Winter 2013

CSE 190: 3D User Interaction

Lecture #2: Displays

Jürgen P. Schulze, Ph.D.

Announcements

- Homework Assignment #1 on-line
  - Due date: January 25 at 1pm
  - To be presented in Sequoiah lab
- Reminder: paper presentations
- Final exam date: conflicts?

PRIME

For more information on PRIME, please visit: http://prime.ucsd.edu

PRIME 2013

Information Session — January 10, 2013 @ 6pm
UCSD International Center Lounge

Pacific Rim Experiences for Undergraduates:
An International Research Internship

PRIME is an **international research internship** and **cultural experience** that prepares students for the global workplace in the 21st century.

- Students have two mentors, a researcher at UCSD and another one at the international internship host site.
- Students do research at advanced institutions on the Pacific Rim countries, including Australia, China, Japan, Taiwan and more!
- Basic expenses are covered by grant funds.

At the information session you will hear from the program directors about the program and application process, from UCSD mentors about the opportunities, and from former PRIME students about the experience from their perspective.

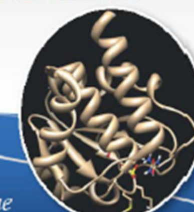
Please Join Us!

Hear from PRIME Alumni!

Find out how you can apply for this exciting opportunity!

Gain research experience abroad and contribute to the international scientific community!

"PRIME gave me a hands-on perspective as to how research can be fun in an international context."
Harriet Hu, 2012 PRIME Australia Alumna



"Without question, PRIME was the most influential experience I had during my time as an undergraduate at UCSD. The foundation of knowledge in high performance computing that I acquired through PRIME is something that I have continued to use every day in my research career."
John Colby (UCLA: MD/PhD), 2004 UCSD PRIME Australia Alumnus

Homework Assignment 1

- Assignment review
- Q&A

Interaction Goals

- Performance
  - efficiency
  - accuracy
  - productivity
- Usability
  - ease of use
  - ease of learning
  - user comfort
- Usefulness
  - interaction helps meet system goals
  - interface relatively transparent so users can focus on tasks

Universal 3D Interaction Tasks

- Navigation
  - travel: motor component
  - wayfinding: cognitive component
- Selection/Picking
- Manipulation
  - specification of object position & orientation
  - specification of scale, shape, other attributes
- System Control
  - changing the system state or interaction mode
  - may be composed of other tasks
- Symbolic Input (text, numbers)

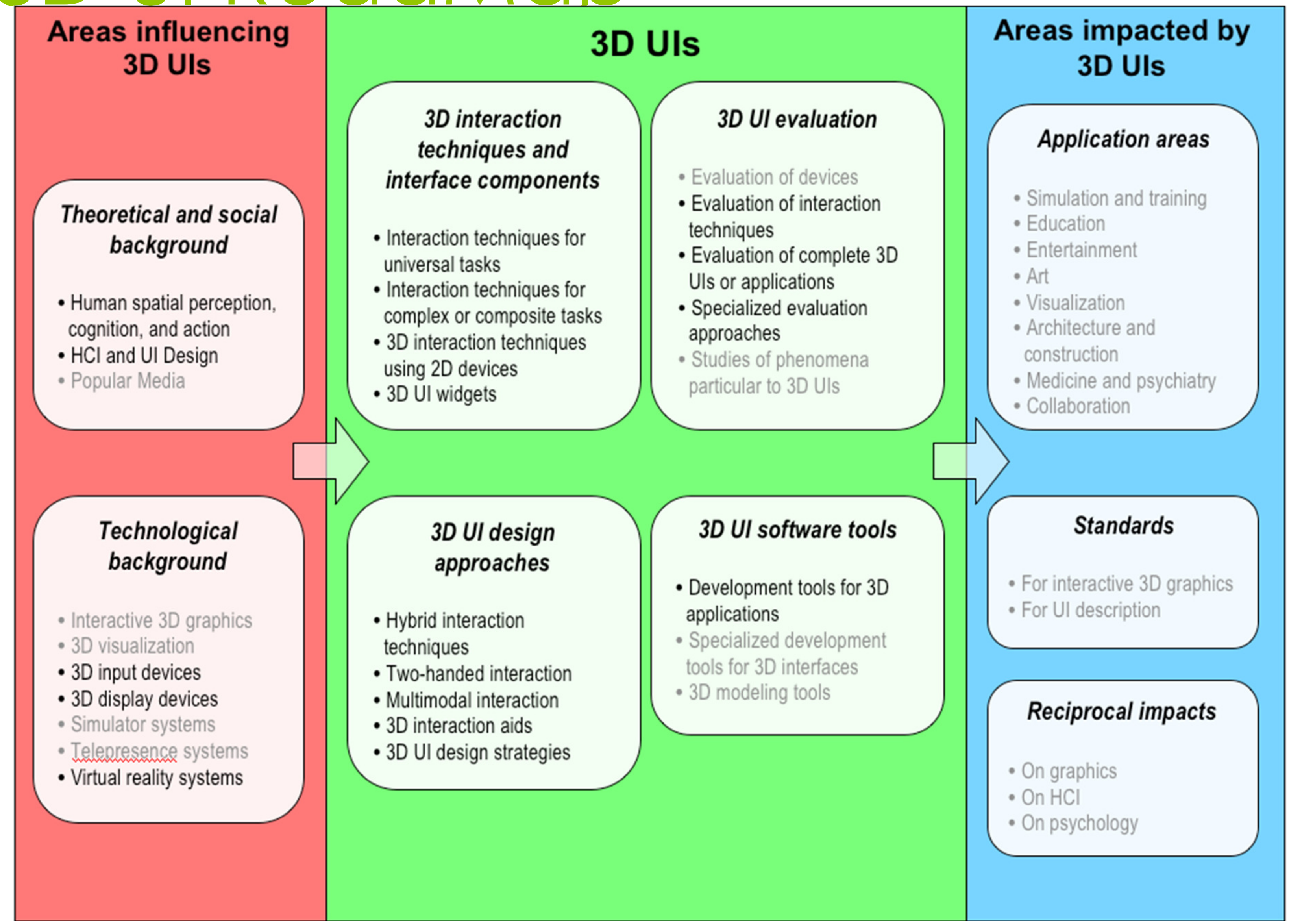
3D UI Design Philosophies

- Artistic approach: Base design decisions on
  - intuition about users, tasks, and environments
  - heuristics, metaphors, common Sense
  - aesthetics
  - adaptation/inversion of existing interfaces
- Scientific approach: Base design decisions on
  - formal characterization of users, tasks, and environments
  - quantitative evaluation results
  - performance requirements
  - examples: taxonomies, formal experimentation

