
COSC368: Humans and Computers

The course provides an introduction to Human-Computer Interaction (HCI). HCI is concerned with understanding, designing, implementing and evaluating user-interfaces so that they better support users in carrying out their tasks. On completing the course you will have knowledge of the theoretical foundations of designing for interaction between humans and computers. You will also have practical experience in implementing and evaluating graphical user interfaces.

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Humans and Computers

Course Information

Lecturers Details

- Lecturer: Andy Cockburn
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- Tutors:
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Schedule

Topics

- Introduction
- Models of interaction and interface technology
- The human
- Interface design
- Evaluation
- UI intellectual property

| | | LECTURES | LABS |
|------|-----------|---|---|
| Week | Beginning | | |
| 1 | 19-July | Introduction to HCI | Lab 1: Python/TkInter refresher |
| 2 | 26-July | Models of interaction | Lab 2: Python/TkInter: Keyboard GUI |
| 3 | 2-Aug | The Human – senses | Lab 3: Python/TkInter: Canvas & Fitts law GUI |
| 4 | 9-Aug | The Human – performance and phenomena | Lab 4: Fitts' law experiment and analysis |
| 5 | 16-Aug | Interface Design – Iteration | Lab 5: Sketching Designs |
| 6 | 23-Aug | Interface Design – Task Centred System Design | Assignment help |
| | 30-Aug | | |
| | 6-Sept | | |
| 7 | 13-Sept | Interface Design – Heuristics | Lab 6: Visual search, decision, skill development |
| 8 | 20-Sept | Interface Design – Heuristics II | Lab 7: Performance prediction |
| 9 | 27-Sept | Interface Design – Graphical design | Lab 8: Heuristic evaluation |
| 10 | 4-Oct | Interface Evaluation & Empirical Methods | Lab 9: Experimental data analysis |
| 11 | 11-Oct | Interface Evaluation & Empirical Methods 2 | Assignment help |
| 12 | 18-Oct | Overflow and UI Intellectual Property | |
| | | | |

Figure 1: Course Schedule**Assessment Structure**

- Labs (9%)
 - 1% per lab
 - Binary marking scheme - go to the lab, get full marks
- Usability analysis and storyboard (25%)
 - Wed 22nd September 5:00 pm
 - Teams of ~six, forming own groups
- Design Specification and Rationale (15%)
 - Wed 20th October 5:00 pm
- Exam (51%)
 - TBA

Textbooks/Resources

- Designing with the Mind in Mind
 - Based on COSC368, Old lecturers thoughts

- Author: Jeff Johnson, Morgan-Kaufmann
- Papers on ACM Digital Library
- Other materials on Learn

Lectures

Lecture One - Introduction

Technologies in this course

- Tkinter
 - Lab one - Refresher
 - Lab two - Keyboard GUI
 - Canvas & fitts law GUI
- Python

NOTE: Labs will be used as the basis for analysis in assessments, so we need to build them

What is HCI?

Human computer interaction (HCI) is a discipline concerned with the design evaluation and implementation of interactive computing systems for human use, and with the study of major phenomena surrounding them.

What is HCI Responsible for?

1. Learnability
2. Efficiency
3. Subjective satisfaction
4. *Memorability*
 - Mostly encapsulated in Learnability
5. *Errors*
 - Opposite of Efficiency

Lecture Two - Goals of HCI

Knowing the user: Preliminary Factors

- safety considerations
- need for throughput
- Frequency of use
- Physical space, lighting, noise, pollution
- Social context
- Cognitive factors: age, fatigue, stress, focus

Managing complexity

- Poorly designed interfaces amplify complexity
- Well designed UI's make interfaces as simple as possible, but no simpler
- Sometimes it may be appropriate to over-simplify *cater to an audience*

Models of Interaction

- A model is a simplification of reality
- They are useful when they help us understand a complex artifact

Don Norman's Model of Interaction

- Helps understand the designer's role in creating a system that is used by a thinking person
- Generally designers have a design model that is incomplete
- Then we get a system image, that is working, but in high incite, we would have built it differently
- The user has a model, that is weak, we need to try to map the designers model with the user model to create a mapping of the system image.

