CSE 190: Virtual Reality Technologies

LECTURE #6: HUMAN VISION

VR Content Presentations

Dale Tubat: DragonBall Z VR/AR

- https://www.youtube.com/watch?v=K_zpjTcn40E

Prasanth Abraham: Gravity Pull - VR Puzzle Game

- https://play.google.com/store/apps/details?id=com.VRMersive.GravityDrop&rdid=com.VRMersive.GravityDrop

Nathan Nguyen: BAMF VR

- https://play.google.com/store/apps/details?id=com.MWB.BAMF&hl=en
- https://www.youtube.com/watch?v=TvlV2Pt_pNc

Eric Duong: Houston Rockets Locker Room Tour

- https://www.youtube.com/watch?v=54NFfToTsrQ

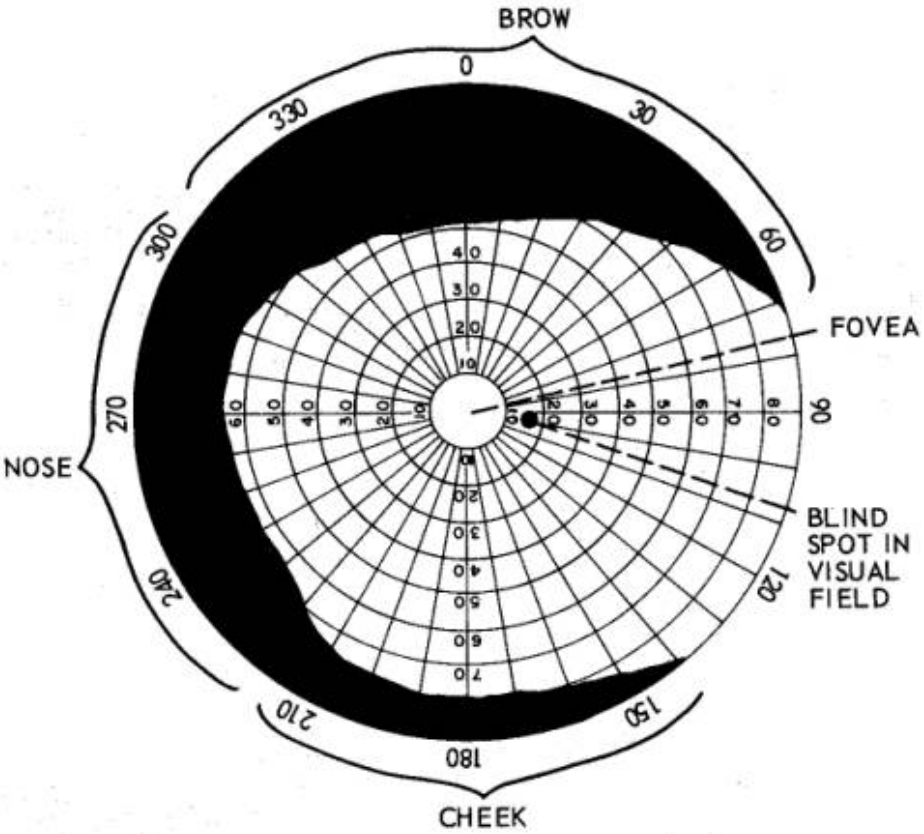
Announcements

Homework project 1 due tomorrow at 2pm

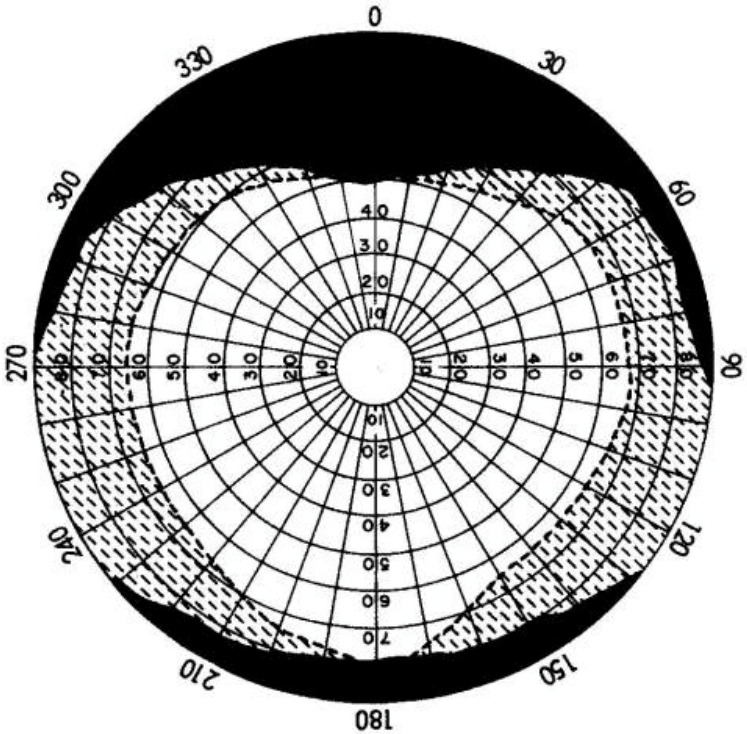
- To be demonstrated in VR lab B210
- One member of each team:
  Upload code to TritonEd by Friday 2pm
- Even hours grading starts at 2pm
- Odd hours grading starts at 3pm

Human Vision

Visual Field / Field of View



monocular visual field