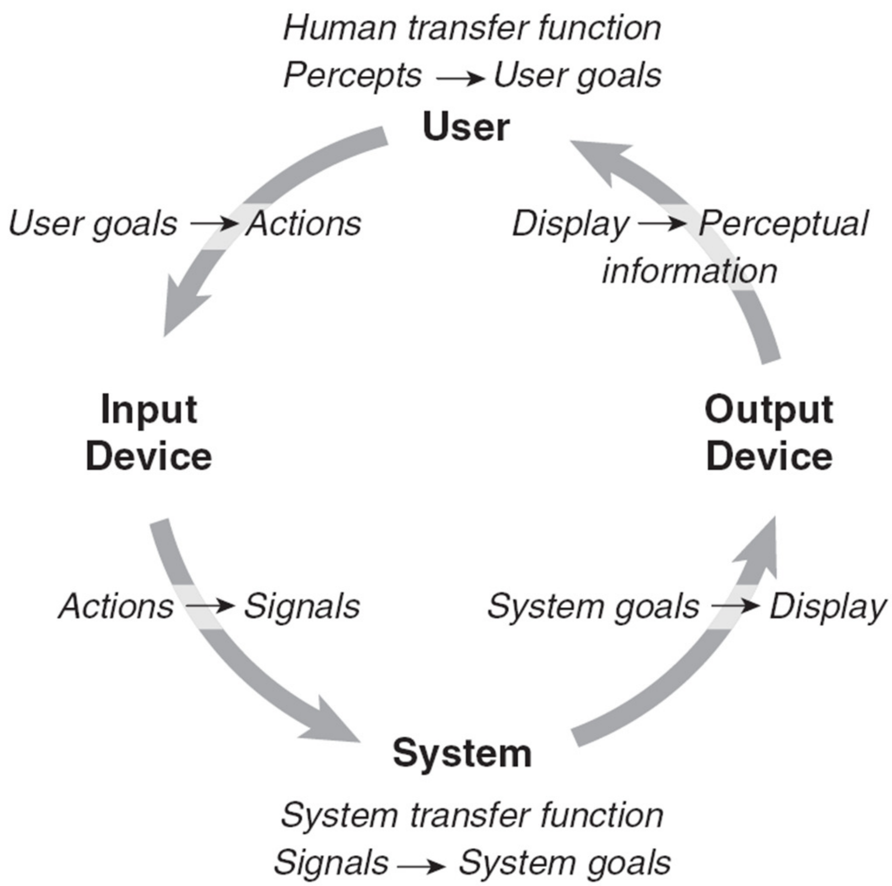
Applications

- Architecture / CAD
- Education
- Manufacturing
- Medicine
- Simulation / Training
- Entertainment – *Games!*
- Design / Prototyping
- Information / Scientific Visualization
- Collaboration / Communication

3D UI RoadMap



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

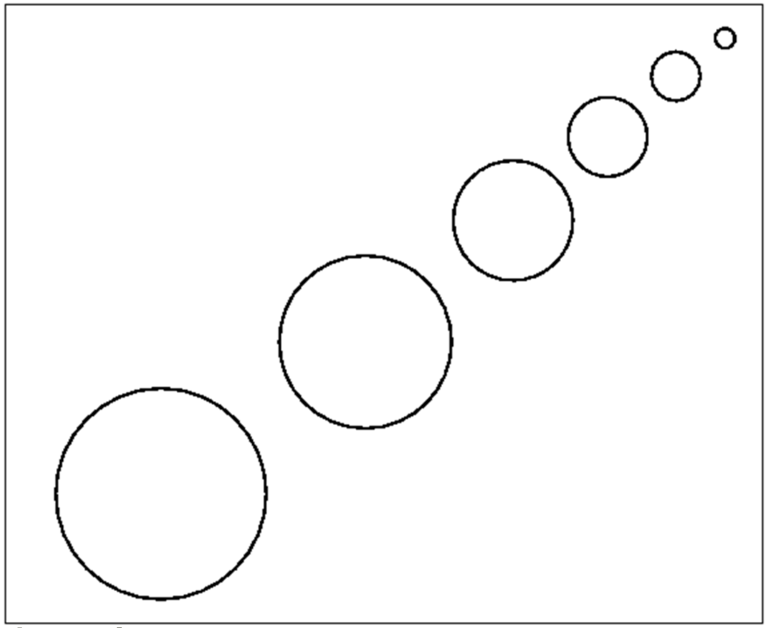
- Visual System
- Depth Cues
- Visual Display Characteristics
- Visual Display Examples
  - monitors
  - surround screen displays
  - workbenches
  - head mounted displays
  - arm-mounted displays
  - virtual retinal displays
  - autostereoscopic displays

Depth Cues – How Do We See 3D?

