3D User Interface Hardware

Lecture #6: Audio/Haptic Displays

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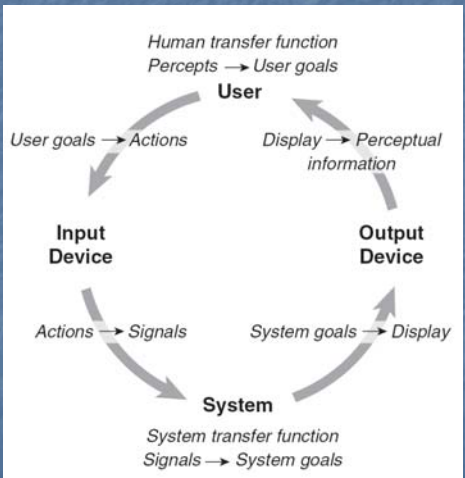
Joseph J. LaViola Jr.

Interaction Workflow



Introduction To Displays

- *Display*: device which presents perceptual information
- Goal: display devices which accurately represent perceptions in simulated world
- Displays do not have to be just visual
  - auditory
  - haptic, tactile
  - olfactory

Lecture Outline

- Audio Displays
  - 3D sound localization depth cues
  - 3D sound generation
  - sound configurations
  - audio and 3DUIs
- Haptic/Tactile Displays
  - haptic cues
  - display characteristics
  - display types
  - haptics and 3DUIs
- Olfactory Displays

Audio Displays

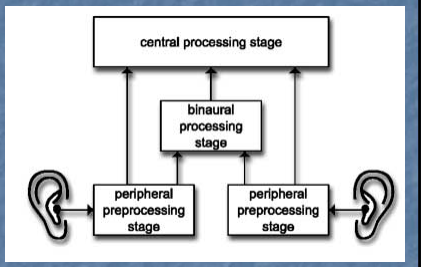
- Present sound to the user
- Spatialized 3D sound
  - sound surrounds user
  - take advantage of localization
- Localization – psychoacoustic process of determining location and direction from which a sound emanates
- Many applications

http://www.loonygames.com/content/2.4/feat/

http://www.proaudio-central.com/articles/pro-audio-asia/Iosono-and-SWD-Group-open-3D-sound-showroom-in-Shanghai

3D Sound Localization – Binaural Cues

- Comparison of sound waves received by each ear
- Interaural time difference – time between arrival of sound at each ear
- Interaural intensity difference – difference in sound intensity at each ear
- Cue does have problems
  - ambiguous situations
  - when two or more sources where ITD and IID are the same



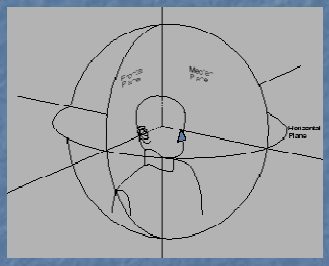
http://www.jeroenbreebaart.com/research_binaural.htm

3D Sound Localization – Spectral and Dynamic Cues

- Dynamic head movement or sound source
  - moving source is fairly weak cue
- Utilize spectral content
  - interaction of sound wave with outer ear
  - occur at relatively high frequencies (above 6KHz)

3D Sound Localization – Head Related Transfer Functions

- Spatial filters that describe how sound waves interact with listener's body
  - listener specific
  - lack reverberation info
- Build in echo free chamber with head model



http://www.tonmeister.ca/main/textbook/node320.html

3D Sound Localization – Reverberation

- Many factors affect a sound source
  - objects
  - atmospheric properties
- Sound hits listener directly and indirectly
- Aids in perception of distance, not direction

3D Sound Localization – Others

- Intensity (i.e., loudness)
  - simple cue
  - common in 3D audio displays
- Vision and Environment
  - sounds in FOV make spatial percepts

3D Sound Generation

- 3D sound sampling and synthesis
  - take samples from real environment
  - binaural audio recording
  - generate HRTFs for each ear
- Auralization
  - rendering a sound field
  - good for reverberation effects
  - wave-based modeling
  - ray-based modeling

Sound System Configurations

- Headphones (stereophonic)
  - High level of channel separation
  - avoid crosstalk
  - isolate listener from external sounds
  - problems with inside the head localization
- External Speakers
  - place speakers around the room
  - no need to wear anything
  - problems with crosstalk
  - Two approaches –transaural audio and amplitude panning

Audio in 3DUIs

- Localization
  - wayfinding aids
- Sonfication
  - turning information into sounds
- Ambient Effects
  - adding realism
- Sensory Substitution
  - sound for touch
- Annotation and Help

