



CS-525V:
Building Effective
Virtual Worlds

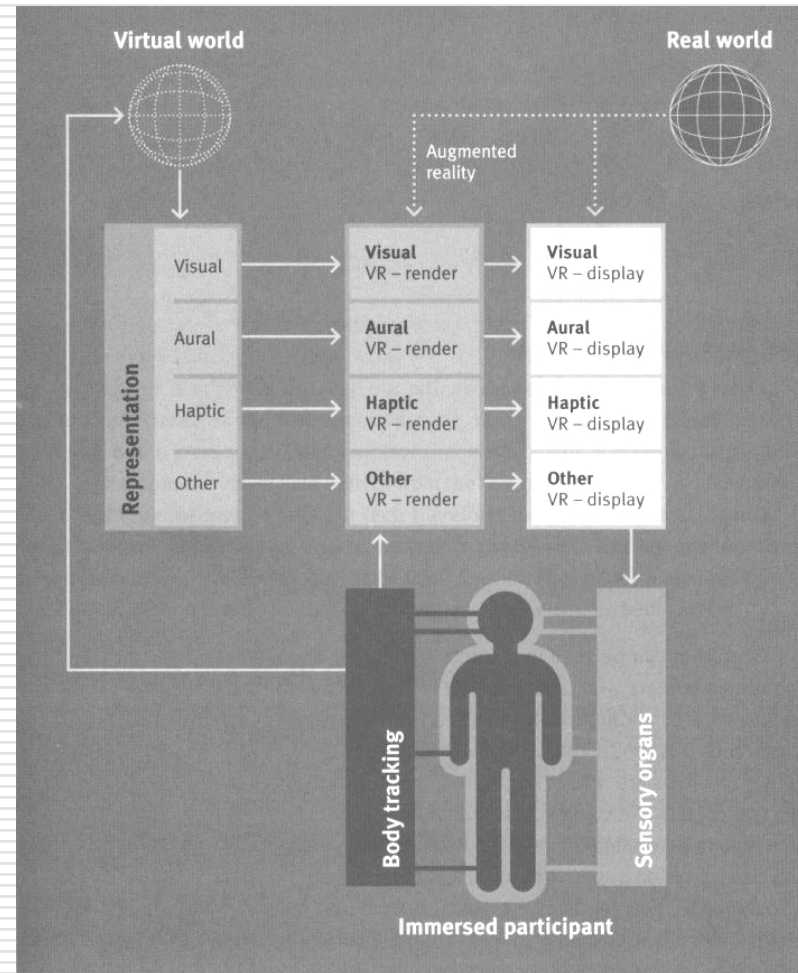
Output Devices

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Overview

- Here we are concerned with technology for stimulating the senses



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

Some Things to Remember

- ❑ Humans are animals, and hence, have evolved over time.
- ❑ Evolutionary forces have guided the development of our senses.
- ❑ Displays 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 Types

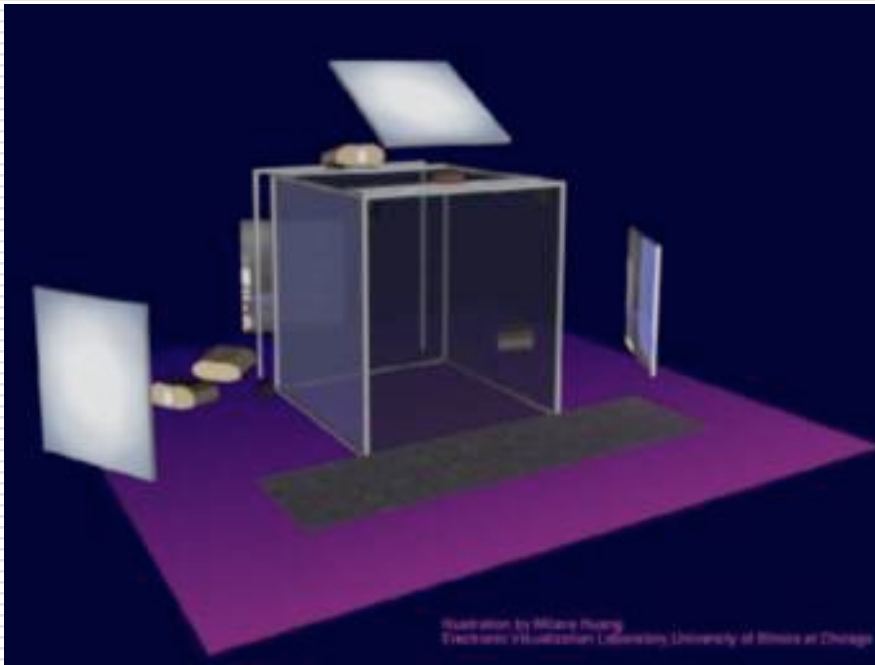
- World-fixed displays
 - Fishtank VR
 - Projection VR

- Body-worn displays
 - Opaque HMDs
 - Transparent HMDs

- Hand-held displays
 - Palm VR
 - Boom-mounted screens

Visual Displays

□ CAVEs



Visual Displays (cont.)