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

Monocular/Static Cues

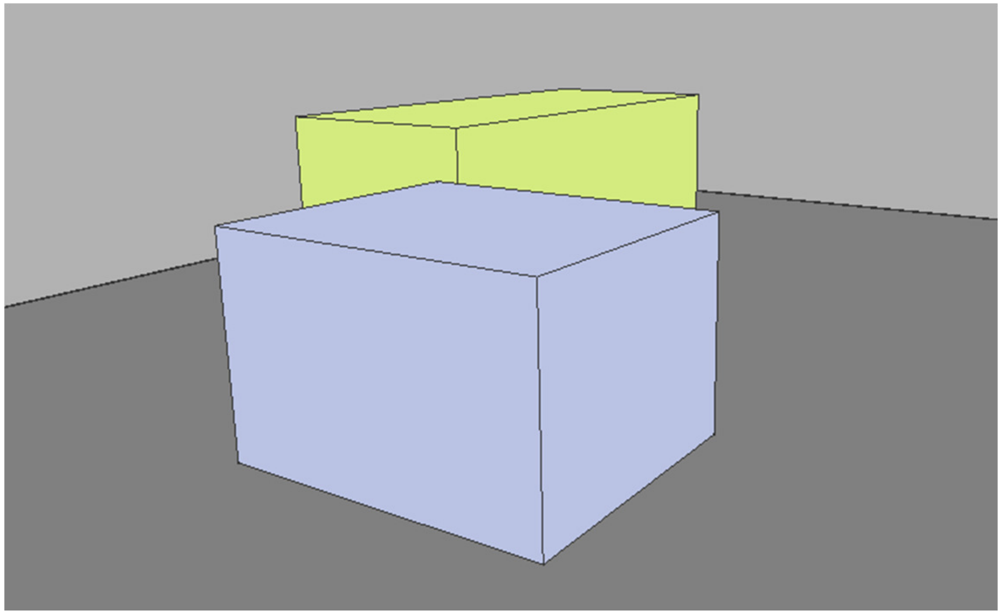
- Relative Size



- Height relative to horizon

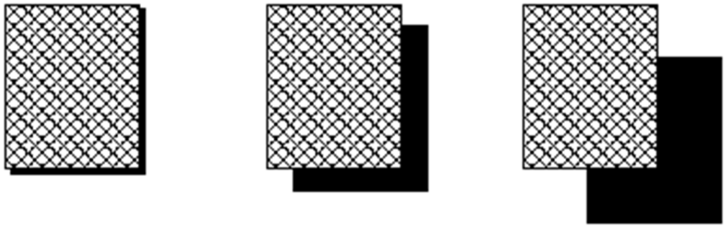
Monocular/Static Cues

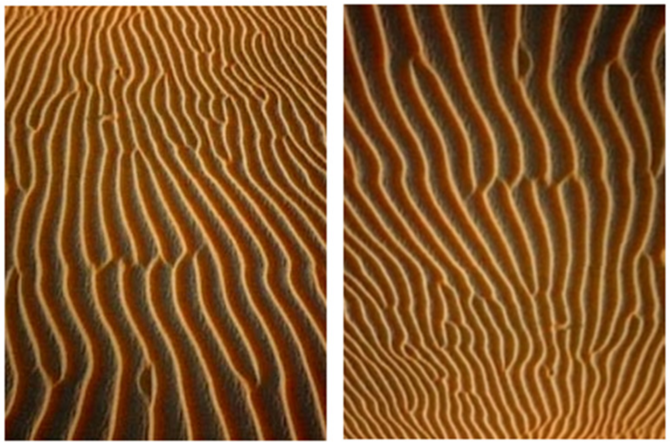
- Occlusion and Linear Perspective



Monocular/Static Cues

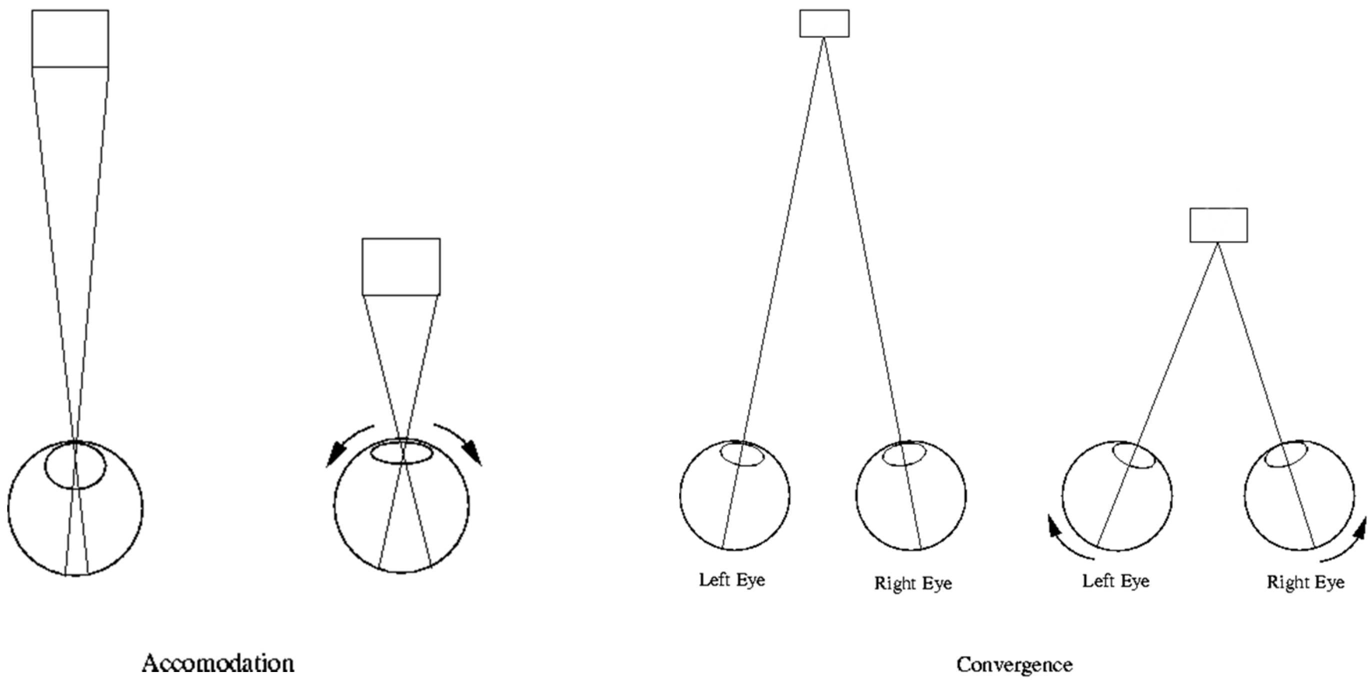
- Shading, Lighting, and Texture





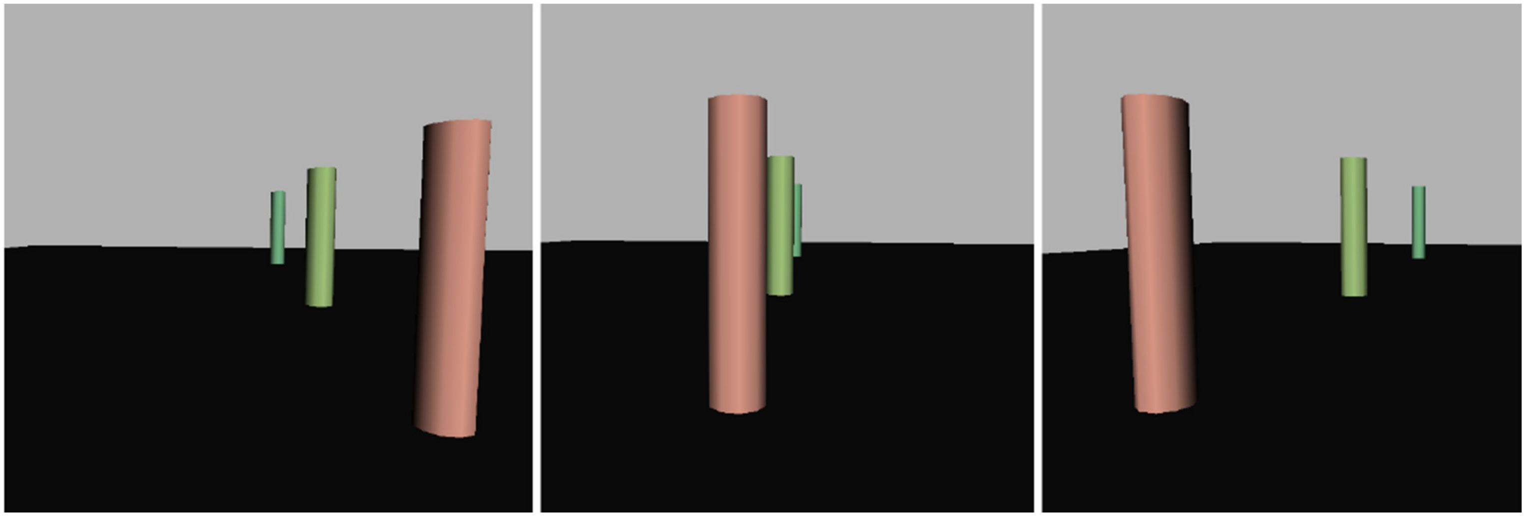
Oculomotor Cues

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



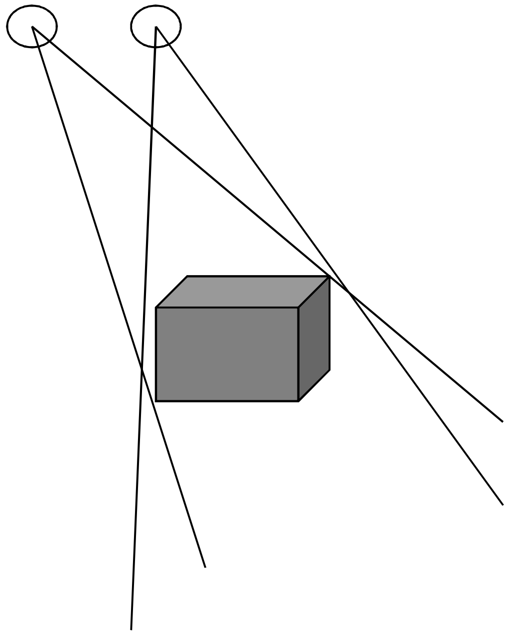
Motion Parallax

- Stationary viewer vs. moving viewer