binocular visual field

Ruch & Fulton, 1960

Retina VR Display

Resolution per eye:

145° x 135° with 150 pixels/degree resolution
→ 21,750 x 20,250 pixels = 440 Mpixels

Transmission of retina quality VR video in stereo: 528 Gbytes/sec
Full sphere: 1.7 Tbytes/sec = 13 Tbit/sec
With 300x compression: 45 Gbit/sec

Presents challenges to:

- Capture or render stereo panoramas
- Compress and transmit retina VR video over network
- Drive display pixels

Summary: Human Visual System

Pixel resolution: 150 pixels/degree
Horizontal field of view: 145° per eye
Vertical field of view: ~135°
Stereoscopic vision
Temporal resolution: ~60-150 Hz (varies with brightness)
Dynamic range: 100:1 (retina), 1 billion:1 (with iris)
Colors: HDR (32 bit color depth)
Accommodation range: ~8cm to infinity

Stereo Imaging Techniques

Stereo Imaging: Concept

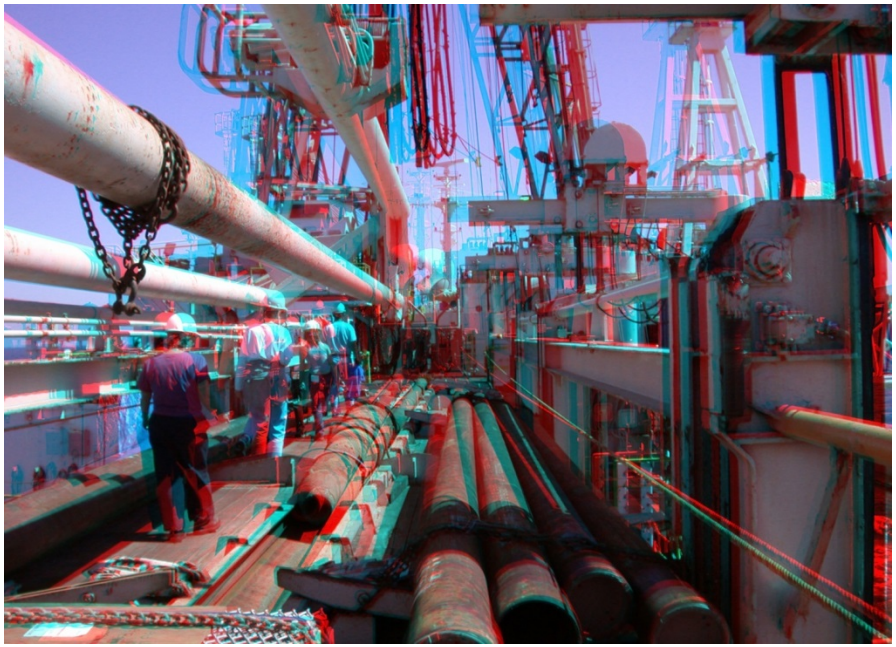
General concept: each eye sees a slightly different image

