Human-Computer Interfaces/Interaction (HCI)

“Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination.” -- Albert Einstein

Definition of HCI

• "Human-computer interaction 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." -- Association for Computing Machinery

  – The interface between the application and the user
  – Know the goal of the user and how the application can assist in accomplishing that goal
  – Provide the necessary tools to the end user to accomplish their goal
  – Placement and usage of tools
  – Non-obtrusive tools
Example of HCI

Why HCI is Important?

- The study of our interface with information.
- It is not just ‘how big should I make buttons’ or ‘how to layout menu choices’
- It can affect
  - Effectiveness
  - Productivity
  - Morale
  - Safety
- Example: a car with poor HCI
- Bad interfaces:
  - Confusing
  - Cumbersome
  - Slow
  - Uninformative
  - ...
Explicit Input/Output

- Context:
  - state of the user
  - state of the physical environment
  - state of the computing system
  - history of user-computer interaction
  - ...

Natural/Implicit Interfaces

- Keyboard/Mouse/Screen/Speakers
- Pen input
- Touch
- Speech/Audio/Sound
- Gesture, eye movement
- Tangible interfaces
- Augmented Reality
- Wearable Computing
- Multi-modal Interactive Interfaces: more than just one input/output channel
Automated Capture

• Motivation
  – Record-taking is hard
  – Multiple streams of information need to be captured
  – Machines are better at some of these things than we are

LiveBoard
Classroom 2000/eClass

Augmented Reality
Augmented Reality

- Virtual sightseeing
  - Superimposition of text, images and videos on real images using a fixed device

Augmented Reality

- Dynamic augmented reality
  - YDreams has developed a technology that enables the insertion and control of virtual elements in a real scene:
    - One can be a virtual actor in a real movie scene
    - One can participate in a car race driving a virtual car against real cars
Super Cilia Skin is a multi-modal interactive interface, conceived as a computationally enhanced membrane coupling tactile-kinesthetic input with tactile and visual output. An array of individual actuators (cilia) use changes in orientation to display images or physical gestures as physical or tactile information.
SandScape is a tangible interface for designing and understanding landscapes through a variety of computational simulations using sand. Users view these simulations as they are projected on the surface of a sand model that represents the terrain. The users can choose from a variety of different simulations that highlight either the height, slope, contours, shadows, drainage or aspect of the landscape model. The users can alter the form of the landscape model by manipulating sand while seeing the resultant effects of computational analysis generated and projected on the surface of sand in real-time.
Wearable Computing

- Computation devices accompany you, rather than you seeking them out

Movement Recognition
Seven Design Principles

1. Equitable use
   – same means for all users, do not segregate/stigmatize users, make design appealing

2. Flexibility in use
   – provide choice of methods & adapt to user’s pace

3. Simplicity and intuitiveness of use
   – support user’s expectations
   – accommodate different languages and literacy skills
   – provide prompting and feedback

4. Perceptible information
   – redundancy of information: use different forms/modes
   – emphasize essential information

5. Tolerance for error
   – minimize impact caused by mistakes
   – remove potentially dangerous situations
   – hazards should be shielded by warnings
Seven Design Principles

6. Low physical effort
   – comfort; minimize fatigue and effort;
   – repetitive or sustained actions should be avoided

7. Size and space for approach and use
   – placement of system should be reachable by all users
   – consider line of sight for standing and sitting user
   – allow for variation in hand size
   – provide room for assistive devices

Multi-Modal Interaction

• Provides access to information through more than one mode of interaction

• Sight is predominant and most interactive systems use visual channel as primary presentation
  – graphics
  – text
  – video
  – animation
Multi-Modal Interaction

- Sound important
  - keeps us aware of surroundings
  - provides clues and cues to switch our attention
  - music - also auditory
    - convey and alter moods
    - conjure up visual images
    - evoke atmospheres
- Touch
  - tactile feedback to operate tools
  - hold and move tools, instruments, pens

Multi-Modal Interaction

- Taste and smell
  - less appreciated
  - check food if bad, detect early signs of fire, ...
Multi-Modal Interaction

