GOMS, KLM & Midterm Review

CS160: User Interfaces

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Slides based on those of John Canny, Francois Guimbretiere and Marti Hearst

Upcoming Schedule

Lo-Fi Protype due now

Hello World Map (before class on Oct 18)

- 10 pts
- Exercise the R3 Paper Application Toolkit

Midterm Exam (next Monday Oct 16)

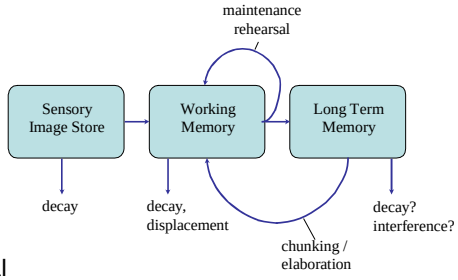
- Covers all lectures, section and readings through Oct 11
- Closed book, no cheatsheets, no electronic devices

Interactive Prototype (due Oct 30) + Presentations

- ***First working*** implementation
- Can include Wizard-of-Oz parts where justified

Review: Memory

Working memory is small
- Temporary storage
  - decay
  - displacement



Long term memory
- Rehearsal
- Relate new to learned material
- Link to existing knowledge
- Attach meaning
  - Make a story

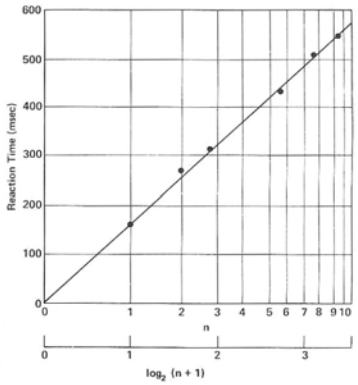
Design interface to facilitate retrieval
- Recognition rather than recall

Review: Decision Making

Hick's Law – cost of taking a decision:

$$T = a + b\log_2(n+1)$$

- Time depends on number of options
  - Choosing a movie at Blockbuster

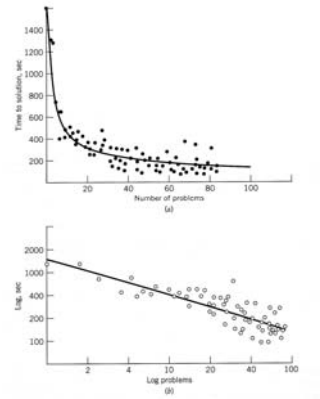


Review: Practice

Task time on the nth trial follows a power law

$$T_n = T_1 n^{-a} + c$$

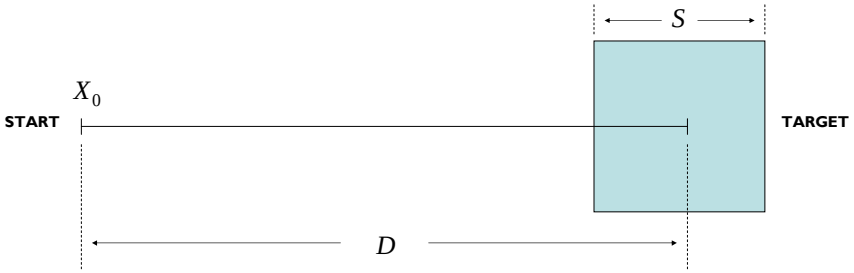
where a = .4, c = limiting constant



Applies to skilled behavior

- Sensory
- Motor

Review: Fitts' Law



Hand movement based on series of microcorrections

X_i = remaining distance after ith move

relative movement accuracy remains constant ➔ $\frac{X_i}{X_{i-1}} = \varepsilon$

Then

$$T = I_m \log_2 \left(\frac{2D}{S} \right)$$

Review: Fitts' Law

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

a, b = constants (empirically derived)
D = distance
S = size

ID is Index of Difficulty = $\log_2(D/S+1)$

- Models well-rehearsed selection task
- T increases as the ***distance*** to the target increases
- T decreases as the ***size*** of the target increases

Topics

- GOMS and KLM
- Midterm Review

GOMS and KLM

GOMS (Card et al.)