Example: Viewmaster:
left eye is shown one image on the disc, right eye sees a different image

Stereo Imaging: Anaglyphic

Anaglyphic

- requires red/blue, red/green glasses
- color is diminished (but not entirely lost)

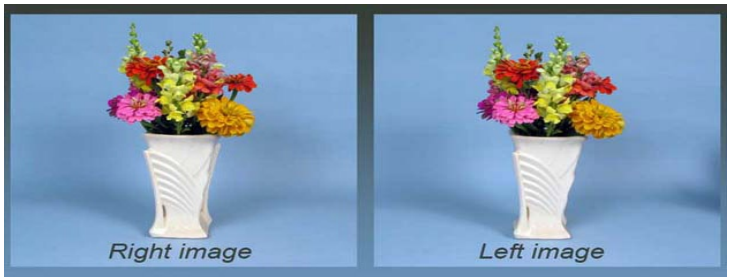


Core drilling ship (Andy Johnson, UIC/EVL)

Stereo Imaging: Side-by-Side

Stereo can be seen by fusing images: converge eyes in front or behind the actual image plane

Eyes converge behind image plane



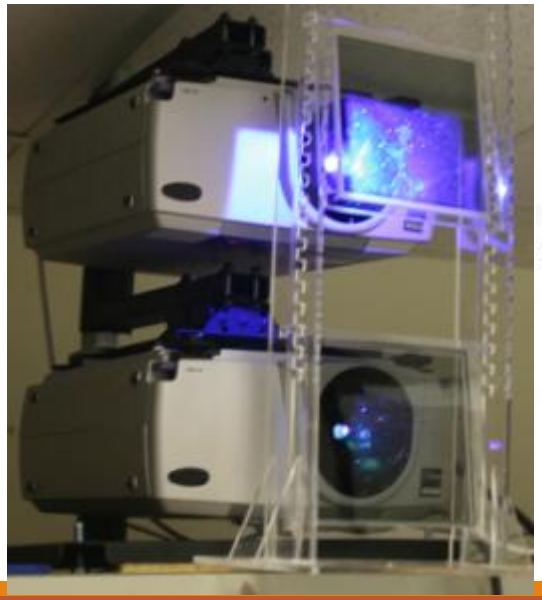
Eyes converge in front of image plane

Stereo Imaging: Polarizing Filters

Linear polarization

Circular polarization: creates circularly polarized light by adding a quarter-wave plate after a linear polarizer

Polarizing glasses are inexpensive (~$2-10)



Stereo projectors

Polarizing glasses

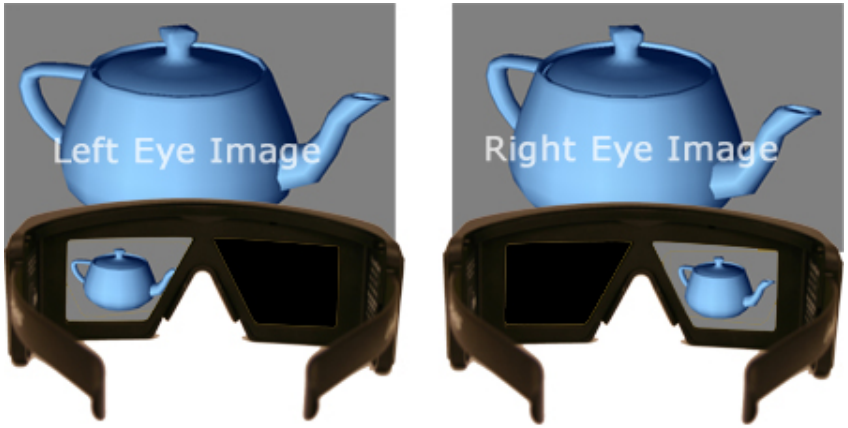
Stereo Imaging: Active Stereo

Display alternates between images for left and right eyes at 120+ Hz

Shutter glasses

- synchronized to display refresh rate
- more expensive than passive glasses (~$30+)
- require batteries

