IMGD 3xxx - HCI for Real, Virtual, and Teleoperated Environments:
The Human Visual System and Visual Display Techniques

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Introduction

- Vision is the most dominant sense
  - Though other senses are better at certain things, like smell for memory recall

- What types of visual elements are common to interactive experiences?

- How can we leverage the visual sense to promote efficiency and effectiveness?
Motivation

- We need to display the state of the world to the user
  - Display: a method of presenting information to any of the senses

- We need to display the user to the user (maybe)

- We need to feed each sense appropriately

- We need to feed multiple senses in concert
  - Display for one sense shouldn't get in the way of display for another sense

- May need to quickly don/doff displays

- For gaming, low-cost is important
Some Things to Remember

- Humans are animals, and hence, have evolved over time.
- Evolutionary forces have guided the development of our senses.
- Displays and cues that leverage this fact have a better shot of being effective.
General Types of Displays

- The senses
  - Visual
  - Auditory
  - Haptic
  - Olfactory
  - Gustatory

- Display anchoring
  - World-fixed displays
  - Body-worn displays
  - Hand-held displays
Visual Display Anchoring Points

- World-fixed displays
  - Fishtank VR
  - Projection VR

- Body-worn displays
  - Opaque HMDs
  - Transparent HMDs

- Hand-held displays
  - Palm VR
  - Boom-mounted screens
Visual Display Types

- Monitors
  - CRT, Plasma, LCD

- Surround-screens (e.g., CAVEs)

- Tabletops

- Hemispheric displays

- Head-mounted displays (HMDs)

- Arm-mounted displays

- Virtual retinal displays

- Autostereoscopic displays

- 3D displays
Surround Screens

- CAVEs
Surround Screens (cont.)

- CAVE
Head-Mounted Displays (HMDs)
Visual Cues

- Depth is the main thing added by VR to more-traditional displays
  - How do we perceive depth?

- Monoscopic cues
- Stereoscopic cues
- Motion-depth cues
- Physiological cues
Monoscopic Cues

- Overlap (Interposition)
- Shading & shadows
- Size
- Linear perspective
- Texture gradient
- Height in the image
- Atmospheric effects
- Brightness
Stereoscopic Cues

- This is based on the *parallax* of objects appearing in two images.
- Camera 1 / camera 2 effect
- Only good within about 5 meters of viewer
Motion Depth Cues

- Changing relative position of head and objects

- Can be user and/or object moving
  - Train leaving a station
  - Use proprioception to disambiguate

http://www.youtube.com/watch?v=1AZAbSXmeoI
Motion Depth Cues (cont.)

- Head movement

(A) and (B) show examples of head movement cues in a virtual environment.
Physiological Cues

- The eye changes during viewing
- Accommodation
  - Muscular changes of the eye
- Convergence
  - Movements to bring images to same location on both retinas
Properties of Visual Displays

- Color
- Spatial resolution
- Contrast
- Brightness
- Number of channels
- Focal distance
- Opacity
- Masking
- Field of view
- Field of Regard
- Head position info
- Graphics latency
- Frame rate
Number of Display Channels

- Spatial multiplexing
  - Different image in front of each eye

- Temporal multiplexing (time interlacing)
  - Use shutter glasses

- Polarization multiplexing
  - Use polarized glasses

- Spectral multiplexing
  - Red/blue left-eye/right-eye images

- Binocular monoscopic

- **Stereo takes twice the resources!**
Masking

- How physical objects block virtual ones
- CAVE: Hands can break effect
- HMD: Not at all
- Fishtank: Display edges/bezel can break effect

http://www.youtube.com/watch?v=Jd3-eiid-Uw
Field of View vs. Field of Regard

Field of view (FOV)
- How much of the scene (in degrees) is visible at any given time

Field of regard (FOR)
- Amount of space (in percent) of the virtual world currently surrounding the user

Examples
- CAVE: 200° FOV facing forward, 75% FOR
- HMD: 100° FOV, 100% FOR
Hand-Held VR

- PDAs are becoming more powerful
  - Can track a tablet PC, and use as VR display

- Call phones have cameras
  - Can do AR
Change Blindness

- There is so much information for the brain to process, we need to filter.
- Change blindness is when we miss things that change from one instant to another.
  - [http://www.youtube.com/watch?v=mAnKvo-fPs0](http://www.youtube.com/watch?v=mAnKvo-fPs0)

- A public service announcement:
  - [http://www.youtube.com/watch?v=Ahg6qcgoay4&NR=1](http://www.youtube.com/watch?v=Ahg6qcgoay4&NR=1)

- Next example from:
  - Show Movie
Change Blindness
Change Blindness (answer)
Change Blindness (answer)
Visuals in Games

- Two main kinds
  - Visuals for representing the world (player)
  - Visuals for representing the state of the game (player)

- Usually for the first type, more is better
- Usually for the second type, less is better
Heads-Up Displays (HUDs)

- **What is a HUD?**
  - "A collection of persistent on-screen elements whose purpose is to indicate player status."
  
  (Greg Wilson, Gamasutra: http://www.gamasutra.com/features/20060203/wilson_pfv.htm)

- **Are HUDs good?**
Creating an Effective HUD

- How can we minimize HUD elements?
- Decide what information the player needs, and what he/she doesn't.
- Put as much of that information into the game
  - E.g., speedometer in car, ammo count on weapon
- Off-load from visuals to something else
  - Examples for what would work?
- Blink-in changes, then fade them out
- Make things configurable
  - View point, map type, transparency
- Camouflage the HUD using themes
HUD-less

(Peter Jackson's King Kong)
Integrated HUD Info

(Doom 3)
Integrated HUD Info

(Project Gotham Racing 3)
Semi-Opaic HUD

(Deus Ex: Invisible War)
Themed HUD

(Metroid Prime)
Need For Speed HUD Elements
Need For Speed HUD Elements
Good Readings

☐ "Learn Faster to Play Better"

☐ "Off with their HUDs"