Describe the user behavior in term of

- Goals
  - Edit manuscript, locate line
- Operators
  - Elementary perceptual, motor or cognitive acts
- Methods
  - Procedure for using operators to accomplish goals
- Selection rules
  - Used if several methods are available for a given goal

Family of methods

- KLM, CMN-GOMS, NGOMSL, CPM-GOMS

Quick Example

Goal (the big picture)
- Go from hotel to the airport

Methods (or subgoals)?
- Walk, take bus, take taxi, rent car, take train

Operators (or specific actions)
- locate bus stop; wait for bus; get on the bus;...

Selection rules (choosing among methods)?
- Example: Walking is cheaper, but tiring and slow
- Example: Taking a bus is complicated abroad

GOMS Output

Execution time
- Add up times from operators
- Assumes **experts** (mastered the tasks)
- **Error free behavior**
- Very good rank ordering
- Absolute accuracy ~10-20%

Using GOMS Analysis

Check that frequent goals can be achieved quickly

Making operator hierarchy is often the value

- Functionality coverage & consistency
  - Does UI contain needed functions?
  - Consistency: are similar tasks performed similarly?
- Operator sequence
  - In what order are individual operations done?

How to do GOMS Analysis

Generate task description

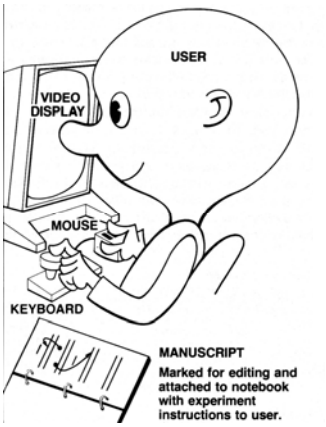
- Pick high-level user **Goal**
- Write **Methods** for reaching Goal - may invoke subgoals
- Write **Methods** for subgoals
  - This is recursive
  - Stops when **Operators** are reached

Evaluate description of task

Apply results to UI

Iterate!

Detailed Task Description



GOAL: EDIT-MANUSCRIPT
. GOAL: EDIT-UNIT-TASK *repeat until no more unit tasks*
. . GOAL: ACQUIRE-UNIT-TASK
. . . GET-NEXT-PAGE *if at end of manuscript page*
. . . GET-NEXT-TASK
. . GOAL: EXECUTE-UNIT-TASK
. . . GOAL: LOCATE-LINE
. . . . [select: USE-QS-METHOD
USE-LF-METHOD]
. . . GOAL: MODIFY-TEXT
. . . . [select: USE-S-COMMAND
USE-M-COMMAND]
. . . . VERIFY-EDIT .

GOMS Example

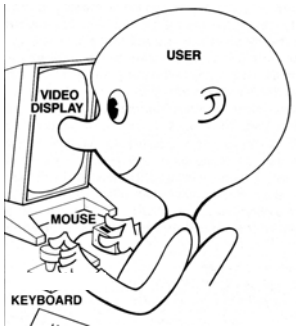
Using a text editor edit the following text as shown

- Goals and sub-goals?
- Operators?
- Methods?
- Selection rules?

Keystroke Level Model (KLM)

Describe the task using the following operators:

- K: pressing a key or a pressing (or releasing) a button
  t_K = 0.08 - 1.2s (0.2 good rule of thumb)
- P: pointing
  t_P = 1.1s (without button press)
- H: Homing (switching device)
  t_H = 0.4s
- D(*n*,*l*): Drawing segmented lines
  t_D = 0.9*n + .16*l
- M: Mentally prepare
  t_M = 1.35s
- R(*t*): system response time
  t_R = t



KLM Heuristic Rules (Raskin's)

0: Insert M
- In front of all K
- In front of all P's selecting a command (not in front of P's ending command)

1: Remove M between *fully anticipated* operators
- PMK → PK

2: if a string of MKs belong to *cognitive unit* delete all M but first
- 4564.23: MKMKMKMKMKMKMK → MKKKKKKK