3D shutter glasses



Stereo Imaging: Infitec

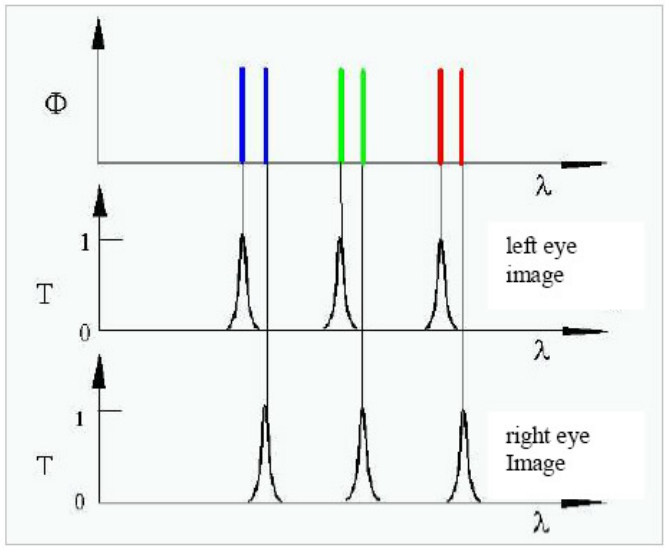
Clever technology, based on wavelength multiplexing

Two separate primary color triplets are filtered by glasses to generate two sets of primary colors

Infitec resulted from a research project at DaimlerChrysler

Projectors with Infitec filters

Infitec glasses



Primary color triplets

Autostereoscopic Displays

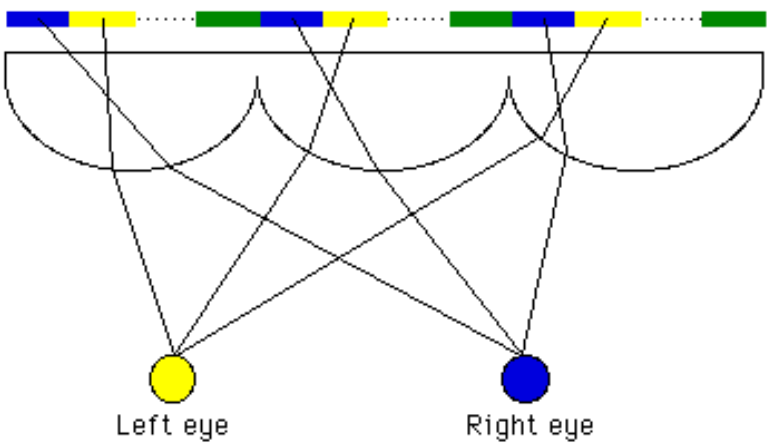
Light sent separately to each eye from a monitor

