What’s this course about?
► Development of user interfaces that are:
  • fit for the purposes
  • of their diverse users
  • in a variety of contexts
► Interactive system development lifecycle
  • gather user requirements
  • create prototypes
  • conduct evaluations to verify the design
► Movie clips of relevant examples of work in the area
► Demonstrations and hands-on exercises on various techniques

Assessment
► 10 homework @ 5% = 50%
► Group project* (3-4 people): 50% for undergrad, 40% for grad
► Grad only: Reviewing work: 10% → pick 3 HCI papers that interest you, critically analyze and summarize them.
*Project: Propose one but follows the following criteria
  • It has to benefit the society (if you involve people with special needs, I will multiply the mark by 1.1)
  • It must involve users at all stages of the project
  • It must contain a build part and an evaluative part
  • Documentation is key. Take pictures, record interviews, make movies, create website (see this for example: http://urbanresource.weixiao.us/).
  • Project deliverable is the system itself, all of the electronic files, paper report and project presentation

Tentative Lecture Timetable
► W1-2: Logistics, people.
► W5: Design process (task analysis, screen design). Evaluation and quality assurance concepts (formative and summative).
► W6: Designing for differently-abled users: users with special needs, accessibility initiatives (WCAG, Section 508, Universal Design), ethical consideration, IRB.

Tentative Lecture Timetable
► W7: Evaluation method 1: inquiry (ethnography, focus group, contextual inquiry, interview, questionnaire). Evaluation method 2: inspection (cognitive walkthrough, heuristics evaluation – Nielsen’s heuristics) and testing (thinking aloud protocol, retrospective testing, co-discovery learning)
► W8: Experimental design, basic analysis of qualitative and quantitative data.
► W10: Mobile/ubiquitous computing. Physical issues (screen size, screen legibility, input mechanism, heat); societal effects of mobility; context awareness and location-dependent technology.

Project Timetable
► Timeline
  • W1: Choose team mates – 3-4, must be multidisciplinary, let me know if you cannot team up (no promise)
  • W3: Project proposal – project description, target audience, why such system and such user population
  • W5: User requirement report due.
  • W8: Prototypes and evaluation report due.
  • W10: Review due (graduate)
► Submit to Moodle by 23:55 Wednesday of that week (TA’s timestamp)
Using course resources

- The lecture notes
  - [http://www.soe.ucsc.edu/classes/cmpe131/Winter10/](http://www.soe.ucsc.edu/classes/cmpe131/Winter10/)

- Suggested readings:
  - Preece, Sharp, Rogers: Interaction Design (2nd ed)

- The lectures
  - 2 lectures of 1hr 45 min / week over 10 weeks

- If you have any questions:
  1. Ask me/TA questions at the end of the class
  2. Send me/TA an email
  3. In emergency situation, knock on my door

What is Human-Computer Interaction?

- 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

- Design of interactive systems that are:
  - enjoyable to use, that do useful things and that enhance the lives of the people that use them.
  - accessible, usable and engaging.

- Methods for:
  - capturing what people want to do rather than just what the technology/designer can do
  - understanding how to translate from what people wants to good design
  - involving people in the design process
  - designing for diverse users and uses

Related fields

- **Interaction design**: Designing interactive products to support the way people communicate and interact in their everyday and working lives
- **User experience**: study of how a product behaves and is used by people in the real world
- **Human-centered computing**: study of humans, as individuals and in social groups, by focusing on the ways that human beings adopt, adapt, and organize their lives around computational technologies
- **User-centered design**: a design philosophy and a process in which the needs, wants, and limitations of the end user of an interface or document are given extensive attention at each stage of the design process
- **Universal usability**: design of products with built-in flexibility enabling use by all people, regardless of age and ability

Bad designs are everywhere

- DZone Spy - Fresh Links In Real Time
- Internet Explorer - Unknown error

How to avoid bad design?

- Identify needs and establish requirements
- Develop alternative designs to meet these
- Build prototypes with increasing complexity and interactivity that can be communicated and assessed by users
- Evaluate what is being built throughout the process (not only at the end)
- Less we forget:
  - Project goals need to be identified, clearly documented and agreed at the beginning
  - Users should be involved throughout the process
  - Iteration is a part of the process – sometimes by throwing away previous prototype
Proper design should consider
► Physical interaction: system input – mouse, speech (or noise), gesture
► Perceptual interaction: system output – visual, audio, haptic?
► Conceptual interaction: do we know how the system works and what we should do?
► Affected by people, activities, contexts, technologies (PACT framework)
  - A student uses a phone to send a text message whilst sitting on a bus
  - Air traffic controllers work together using computers and flight strips to ensure smooth running of an airport in the air traffic control centre.
  - A 70-year-old woman programs various buttons to set the intruder alarm in her house.

