Human Computer Interaction

UNIT-2

Lecture 5:

Model-based Design

Mr. Nachiket Sainis / Reena Saini

B K Birla Institute of Engineering & Technology, Pilani

Lecture 5:
Individual Models of Human Factors - I

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

- 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.

Fitts' Law

- **The Fitts' law**: a law governing the manual (motor) movement
- 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
- The Fitts' law is a model of human motor performance.
- It mainly models the way we move our hand and fingers.
- The law is not general; it models motor performance under certain constraints.

Fitts' Law - 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).
- 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.

- 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).

  – The movement is assumed to be rapid, aimed and error-free

- 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

Task Difficulty

- The larger the D is, the harder the task becomes.
- 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).
- 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)

Original Formula by Fitt's: $\mathbf{ID= \log_2(2D/W)}$

ID - Example

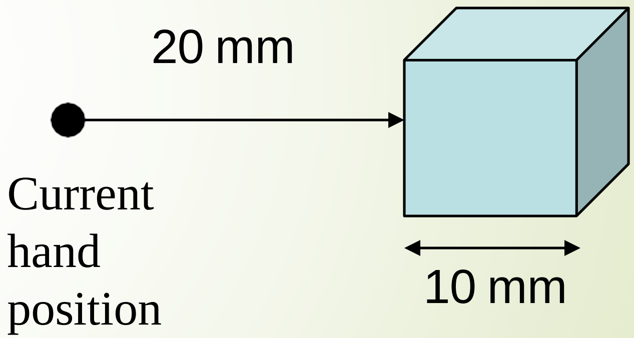
- Suppose a person wants to grab a small cubic block of wood (side length = 10 mm) at a distance of 20 mm. What is the difficulty for this task?

Here D = 20 mm, W = 10 mm

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

$= \log_2(2+1)$

$= \log_2 3 = 1.58$ 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,

$$TP = ID/MT \text{ bits/s}$$

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.
- 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.
- 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

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)