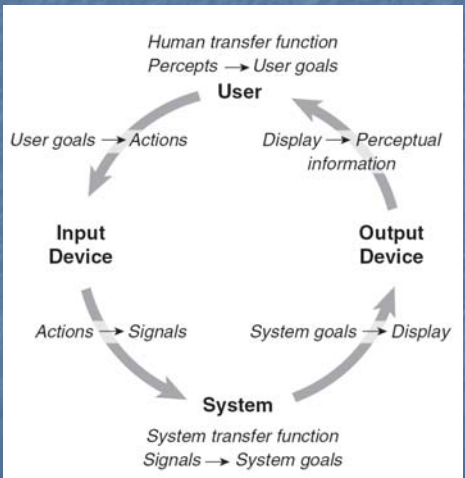
3D User Interface Hardware

Lecture #5: Visual Displays

Spring 2016

Joseph J. LaViola Jr.

Interaction Workflow



Introduction To Displays

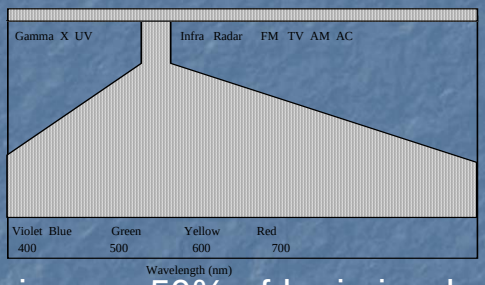
- *Display*: device which presents perceptual information
- Often ‘display’ used to mean ‘visual display’
- Goal: display devices which accurately represent perceptions in simulated world

Lecture Outline

- Visual System
- Depth Cues
- Visual Display Characteristics
- Visual Display Examples
  - single screen displays
  - surround and multi-screen displays
  - workbenches and tabletop displays
  - head mounted displays
  - anywhere displays
  - autostereoscopic displays

Vision

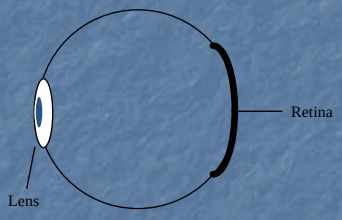
- Stimulus: light of wavelengths ~350-750 nm



- Visual dominance: 50% of brain involved in processing!

Eye Physiology

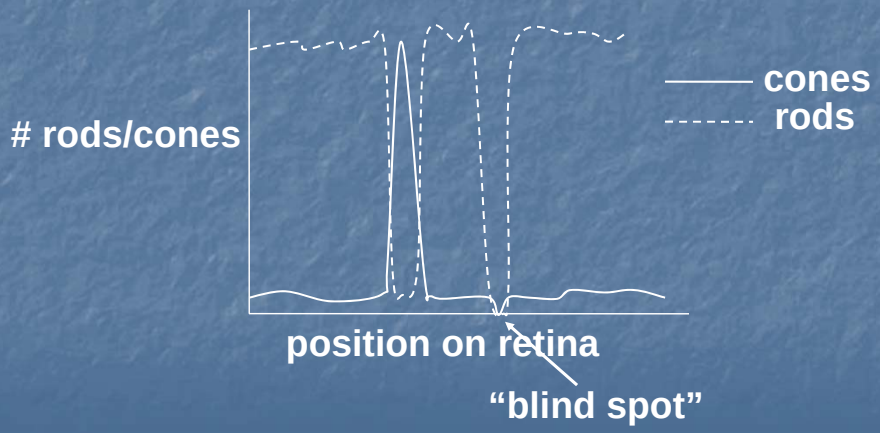
- Camera metaphor:
  - lens (can change)
  - film (retina)
  - amount of exposure (pupil)



Retina

- Photoreceptors: rods & cones
- Distinction of function
  - rods: periphery, motion, B&W, sensitivity
  - cones: fovea, static, color, acuity

Rod/cone Distribution

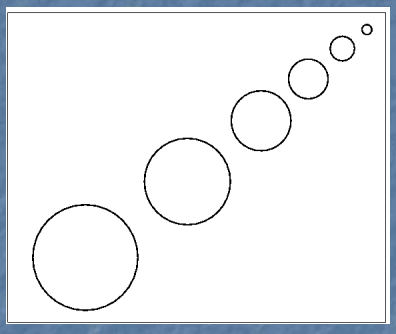


Depth Cues – How Do We See 3D?