The P: People: Model Human Processor
► Based on years of basic psychology experiments found in the literature
► Models the information processes of a user interacting with a computer
  - the higher level: identified with consciousness and working memory
  - the lower level: processed in parallel with the higher level without conscious effort
  - Skilled performance differs from novice performance
► Enables calculations to be made of how long a user will take to carry out a task
► Focus on a single user interacting with some entity
  - Neglects effect of other people and the environmental support

2.1 Vision: the eyes
► Lens focuses light to the retina
  - Light passes through the lens
  - Focused on the retina
  - Rod cells (periphery)
  - Cone cells (fovea)
► Central 1-2° gives foveal vision
► Remaining 180° gives peripheral vision
► Cone cells
  - Detect color and hi-res images
  - X-ganglia (wires from the cell to the brain) provide early pattern detection.
► Rod cells
  - Good for low levels of luminance
  - Y-ganglia permit early movement detection
  - Sense shades of grey but can't detect colors.

Interactions

MHP Diagram

How we see the world
Vision: color

- Cone cells detect color (hue, saturation, value) through photo-pigments.
  - mainly reds (64%) & very few blues (4%).
  - Center of retina (high acuity) has no blue.
  - Means disappearance of small blue objects you fixate on.
- Brightness is determined mainly by R+G
- Shapes are detected by finding edges
  - combine brightness & color differences for sharpness
  - harder to deal w/ blue edges & blue shapes

Designing with Color

- Color is emotional
  - Psychological and cultural
  - Physiological: some colors excite neurons in the brain more than others (red)
- Color is good for segmentation (grouping)
  - Reduce the amount of time to search for information
  - Too many colors can increase search time
- Color is good for drawing attention
- Color should be used as redundant coding
  - 10% of the male population has some form of color deficiency or color confusion

Kansei’s colors

- Invented by Nagamachi in Japan in 1970
- KANSEI study seeks the structure of emotions, which exists beneath human behaviors
- Used a lot in customer product (first used in the US by Mazda)
- Not just colors

Designing with color

- http://websitetips.com/colortools/sitepro/
- Use contrast for structure & hierarchy
- Color palettes
  - Monochromatic
  - Complementary
  - Analogous

Color Palette Examples

- Monochromatic - http://www.pbs.org/wgbh/amex/foster/
- Analogous - http://www.pbs.org/art/math/prog/
Designing with color

- White on Red
- White on Green
- White on Black
- Red on Yellow
- White on Blue
- Yellow on Black
- Red on White
- Black on White
- Green on White
- Yellow or Orange on Green
- Blue on Yellow or Orange
- Yellow or Orange on Blue

Good

Better

Best

Bad

Relative to surrounding

Audition (hearing)

- Receiving vibrations and perceiving sounds
  - Outer ear protects inner/middle ear and amplifies sound
  - Middle ear transmits sound waves as vibrations to inner ear
  - Pinna → canal → ear drum → ossicles (amplifier) → cochlea (detection)

- Hearing without awareness
  - *cocktail party phenomenon*: the effect of not being aware of the content of other people's conversations until your name is mentioned
  - *dichotic listening task*: different stimuli delivered to 2 ears via headphones; still aware of ignored signal

Auditory Characteristics

- **Pitch**
  - 20Hz – 15KHz frequency
  - Human is less accurate in distinguishing high frequencies than low ones
  - Tuned to 3KHz by shape of outer ear

- **Timbre**
  - 'signature' of sound source
  - complex set of resonance overlaying the fundamental frequency

- **Amplitude and loudness**
  - *Loudness* is a psychological property of sound
  - Our ears are capable to cope with 0 to 160db (pain at 130db!)
  - Prolonged exposure above 85 db can cause hearing damage → noise-induced hearing loss (NIHL)

Auditory characteristics

- **Sound filtering**
  - Can attend to sounds over background noise
  - Reduces with aging → speech discrimination problem

- **Location**
  - Horizontal plane
  - Pinnae separation and acoustic delay

Designing with Sounds

- **Earcons**
  - Synthetic sounds used to convey information
  - Structured combinations of notes (motives) represent actions and objects

- **Auditory icons**
  - Natural sounds with associated semantics which can be mapped onto similar meanings in the interaction e.g. throwing something away ~ the sound of smashing glass
Haptics (touch)
► Receiving thermomechanical forces and perceiving physical properties of things
► Three kinds of cutaneous receptor (skin)
  ▪ Thermoreceptors (temperature)
  ▪ Mechanoreceptors (pressure)
  ▪ Nocioceptors (pain)
► Kinaesthesis - body pose
  ▪ Two kinds of proprioceptor in joints
► Reaction times depend on fitness
  ▪ Practice improves
  ▪ Deteriorate with age

