMN)GOMS
  - Those models, as we mentioned before, are simple models of human information processing
- They are one of three cognitive modeling approaches used in HCI

Objective

- A second type of cognitive models used in HCI is the individual models of human factors
- To recap, these are models of human factors such as motor movement, choice-reaction, eye movement etc.
  - The models provide analytical expressions to compute values associated with the corresponding factors, such as movement time, movement effort etc.

Objective

- In this lecture, we shall learn about two well-known models belonging to this category
  - **The Fitts' law**: a law governing the manual (motor) movement
  - **The Hick-Hyman law**: a law governing the decision making process in the presence of choice

Fitts' Law

- It is one of the earliest predictive models used in HCI (and among the most well-known models in HCI also)
- First proposed by PM Fitts (hence the name) in 1954

Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology*, 47, 381-391.

Fitts' Law

- As we noted before, the Fitts' law is a model of human motor performance
  - It mainly models the way we move our hand and fingers
- A very important thing to note is that the law is not general; it models motor performance under certain constraints (next slide)

Fitts' Law - Characteristics

- The law models human motor performance having the following characteristics
  - The movement is related to some *"target acquisition task"* (i.e., the human wants to acquire some target at some distance from the current hand/finger position)

Fitts' Law - Characteristics

- The law models human motor performance having the following characteristics
  - The movement is *rapid* and *aimed* (i.e., no decision making is involved during movement)
  - The movement is *error-free* (i.e. the target is acquired at the very first attempt)

Nature of the Fitts’ Law

- Another important thing about the Fitts’ law is that, it is both a descriptive and a predictive model
- Why it is a descriptive model?
  - Because it provides “throughput”, which is a descriptive measure of human motor performance

Nature of the Fitts' Law

- Another important thing about the Fitts' law is that, it is both a descriptive and a predictive model
- Why it is a predictive model?
  - Because it provides a prediction equation (an analytical expression) for the time to acquire a target, given the distance and size of the target

Task Difficulty

- The key concern in the law is to measure "task difficulty" (i.e., how difficult it is for a person to acquire, with his hand/finger, a target at a distance D from the hand/finger's current position)
  - Note that the movement is assumed to be rapid, aimed and error-free

Task Difficulty

- Fitts, in his experiments, noted that the difficulty of a target acquisition task is related to two factors
  - Distance (D): the distance by which the person needs to move his hand/finger. This is also called *amplitude* (A) of the movement
  - The larger the D is, the harder the task becomes

Task Difficulty

- Fitts, in his experiments, noted that the difficulty of a target acquisition task is related to two factors
  - Width (W): the difficulty also depends on the width of the target to be acquired by the person
  - As the width increase, the task becomes easier

Measuring Task Difficulty

- The qualitative description of the relationships between the task difficulty and the target distance (D) and width (W) can not help in "measuring" how difficult a task is
- Fitts' proposed a 'concrete' measure of task difficulty, called the "index of difficulty" (ID)

Measuring Task Difficulty

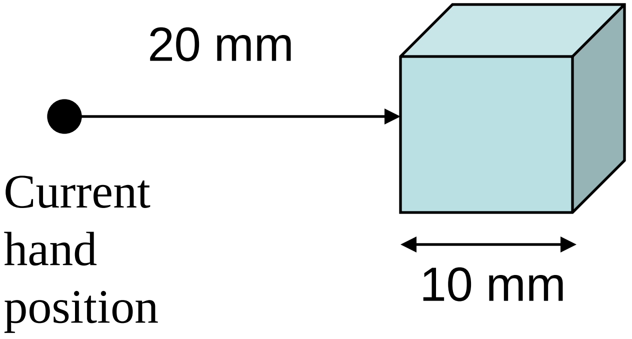
- From the analysis of empirical data, Fitts' proposed the following relationship between ID, D and W

$$ID = \log_2(D/W+1) \text{ [unit is } \textit{bits}\text{]}$$

(Note: the above formulation was not what Fitts originally proposed. It is a refinement of the original formulation over time. Since this is the most common formulation of ID, we shall follow this rather than the original one)

ID - Example

- Suppose a person wants to grab a small cubic block of wood (side length = 10 mm) at a distance of 20 mm. What is the difficulty for this task?



ID - Example

- Suppose a person wants to grab a small cubic block of wood (side length = 10 mm) at a distance of 20 mm. What is the difficulty for this task?

Here D = 20 mm, W = 10 mm

Thus, ID = $\log_2(20/10+1)$

$= \log_2(2+1)$

$= \log_2 3 = 1.57$ bits

Throughput

- Fitts' also proposed a measure called the *index of performance* (IP), now called *throughput* (TP)
  - Computed as the difficulty of a task (ID, in bits) divided by the movement time to complete the task (MT, in seconds)
- Thus, TP = ID/MT bits/s

Throughput - Example

- Consider our previous example (on ID). If the person takes 2 sec to reach for the block, what is the throughput of the person for the task

Here ID = 1.57 bits, MT = 2 sec

Thus TP = 1.57/2

= 0.785 bits/s

Implication of Throughput

- The concept of throughput is very important
- It actually refers to a measure of performance for rapid, aimed, error-free target acquisition task (as implied by its original name “index of performance”)
  - Taking the human motor behavior into account

Implication of Throughput

- In other words, throughput should be relatively constant for a test condition over a wide range of task difficulties; i.e., over a wide range of target distances and target widths

Examples of Test Condition

- Suppose a user is trying to point to an icon on the screen using a mouse
  - The task can be mapped to a rapid, aimed, error-free target acquisition task
  - The mouse is the test condition here
- If the user is trying to point with a touchpad, then touchpad is the test condition

Examples of Test Condition

- Suppose we are trying to determine target acquisition performance for a group of persons (say, workers in a factory) after lunch
  - The “taking of lunch” is the test condition here

Throughput – Design Implication

- The central idea is - Throughput provides a means to measure user performance for a given test condition
  - We can use this idea in design
- We collect throughput data from a set of users for different task difficulties
  - The mean throughput for all users over all task difficulties represents the average user performance for the test condition

Throughput – Design Implication

- Example – suppose we want to measure the performance of a mouse. We employ 10 participants in an experiment and gave them 6 different target acquisition tasks (where the task difficulties varied). From the data collected, we can measure the mouse performance by taking the mean throughput over all participants and tasks (next slide)

Throughput – Design Implication

D	W	ID (bits)	MT (sec)	TP (bits/s)
8	8	1.00	0.576	1.74
16	8	1.58	0.694	2.28
16	2	3.17	1.104	2.87
32	2	4.09	1.392	2.94
32	1	5.04	1.711	2.95
64	1	6.02	2.295	2.62
			Mean	2.57

Each value indicates mean of 10 participants

The 6 tasks with varying difficulty levels

Throughput = 2.57 bits/s

Throughput – Design Implication

- In the example, note that the mean throughputs for each task difficulty is relatively constant (i.e., not varying widely)
  - This is one way of checking the correctness of our procedure (i.e., whether the data collection and analysis was proper or not)

Note

- In this lecture, we got introduced to the concept of throughput and how to measure it
- In the next lecture, we shall see more design implications of throughput
- We will also learn about the predictive nature of the Fitts' law
- And, we shall discuss about the Hick-Hyman law