3: if K is a *redundant terminator* then delete M in front of it
- ↵↵: MKMK → MKK

4a: if K terminates a constant string (command name) delete the M in front of it
- cd↵: MKKMK → MKKK

4b: if K terminates a variable string (parameter) keep the M in front of it
- cd class↵: MKKKMKKKKKMK → MKKKMKKKKKMK

Using KLM

Encode using all physical operator (K, P, H, D(*n*,*l*), R(*t*))

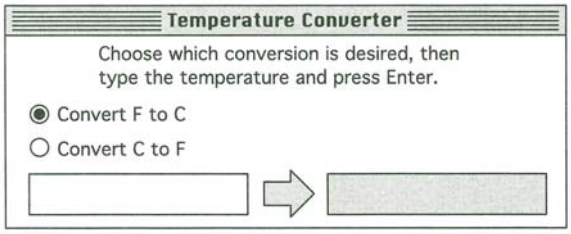
Apply Raskin's KLM rules [0-4]

Transform R followed by an M
- If $t \leq t_M$: R(*t*) → R(*0*)
- If $t_M < t$: R(*t*) → R($t - t_M$)

Compute the total time by simply adding all time

Converting Temp. Design I

Convert 92.5



Assume the focus is on the dialog box, so typing on the keyboard will enter text in the text field directly

Converting Temp. Design I

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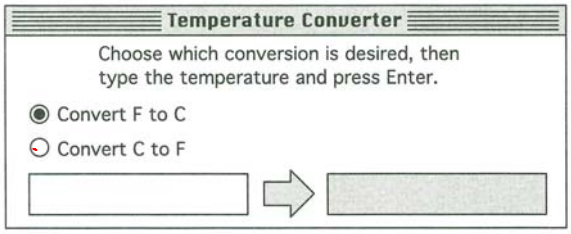

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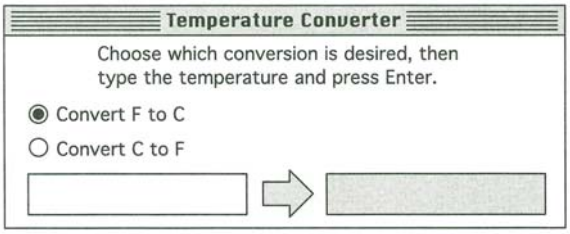

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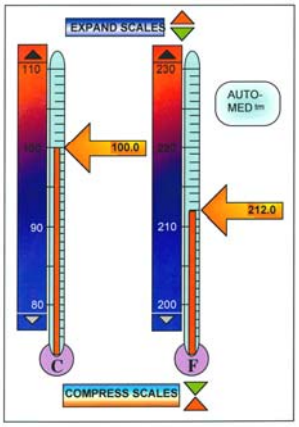
MKKKKMK (3.7s)

Average: 5.4s

HMPKHMKKKKMK (7.15s)

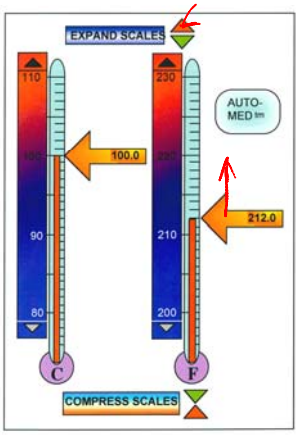
Converting Temp. Design 2



HPKPK

H MPMKPMK

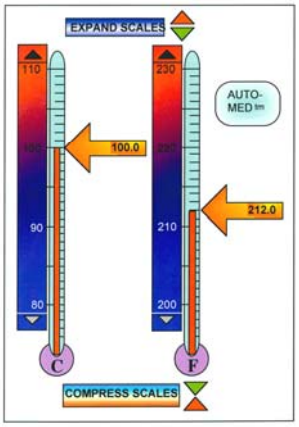
Converting Temp. Design 2



H + 3(PKSK) + PKPK

H + 3(MPKKSKK) + MPKKPKK

Converting Temp. Design 2



HMPKPK (4.35s)

Average: 13.125s

H + 3(MPKSK) + MPKPK (21.9s)