- Human-human everyday interaction multi-modal
- Each sense provides different information to make whole
- Want human-computer interaction to be multi-modal
  - visual channel can get overloaded
  - provide richer interaction
  - provide redundancy for an equivalent experience to all

Sound in the Interface

- Contributes to usability
- Audio confirmation
  - changes in key clicks
  - error occurrences
- Provide information when visual attention elsewhere
- ...or environment has visual limitations
- Dual presentation through sound and vision supports universal design
  - enables access to visual and hearing impaired
- Two kinds: speech and nonspeech
Sound in the Interface: Speech

- Speech recognition
  - Useful when hands are occupied
  - Alternative means of input for users with visual, physical and cognitive impairment
  - single-user systems; require training
  - barriers
    - background noise
    - redundant and meaningless noise (‘uh’)
    - variations between individuals and regional accents
  - Examples
    - speech-based word processors
    - telephone-based systems
    - interactive systems that give feedback

Sound in the Interface: Speech

- Speech Synthesis
  - Complementary to speech recognition
  - Problems
    - monotonic - doesn’t sound natural
    - canned messages
    - spoken output cannot be reviewed or browsed easily
    - intrusive (more noise or equipment)
  - Application areas
    - blind or partially sighted
      - accessible output medium (screen readers)
    - assist those with disabilities affecting their speech
      - predefined messages can be stored
Sound in the Interface: Non-Speech Sound

• Assimilated quickly
• Learned regardless of language
• Require less attention
• Uses:
  – indications of changes or errors in interactive system
  – provide status changes
  – sound representation of actions and objects
  – provide confirmation
  – give redundant information
• Two Kinds - auditory icons and earcons

Sound in the Interface: Non-Speech Sound

• Auditory icons
  – Use natural sounds to represent types of objects and actions

  – Example: Mac’s SonicFinder
    • crumpling paper when putting file in wastebasket

  – Problem: Some objects or actions don’t have a natural sound
Sound in the Interface: Non-Speech Sound

• Earcons
  – use structure-combinations of notes (motives) to represent actions and objects
  – vary according to rhythm, pitch, timbre, scale and volume
  – hierarchically structured
    • compound earcons - combine motives
      – ‘create’ and ‘file’
    • family earcons - ‘error’ family
    • makes learning easier
  – even lack of musical ability has little effect on ability to remember earcons

Touch in the Interface

• Touch both sends and receives information
• Touch in the interface is haptic interaction
• Two areas:
  – cutaneous - tactile sensations through skin
    • vibrations against skin; temperature, texture
  – kinesthetics - perception of movement and position
    • resistance or force feedback
• Entertainment or training
• Tactile devices
  – electronic braille display
  – force feedback devices in VR equipment
Handwriting Recognition

- Handwriting provides textural and graphical input
- Technology for recognition
  - digitizing tablet
    - sampling problems
  - electronic paper - thin screen on top
- Recognizing handwriting
  - variation among individuals (even day-to-day)
  - co-articulation - letters are different next to others
  - cursive more difficult

Gesture Recognition

- Subject in multi-modal systems recently
- Involves controlling computer with movements
  - put that there
- Good situations
  - no possibility for typing (VR)
  - supports people with hearing loss (sign language)
- Technology expensive
  - computer vision
  - data glove (intrusive)
Users with Disabilities

- Federal law to ensure access to IT, including computers and web sites. (1998 Amendment to Rehabilitation Act)
- Disabilities
  - Vision
    - Blind (http://www.switched.com/2011/03/10/money-reader-app-helps-blind-id-cash/)
    - Low-vision
    - Color-blind
  - Hearing
    - Limited hearing
  - Mobility
  - Learning
    - Dyslexia
    - Attention deficient, hemisphere specific, etc.
- Keyboard and mouse alternatives
- Color coding
- Font-size

Users with Disabilities

- Contrast
- Text descriptors for web images
- Screen magnification
- Text to Speech (TTS) – JAWS (web pages)
  - Check email on the road, in bright sunshine, riding a bike
- Speech recognition
- Head mounted optical mice
- Eye gaze control

Computer Science and Engineering - University of Notre Dame
Elderly

- Reduced
  - Motor skills
  - Perception
  - Vision, hearing, touch, mobility
  - Speed
  - Memory

- Other needs
  - Technology experience is varied (How many grandmothers use email? Mothers?)
  - Uninformed on how technology could help them
  - Practice skills (hand-eye, problem solving, etc.)