- Monocular/static cues
- Occulomotor cues
- Motion Parallax
- Binocular Disparity and Stereopsis

Monocular/Static Cues

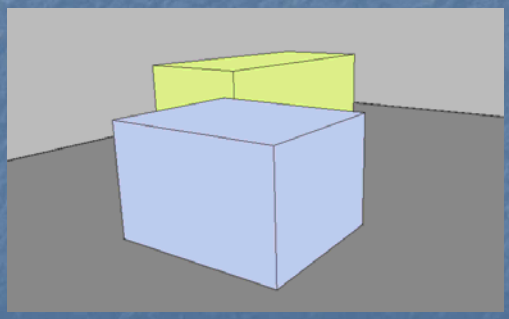
- Relative Size



- Height relative to horizon

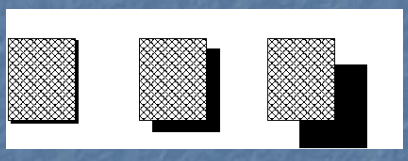
Monocular/Static Cues

- Occlusion and Linear Perspective



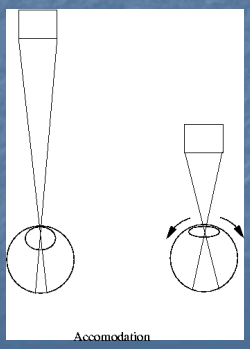
Monocular/Static Cues

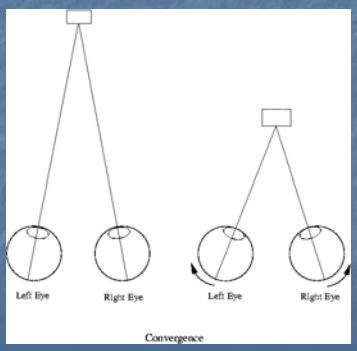
- Shading, Lighting, and Texture



Oculomotor Cues

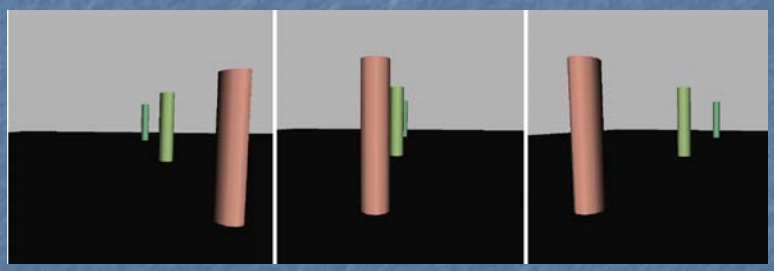
- Accommodation – physical stretching and relaxing of eye lens
- Convergence – rotation of viewer's eyes so images can be fused together at varying distances





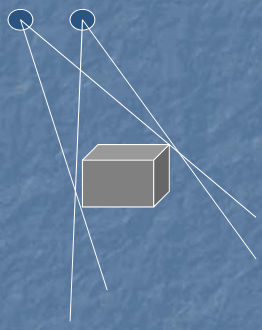
Motion Parallax

- Stationary viewer vs. moving viewer



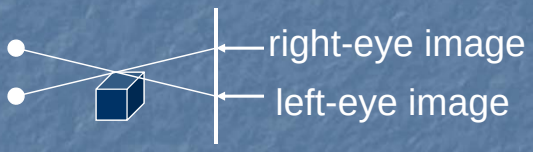
Binocular Disparity and Stereopsis

- Each eye gets a slightly different image
- Only effective within a few feet of viewer
- Many implementation schemes



