CSE 190: Virtual Reality Technologies

LECTURE #7: VR DISPLAYS

Announcements

Homework project 1 late deadline Sunday, April 16th at 11:59pm

Next Monday: Discussion homework project 2

Update on cloud Macs: now working

- cloudlabs.ucsd.edu

2 VR app presentations:

- Mingxun (Tyler) Song: VirtualSpeech
- Luke Deerinck: Romans From Mars

VR Display Types

3D Monitor

PC with 3D TV

Active or passive stereo

A.k.a. “Fishtank VR”

Requires separate tracking system

3D Monitor – Advantages

Inexpensive

Crisp image at HD or 4k resolution

Keyboard and mouse work as usual

Can be used with most 3D input devices

3D Monitor – Disadvantages

Not very immersive (small FOR)

User seated, cannot move around

Stereo can be problematic

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

Occlusion from physical objects (hands, controller) can be problematic

Powerwalls

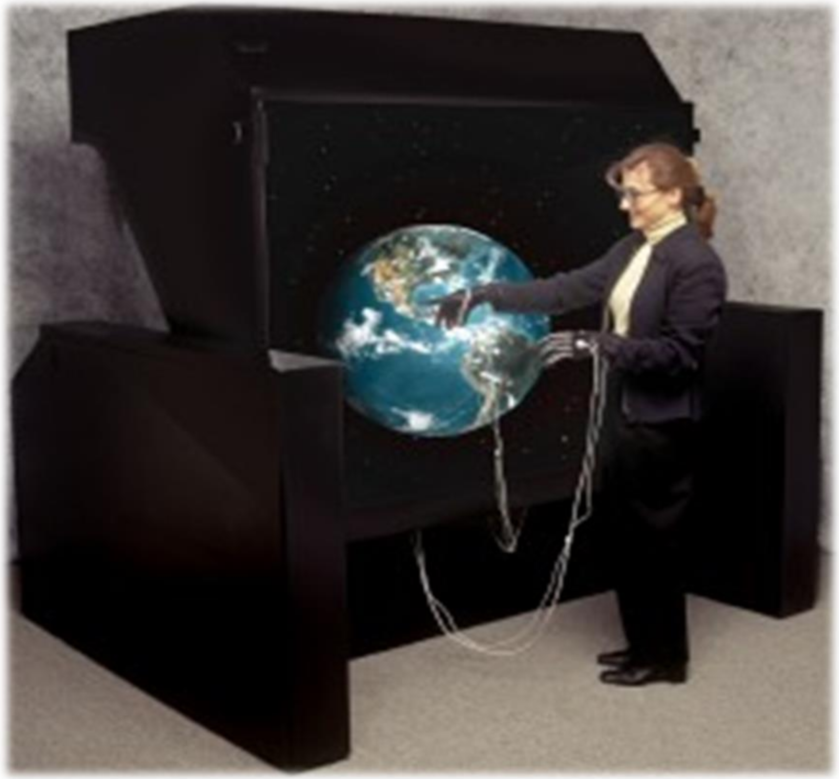
Large 3D stereo display(s)

