Course Overview

- **Introduction**
- **Understanding Users and Their Tasks**
- Principles and Guidelines
- Interacting with Devices
- Interaction Styles
- UI Design Elements
- Visual Design Guidelines
- UI Development Tools
- Iterative Design and Usability Testing
- Project Presentations & Selected Topics
- Case Studies
- Recent Developments in HCID
- Conclusions

Chapter Overview Chapter-Topic

- Motivation
- Objectives
- Human Information Processing
- Implications for HCID
- User Profiles
- Task Analysis
- Formal Modeling
- Important Concepts and Terms
- Chapter Summary

[Dix, Preece, Mustillo, Norman]

Restrained Human Interaction

- practical exercise to demonstrate some aspects of human interaction

STOP

Without talking, let your neighbor know about your efforts to find a copy of the textbooks for this class.

Restrained Human-Computer Interaction

- mental exercise to demonstrate some aspects of the interaction between humans and computers

STOP

You've been working on the COMP 675 assignment all night, and you finally finished the spell check at 4:37am. You're ready to print it out, when with a swishing noise - not very loud - your display goes blank.

Will you be able to print out your document without using the visual output from the computer?

Motivation

- In order to design good interfaces between humans and computers, the designer must have a basic understanding of
  - how humans deal with information
  - how computers deal with information
- Some properties of the human information processing apparatus impose limitations on HCI.
- Technological and economical considerations impose limitations on the computer's side.

Objectives

- to know the most important aspects of human information acquisition, storage, retrieval, and communication
- to be aware of the consequences of human information processing for HCID
- to understand the importance of the users' limitations, preferences, and contexts
- to be able to apply formal and informal techniques for user needs and task analysis

Human Information Processing

- **Perception**
  - visual
  - auditory
  - other senses (tactile, gustatory, smell)
- **Cognition**
  - memory
  - problem solving
  - learning
- **Motor behavior**
  - speaking, typing, pointing, others

Vision

- primary channel for information from computer to human
- stages of visual perception
  - reception of the light stimulus
  - conversion of light into electrical signals
  - processing of the signals
  - interpretation of the information
- aspects of visual perception
  - brightness, color, luminance
  - patterns
  - movement

Vision Characteristics

- low-level perception of light
- transformation and interpretation of complete images
- concentration on critical tasks
  - patterns, color in the fovea
  - movement in the peripheral area
- compensation for physiological and environmental effects
  - movement
  - normalization of color and brightness despite changes in luminance
  - disambiguation between possible interpretations

Reading

- perception and processing of written text
- most important cognitive activity for HCI
- selection by movement, focusing
- stages
  - visual perception of patterns
    - characters, words
  - decoding of the patterns
  - translation into an internal language representation
  - syntactic and semantic analysis
- relevance for HCI
  - typical reading speed: 250 words per minute
  - legibility

Hearing

- processing of sound
- stages of auditory perception
  - reception of the sound waves
  - conversion into electrical signals
  - processing of the signals
  - interpretation of the information
- aspects of visual perception
  - pitch (frequency)
  - loudness (amplitude of the sound)
  - timbre (type of sound)
  - location

Hearing Characteristics

- low-level auditory processing
- detection of patterns
  - familiar noises
  - language
- selection by filtering out noise
- very important for human communication
- relevance for HCI
  - somewhat neglected in favor of vision
  - speech understanding may substantially alter HCI
  - additional information
    - alarm, system status, pleasure

Touch

- also known as haptic perception
- stimuli are received through the skin
  - heat/cold, pressure, pain
- feedback on the position of body and limbs (kinesthesis)
  - touch typing
- relevance for HCI
  - only serves for secondary purposes
    - tactile feedback on keyboard, mouse
  - more important for virtual reality environments