No headgear required

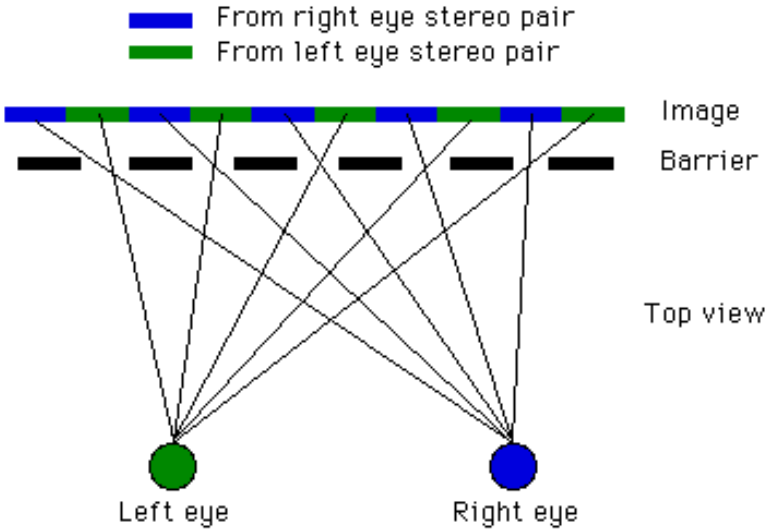
Tracked (dynamic) vs. non-tracked (static, sweet spot)

Approaches:

- lenticular screen
- barrier screen



Lenticular screen



Barrier screen

3D Displays

Introduction To Displays

Display: device which presents perceptual information

Often term “display” is used for “visual display”

Goal: display devices which accurately represent visual perception in a simulated world

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

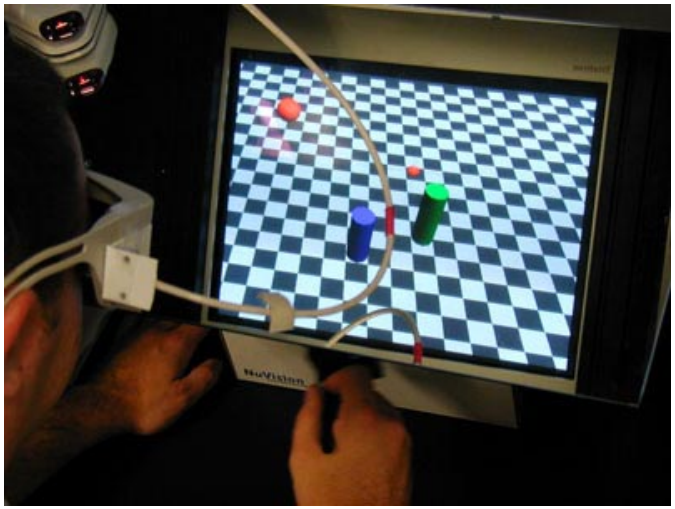
Ergonomics

Display Types

Stereo Monitor

Active or passive stereo

“Fishtank VR”



Stereo Monitor – Advantages

Inexpensive

Crisp image at HD or more

Keyboard and mouse work as usual

Can be used with most 3D input devices

Stereo Monitor – Disadvantages

Not very immersive

User seated, cannot move around

Does not take advantage of peripheral vision

Stereo can be problematic

- Active: user's 3D glasses need to face emitter
- Passive: blank pixel lines can be perceptible