□ CAVE

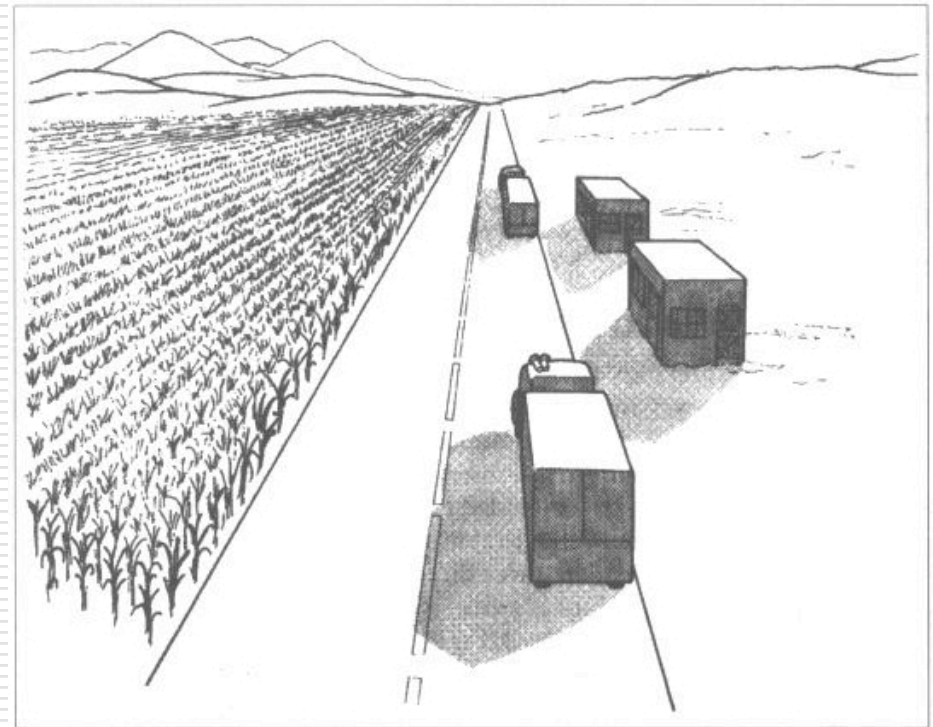


Visual Cues

- ❑ 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* objects appearing in two images.
- ❑ Camera 1 / camera 2 effect
- ❑ Only good within about 5 meters of viewer

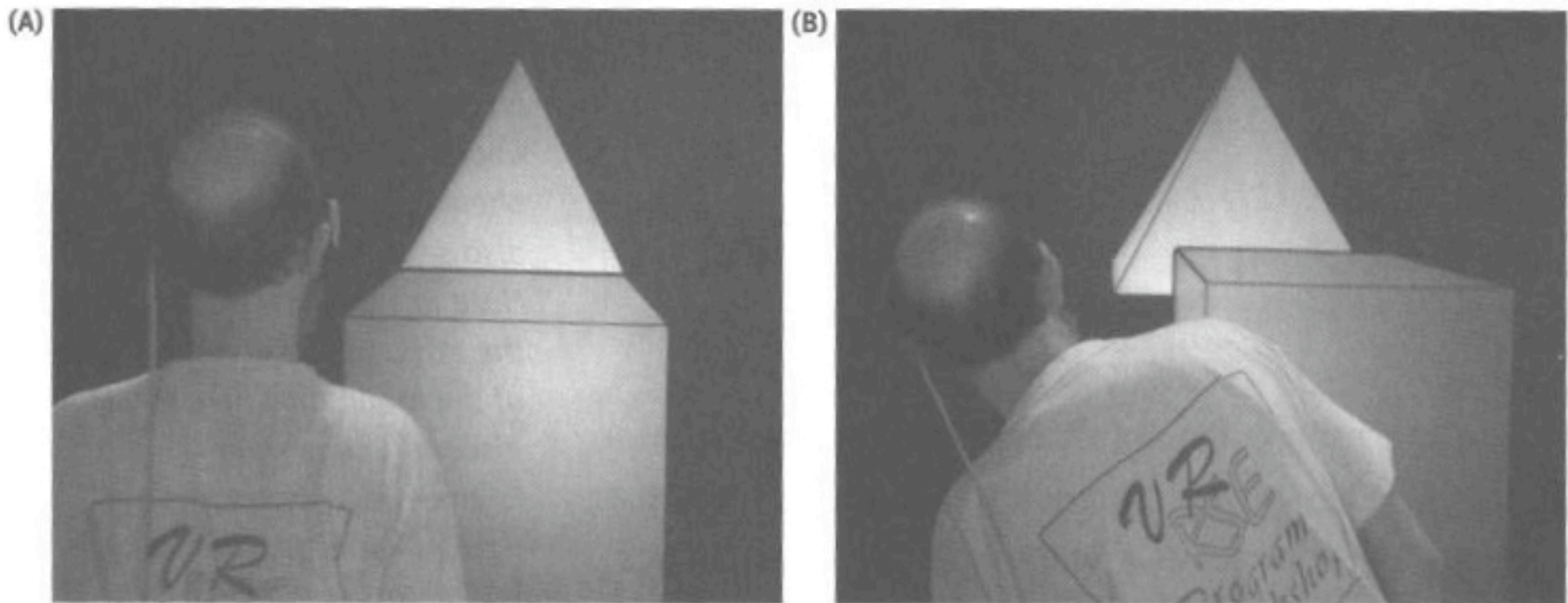
Motion Depth Cues

- Changind relative position of head and objects
- Can be use 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



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
- Cell phones have cameras
 - Can do AR