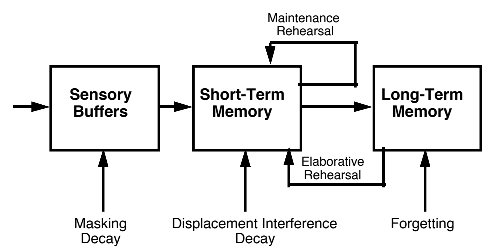
Movement

- motor control
- feedback loop between sensors and muscles
  - mostly haptic sensors, but also hearing and vision
- response time
  - reaction time
  - movement time
- accuracy
- relevance for HCI
  - important for typing, mouse navigation

Human Memory

- storage of
  - factual knowledge
  - actions and procedures
  - emotions
- three types of memory
  - sensory buffers
  - short-term memory
    - also known as working memory
  - long-term memory

Overview Human Memory



 [Dix, Mustillo]

Sensory Memories

- buffers for stimuli received through the senses
- a sensory memory exists for each sensory channel
  - iconic memory for visual stimuli
  - echoic memory for aural stimuli
  - haptic memory for touch
- very short duration
  - fractions of seconds
- constantly overwritten by new stimuli
- normally not consciously noticed
  - only as side-effects
- attention directs the transfer of information to short-term memory

Short-Term Memory

- temporary recall of information
  - sentence comprehension, reasoning, interpretation of sensory information
  - quick access
    - around 70 ms
  - quick decay
    - around 200 ms
  - very restricted capacity
    - 7 +/- 2 items
    - chunking can be used to improve recall

Short-Term Memory (cont.)

- relevance for HCI
  - use chunking to utilize short-term memory capacity more effectively
    - e.g. phone numbers, ZIP codes
  - severe limitations for interaction
    - don't expect the user to keep more than 7 +/- 2 items of information "on hold"
      - frequent problem with navigation in Web pages, voice mail labyrinths
  - closure
    - short-term memory is flushed when a task is perceived to be finished

Long-Term Memory

- permanent storage of all types of knowledge
  - longer recall time
    - about a tenth of a second
  - very high capacity
  - slow rate of forgetting
    - decay or interference?
- types of long-term memory
  - episodic
    - events and experiences
  - semantic
    - structured, inter-related records of facts, concepts, rules, skills, etc.
    - derived from episodic memory
    - inspiration for semantic networks

Long-Term Memory (cont.)

- important functions
  - storage
  - forgetting
  - retrieval

Reasoning and Problem Solving

- essential activities for "intelligent" behavior
  - despite advances in Artificial Intelligence, humans are still much better at most tasks
- relies heavily on memory for storage and retrieval of knowledge
- important for the interpretation and disambiguation of complex sensory inputs

Reasoning

- various types of reasoning
  - deduction
    - derivation of logical conclusions from given premises
      - not always valid in the "real world"
  - inductive reasoning
    - generalization from known to unknown cases
    - unreliable; cannot be proven to be true
  - abductive reasoning
    - derivation of (probable) causes from known facts
    - used for explaining outcomes of situations
    - unreliable

Problem Solving

- finding a solution to an unfamiliar task
- reasoning may be one method to find a solution
- creativity is also very important

Problem Solving Theories

- Gestalt theory
  - reuse of experience
  - insight and restructuring of the problem
- problem space theory
  - getting from the initial state to a solution state via intermediate states generated by state transition operators
  - basis for many AI approaches

Problem Solving Theories (cont.)

- analogy
  - mapping knowledge from similar domain to the new problem
- mental models
  - internal theories about the functioning of systems
    - usually partial, and almost always incomplete, inconsistent
    - unstable

Problem Solving and HCI

- help the user with the construction of mental models
  - easy to understand, consistent behavior of the (partial) system
- provide cues to trigger the best solution to a problem
- try to predict errors likely to be made by users
  - changes in the context
  - incorrect understanding
  - fatigue

