Lecture 2: Human Factors

Why Bother with Human Factors

- We build systems where humans are essential components
- We need to know the properties of this component
  - To predict human behavior
  - To guide our design
    • And avoid stupid errors
  - To perform early evaluation of our systems without users
What We May Hope to Predict?

- How fast will it be? Will it be faster than the old system?
- Will users like the user interface?
- How easily will they learn it? Will they be able to walk up and use it, first time?
- How many errors will they make?
- I.e., to answer questions about usability!

What Kind of Theories We Can Use?

- Explanatory theories
  - Develop a model to explain observed behavior
- Empirical laws
  - No solid theory, but enables us to make quantitative prediction
- Dynamic models
  - Full Scale Predictive Models
    - Keystroke-level model, GOMS, ACT-R
    - We will discuss it during future lectures
Hick’s Law

\[ T = k \log_2 (n + 1) \quad \text{Time to select one of } n \text{ targets} \]

Fitt’s Law

- Size and distance vs. time/complexity
  \[ T_{\text{point}} = I_M \times \log_2 (\text{Distance/Size} + 0.5) \]
  - \( I_M \) - 100 msec
  - Clicking - 200 msec
  - Homing - 400 msec

- Fitt’s Law is an empirical law, however, it could be “derived” from our predictive model of human cognition
The Human Virtual Machine

- How to integrate all these theories and facts together?
- The concept of the Human Virtual Machine (Card - Moran - Newell)
  - Step-by-step simulation of tasks and processes
  - Simplification by abstraction
  - Overlaps and gaps in the body of theory

Card/Moran/Newell Model from The Psychology of HCI, 1982
Processors and Memory

- Human information processing includes several processors
- Each processor acts as an independent subsystem
- Processors interacts with different kinds of "memories" that acts as storages
- We can use the model to predict empirical data and use empirical data to update the model

Human Information Processing

![Diagram of human information processing]

The World

Perceptual Processor

Motor Processor

Cognitive Processor

Working Memory

Long-Term Memory
Perception

- Communication: computer -> user
  - Vision
  - Sound
  - Touch
- We will concentrate on visual aspect - developing GUI

Visual Perception

- Fovea (2 degrees!)
  - detailed vision
- Rest of eye
  - Sensitivity to changes - movement, blinking
- Natural attention to periphery
  - 100 msec to detect signal, 30 msec to move eye
- Used in several design principles
**Visual Search**

- Looking for target in the world (screen)
- Fast if target is different along some dimension (parallel)
  - Color, orientation, size, curvature
  - Target “pops-out”
- Hard to discriminate multiple features (serial)
- Screen clutter, density, location, grouping - make a lot of difference

**Memory**

- Working Memory - active part
  - Stores perception data - acoustic, visual
- Long Term Memory - permanent store
  - Stores information: facts, procedures, history
- Working Memory has a limited size
  - 7 chunks
Long Term Memory

- Unlimited size
- Recall is the problem
- Indirect, associative nature
- Similar information items interfere each other’s retrieval
- Recognition is easier than recall
- Information to Long Term Memory can only come from Working Memory

Some extensions: 90’s model

- Extends modality effects to working memory with modality specific interference between tasks and modality independent interference for the central executive
- Adds bottleneck by-pass for “LT-WM” to account for automaticity & skilled performance
The Role of Attention

Central Executive

- Coordinate multiple tasks (OS)
- Hold & manipulate info from LTM (RAM)
- Control retrieval strategies from LTM (data access)
- Attend selectively to stimuli (time share)
Cognitive Processor

- Cognitive Processor does all “thinking”
- Least known processor
- Two levels of activities
  - Routine Skill
  - Problem-solving
- Routine skills can be predicted, modeled and measured (ACT-R, GOMS)
- Problem solving is indirect, heuristic, with backtracking

Motor Processor

- Takes information from WM and acts
- Specific motor actions in HCI
  - Typing
  - Pointing
- Typing is well-studies
  - Keyboard influence
  - Individual typing speed
Example with Cycle Times

- The “processors” model enables us to predict a number of phenomena
  - Cycle time and drawing a zig-zag line
    - How often we can send a reversal signal? 70 msec
    - How often we can correct errors? 100+70+70 = 240 msec

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Average cycle time</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual (visual and auditory)</td>
<td>100 msec</td>
<td>50 - 200 msec</td>
</tr>
<tr>
<td>Cognitive</td>
<td>70 msec</td>
<td>25 - 170 msec</td>
</tr>
<tr>
<td>Motor</td>
<td>70 msec</td>
<td>30 - 100 msec</td>
</tr>
</tbody>
</table>

Barnard’s Model (1991)

Three separate cognitive subsystems, more processors...
Other Levels of Theories

- Sociological and anthropological theories of human behavior
- Theories of the organization of human activity
- Sociological theory of group organization
- Theories of learning

Errors

- Murphy’s Law
- Errors can happen on all stages
  - Perception
  - Processing
  - Memorization and recall
  - Knowledge
  - Problem-solving
- Techniques to fight errors