Converting Temp. Design 3

Simple text interface with the following prompt:

"To convert temperatures, type the numeric temperature, followed by C if it is in degrees Celsius or F it is in degrees Fahrenheit. Then press enter key. The converted temperature will be displayed"

K K K K K K

⋮

M K K K K K M K

Converting Temp. Design 3

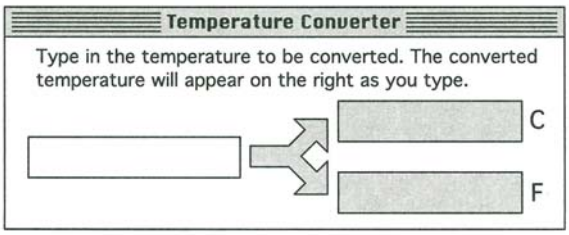
Simple text interface with the following prompt:

"To convert temperatures, type the numeric temperature, followed by C if it is in degrees Celsius or F it is in degrees Fahrenheit. Then press enter key. The converted temperature will be displayed"

MKKKKKMK (3.9s)

Average: 3.9s

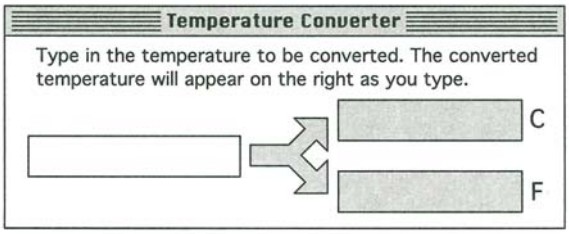
Converting Temp. Design 4



K K K K

M K K K K

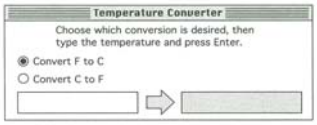
Converting Temp. Design 4

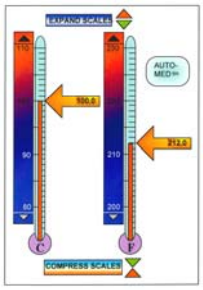


MKKKK (2.15s)

Average: 2.15s

Pros and Cons





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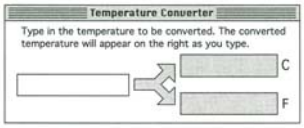


Applications of GOMS

- Compare different UI designs
- Profiling (time)
- Building a help system? Why?
  - Modeling makes user tasks & goals explicit
  - Can suggest questions users will ask & the answers

What GOMS Can Model

Task must be goal-directed
- Some activities are more goal-directed
  - Creative activities may not be as goal-directed

Task must be a routine cognitive skill
- As opposed to problem solving
- Good for things like machine operators

Serial & parallel tasks (CPM-GOMS)

Advantages of GOMS

- Gives qualitative & quantitative measures
- Model explains the results
- Less work than user study – no users!
- Easy to modify when UI is revised

Research: Need tools to aid modeling process since it can still be tedious

Disadvantages of GOMS

- Not as easy as other evaluation methods
  - Heuristic evaluation, guidelines, etc.
- Takes lots of time, skill, & effort
- Only works for goal-directed tasks
- Assumes tasks **expert** performance without **error**
- Does not address several UI issues,
  - readability, memorizability of icons, commands

Summary

GOMS and KLM

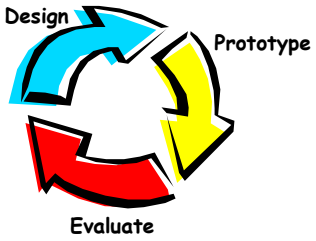
- A simple model for evaluating interface
- Requires detailed initial task description
- Description may be more useful than perf. predictions