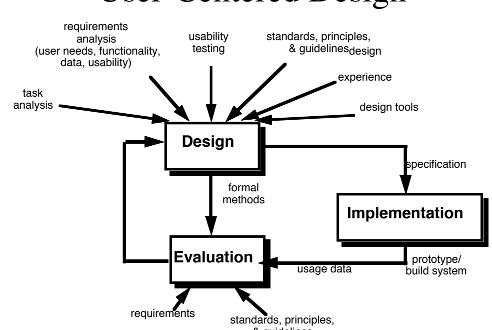
Cognition and HCI

- guidelines
  - principles and guidelines derived from cognitive theory and psychology
- models of user behavior
  - analytic or predictive models
- evaluation techniques
  - empirical methods to asses the performance of systems

User Modeling

- informal approaches
  - user needs analysis
  - task analysis
- formal models
  - GOMS

User-Centered Design



 [Mustillo]

Designing Usable Systems

- **Know the user**
  - Individual user characteristics *(who they are)*
  - The user's current & desired tasks *(what they do)*
  - Functional analysis *(how they work)*
  - The user's evolution & job *(how they change)*

Users

- Users are <u>not</u> a homogeneous group of people. They differ from each other in many ways:
  - **Physically**
    - height, weight, strength, reach, left- or right-handedness, dexterity, visual acuity, general health & fitness, etc.
  - In terms of prior **experience & knowledge**
    - task they want to perform
    - computer systems

Users (cont.)

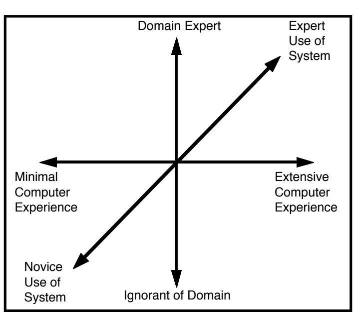
- **Psychologically**
  - personality
    - adventurous or timid,
  - cognitive capabilities
    - quick or slow learners
    - good or bad memories
    - motivation
- **Socio-culturally**
  - background, education, age, race, gender, ethnic background
  - Implications for the design of international UIs

Designing a good user interface requires a thorough understanding of users and the factors that affect them.

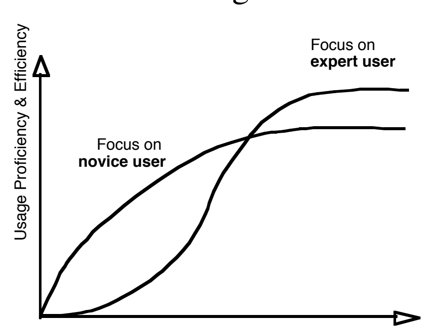
Factors to Consider

- Organizational
  - Training, job, politics, roles, work organization
- Environmental
  - Noise, heating, lighting, glare
- Comfort
  - Seating, equipment,work layout
- Current UI
  - Media, input devices, output devices, documentation
- Task Factors
  - Easy, complex, novel, repetitive, skills
- Constraints
  - Time, cost, resources (staff), equipment
- System Functionality
  - Hardware, software, applications

User Categories



User Learning Profiles



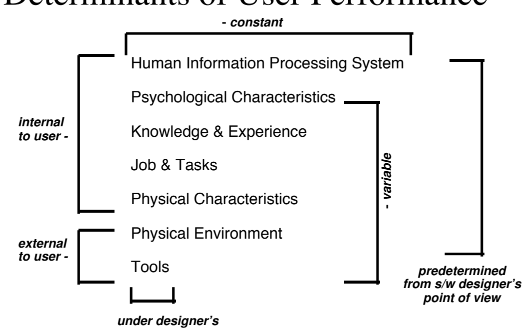
User Needs Analysis

- Defines the needs of specific users under study
- Used early in the development process to create a user profile of the target users
  - in terms of their abilities, preferences, work environment, etc.
- Provides a specific description of relevant characteristics of the intended user population.
- Feeds directly into task analysis
  - identify important categories of users to focus on

Determining a User Profile

- **Informal methods** for understanding & characterizing users:
  - Surveys/questionnaires
  - Focus groups
  - Structured interviews
  - Observation/listening
  - Personal records
  - Become a user

Determinants of User Performance



Users' Psychological Characteristics

- Cognitive style
  - verbal, analytic, spatial, intuitive
- Attitude
  - positive | neutral | negative
- Motivation
  - high | moderate | low