Occlusion from physical objects can be problematic

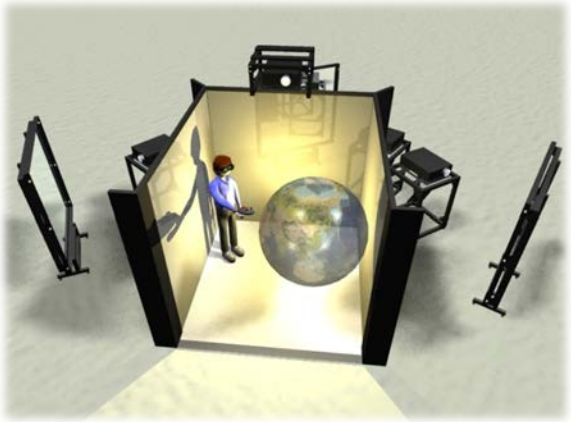
Surround Screen VE

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

Requires elaborate head/wand tracking



StarCAVE

18 graphics workstations

Dual graphics cards per node

CentOS Linux

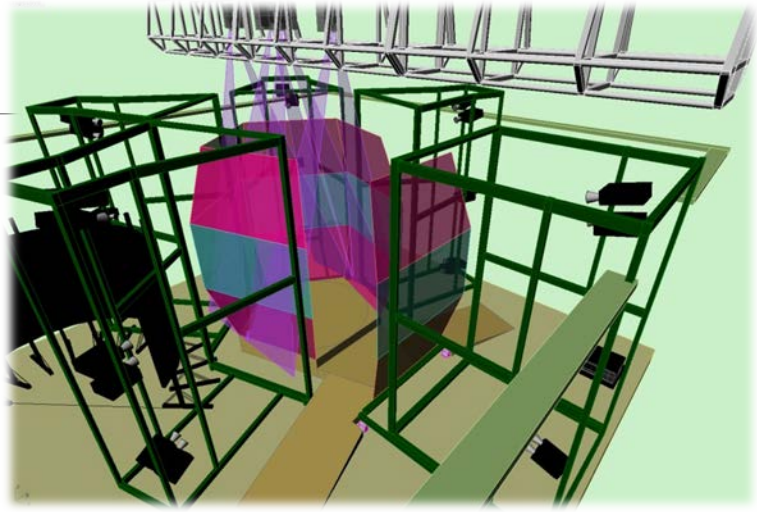
34 HD projectors:
~34 megapixels per eye