Motor subsystem: Fitts’ Law
► Fitts’ Law predicts that the time to point at an object using a device is a function of the distance from the target object & the object’s size.
► The further away & the smaller the object, the longer the time to click on it.
► Fitts’ Law is useful for designing systems for which the time to click on an object is important

Motor subsystem
► Fitts’ Law
  \[ MT = a + b \log_2 \left( \frac{2A}{W} + c \right) \]
  ▪ \( MT \) is the movement time
  ▪ \( a \) and \( b \) are empirically determined constants, that are device dependent.
  ▪ \( c \) is a constant of 0, 0.5 or 1
  ▪ \( A \) is the distance of movement from start to target centre
  ▪ \( W \) is the width of the target, which corresponds to “accuracy”
  ▪ It has an assumption that the most time used is for homing (i.e. better to locate objects on the edges of the screen even if it’s further)
  ▪ BUT, only accounts for direct line movements

Cognition
► Interacting with technology is mostly cognitive
► We need to take into account cognitive processes involved and cognitive limitations of users
► We can provide knowledge about what users can and cannot be expected to do
► Identify and explain the nature and causes of problems users encounter
► Supply theories, modelling tools, guidance and methods that can lead to the design of better interactive products
► A raft of theories, from fine grained to high level
► Most relevant to HCI are attention, perception and recognition, and memory

Attention
► Sternberg (1999): A means of focusing limited mental resources on the information and cognitive processes that are most salient at a given moment
► Two states:
  ▪ Focused attention: ability to attend to stimulus in presence of distracters
  ▪ Divided attention: ability to attend simultaneously to lots of things
► Driven by meaning (top-down) and by change (bottom-up)
  ▪ Captured by salience and grouping: spatial, intensity, color, size, timbre, pitch, convention
  ▪ Involuntary capture and movement: Perceptual filters “trigger” attention capture (cocktail party effect, buzzing light)

Designing for Attention
► Design to assist attentional focus in the right place and at the right time
► Help user to.
  ▪ attend their task not the interface.
  ▪ decide what to focus on, based on their tasks, interest, etc.
  ▪ to stay focused, do not provide unnecessary distractions → clippy, anybody?
  ▪ structure their task.
► Use alerts (only) when appropriate!
► Avoid using too many changes/functions just because the system allows it
Designing for attention
► Make things salient: use colour, larger font, white space, underlining, animation, noises
► Presenting information that is relevant to goal (Google’s advertisement)

Sensation and Perception
► Sensation = sensing our environment through touch, taste, sight, sound, and smell
► Perception = the way we interpret these sensations and therefore make sense of everything around us

Perception: “knowing”
► Gestalt psychology
  ▪ Perceptions are formed by grouping of stimuli based on prior knowledge
► Object constancy
  ▪ When landing, you just “know” that the houses are real
► Depth perception
  ▪ Motion parallax, interposition, perspective

Gestalt Psychology – Law of Perceptual Organization
1) Proximity (grouping)
2) Similarity (color/shape)
3) Closure

Gestalt Psychology – Law of Perceptual Organization
4) Continuity
5) Symmetry

Homework
► Find a (set of) user interfaces (web page, game board, computer application’s interface, cell phone’s homepage, microwave oven etc) that are Halls of Shame and Halls of Fame in terms of the 5 Gestalt principles (screenshots, please)
► Suggest improvements for those you argue are Halls of Shame

► But Gestalt perception is also affected by:
► Stimulus factors: color and contrast, size, intensity, position, distance
► Individual response factors: interest, involvement, needs, values
► Affect “perceptual judgement”
Good vs. bad

http://www.ethias.be

Sensory buffers/memory
- Very brief, but accurate representation of what was perceived
  - Details decay quickly (70 - 100 ms visual; 0.9 - 3.5 s auditory)
  - Limited capacity (7 - 17 letters visual; 4 - 6 auditory)

Short-term memory
- Decay 5-226 sec, rehearsal prevents decay, interference speeds up decay
- Rapid access
- Serves as “working memory”
  - Permits combination of sensory and memory information

Long-term memory
- The sum of all we know
  - Slow access (100ms to days) – tip-of-the-tongue
  - Limitless capacity, stable content
- Semantic memory: Memory for meaning
  - Facts and skills
  - Relationships between things
- Built up by association → Hebbian learning
  - Experience and exposure
  - Intermittent exposure best
  - More associations the better for recall

Short-term memory
- Limited capacity
  - 7 ± 2 chunks (Miller) – often misinterpreted
  - A chunk is a meaningful grouping of information – allows assistance from LTM (individual differences)
- Early and late best
- Applies to ‘raw’ content (strategies & meaning affect memory)
- Can you memorize these?
  - HEC ATR ANU PTH ETR EET
  - 746335892147530
- Easier when grouped
  - THE CAT RAN UP THE TREE
  - 746 335 892 147 530
  - Serial position in list