Implications for UI Design

User Characteristic	*Design Goal*
Low motivation, discretionary use	Ease of learning
Low motivation, mandatory use	Control, power
High motivation, due to fear	Ease of learning, robustness, control, power
High motivation, due to interest	Power, ease of use

Knowledge and Experience

Reading Level
__ < 5th grade
__ 5th - 12th grade
__ > 12th grade

Typing Skill
__ < 15 wpm
__ 15 - 50 wpm
__ > 50 wpm

Education
__ No degree
__ Trade school
__ High school
__ CEGEP degree
__ University degree
__ Advanced degree

System Experience
__ Novice
__ Moderate
__ Expert

Task Experience
__ < 1 yrs.
__ 1 - 3 yrs.
__ > 3 yrs.

Application Experience
__ No similar apps.
__ One similar app.
__ Some similar apps.

Native Language
__ English
__ French
__ Other

Use of Other Systems
__ Little or none
__ Some
__ Frequent

Computer Literacy
__ None
__ Moderate
__ High

Task & System Experience

- little task or system experience
  - informative system messages
    - e.g., Pitch 1 = 10 pt, 2 = 12 pt
  - good error recovery procedures
- high degree of both task & system experience
  - efficient commands & concise syntactic error messages
- a lot of system but little task experience
  - semantic help facilities & messages
    - e.g. “Press F6 for a list of departments”
  - efficient command syntax
- a lot of task but little system experience
  - minimal semantic prompting, but a lot of syntactic prompting & instructions
    - e.g., “Click on ENTER to accept form”

Users’ Jobs and Tasks

Frequency of Use
__ < 2 days/month
__ 2 - 10 days/month
__ > 10 days/month

Primary Training
__ None
__ User manual only
__ Formal training

System Use
__ Mandatory
__ Discretionary

Job Category
__ Executive
__ Manager
__ Secretary
__ Clerical

Turnover Rate
__ < 5% per yr.
__ 5 - 10% per yr.
__ > 10% per yr.

Other Tools
__ Telephone
__ Calculator
__ Other

Task Importance
__ Low
__ Moderate
__ High

Task Structure
__ Low
__ Moderate
__ High

User’s Jobs and Tasks (cont.)

Considerations	***Implications for User Interface Design***
Frequency of Use	**Design Goals**
High	Ease of use
Low	Ease of learning & remembering
Task Importance	
High	Ease of use
Low	Ease of learning & remembering
System Use	
Discretionary	Ease of use
Mandatory	Ease of learning & remembering

Users’ Physical Characteristics

Handedness
__ Right
__ Left
__ Ambidextrous (both hands)

Gender
__ Female
__ Male

Age
__ 18 - 25
__ 26 - 40
__ 41- 55
__ 56+

Glasses
__ Yes
__ No

Color Anomaly *
__ Yes
__ No

In the total population, about 8% of males & 0.4% of females have some sort of color vision deficiency).

Implications for UI Design: Examples

- Placement of keys, & design of alternate input devices should accommodate both right- & left-handed users.
- Color & color combinations should be selected judiciously.
- Physical handicaps (e.g., lowered vision -> larger type).

Physical Environment

- Working conditions
  - noise level
  - privacy
  - strenuous labor
  - use of machinery
- Implications for UI design
  - Extraneous noise should be minimized.
  - Judicious use of input/output devices (e.g., public spaces)
  - Glare control
  - Adjustable furniture & table heights

Example: User Tasks

	Applications	
Information Kiosk (Mall)		**Airline Reservation**
	User Definitions	
All job types All education types Male & female English, French, Spanish, etc. Low computer literacy Low frequency of use No training, no manual Discretionary use		Clerical High school to BA/B.Sc. Mostly female English/French Moderate computer literacy training Mandatory use
	Design Choices	
Touch screen Menus, icons Easy to learn (heavy prompting, highly structured, rigid, fault tolerant)		Keyboard Command language Easy to use (hidden help, highly flexible) High efficiency

Tasks

Activities that a user needs to do in order to achieve an objective.