Lecture Three - The Human

Don Norman's Execute-Evaluate Cycle

- Execute:
 - Goal > Intention > Actions > Exeution
 - Gulf of Execution: Problem arrives when executing intention/action
- Evaluate:
 - Perceive > Interpret > Evaluate
 - Gulf of Evaluation: Problem assessing state, determining effect, etc. **UIISO Interaction Framework**
- Emphasises translations during interaction - This is a cycle

1. Articulation: user's task language to input language
2. Performance: callbacks, etc.
3. Presentation: show new state
4. Observation: interpretation
5. Back to step one

Mappings

- Good mappings (relationships) between User and I/O, increasing Usability.
- We can try to allocate real world relationships by using mappings to real world items
 - We can also use spacing and different design to make things more intuitive

Affordance

- Objects afford particular actions to users
 - Buttons afford pushing, chairs for sittings, sliders for sliding, dials for turning, handles for pulling.
 - Poor affordance encourages incorrect actions
 - Strong affordance may stifle efficiency

Over and Under-Determined Dialogues

- Ideally dialogue is well-determined, natural translation from task to input language
- **Under-determined** - User knows what they want to do, but not how to do it
- **Over-determined** - User forced through unnecessary or unnatural steps

Direct Manipulation

- Visibility of object
- Direct, rapid, incremental, reversible actions
 - This allows users to learn the interface and experiment without loss of data or risk
 - Unix's `sudo rm -rf / --no-preserve-root` is **NOT** an example of this as it is not reversible
- Rapid feedback
- Syntactic correctness
 - Disable illegal actions
- Replace language with action
- Advantages:

- Easy to learn
 - Low memory
 - Easy to undo
 - Immediate feedback to user actions
 - Enables user to use spatial cues
- Disadvantages:
 - Consumes screen real estate
 - High graphical system requirements
 - May trap user in *beginner mode*

Lecture Four - User Interaction and Psychology Behind Design

Psychological and physiological abilities have implications for design

- Perceptual: how we perceive things (input)
- Cognitive: how we process information
- Motor: how we perform actions (output)
- Social: how we interact with others

We are using these as a way to treat the human as an information processor, we are essentially mapping humans to a model in order to create a general solution.

The Human Information Processor

Based on a book by: card, Moran, Newell 1983

- Underlying psychology of interaction
- Predictive engineering models (GOMS/KLM)
 - GOMS, A library of models in order to map user interfaces and engineer effectively
- Extensive empirical validation
- Core computer science
- We will further break up the human brain into:
 - Long-term memory
 - Working memory
 - * Visual image storage
 - * Auditory image store

