Human-Computer Interfaces

# Input Mechanisms:

* Keyboards – QWERTY layout was built to minimize pressing of neighboring keys in succession to prevent jams in typewriters. Tactile feedback often desired, missing in modern keyboards.
* Keypads – Numeric keypads very prevalent. Used in older phones for entering text through multitap and/or predictive text entry.
* Chording Devices – Pressing multiple keys simultaneously to represent either letters, words or even phrases. Eg. Stenotype, where words are entered phonetically.
* Handwriting – Single Letter Recognition or Cursive Handwriting Recognition (Writer Dependent/Independent). Very useful for languages like Chinese & math equations.
* Speech Recognition:
  + Continuous Speech Recognition: Speaker Dependent (high accuracy) or Speaker Independent (low accuracy).
  + Spoken Command Recognition: Recognize command words or command phrases. Usually speaker independent but highly accurate because range of commands is limited. Eg. Siri, Cortana, Windows Speech Recognition.
* Relative Pointing – Mouse, Trackball & Touchpad. Maps velocity of device → digital velocity on screen.
* Absolute Pointing – Stylus or Touch-based Displays, Aimed Pointing (eg. Wii). Direct pointing to actual position on screen. Maps displacement of device → displacement on screen.
* Steering – Pointing Stick (IBM TrackPoint), Joysticks & Gamepads. Maps displacement of device → digital velocity on screen.
* Multi-Touch/Surface Computing – Allows complex interactions beyond normal pointing or dragging. Rotation, scaling, custom gestures can be used. Interaction is also possible via tagged physical devices on the surface of the device.
* Sketching as Input – Intelligent systems can interpret sketches into higher level concepts. 3D Models from 2D Sketches, Physics Simulations or GUI Lo-Fi Sketch Interpretations.
* Natural 3D Motion – Accelerometers, Tilt Sensors, Electronic Compasses, Gyroscope etc. Body posture and motion can also be sensed via something like the Kinect.
* Affective Computing – Goal is to recognize the user’s affective state of mind via body posture, vocal indicators and facial expressions. Still fairly immature technology.
* Brain-Computer Interface – Goal is to measure the electrical signals in the brain and convert them into inputs for a computer. Challenging because of high level of noise and difficulty in finding systematic patterns in the electrical signals. Ongoing area of research.

# Output Mechanisms

* Displays transfer visual information to the user.
  + CRT, LCD, Plasma, LED, E-Ink, Retinal Projectors etc.
  + Built for either Mobility, Office Work, Entertainment or Immersion.
  + Physical size of a display is defined by it’s diagonal length.
  + Aspect ratio of a display is the ratio of it’s width to it’s height.
  + The viewing angle of a display is the maximum off-center viewing angle where the display quality is still acceptable.
  + A display’s field of view is the visual angle the display takes up from the viewer’s position. Depends on the size of the display, aspect ratio and distance from the viewer. A larger field of view typically results in a greater viewer immersion.
  + Pixel density of a display is measured in pixels-per-inch. Analog CRT monitors’ resolution is decided by the graphics adapter. LCD monitors’ native resolution is fixed.
  + Brightness is specified by the peak luminance (monitors/TVs) or in luminous flux (projectors). A higher brightness is more important in well-lit places.
  + The black level is the luminance of black pixels. Low black level is more important in dark places. CRTs have low black levels.
  + The contrast of a display is the ratio between the peak luminance and black level. Not very useful since it does not account for ambient light.
  + The color gamut of a display is the range of colors that a display can reproduce.
  + 3D Displays use two human visual cues:
    - Stereopsis – seeing two slightly different images in each eye
    - Motion Parallax – seeing slightly different images as you move around
  + Different Forms of 3D Displays (can be combined):
    - Stereoscopic – a different image to each eye; requires special glasses.
      * Good for many simultaneous viewers.
    - Autostereoscopic – a different image to each eye; doesn’t require glasses.
      * Typically limited to one or very few viewers.
    - Multi-view – different image depending on viewer’s position.
      * Usually single viewer only.
* Audio:
  + Not just for alerts but can also be used to cue material properties for virtual objects.
  + Music uses the full frequency range of human hearing.
  + Human voice uses 100Hz to 8kHz, including overtones.
  + Stereo audio gives a sense of direction but not true surround sound.
  + Binaural audio is achieved by placing microphones in the ears of a dummy head or synthesized via HRTF.
  + Loudspeaker-based surround sound is achieved by positioning speakers in a particular way inside a room.
  + Text-to-Speech uses a speech synthesis engine to provide information when the user cannot see the screen (eg. driving) or is used to help people with speech disabilities.
* Haptics:
  + Haptic devices provide tactile (or even temperature) feedback to users.
  + Basic Vibration Cues (“force feedback”)
  + Sensation of Virtual 3D Shapes – achieved through resistive feedback via air bladders (crude) or actuators (more accurate).
* Motion Simulators:
  + Simulation based on motion cueing techniques.
  + Using tilt to align virtual force direction with real gravity to simulate long acceleration.
  + Simulating short acceleration by initial identical acceleration by simulator followed by a gradual return to the neutral position.
* Digital Scent Synthesis – aromatic compounds pre-dissolved in solvent and when needed, atomized into a fine spray.
* “4D” Experiences – rides & theater that stimulate multiple human senses simultaneously.