- Important *what* & *how* questions to ask when trying to understand users' tasks:
  - What tasks do users perform?
  - Which tasks are most critical?
  - What steps are taken to perform tasks?
    - Is there a typical order that must be followed?
    - Are there other ways?

Tasks (cont.)

- more questions ...
  - What are the implications of doing the task one way vs. another?
  - What are the users' goals for performing tasks?
  - What information is needed to complete tasks?
    - What kinds of skills & knowledge are required to perform the task (i.e., training)?
  - What tools are used to complete tasks?
  - What output is generated from the tasks?

Tasks (cont.)

- Additional questions:
    - Is the task required?
    - Is the task repetitive?
    - To what extent does the task vary from one occasion to the next?
    - Will the task be carried out regularly, infrequently, or only once?
    - How critical is the task? Is it really important?
    - Are there specific critical criteria, such as error or speed that are important?
    - Is time a critical factor?
    - Will users do the task alone or with others?
    - Will users be switching between this & other tasks?
    - Will users do just one task or multiple tasks?
    - What is the users' experience with doing the task?
    - How complex is the task?
    - Is the task important for users (i.e., perceived task importance)?

Task Analysis

- identifies all tasks required to successfully complete a job or an activity
- specifies the order in which they must be completed
- Task Analysis Methods
  - Hierarchical
  - Sequential

Task Components

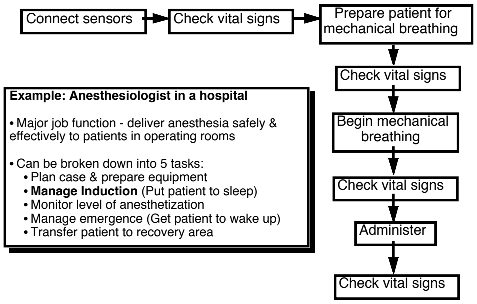
- Each task has:
  - an objective (goal) to achieve
  - a starting point that initiates it
  - an action or set of actions (can be perceiving & using information, making decisions, or performing an observable action)
  - a stopping point when information is received that the objective of
  - the task has been achieved
- Each task can be decomposed, or broken down into smaller sub-tasks.

Hierarchical Task Analysis

- one of the most well known forms of task analysis
- graphical technique that focuses on what activity happens, rather than on what should happen.

Example: Task Analysis

Task: Manage Induction



Example: Anesthesiologist in a hospital

• Major job function - deliver anesthesia safely & effectively to patients in operating rooms

• Can be broken down into 5 tasks:
- Plan case & prepare equipment
- **Manage Induction** (Put patient to sleep)
- Monitor level of anesthetization
- Manage emergence (Get patient to wake up)
- Transfer patient to recovery area

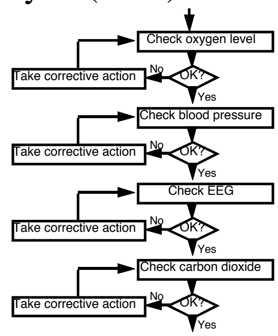
Task Analysis (cont.)

Sub-Task:
Check vital signs

Objective:
Assure that vital signs are OK

Starting point:
Sensors are connected

End point:
All vital signs are OK.



Performing a Task Analysis

- Interviews with observations of representative users
  - Obtain a description of how users currently accomplish the task
  - Ask users to describe their relevant work activities.
    - Ask "why" questions to get at major goals.
    - Ask "how" questions to get at details of actions of actions that accomplish goals.

