Cognitive models

- They model aspects of user:
  - understanding
  - knowledge
  - intentions
  - processing

- Common categorisation:
  - Competence Models vs. Performance Models
  - Competence: What users ideally should do
  - Performance: What users actually do

Cognitive models

1. Goal and task hierarchies (GOMS, CCT)
2. Linguistic notations (BNF, TAG)
3. Physical and device models (KLM)
   -> Architectural models, foundation for 1-3
   (Display-based interaction, not modelled)

Techniques

- Goals, Operators, Methods and Selection (GOMS)
- Cognitive Complexity Theory (CCT)
- Hierarchical Task Analysis (HTA) - Chapter 15

1.1 GOMS

Goals
- what the user wants to achieve

Operators
- basic actions user performs

Methods
- decomposition of a goal into subgoals/operators

Selection
- means of choosing between competing methods
GOMS example

GOAL: CLOSE-WINDOW
  [select GOAL: USE-MENU-METHOD
   . MOVE-MOUSE-TO-FILE-MENU
   . PULL-DOWN-FILE-MENU
   . CLICK-OVER-CLOSE-OPTION
   GOAL: USE-CTRL-W-METHOD
   . PRESS-CONTROL-W-KEYS]

For a particular user:
Rule 1: Select USE-MENU-METHOD unless another rule applies
Rule 2: If the application is GAME, select CTRL-W-METHOD

1.2 Cognitive Complexity Theory

- Two parallel descriptions:
  - User production rules
  - Device generalised transition networks
- Production rules are of the form:
  - if condition then action

Example: editing with vi

Why many users like the vi-Editor:
- Vi is available on many platforms; very important for system administrators because they often work on different systems
- You don't need X or mouse for high efficiency
- Vi is compact, fully developed, and runs on *any* Unix-system
- Vi supports syntax highlighting
- Vi is very well configurable

Example: Petri-net based modelling

An example from the lecturer's research is offered on slides 34-44. The title of the subject is:

Petri-net based modelling
Notes on Cognitive Complexity Theory

- Parallel model
- Proceduralisation of actions
- Novice versus expert style rules
- Error behaviour can be represented
- Measures
  - depth of goal structure
  - number of rules
  - comparison with device description

Pro and cons of Cognitive Complexity Theory

Advantage:
- Due to parallelism, the production rules allow for modeling of complex procedures.
- Therefore, synchronous procedures can also be described; for instance, drink tea AND edit a text.
- Through a comparison of user- and system-states, a degree of dissonance can be discovered, allowing to optimize the user interface.

Problems
- Even smaller parts of a user interface give very complex CCT-Models.
- Alternative ways to model the same user—system lead to different degrees of dissonance.
- Some elements of the CCT syntax have no cognitive analogue, but are used due to the shortcomings of the annotation itself.

http://collide.informatik.uni-duisburg.de/Lehre/DidaktikSeminar/BuA/page04.php

2 Linguistic notations

- Understanding the user's behaviour and cognitive difficulty based on analysis of language between user and system.
- Similar in emphasis to dialogue models
- Backus–Naur Form (BNF)
  - [ Task–Action Grammar (TAG) ]

Backus–Naur Form (BNF), example

Consider this BNF for a US postal address

```
<postal-address> ::=<name-part> <street-address> <zip-part>
<name-part> ::=<name> | <initial> "."
<street-address> ::=<house-num> <street-name> <EOL>
<zip-part> ::=<town-name> "," <state-code> <ZIP-code> <EOL>
```

This translates into English as

"A postal-address consists of a name-part, followed by a street-address part, followed by a zip-code part. A personal-part consists of either a first-name or an initial followed by a dot. A house-name consists of either a personal-part followed by a last-name part (Jr., Sr., or dynastic number) and end-of-line, or a personal part followed by a name part (recursion in BNFs, covering the case of people who use multiple first and middle names and/or initials)."
3 Physical and device models

- The Keystroke Level Model (KLM)
- Buxton’s 3-state model
- Based on empirical knowledge of human motor system
- User’s task: acquisition then execution.
  - these only address execution
  - Complementary with goal hierarchies

3.1 Keystroke Level Model (KLM)

- six execution phase operators
  - Physical motor:  K - keystroking
  - P - pointing (use Fitt’s Law)
  - H - homing
  - D - drawing
  - Mental: M - mental preparation
  - System: R - response
- times are empirically determined.
  \[ T_{execute} = TK + TP + TH + TD + TM + TR \]

Fitt’s Law for ann Estimation of Pointing Time

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

- D: Distance to target
- S: Size of target
- a, b: Empirically estimated constants

Original form of Fitt’s Law, 1954, without a constant:
\[ T = \log_2(2A/W) \]
Fitt's Law, example 2: www.tele-actor.net/fitts/

Demo application intro page
Demo application program

Keystroke Level Model (KLM)
1. Move hand to mouse H[mouse]
2. Position mouse after bad character PB[LEFT]
3. Return to keyboard H[keyboard]
4. Delete character MK[DELETE]
5. Type correction K[char]
6. Reposition insertion point H[mouse]MPB[LEFT]

\[ T_{\text{exam}} = T_K + T_B + T_F + T_H + T_D + T_M + T_K \\
= 2T_K + 2T_B + T_F + 3T_H + 0 + 2T_M + 0 \]

KLM example

GOAL: ICONISE-WINDOW
[select]
GOAL: USE-CLOSE-METHOD
- MOVE-MOUSE-TO-FILE-MENU
- DOWN-FILE-MENU
- CLICK-OVER-CLOSE-OPTION
GOAL: USE-CTRL-W-METHOD
PRESS-COMPLETE-W-KEY

- compare alternatives:
  - USE-CTRL-W-METHOD vs.
  - USE-CLOSE-METHOD
- assume hand starts on mouse

<table>
<thead>
<tr>
<th>USE-CTRL-W-METHOD</th>
<th>USE-CLOSE-METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>1.35</td>
</tr>
<tr>
<td>K[ctrl key]</td>
<td>0.28</td>
</tr>
<tr>
<td>P[on option]</td>
<td>0.1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2.92</td>
</tr>
</tbody>
</table>

Buxton's 3-state model

3.2 Buxton's 3-state model

Table 13.2: Time loss coefficients (after MacKenzie, Selim and Buxton [2001])

<table>
<thead>
<tr>
<th>Painting mode 1</th>
<th>Mouse</th>
<th>Trackball</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time loss</td>
<td>107</td>
<td>75</td>
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<tr>
<td>Total</td>
<td>223</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dragging mode 2</th>
<th>Mouse</th>
<th>Trackball</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time loss</td>
<td>135</td>
<td>-349</td>
</tr>
<tr>
<td>Total</td>
<td>249</td>
<td>186</td>
</tr>
</tbody>
</table>

Architectural models, basis for all (1-3)

- All of these cognitive models make assumptions about the architecture of the human mind.
- Long-term/Short-term memory
- Problem spaces
- Interacting Cognitive Subsystems
- Connectionist
Example: Automating Inspection Methods -
- Analysis Support—Web UIs

Lecture on Monday 28th February, 13-15:
Moved to: VASA A.
Reason: MTS-Dagar