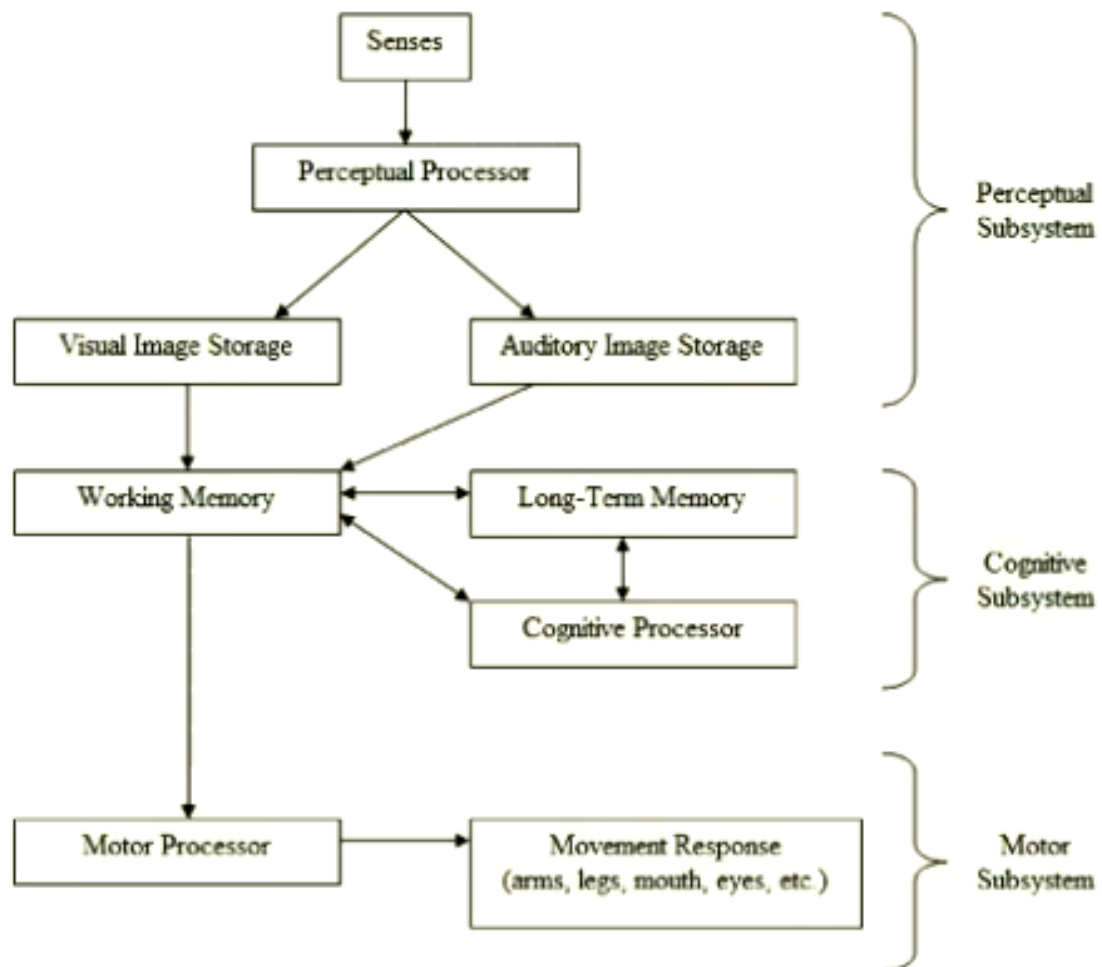


Figure 2: Sensory Model

- Human Input
 - Vision, hearing, haptics, olfaction
 - Vision:
 - * Photoreceptors cells, rods: low light, monochrome, Cones: normal light, colour in fovea
 - * Fovea: detailed vision of ~2 deg/sec
 - * Retina: non-detailed vision of ~120 deg/sec; sensitive to movement
- Human Output
 - Pointing, steering, speech, typing, ...
- Human Processing

- Visual search, decision times, learning
- Human Memory
- Human phenomena & Collaboration
- Human Error
- And UI implications of each

Visual Acuity

- Point acuity:
 - One minute of arc
- Grating acuity:
 - 1-2 minutes of arc
- Letter acuity:
 - Five minutes of arc
- Vernier acuity:
 - 10 seconds of arc

We can do the maths to figure out the acuity in order to figure out if the text/shapes is readable in order to create user interfaces for a wider audience. For example we can calculate letter acuity in order to see if text will be visible to a whole stadium.

Eye movement

- Fixations: Visual processing occurs when the eye is stationary (nearly)
- Saccades: Rapid eye movements (900 deg/sec), blind
- Eye movement used as input via eye-tracker
 - Midas touch problem
- Smooth-pursuit: for tracking moving objects up to 100 deg/sec; cannot be induced voluntarily
 - Relevant in scrolling e.g. (SDAZ)
 - The problem with scrolling is not computers cannot scroll fast and accurate, but that we cannot keep up with the scrolling (our eyes fall into motion blur).

Lecture Five - Human Input: Depth-based UI's

Size and Depth Cues

- Familiarity
- Linear perspective
- Horizon distance
- Size constancy
- Texture gradient
- Occlusion
- Depth of focus
- Aerial perspective
- Shadows/Shading
- Stereoscopy

Depth-based UI's: 3D

- The real world is 3D
- So all interaction should be 3D, right?
 - No this is just a bad idea (lecturers opinion)
- 3D can be invaluable for interaction with 3D objects or in 3D Environments
- Terrible for navigation, too many mechanics
 - Occlusion is a huge issue (lots of stuff overlapping, cannot see)
 - Complexity

Depth-based UI's Zooming

- Overview first, zoom and filter, details on demand
- Allowing users to see everything, then allowing the user to get more specific when they want to
- Example: *zillow* website

Input: Haptics

- Proprioception: sense of limb location +
- Kinaesthesia: particularly limb movement +
- Tactition: sensations
- Potentially powerful: e.g. Braille

Human Output

- Motor response times depend on stimuli
 - faster for combined signals
- Muscle actions

- Isotonic: contraction yields movement
- Isometric: contraction with no movement

Fitts' Law

- A model of rapid, aimed human movement
- Predictive of tasks; descriptive of devices
- Derived from Shannon's theory of capacity of information channels
- Extremely accurate and extensively validated for many types of aimed pointing
 - Consider velocity profile

Lecture Six - Input Devices: Pointing, Scrolling and Textual

Fitt's Law

- Movement of time (MT) is linear with ID
 - $MT = a + bID$ or $MT = a + b \log_2(A/W + 1)$
 - Reciprocal of slope ($1/b$) also called throughput or bandwidth of device, measured in bits/second

NOTE: we are expected to be able to reproduce these formulae

Pointing and Scrolling

- Human output received as system input
- Direct vs Indirect
- Control: Position (zero-order), rate (first order), acceleration (second-order)
- Isotonic (force with movement)
- Isometric (force without movement)
- Control-Display gain and Transfer Functions

Steering Law

- A model of continuously controlled 'steering'
 - $MT = a + bID$ or $MT = a + b(A/W)$
 - A is the tunnel length; W is tunnel width
 - (A/W) is still called the **index of difficulty**