Haptic Displays

- Provide user with sense of touch
  - simulate interaction between virtual objects and user
  - force (joint/muscle)
  - tactile (skin-based)

www.novint.com

Haptic Cues – Tactile Cues

- Taction – perceived by variety of cutaneous receptors under skin surface
  - surface texture
  - temperature
  - pressure
  - pain
- Found in varying concentrations on the body

Haptic Cues – Kinesthetic Cues

- Perceived by receptors in muscles, joints and tendons
  - help to determine movement, position and torque of different body parts
  - relationship between user and object via muscular tension
- Both active (movement self-induced) and passive (movement by external force)

Haptic Display Characteristics

- Presentation capability – what types of output
- Resolution
  - Spatial – minimum proximity of stimuli
  - Temporal – refresh rate
- Ergonomics
  - Don't want to break anyone

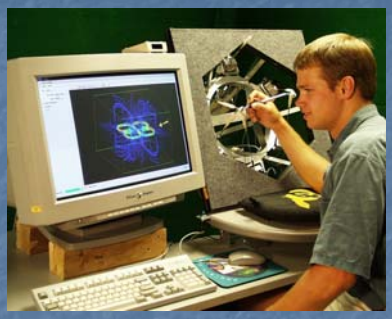
Haptic and Tactile Displays

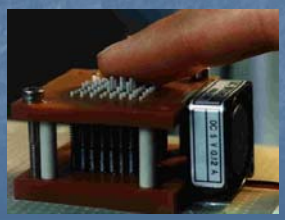
- "For every action there is an equal and opposite reaction"
  - Sir Isaac Newton
- Main forms of feedback
  - ground referenced
  - body referenced
  - tactile
  - in air
  - combination
  - passive – physical props

Haptic Displays

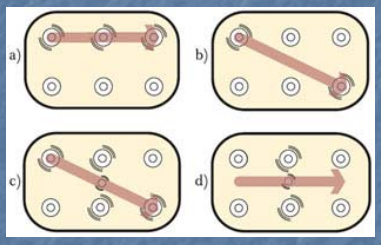
- Motionware device
- Provides vestibular stimulation
- Sends signals to the 8th cranial nerve
- Gives user a sense of motion
- No longer exits

Other Haptic Devices



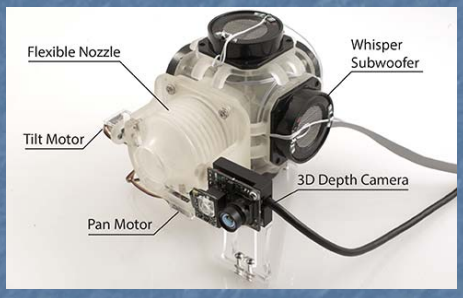


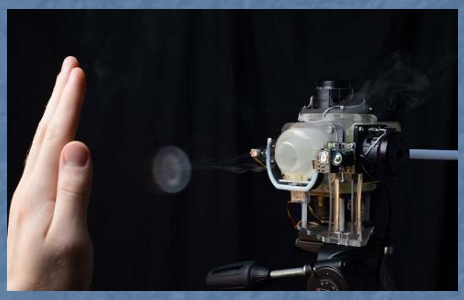
Tactile Display Example



Surround Haptics – Disney Research Pittsburgh
http://www.disneyresearch.com/project/surround-haptics/

In Air Tactile Display Example (1)





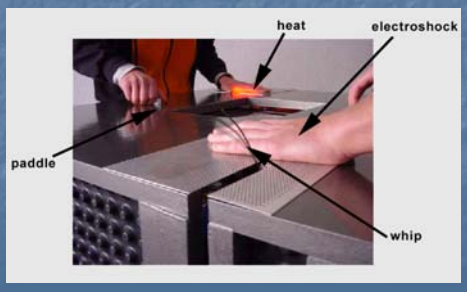
Aireal – Disney Research Pittsburgh
http://www.disneyresearch.com/project/aireal/

In Air Tactile Display Example (2)

Ultra Haptics – Bristol Graphics and Interaction
http://big.cs.bris.ac.uk/projects/ultrahaptics

PainPong

- PainStation
  - two person console
  - electro shock, heat, whipping:
    bad performance → pain



PainStation - Pong
Courtesy of www.painstation.de

Hall of Pain (www.painstation.de)




Haptics – Interface Design

- Useful for object manipulation
- Problem with these devices is they are very intimidating
- Mimic real world interaction
- Untapped area for games
  - scary too!!

Olfactory Output

- Least developed area
  - maybe for good reason!
- Has practical applications
  - fire fighting
  - surgical training
- Number of practical problems

http://www.cyber.t.u-tokyo.ac.jp/~narumi/metacookie.html

http://silvia.mn.ee.titech.ac.jp/English/MNL_olfactory_display.htm

Next Class

- Input devices
- Readings
  - 3DUI Book – Chapter 3, pages 59-86