Human Computer Interaction

HCI's Goal
Improve Productivity
  computer users
  software engineers

Users
Cognitive models of people as information processing systems
Knowledge about how people perform at different tasks - human factors
Individual differences

Tasks
Frequency, definition
Modifiability, existence of multiple operations & strategies
System

Ease of use, modifiability, plasticity of interaction
Ease of learning, sensitivity to user level
Task match

Class Goals
Understand user parameters for future software development and evaluation
Review software interaction styles and their applicability
Survey Interaction devices and their use. Speculate on future HCI environments
Understand HCI methodology for the evaluation of HCI research.
Review HCI role in Software Engineering and Information Technology
HCI is multidisciplinary

Computer Science
   Software Engineering, desktop (general) & specialized applications
   User Interaction, functional design

Psychology
   Models of human information processing
   language use and meaning
   human performance: human factors
   behavioral research methodology

Engineering
   Hardware interaction devices
   Human factors

Task match
HCI dialog

- mental model
- response model

IO devices
- visual
- auditory
- hands
- voice
- motion

application
- UI design
- user model
HIP is a "systems" metaphor of multiple processors and memories to explain human cognitive behavior.

*Assumes* rational, goal directed actions.

**Human Information Processing**

- **Form intention:** acquire task, make mental representation of goal
- **Select action:** review possible actions, select appropriate action
- **Execute action**
- **Evaluate system response**
HIP Processors & Memories

Processor parameter is cycle time

Memory parameters:
- storage capacity
- decay rate (forgetting)
- information code (storage mechanism)

Memory Hierarchy
- information is transferred between "memories"
- by perceptual and cognitive processors

Sensory / image (receptor): mechanical, chemical, neural

Awareness: visual-acoustic-tactile -semantic (short term)

Unconscious: semantic and procedural knowledge (long term)
## Perceptual

- **Processor cycle**: 50 - 200 msec.
- **Eye movement**: 70 - 700 msec.

<table>
<thead>
<tr>
<th>Image store</th>
<th>Visual</th>
<th>Auditory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>7 - 17 symbols</td>
<td>4 - 7 symbols</td>
</tr>
<tr>
<td>Decay</td>
<td>70 - 1000 msec.</td>
<td>900 - 3500 msec.</td>
</tr>
<tr>
<td>Code</td>
<td>physical (neural / chemical)</td>
<td>physical (waves)</td>
</tr>
</tbody>
</table>

- **Tactile store**: ??

- **Motor**: not well understood in HIP context

- **Cycle**: 30 - 100 msec
**Cognitive**

<table>
<thead>
<tr>
<th>Memories</th>
<th>Awareness / Working</th>
<th>Long Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>capacity</td>
<td>$7 \pm 2$</td>
<td>unknown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>est. $10^8 .. 10^{12}$</td>
</tr>
<tr>
<td>decay</td>
<td>5 - 225 msec</td>
<td>unknown</td>
</tr>
<tr>
<td>code</td>
<td>acoustic - visual</td>
<td>semantic</td>
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</tbody>
</table>

Working memory is consciousness
Long Term memory is unconsciousness

Chunks are organized groupings of information

Experts chunk information differently (size && structure)

Working memory is an intermediate store while matching and retrieval processes are performed in long term memory

Information is retained in WM through rehearsal
Categories of Long Term Memory

- **Episodic**: life events
- **Semantic**: abstract facts, concepts, "aha" learning
- **Procedural**: actions, motor and cognitive skills for doing things, scripts, plans, incrementally learned
Syntactic Semantic Model of User Knowledge

Syntactic knowledge

Task and environment specific knowledge.

Syntactic knowledge facts are often discrete and disjoint from other syntactic facts.

- text editor command to move forward 1 word
  - emacs "esc f"
  - vi "W"

**Learning:** arbitrary nature often requires rote learning, learn by doing.

**System dependency:** syntactic rules vary with system. Same goal requires different operations. (how to terminate a session)

**Interference:** same operations can have different results across applications and systems. (what does the "end" key do)

**Reduce Syntactic Complexity:** structured command sets, menus, direct manipulation environments. (structure command sets, menus, GUI)
Semantic Knowledge

Conceptual knowledge about the domain of a task and environment.

Concepts are built upon each other, they are interconnected and have some "semantic" structure -- relationship.

Semantic knowledge is best taught by analogy, or example, to other knowledge and by practical experience.

  Pictorial representations are helpful.
  Negative examples (misses).

Task experts maybe computer novices & computer experts maybe task novices.

concepts: stable memory, generalize across computer systems and applications.

tasks: often decomposable into subtasks with analogy to other known tasks.
Human performance

Measured as correct or error.