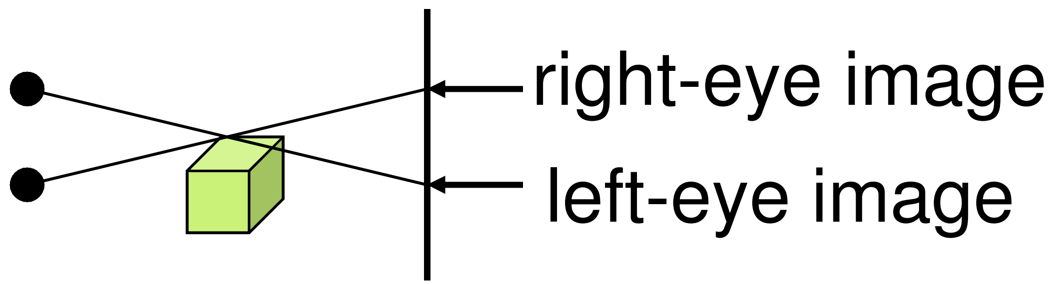
Binocular Disparity and Stereopsis

- 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



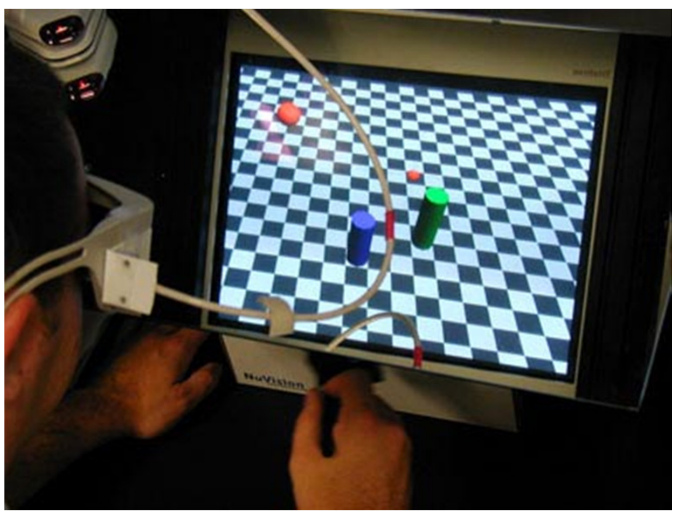
- Only "true 3D" displays can provide these correctly

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

Stereo Monitor

- Ordinary workstation equipped with emitter and shutter glasses



Stereo Monitor – Advantages

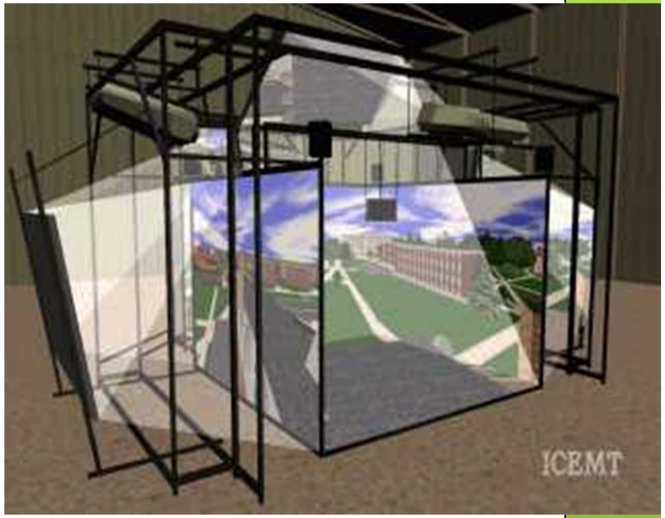
- Least expensive in terms of additional hardware over other output devices
- Allows usage of virtually any input device
- Good resolution
- User can take advantage of keyboard and mouse