Midterm Review

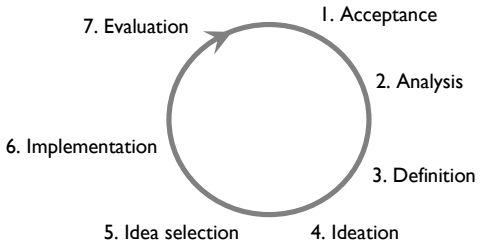
General Information

- Closed book, no cheatsheets, no electronic devices
- Format
  - Short answer and longer answer questions
  - Will involve some recall (I know this is bad interface design)
- Test-taking strategy
  - Questions will not be ordered in difficulty
  - Go through entire test, read questions, answer simple ones first
  - Read questions thoroughly
- Covers all material in lectures, sections and readings
  - Lectures mostly go over material in readings
  - Use lectures as guide to most important aspects of readings

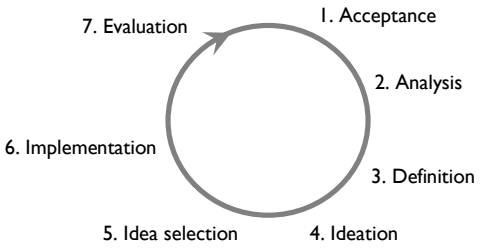
The Design Cycle

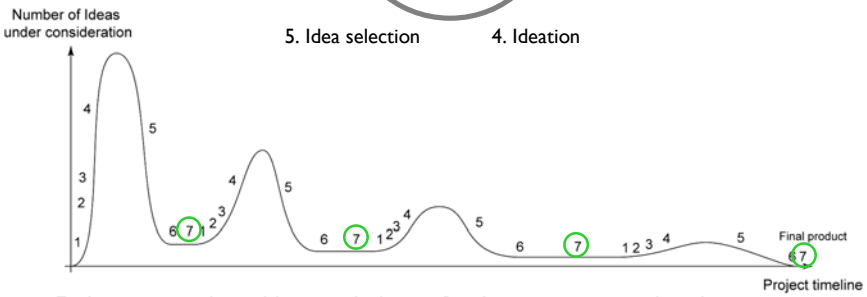


[Koberg & Bagnall]



Design Cycle Over Project Lifespan





Evaluation reveals problems with design. Re-design requires cycling the process.

IDEO's Brainstorming Rules

1. Sharpen the Focus
2. Playful Rules
3. Number your Ideas
4. Build and Jump
5. The Space Remembers
6. Stretch Your Mental Muscles
7. Get Physical

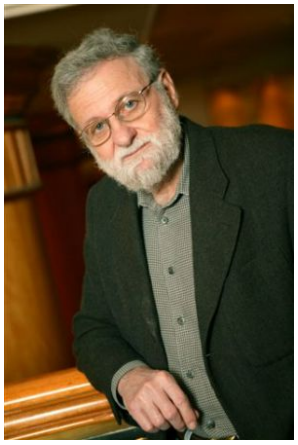
Aim for quantity

Hope for quality

Affordances

What is an affordance?

"… the term **affordance** refers to the *perceived* and *actual* properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used.



Some affordances obvious
- Knobs afford turning
- Buttons afford pushing
- Glass can be seen through

Some affordances learned
- Glass breaks easily
- Floppy disk
  - Rectangular – can't insert sideways
  - Tabs prevent backwards insertion

The Design of Everyday Things. 1988. Don Norman

Paper VS Computer

Easy to draw, write, annotate, …
Easy to read
Easy to manipulate
Easy to spread out and share
Cheap

Very difficult to modify and update
- Modification requires digital tools
- Printing is slow and often not possible

Expensive to distribute and archive
- Bits are much easier to move and save

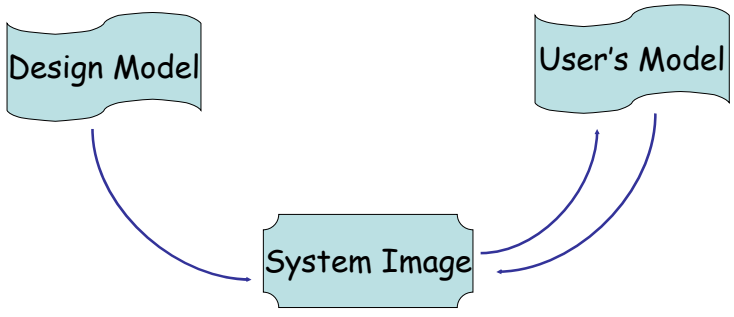
Other issues

Other Comparisons

- Anoto VS Paper
- Anoto VS Computer

- What about Tablet PCs?