Correct Performance

Correctness  count or percentage task correctly performed.
Speed        time to perform task
Efficiency   path to perform task
Learning     time to learn task practice trials to learn task

Error Performance

Frequency count or percent of errors
Categorization of errors: omission or commission, ...
**Human Error**

**Error** a planned mental or physical activity that failed its intended outcome where the failure is not attributable to chance events.

**Intention** a specification of desired action, a goal. Intentions generate plans (schemas, actions) to achieve goal.

**Mistake** an error in intention (deficient judgment or inference).

**Lapse** a failure in storage of the intention.

**Slip** an error in execution of intention. Can make slips on mistakes...

<table>
<thead>
<tr>
<th>Cognitive Stage</th>
<th>Primary Error Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>planning</td>
<td>mistakes</td>
</tr>
<tr>
<td>storage</td>
<td>lapses</td>
</tr>
<tr>
<td>execution</td>
<td>slips</td>
</tr>
</tbody>
</table>
Mode error. A slip in formalizing intent. Action is valid in one environment are errors in another.

Lack of feedback -- mode is unknown
Vi has insertion mode and command mode, but no mode indicator
soln: one mode, or clear mode indicators

Description error. Ambiguous specification of intent. Commands have no or little semantic rules -- function keys

bad commands: Vi "d" deletes 2 lines, "D" deletes end of line "^D" moves cursor forward 1/2 screen

soln: menu selection, semantic rules, distinct command keys

Capture error. Dominant command sequence overrides less used plan.
save before exit (y)

Externally Triggered event. Plan activated due to external interruption during intent formalization.
Individual Differences

Control

User prefers to be in control of application

system requests not system commands

system actions result of user initiation. system does not seem to "run away" from user.

user controls system response, pace.

Direct manipulation via pointer device or keyboard facilitates user sense of control.

Consistent system response time facilitates planning, pacing & "control".

HCI history = movement from system control to user control.

system  Batch ➔ Timesharing ➔ GUI  user
Closure

Viewing the completion of tasks is an example of closure. The motivation to see action complete is closure.

User desire for closure might result from the reduction in "memory" load uncompleted tasks represent.

Users w/ high closure needs may prefer to use many primitive commands versus abstract commands.

In text editing: using a query replace string versus a non query replace string command.

Full screen editors provide greater closure (seeing the results of one's actions) than line editors. VI versus ed.

Experts users often prefer to watch the results of know actions than to run processes in a background - non visible mode.
Individuality

Users vary on many personality traits and abilities and on many sensory / physical abilities. EG: Myer Briggs Types below:

INTROVERSION / EXTROVERSION

Introverted prefer working alone, familiar environments, little external stimulation (quiet...). (the minority)

Extroverted users prefer external stimulation, variety in the environment, working with others.

SENSING / INTUITIVE

Sensing users prefer detail work, like applying known skills (repetitive)

Intuitive users prefer new problems, discovery, and "high/level" not detail work.
PERCEPTIVE / JUDGING

Perceptive users like learning new environments but have problems evaluating systems.

Judging users prefer working by a detailed plan and completing the goal -- often w/o regard for new information.

FEELING / THINKING

Feeling users are aware of, and seek to, please others. They relate well with others.

Thinking users tend to be unemotional, treat others "coldly" and make decisions on "logical" bases.

These 4 dimensions are not independent!
CIT more extroverted (less introverted) than CS majors

$F = 11.085 \ (1, \ 124), \ p < .001$
PERSONALITY dimensions

- risk takers / risk avoiders
- tolerance for stress and ambiguity
- internal / external locus of control
- compulsiveness, motivation.

COGNITIVE individuality dimensions

- convergent (single answer) / divergent (many answers) thinking
- creativity, intelligence (verbal, visual, ...)
- learning styles and ability
- visual / verbal thinking style
Physical differences

Users can also vary on their physical abilities or disabilities. Reading and typing speeds, hand coordination, spatial perception, color perception.

Is it possible for software to adapt itself to the personality of a user? Microsoft's "Office Assistants" -- social personality interfaces

User modeling is an emerging area?
**Users**

- World Knowledge
- Learning
- Pattern matching
- Conceptual / analogical
- Productive Thinking
- Vision & Hearing

**Strengths**

- Fast Accurate
- Reproductive "Thinking"
- Never Forgets
- Non Ambiguous Knowledge

**Weaknesses**

- Limited World Knowledge
- search results = knowledge ??
- limited Pattern Matching, Analogy
- limited Learning
- limited Vision & Hearing

**Computer Applications**

- Fast Accurate
- Reproductive "Thinking"
- Never Forgets
- Non Ambiguous Knowledge