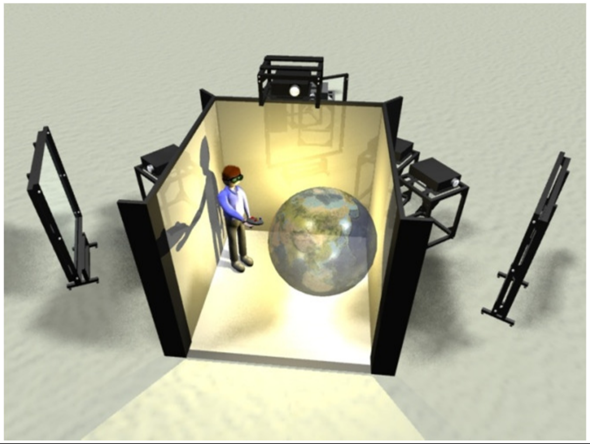
Stereo Monitor – Disadvantages

- 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 Screen VE (1)

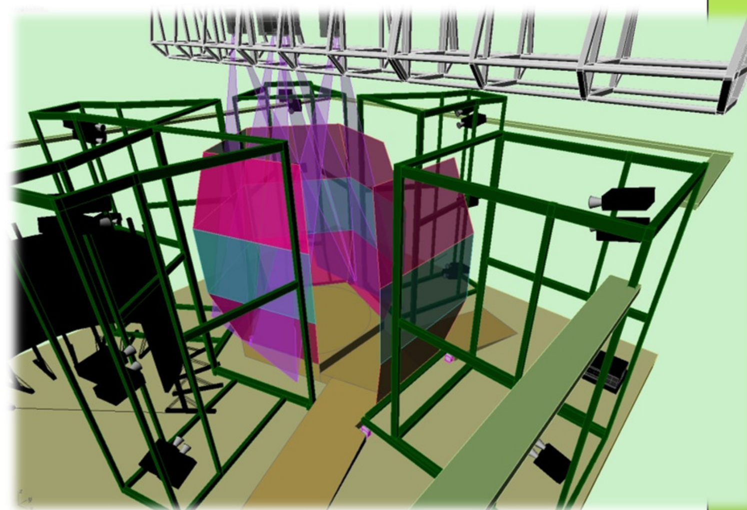
- Has 3 to 6 large screens
- Puts user in a room for visual immersion
- Usually driven by a single or group of powerful graphics engines

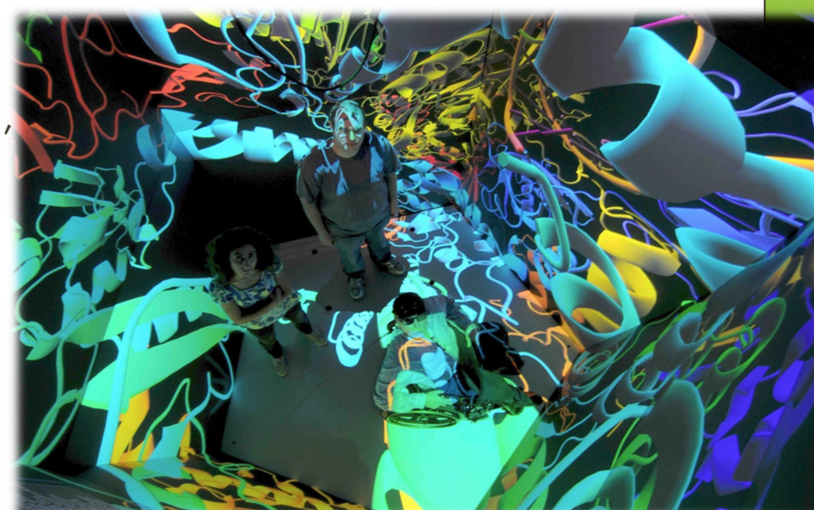




The StarCAVE

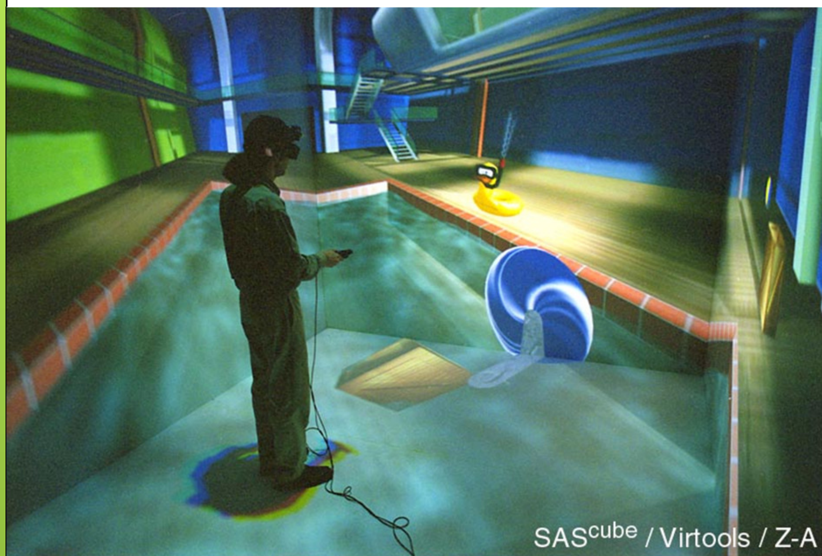
- 18 Dell XPS 710 PCs
- Dual Nvidia GeForce 285 graphics cards
- CentOS Linux
- 34 JVC HD2k projectors (1920x1080 pixels):
  ~34 megapixels per eye
- 360 degrees immersion
- Passive stereo, circular polarization
- 15 screens on 5 walls, ~8 x 4 foot each, plus floor projection
- 4-camera optical tracking system