Conceptual Models



- What is the user's conceptual model?
- How does the user form the conceptual model?

- What if the designers model doesn't match the user's model?

Norman's Design Principles

- Make controls visible
- Make sure mapping is clear
- Provide feedback

Task Analysis Questions

1. Who is going to use system?
2. What tasks do they now perform?
3. What tasks are desired?
4. How are the tasks learned?
5. Where are the tasks performed?
6. What's the relationship between user & data?
7. What other tools does the user have?
8. How do users communicate with each other?
9. How often are the tasks performed?
10. What are the time constraints on the tasks?
11. What happens when things go wrong?

What is the purpose of task analysis?

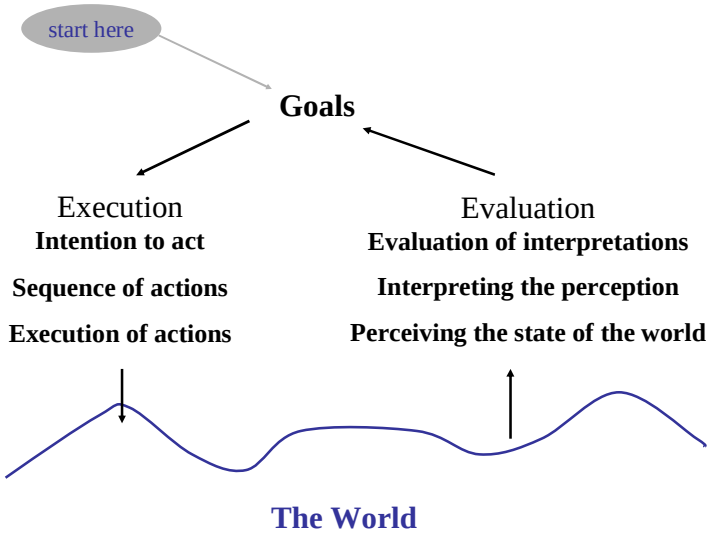
Master-Apprentice Model

Allows user to teach us what they do

- Master (user) works & talks
- We interrupt to ask questions as they go
- Each step reminds master of the next
  - Better than asking user to summarize work habits

What are other models?
How do other models compare?
What is a persona?

Action Cycle



Metaphor

Definition

The transference of the relation between one set of objects to another set for the purpose of brief explanation

Examples?

When are they effective?

When are they not effective?

Direct Manipulation

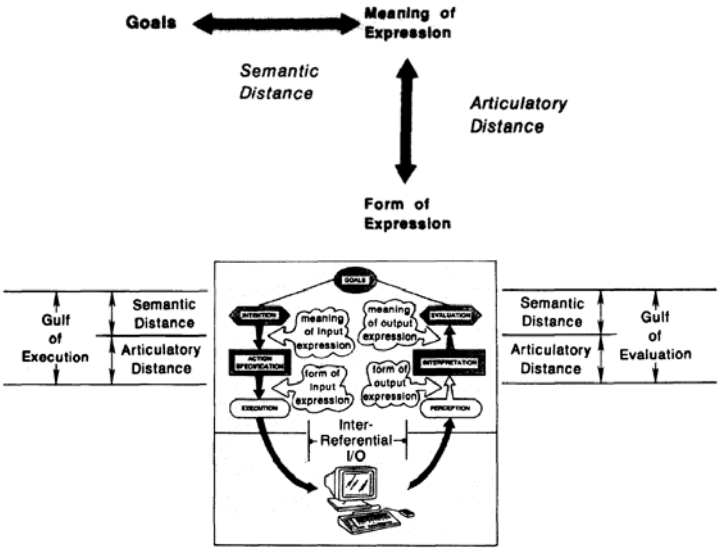
Direct Manipulation

- An interface that behaves as though the interaction was with a real-world object rather than with an abstract system

Central ideas

- Visibility of the objects of interest
- Rapid, reversible, incremental actions
- Manipulation by pointing and moving
- Immediate and continuous feedback

Semantic & Articulatory Distance



Cognition


Jef Raskin

Cognetics
- Ergonomics of the mind
- What does that mean?