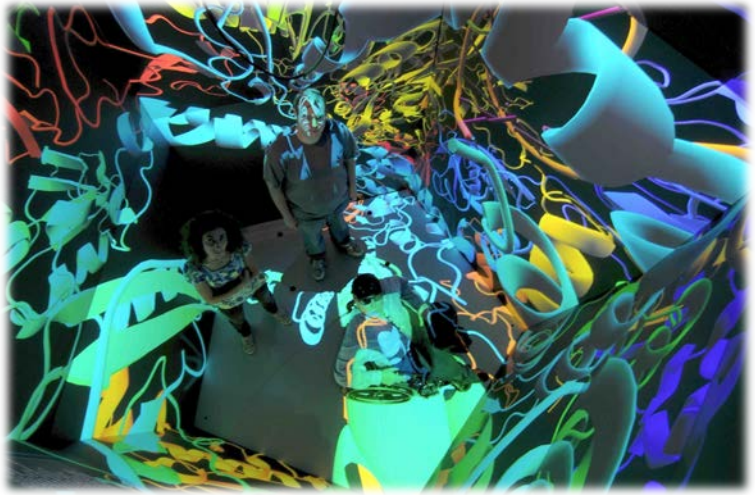
360 degrees immersion

Passive stereo, circular polarization

15 screens on 5 walls, ~8 x 4 foot each, plus floor projection

4-camera optical tracking system





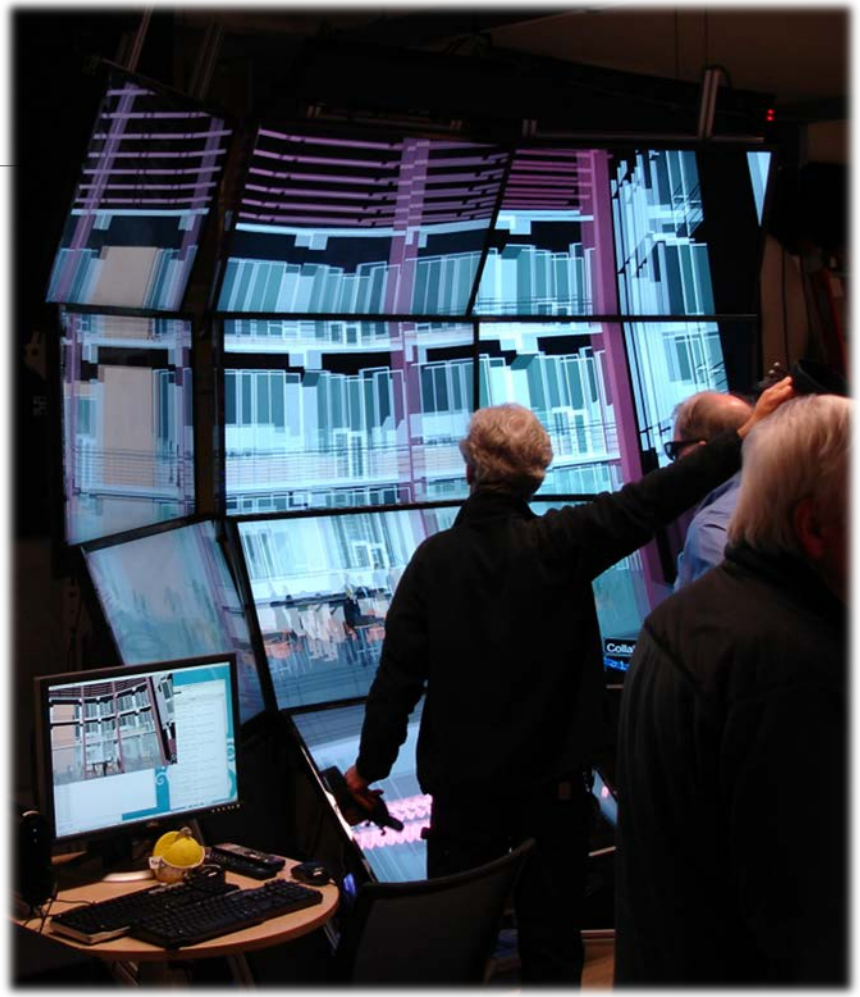
NexCAVE

First LCD-based CAVE

14 42” HD passive stereo displays

8 rendering PCs

2-camera optical tracking system



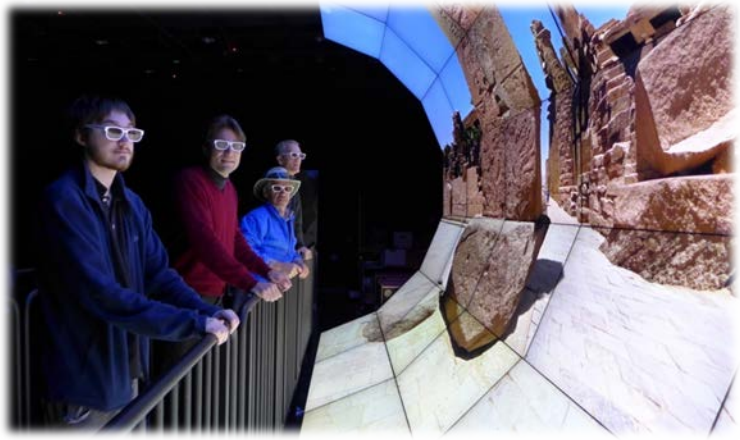
WAVE

35 55” HD monitors with narrow bezels

18 rendering PCs

Passive stereo

9600x7560 pixels combined



Other CAVEs

Surround Screen Virtual Environments – Advantages

Provide high resolution and large FOV

Passive stereo: user only needs a pair of light weight glasses for stereo viewing

User has room to move around

Real and virtual objects can be mixed

A group of people can use the space simultaneously

Disadvantages

Expensive (typically >$100k)

Require a large amount of physical space

Projector calibration must be maintained

Normally only one user head tracked

Stereo viewing can be problematic (ghosting, focal plane far away)

Physical objects can get in the way of 3D image

CAVE 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 seat, treadmill)

VR Workbenches etc.

Similar to CAVEs but only one or two displays

Can be a desk or a large single display (e.g., PowerWall)

Traditionally a table top metaphor

VR Workbenches etc.

VR Workbenches etc.

zSpace

Full HD resolution

Active stereo screen

Passive glasses

Tracked glasses and stylus

Stylus with infrared markers and gyroscope

Workbenches – Advantages

High resolution

For certain applications, makes for an intuitive display

Can be shared by several users

Workbenches – Disadvantages

Limited movement

Typically only one user 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 create graphical representations of physical objects