- Touch screens, larger fonts, louder sounds

Children

- Technology savvy?

- Age changes much:
  - Physical dexterity
    - (double-clicking, click and drag, and small targets)
  - Attention span
  - Intelligence/education

- Varied backgrounds (socio-economic)

- Goals
  - Educational acceleration
  - Socialization with peers
  - Psychological - improve self-image, self-confidence
  - Creativity – art, music, etc. exploration
Children

- Teenagers are a special group
  - Next generation
  - Beta test new interfaces, trends
  - Cell phones, text messages, simulations, fantasy games, virtual worlds
- Requires Safety
- They
  - Like exploring (easy to reset state)
  - Don’t mind making mistakes
  - Like familiar characters and repetition (ever had to babysit a kid with a Toy Story DVD?)
  - Don’t like patronizing comments, inappropriate humor

Visually Impaired

- **PortaNum** is a magnifier system that allows to the visually impaired people to read remote documents
  - Choice of needed images
  - Zooming and further treatment of image (inversion, color, contrast, …)
  - Image recording and scanning
Anti-Wandering System

- **Quo Vadis** is a safety system equipped with selective electronic
  - Access modes for patients suffering from disorientation
  - Small badge contains a mini transceiver
  - Radio calling and alarm system
  - Working area of beacon is 0.3-300 m
  - Info transmitted through a pager
  - Safety area can be restricted at night time

Sign Language Interpretation System

- Virtual remote sign language interpretation carried out in real time through networks using NTSC video signal
- A sign language interpreter translates the conversation between the deaf person and the hearing person using video and voice
Hearing Impaired

- See-through head mounted display as the information offering device for hearing impaired students using holographic optical elements
- Quality of displaying images is very clear and the caption on the display can be read very easily

Assistive Technologies

- 35% of all assistive technologies purchased are abandoned
- Waste of resources, time, and funds for users and disability services
- Bad experiences lead to disillusionment about assistive technologies
Near & Future Interfaces

• Measures for success:
  – Time to learn
  – Speed of performance
  – Natural
  – Rate of errors
  – Retention over time
  – Subjective satisfaction

OXYGEN Project (MIT)

Speech and vision technologies enable us to communicate with Oxygen as if we’re interacting with another person, saving much time and effort.
AwareHome (GaTech)

Designing the Interactive Experience

- Digital Family Portrait
  - reconnects geographically distant extended family members by allowing them to remain aware of each other in a non-obtrusive, lightweight manner
- What Was I Cooking?
  - a context-aware system that captures the transient information of recent activities and passively displays them as visual cues.
- Gesture Pendant
  - Gesture Pendant recognizes and then translates gestures into commands for your home appliances

AwareHome with human-like perception could improve quality of life for many, especially seniors.

Easy Living (Microsoft)

- EasyLiving is developing a prototype architecture and technologies for building intelligent environments
- System Architecture

Key features
- Computer vision for person-tracking and visual user interaction.
- Multiple sensor modalities combined.
- Use of a geometric model of the world to provide context.
- Automatic or semi-automatic sensor calibration and model building.
- Fine-grained events and adaptation of the user interface.
- Device-independent communication and data protocols.
- Ability to extend the system in many ways.
Easy Living (Microsoft)

- **Personal Detection**
  - Stereo Processing with commercial software
  - Background subtraction and person detection
  - Reports sent to central personal tracker about 7Hz

- **Personal Tracking**
  - Process each new report from a sensor

HomeLab (Philips)

- **Philips HomeLab**
  - appearance looking and feeling like a regular home
  - for testing its new home technology prototypes in the most realistic possible way
  - WWICE
  - PHENOM
  - EASY ACCESS
  - POGO: an interactive game for children
    - virtual story world interfaced by active tools
  - Intelligent Personal-Care Environment
    - based on measurements from the activity monitor