Value of Task Analysis

- Focuses attention on users' tasks
- Provides a rational basis for making design decisions
  - Objectives of each task
  - Which tasks are important
  - Which tasks depend on each other

Sample User Needs Analysis

User Profiles	Male and Female (x% M). More females than males. • Adult (x- y years) • North America, US/Canada • SOHO (telecommuters/home business/bring office work home) • Primarily English speaking • Medium to advanced computer skills • Perceive using technology as a means of saving time and money • Own more than one telephone • Comfortable with advanced telephone terminals • Learn primarily by reading documentation • No previous knowledge of PVD application • Minimal or cursory contact with speech recognition technology
User Tasks	• Perform many diverse tasks, ranging from accounting to technical consulting • Rely on PC to do work
User Requirements	• Easy to use - requires no or limited training • Intuitive - the applicationís goals and how to accomplish them are obvious • Fast - must successfully contact the user with the intended caller in little time • Natural - requires little learning • Available 24 hours per day • Speech driven - just say the name • Supports hands-free operation • Easy, fast access (single button) - no need to dial multiple digits
User Environments	• Stand-alone or networked desktop PC • Variable noise conditions (quiet to noisy) • May contain other peripherals (e.g., modem, fax machine, printer)
Matching Requirements to User Tasks	• PVD application must be immediately available when the user presses the start button

Formal User Modeling

- Categories of formal modeling methods
  - Exploratory tools in research
  - Theoretical formulations of user behavior
  - Evaluation of interfaces
- Need for formal modeling
  - only formal methods can provide a true representation of how users will interact with a given system (interface)

GOMS

- *Goals*, *Operators*, *Methods*, & *Selection rules*
- **GOMS** is the best known & most widely cited of the formal analytical user models
- developed to describe a task & the user's knowledge of how to perform a task in terms of a limited set of categories
- based on the pioneering work of Card, Moran, & Newell (1983)

GOMS Analysis

- **G**oals
  - What task does the user want to perform?
- **O**perators
  - motor, perceptual, or cognitive primitives
  - What actions does the software allow the user to take?
- **M**ethods
  - sequences of sub-goals & operations needed to accomplish a goal?
- **S**election Rules
  - decide what to do next
    - user has several goals pending
    - there are several methods that will accomplish a given goal

GOMS Levels

- *GOMS model*
  - describes the *general* methods for accomplishing a set of tasks
- *Unit task level*
  - breaks users' tasks into sub-tasks called *unit tasks*
  - estimates the amount of time that it takes for the user to perform these tasks
- *Keystroke-level model*
  - describes & predicts the amount of time to perform a task
    - number of keystrokes needed

GOMS Example

- Operators
  - 4 physical-motor operators,
    - K (keystroking), P (pointing), H (homing), D (drawing)
  - 1 mental operator (M)
  - 1 system response operator (R)
- Execution time
  - $T_{execute} = T_K + T_P + T_H + T_D + T_M + T_R$

Usefulness of GOMS

- **GOMS can be useful to**
  - predict the quality of an existing system or a prototype
  - check the consistency of methods (to ensure that similar goals are achieved by similar methods)
  - check that the most frequent goals are achieved by relatively quick methods
  - as a quantitative evaluation technique
  - choose between alternative designs
  - predict the execution time of tasks that skilled users are likely to perform (e.g., pilots - *skilled performance time)*
  - to predict how long it will take to learn to perform a task
    - learning time

Limitations of GOMS

- skilled users, not beginners / intermediate users
- account of skilled performance at asymptote
  - but no account of either *learning* of the system or its *recall* after a period of disuse.
- errorless performance
  - no account of the *errors* that frequently occur even in skilled performance.
- focuses on perceptual & motor components, but not on *cognitive processes*.
- Assumes a *serial* nature of tasks

Limitations of GOMS (cont.)

- Does not address
  - *mental workload* - how much must be held in mind while using the system.
  - amount & kind of *fatigue* users experience using a system.
  - *functionality*, just usability of a task on the system
    - what tasks should be performed.
- Does not account for *individual differences*.
- Says nothing about the system's *acceptability* or *usefulness.*

Chapter Summary

- humans as information processing systems
  - acquisition, storage, processing and retrieval of information
    - perception, memory
    - reasoning and problem solving
- understanding the user
  - different types of users, user profile
  - knowledge and experience
- task analysis
  - jobs and tasks
- user modeling
  - GOMS: Goals, Operators, Methods, and Selection rules