Text Input

- Alternative keyboard (Devorak)

- Chord keys
- Constrained keyboards
- Reactive/predictive systems (e.g. Dasher)
- Gestural input (unistrokes, shapeWriter/swipe)
- Hand-written recognition

Visual search time

- Extensively researched in psychology
- Linear complexity $O(n)$, unless we can create a pop out effect, then complexity is $O(1)$
- We should try to avoid this if possible, because it is slow with large values of n

Lecture Seven - Human Processing: Visual Search Time

- Extensively researched in psychology
- Visual search time is a linear function
- Pop-out effects can reduce linearity to $O(1)$

Hick/Hyman Law of Decision Time

- $T = a + b \times H$
- H is information entropy
- With $H_i = \log(\frac{1}{p_i})$
- For all n with equal probabilities $H = \log_2(n)$
- We make frequent decisions quickly
- Decision times are fast $O(\log n)$
- Applies to name retrieval and location retrieval
- In GUI's replace visual search with decision from spacial stability

We want to design for novice users to be able to transition to expert users.

Lecture Eight - Human Memory

Zipf's Law, Pareto Principle

- Frequency of words (Zipf 1932)
 - $P_n = n^{-a}$
 - P_n is a scaling factor of frequency of n^{th} rank word
 - $a = 1$
 - Models frequency of commands, URL's, apps, windows, etc.

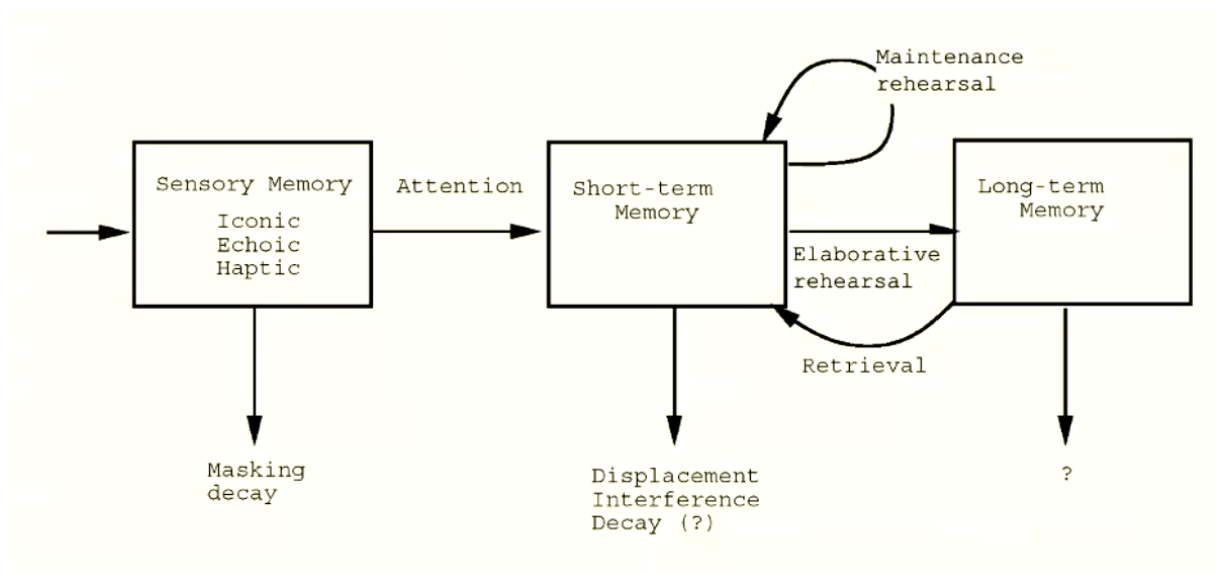


Figure 3: Human Memory: Simplified Model

Short-term memory

- Input from sensory or long-term memory
- Capacity up to 7 (+/-) 2 chunks
- Chunks used to aid storage and reconstruction
- Fast access, rapid decay
- Constant update and interference
- Maintenance rehearsal

Human Error: Mistakes

- Errors of conscious decision making
- Due to incorrect or incomplete model of system
- Only detected with feedback

Human Error: Slips

- Errors of automatic and skilled behaviour
 - Capture error
 - * Two action sequences with common starting point
 - Description error
 - * More than one object allowing the same/similar action
 - Data-driven error

- * External data interferes with STM
- Loss-of-activation error
 - * Goal displaced/decayed
- Mode Error
 - * Right action, wrong system state
- Mode slip
 - * Pointing or steering error
- Premature closure error
 - * Dangling UI actions required after perceived goal completion
- What is a mode?
 - * system partition
 - * Modal dialog
 - * Ensure modes are visible and noticeable