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Cognitive models

- goal and task hierarchies
- linguistic
- physical and device
- architectural

Cognitive models They model aspects of user: understanding knowledge intentions processing Common categorisation: Competence vs. Performance Computational flavour

No clear divide

Goal and task hierarchies

• Mental processing as divide-and-conquer • Example: sales report

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- produce report gather data

 - find book names . do keywords search of names database

goals vs. tasks

• goals - intentions what you would like to be true

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- tasks actions how to achieve it
- goals are internal • GOMS
- actions externaltasks are abstractions • HTA

Issues for goal hierarchies

• Granularity - Where do we start?

- Where do we stop?
- · Routine learned behaviour, not problem solving
- The unit task
- Conflict
- More than one way to achieve a goal
- Error

Techniques

- Goals, Operators, Methods and Selection (GOMS)
- Cognitive Complexity Theory (CCT)

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 Hierarchical Task Analysis (HTA) -Chapter 15

GOMS

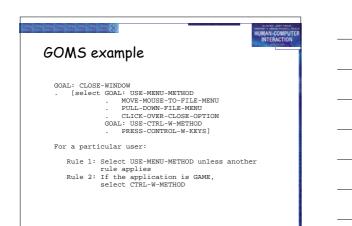
Goals - what the user wants to achieve

Operators – basic actions user performs

Methods

- decomposition of a goal into subgoals/operators

Selection – means of choosing between competing methods





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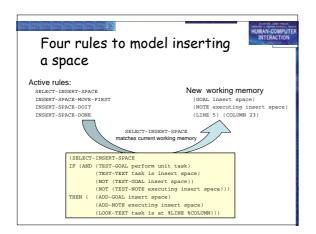
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- Two parallel descriptions: - User production rules
 - Device generalised transition networks
- Production rules are of the form: - if condition then action
- · Transition networks covered under dialogue models

Example: editing with vi

- · Production rules are in long-term memory
- Model working memory as attribute-value mapping: (GOAL perform unit task) (TEXT task is insert space) (TEXT task is at 5 23)

 - (CURSOR 8 7)
- · Rules are pattern-matched to working memory,
 - e.g., LOOK-TEXT task is at %LINE %COLUMN is true, with LINE = 5 COLUMN = 23.





Notes on CCT

- Parallel model
- Proceduralisation of actions
- Novice versus expert style rules
- Error behaviour can be represented

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- Measures
 - depth of goal structure
 - number of rules
 - comparison with device description

Problems with goal hierarchies

- a post hoc technique
- · expert versus novice
- How cognitive are they?

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)

Very common notation from computer science

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- · A purely syntactic view of the dialogue
- Terminals
 - lowest level of user behaviour
 - e.g. CLICK-MOUSE, MOVE-MOUSE
- Nonterminals
 - ordering of terminals
 higher level of abstraction
 - e.g. select-menu, position-mouse

Example of BNF

Basic syntax:
 nonterminal ::= expression

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An expression
 – contains terminals and nonterminals
 – combined in sequence (+) or as alternatives (|)

draw line ::= select line + choose points + last point select line ::= pos mouse + CLICK MOUSE choose points ::= choose one | choose one + choose points choose one ::= pos mouse + CLICK MOUSE last point ::= pos mouse + DBL CLICK MOUSE pos mouse ::= NULL | MOVE MOUSE + pos mouse

Measurements with BNF

- Number of rules (not so good)
- Number of + and | operators
- Complications
 - same syntax for different semantics
 - no reflection of user's perception
 - minimal consistency checking

Task Action Grammar (TAG)

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- · Making consistency more explicit
- Encoding user's world knowledge
- Parameterised grammar rules
- · Nonterminals are modified to include additional semantic features

Consistency in TAG

- · In BNF, three UNIX commands would be described as: $\begin{array}{l} copy & ::= cp + filename + filename | cp + filenames + directory \\ move & ::= mv + filename + filename | mv + filenames + directory \\ link & ::= ln + filename + filename | ln + filenames + directory \end{array}$
- No BNF measure could distinguish between this and a less consistent grammar in which

link ::= In + filename + filename | In + directory + filenames

Consistency in TAG (cont'd)

• consistency of argument order made explicit using a parameter, or semantic feature for file operations

```
    Feature Possible values
```

Op = copy; move; link

Rules

```
CUIES
file-op[Op] :: = command[Op] + filename + filename
| command[Op] + filenames + directory
command[Op = copy] :: = cp
command[Op = move] :: = mv
command[Op = link] :: = ln
```

Other uses of TAG

- User's existing knowledge
- Congruence between features and commands

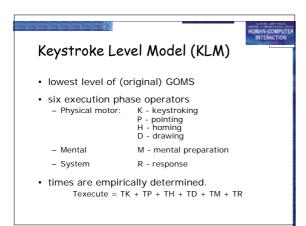
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• These are modelled as derived rules

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



KLM example			HUMA	N-COMPL TERACTIO
GOAL: ICONISE-WINDOW [select GOAL: USE-CLOSE-METHOD MOVE-MOUSE-TO- FIL PULL-DOWN-FILE-MEN CLICK-OVER-CLOSE-O GOAL: USE-CTRL-W-METHOD	J PTION			
PRESS-CONTROL-W-KE				
	USE-CTRL-W	V-METHOD	USE-CLOSE-	METHOD
 PRESS-CONTROL-W-KE compare alternatives: USE-CTRL-W-METHOD VS. 		0.40	USE-CLOSE- P[to menu]	METHO
compare alternatives:	USE-CTRL-W			1.1
 compare alternatives: USE-CTRL-W-METHOD VS. USE-CLOSE-METHOD 	USE-CTRL-W	0.40 1.35	P[to menu]	1.1
 compare alternatives: USE-CTRL-W-METHOD VS. 	USE-CTRL-W H[to kbd] M	0.40 1.35	P[to menu] B[LEFT down	1.1] 0.1 1.35
 compare alternatives: USE-CTRL-W-METHOD VS. USE-CLOSE-METHOD 	USE-CTRL-W H[to kbd] M	0.40 1.35	P[to menu] B[LEFT down	1.1] 0.1 1.35

Architectural models

• All of these cognitive models make assumptions about the architecture of the human mind.

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- Long-term/Short-term memory
- Problem spaces
- Interacting Cognitive Subsystems
- Connectionist
- ACT

Display-based interaction

- Most cognitive models do not deal with user observation and perception
- Some techniques have been extended to handle system output (e.g., BNF with sensing terminals, Display-TAG) but problems persist
- Exploratory interaction versus planning