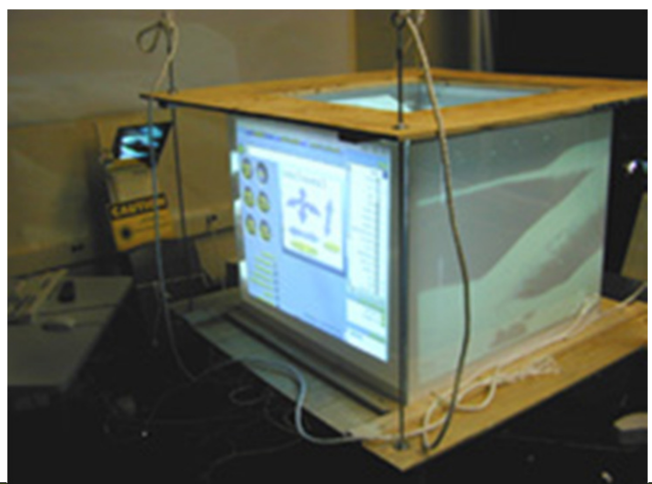




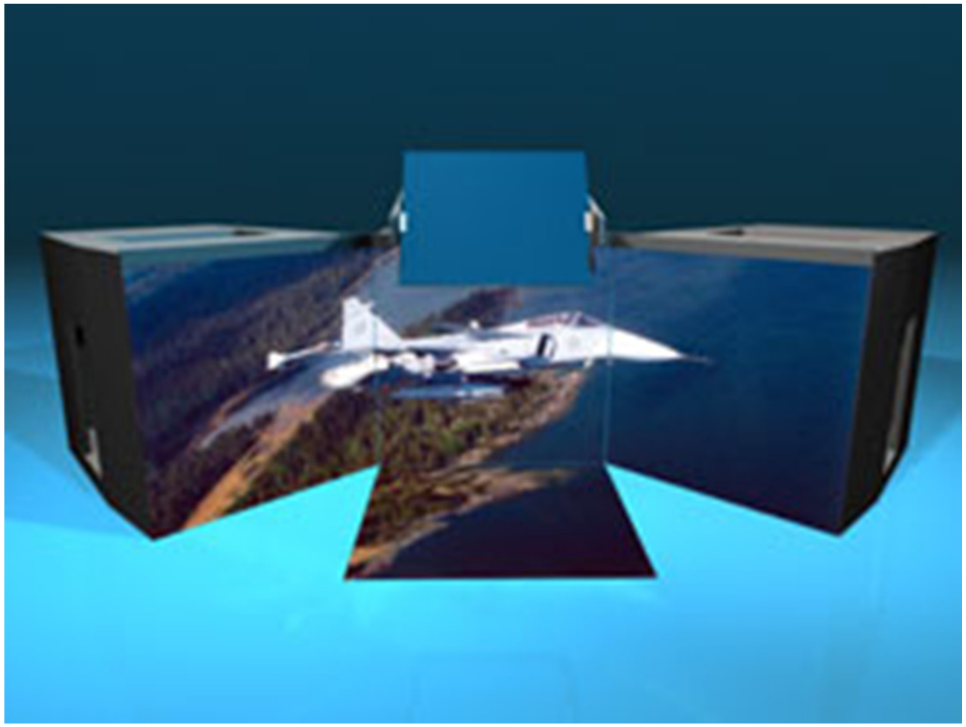
NexCAVE

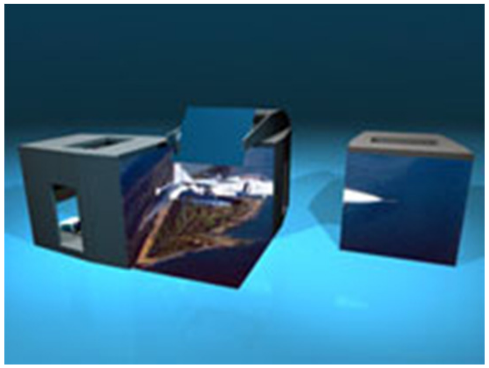
- 14 42" JVC Xpol displays:
  LCD panels with polarizing filters,
  1920x1080 pixels
- 8 rendering PCs
- Nvidia GeForce 480 GPUs
- 2-camera ART TrackPack optical tracking system


SAS^cube / Virtools / Z-A



Surround Screen VE (3)





SSVE – 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

SSVE – Disadvantages

- Very expensive (6-7 figures)
- Requires a large amount of physical space
- Projector calibration must be maintained
- No more that two users can be head tracked
- Stereo viewing can be problematic
- Physical objects can get in the way of graphical objects

SSVE – Interface Design

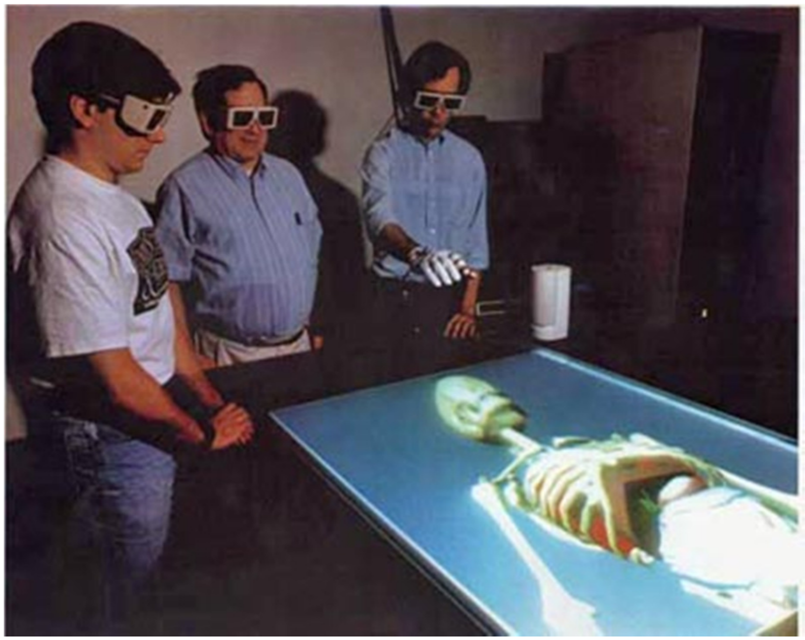
- Do not need to represent physical objects (i.e. hands) as graphical objects
- Can take advantage of the user's peripheral vision
- Do not want the user to get too close to the screens
- Developer can take advantage of the space for using physical props (i.e. car, motion platform)

Workbenches and Variants (1)