Accommodation-Convergence Mismatch

- Standard stereo displays confuse the brain based on oculomotor cues



- Only “true 3D” displays can provide these correctly

Visual Display Characteristics

- Field of View (FOV) and Field of Regard (FOR)
  - FOR – amount of physical space surrounding viewer in which visual images appear
  - FOV – maximum visual angle seen instantaneously
- Spatial Resolution
  - number of pixels and screen size
- Screen Geometry
  - rectangular, hemispherical, etc...
- Light Transfer Mechanism
  - front projection, rear projection, laser light, etc...
- Refresh Rate
  - not the same as frame rate
- Ergonomics

Single Screen Displays

- Ordinary monitor, TV, tablet equipped with emitter and shutter glasses

Stereo Monitor – Advantages

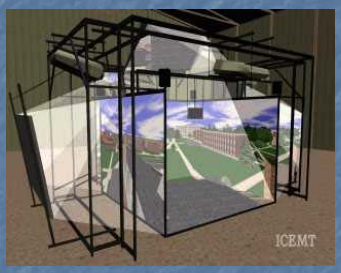
- Least expensive in terms of additional hardware over other output devices
- Allows usage of virtually any input device
- Good resolution
- User can take advantage of keyboard and mouse

Stereo Monitor – Disadvantages

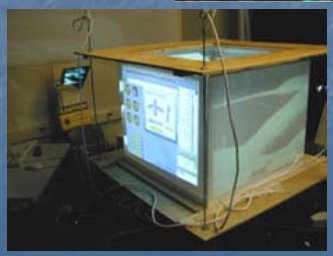
- Not very immersive
- User really cannot move around
- Does not take advantage of peripheral vision
- Stereo can be problematic
- Occlusion from physical objects can be problematic

Surround and Multi-Screen Displays

- Has many screens and projectors (often planar at 90 degree angles
- Surround user for visual immersion
- Usually driven by a single or group of powerful graphics engines



Surround and Multi-Screen Displays



Surround and Multi-Screen Displays

Display with screens at 120 degree angles

Surround and Multi-Screen Displays

Multi-screen surround displays where the screens are at nonorthogonal angles.

Surround and Multi-Screen Displays

Non-planar surround screen displays (cylindrical and hemispherical)

SS Displays – Advantages

- Provides high resolution and large FOV
- User only needs a pair of light weight shutter glasses for stereo viewing
- User has freedom to move about the device
- Environment is not evasive
- Real and virtual objects can be mixed in the environment
- A group of people can inhabit the space simultaneously

SS Displays – Disadvantages

- Can be expensive (6-7 figures)
- Requires a large amount of physical space
- Calibration must be maintained
- Non-planar displays require nonstandard projection
- No more that two users can be head tracked
- Stereo viewing can be problematic
- Physical objects can get in the way of graphical objects

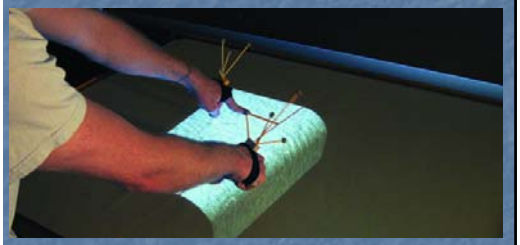
SS Displays – Interface Design

- Do not need to represent physical objects (i.e. hands) as graphical objects
- Can take advantage of the user's peripheral vision
- Do not want the user to get too close to the screens
- Developer can take advantage of the space for using physical props (i.e. car, motion platform)