Cognitive Conscious/Unconscious
- What are they?

Locus of Attention
- What is it?
- Why locus rather than focus?

Modes

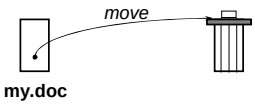
Definition

- The same user actions have different effects in different situations

Noun-Verb *VS* Verb-Noun

Noun-Verb: Select object, *then* perform action
Verb-Noun: Select action, then perform it on object

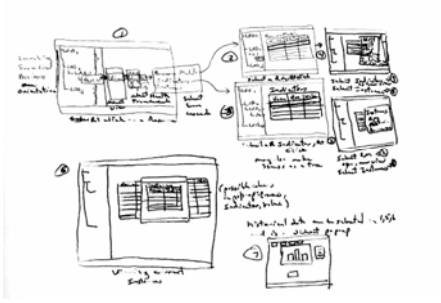
What are some examples of these two approaches?
What are the pros and cons of these two approachs?

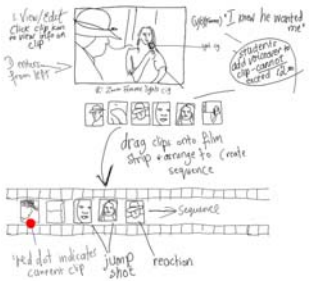


Storyboarding

Series of key frames depicting key steps in reaching a goal

- Can use a pin board for easy rearrangement/editing
- Describe the interaction in context
- Often useful to show user in at least 1st frame (establishing shot)





Fidelity in Prototyping

Fidelity refers to the level of detail

High fidelity,

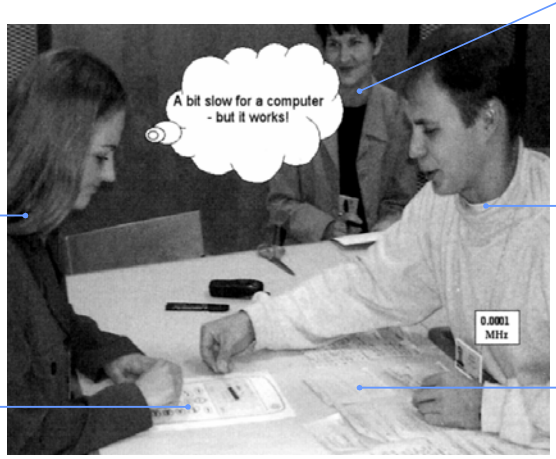
- Prototypes look like the final product

Low fidelity,

- Artists renditions with many details missing

Why do we create prototypes?

Testing Prototypes



Observer
(or video camera)

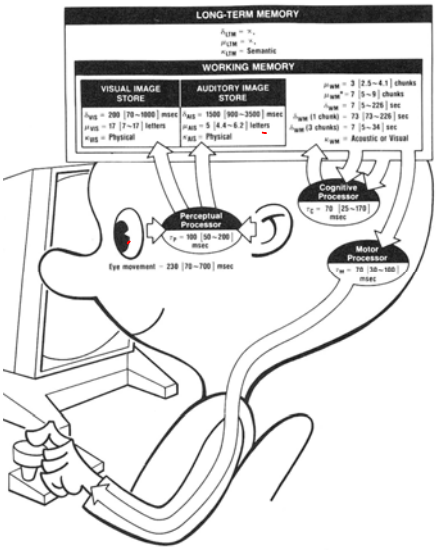
User

"Computer"

Interface

Interface elements

Model Human Info Processor



5 Parts
- Perceptual
- Cognitive
- Motor
- Working memory
- Long-term memory

Unified model
- Probably inaccurate
- Predicts perf. well
- Very influential

Last time and this time

- Hick's Law
- Power Law of Practice
- Fitts' Law
- GOMS and KLM

Next Time

Midterm Exam