Long-term memory
- Link strength
  - Affects ease of access
  - Function of usage frequency

Long-term memory
- Episodic memory: story memory
  - Reconstruction rather than replay
  - Built on ‘key events’
  - Filling in the gaps
- Scripts and frames for concepts
  - Typical sequences of events
  - Part of semantic memory, used by episodic memory
- Forgetting: Destruction or inaccessibility?
  - Both e.g. concussion and stroke damage
  - Interference: referential confusion
  - Lack of use: connection partly overwritten
Designing for Memory

Recall

- info reproduced from memory

Recognition

- presentation of info provides knowledge that info has been seen before
- easier because of cues to retrieval

We want to design UIs that rely on recognition!

Perceptual Processor: 100ms/cycle

- Light blinks appearing within 100ms
  - look like a single brighter light
- Light blinks in two locations within 100ms
  - look like motion of a single light
- Auditory clicks occurring within 100ms
  - sound like one louder tone
- Multiple taps occurring within 100ms
  - feel like one tap of greater pressure
- SRT (press space bar when anything flashes on the screen)
  - 1 perceptual cycle + 1 cognitive cycle + 1 motor cycle = 100ms + 70ms + 70ms = 240ms

A raft of cognitive models

- KLM (Keystroke Level Model) → Assumes that routine cognitive skills can be decomposed into a serial sequence of basic cognitive operations and motor activities, which are:
  - \( K \): A keystroke (280 ms)
  - \( M \): A single mental operator (1350 ms)
  - \( P \): Pointing to a target on a small display (1100 ms)
  - \( H \): Moving hands from the keyboard to a mouse (400 ms)
- GOMS (Goal Operator Method Selection Rules)
  - Goals = What the user wants to do.
  - Operators = Specific steps a user is able to take and assigned a specific execution time.
  - Methods = Well-learned sequences of subgoals and operators that can accomplish a goal.
  - Selection Rules = Guidelines for deciding between multiple methods.

Reasoning

- Deduction
  - Derive logical conclusion from given premises
  - Vegetables are healthy, potatoes are vegetables, chips are potatoes → chips are healthy.
- Induction
  - Generalisation from instances
  - The swans (I’ve seen) are white → Swans are white
- Abduction
  - Reasoning from event to cause
  - When Sam is drunk, he drives fast. Sam passes my car with 90 mph → he is drunk.
Designing for reasoning

► Affordance: the properties that things (are perceived to) have and how these relate to how the things could be used
► Metaphor: describing a first object as being or equal to a second object in some way
► Mapping: the set of possible relations between objects → spatial & semantic

Play the guessing game?

► Desk drawers => lesson plans
► Television set => video clips
► Notice board => online message board
► Telephone => contact information
► Computer screen => Useful links
► Travel centre => conferences

What about the cat?
Mathematics Education on the Web: MEOW

Let's check this metaphor


Mental model

► A person’s understanding of the world
  ▪ Partial, informal, unstable
► Properties, interactions, forces, effects
  ▪ E.g. cooking with a gas oven, way a can opener works
► Forged by experience
  ▪ Trial and error
  ▪ Consistent with model = believe in model
► Deep versus shallow models (e.g. how to drive a car and how it works)

Case 1: You arrive home hungry, frozen pizza instruction says heat in 350°F oven. Set oven to max to speed up hot water?
Case 2: In desperate need hot shower, open tap to the max to speed up hot water?

User’s Mental model

► Execution-Evaluation (Norman) Cycle

Executing action
Specifying action sequence
Forming intention
Establishing goal
Perceiving system state
Interpreting system state
Evaluating system state wrt goals and intentions

http://www.youtube.com/watch?v=lBlsTYRBkr4

Designing for mental model

► People have preconceived models that you may not be able to change – so adapt
  ▪ Disconnecting = pulling the wire out, not eject
► Interface must communicate model
  ▪ Help/documentation to communicate your model
  ▪ Visibility – don’t let users guess
  ▪ Constraint – restrict what is irrelevant
Error

► Mistakes
  ▪ Wrong intention caused by “wrong” model
► Action slips
  ▪ Right intention but failed to do it right
► We should design to minimize error
► Error messages are a big thing!

Homework

► Analyze your own cell phone (report the model of your phone) → screenshots, please, if appropriate
  ▪ In terms of visibility, constraint, mapping, metaphor, affordance
  ▪ For a task of taking picture and send it to a person in your address book through MMS, analyze how good/bad it is following the Norman’s cycle
  ▪ Finally, describe a function in your cell phone that might induce an action slip