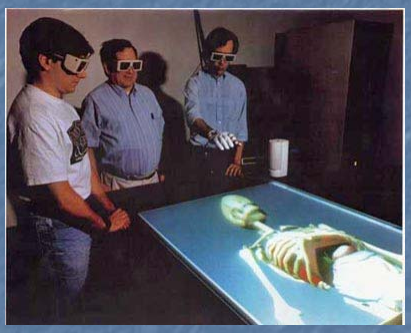
Workbenches and Table Top Displays

- Similar to SS Displays but one display (two at most)
- Traditionally a table top metaphor
- Considered smaller version of SS Display

Workbenches and Table Top Displays



Workbenches and Table Top Displays



Workbench Displays – Advantages

- High resolution
- For certain applications, makes for an intuitive display
- Can be shared by several users

Workbench Displays – Disadvantages

- Limited movement
- At most two users can be head tracked
- No surrounding screens
- Physical objects can get in the way of graphical objects
- Stereo can be problematic

Workbench Displays – Interface Design

- Ergonomics are important especially when designing interfaces for table displays
- User can take advantage of direct pen-based input if display surface permits
- No need to make graphical representations of physical objects

Head Mounted Displays

- Device has two CRT, OLED, or LCD screens plus special optics in front of the users eyes
- User cannot naturally see the real world
- Provides a stereoscopic view that moves relative to the user

Head Mounted Displays

- Variants
  - Virtual Retinal display
  - Arm mounted display

Head Mounted Displays

- Used for Augmented Reality
  - video see though
  - optical see through

HMDs – Advantages

- Provides an immersive experience by blocking out the real world (except for AR)
- Fairly easy to set up
- Does not restrict user from moving around in the real world
- Good quality HMD is relatively inexpensive
- Can achieve good stereo quality

HMDs – Disadvantages

- Often have reduced field of view (FOV)
- Does not take advantage of peripheral vision
- Isolation and fear of real world events
- Devices can cost in the 100,000 dollar range
- Sometimes do not fit well

HMDs – Interface Design

- Physical objects require a graphical representation
- Limits the types of input devices that can be used

Anywhere Displays

- Goal is to use anything as a display screen
  - objects
  - non planar surfaces
- Projection mapping
- Spatial augmented reality

Anywhere Displays

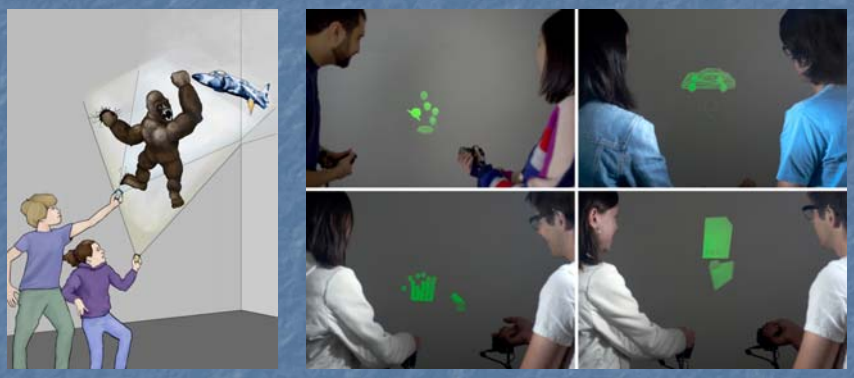
AutoStereoscopic Displays

- Lenticular
- Volumetric
- Holographic

Simulated Autostereo – pCubee

University of British Columbia
http://hct.ece.ubc.ca/research/pcubee/

Other Display Technologies



SidebySide/Motion Beam
Disney Research, Pittsburgh

Other Display Technologies

Compressive Displays
Ramesh Raskar, Camera Culture Group, MIT

Which Visual Display to Use?

- Consider lists of pros and cons
- Consider depth cues supported
- Consider level of visual immersion
- But this is a very hard question to answer empirically

Next Class

- Audio and Haptic displays
- Readings
  - 3DUI Book – Chapter 3, pages 29-59