- Similar to SSVE but one display (two at most)
- Can be a desk or a large single display (i.e. PowerWall)
- Traditionally a table top metaphor

Workbenches and Variants (2)

Workbenches and Variants (3)



Workbenches – Advantages

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

Workbenches – 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

Workbenches – 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 either two CRT 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

HMDs – Advantages

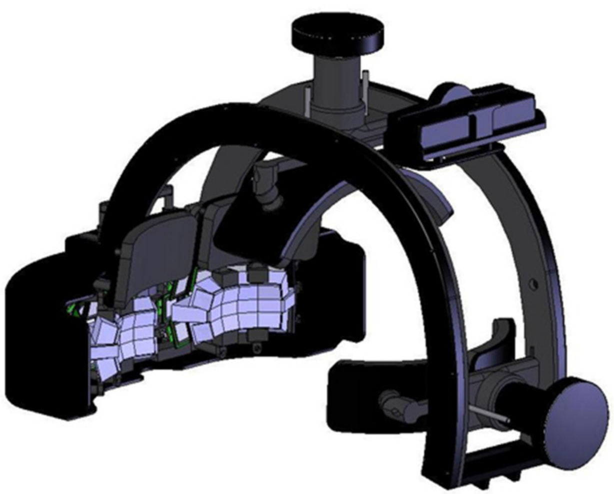
- Provides an immersive experience by blocking out the real world
- Fairly easy to set up
- Does not restrict user from moving around in the real world
- Average quality HMD is relatively inexpensive
- Can achieve good stereo quality

HMDs – Disadvantages

- Average quality HMDs have poor resolution and field of view (FOV)
- Does not take advantage of peripheral vision
- Isolation and fear of real world events
- Good quality devices cost in the 100,000 dollar range
- Heavy and do not fit well

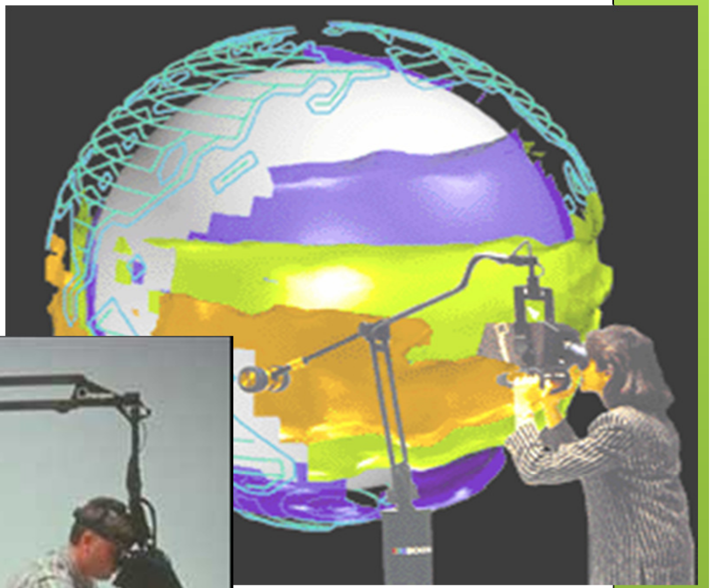
HMDs – Interface Design

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



Arm Mounted Display (BOOM)

- Like a HMD but mounted on an articulated arm
- Mostly use CRT technology
- Not really used anymore



BOOM – Advantages

- Provides better resolution than HMDs and generally a higher FOV
- Light weight relative to the user
- Excellent tracking with minimal lag
- Easy to set up and switch users
- Good stereo quality

BOOM – Disadvantages

- Limited user movement
- Like looking through binoculars
- Does not take advantage of peripheral vision
- Requires the user to hold onto the BOOM for control

BOOM – Interface Design

- Must have at least one hand on the device which limits two-handed interaction
- Physical objects require graphical representation

Virtual Retinal Displays (VRD)

- Scan images directly onto the retina
- Invented at the HIT Lab in 1991
- Used for both virtual and augmented reality
- Commercially being developed at Microvision, Inc.

VRDs – Advantages

- Lightweight relative to the user
- Ability for high resolution and FOV
- Potential for complete visual immersion
- Can achieve good stereo quality

VRDs – Disadvantages

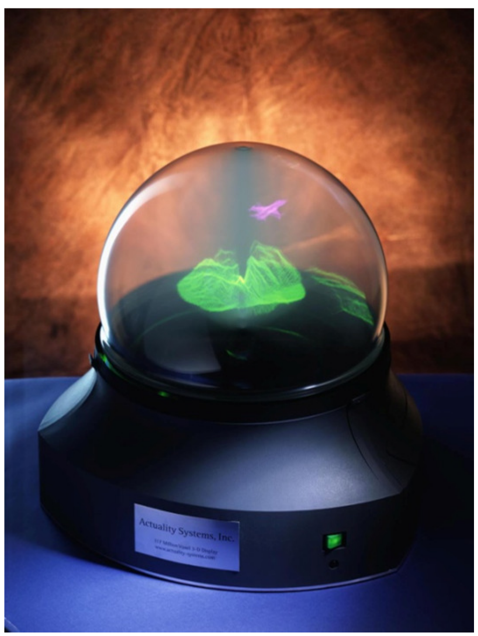
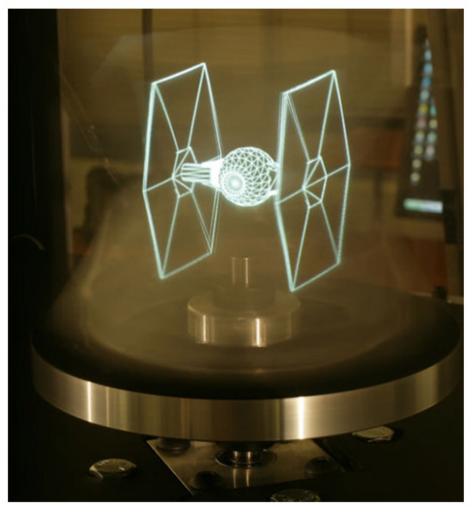
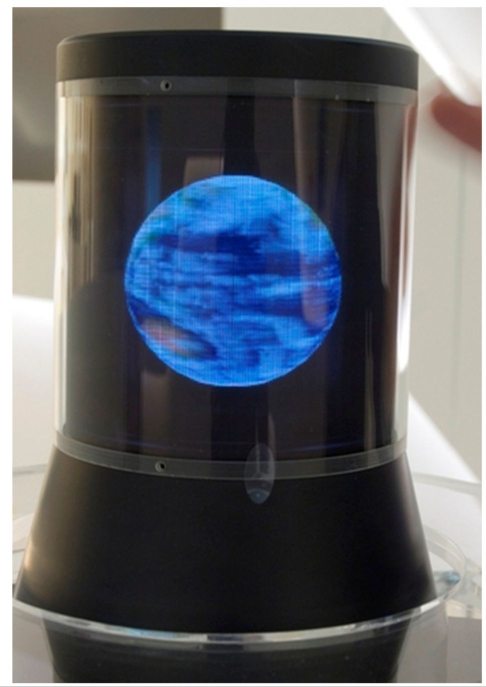
- Currently has low resolution and FOV is small
- Displays are currently monochrome

VRDs – Interface Design

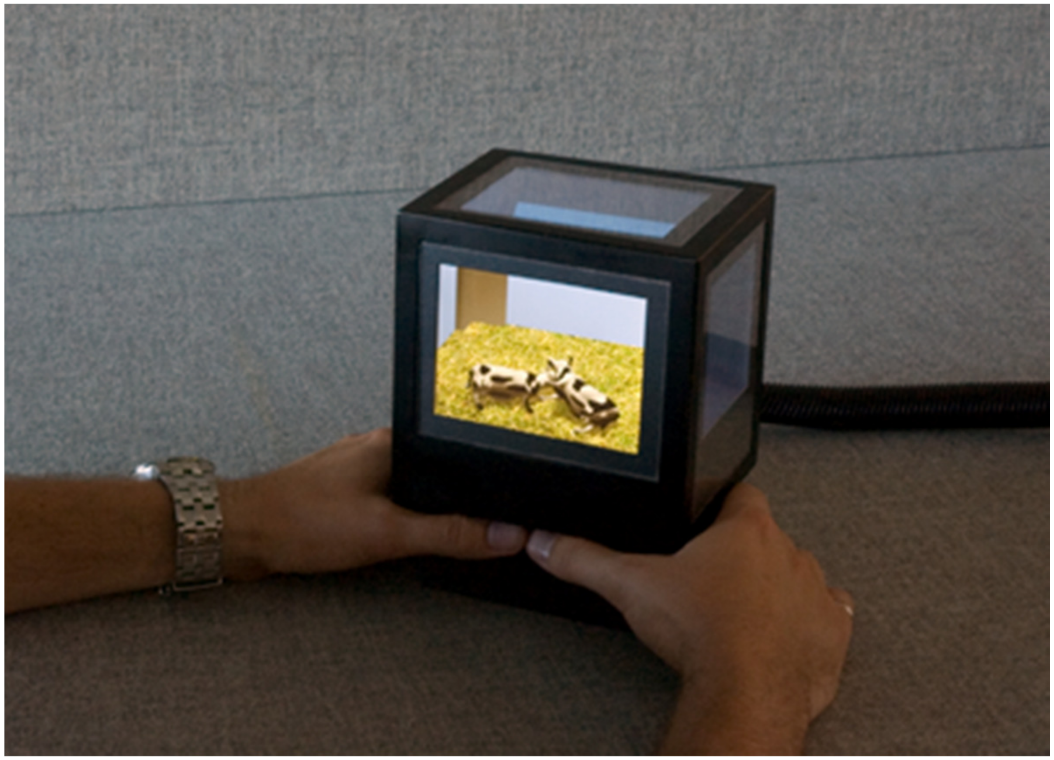
- Avenue of research
- Questions arise about eye movement

AutoStereoscopic Displays

- Lenticular
- Volumetric
- Holographic

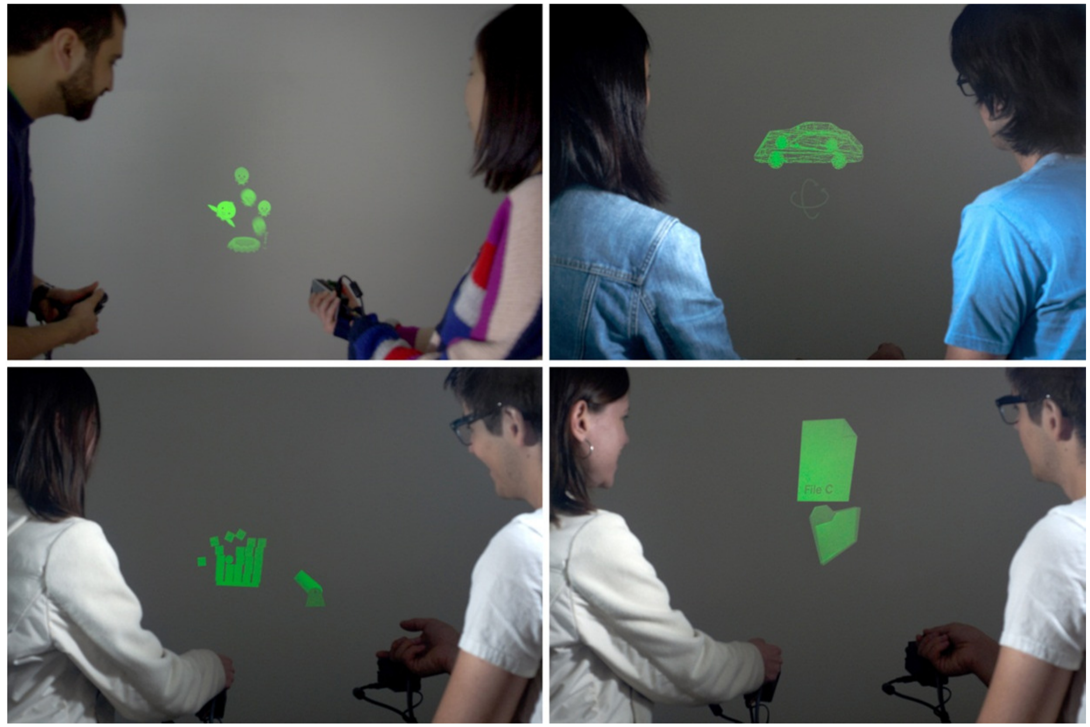




Simulated Autostereo – pCubee



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

Other Display Technologies



SidebySide/Motion Beam
Disney Research, Pittsburgh

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