Configured as a mostly flat surface

Head tracking optional

VR Workbenches

- 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

VR Workbenches

VR table display

Dual-screen VR workbench

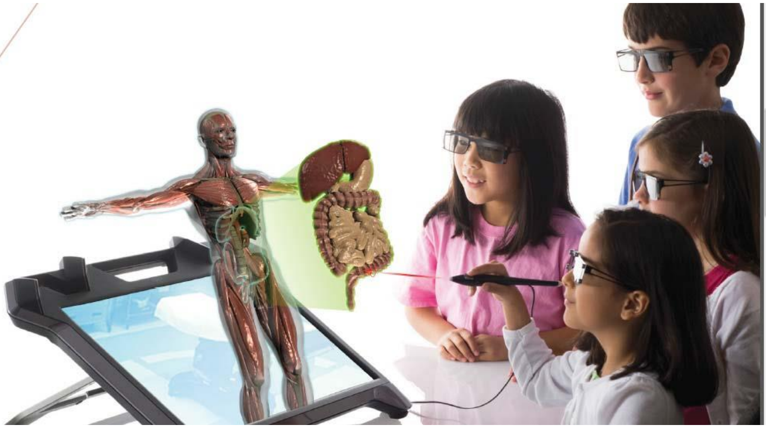
zSpace

3D display with built-in head and stylus tracking

Full screen passive circular polarization

Full HD for each eye

Polarization switching full screen LC layer



Workbenches – Advantages

High resolution

For certain applications, makes for an intuitive display

Best for single user, but can be shared by several users

Workbenches – Disadvantages

Limited movement

Typically only one head-tracked user

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 because users can see them

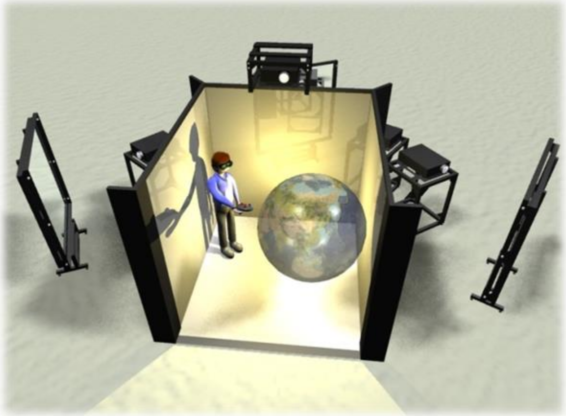
Surround Screen VE

Puts user in a room for visual immersion

Usually driven by a cluster of powerful graphics computers

Multiple displays around the user

3D tracking for head and controller



SunCAVE at UCSD

Built 2017

70 x 55” LCD 4k displays

Passive stereo

36 graphics PCs

71 Nvidia GTX 1080 GPUs

500 Mpixels

40 Gbps network

WAVE at UCSD

35 55” HD monitors with narrow bezels

Cylindrical display arrangement

18 rendering PCs

Passive stereo

70 Mpixels

Other CAVEs

Location: HLRS (Stuttgart, Germany)

5-sided cube, 2.7m width, rear projection

Resolution: 2560x1600 pixels per wall

Projectors: Barco F80-Q7 single chip active stereo DLP projectors with separate inputs for left and right images

Rendering: 11 nodes powered by two quad core Sandy bride 3.3 GHz Xeon CPUs, 128 GB RAM, Nvidia P6000 GPUs

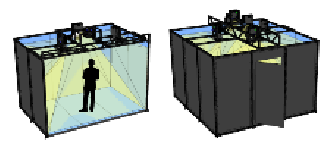
ART Trackpack optical tracking system

Network: 10 Gbit/sec Infiniband

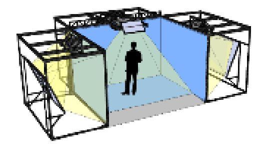
Other CAVEs

VisCube by Visbox (Illinois)

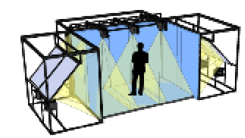
Founded in 2000 by former NCSA employees



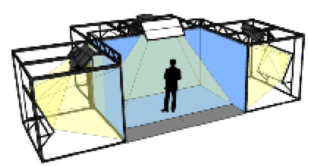
VisCube M4, M5
Low cost CAVE VR system
Ultra compact, 10'-11' tall
4-5 screens, 12' front wall
2560×1600 projectors



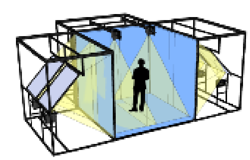
VisCube C4
Affordable CAVE VR system
Fits under 9' ceiling
3 walls + floor, 12' front wall
2560×1600 projectors



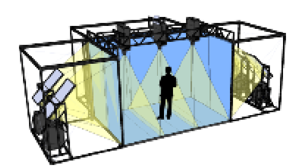
VisCube C4-T3
High Resolution CAVE
Fits under 9' ceiling
3 walls+floor, 12' wide front wall
4096×2560 front/floor
2880×2560 sides



VisCube C4-4K
High resolution CAVE
Requires 10.5' ceiling height
3 walls+floor, 14.3' front wall
4096×2160 projectors



VisCube C4-T2
Tall and high resolution CAVE
Compact, 10.5' tall
3 walls+floor, **10' x 9' walls**
2840×2560 per surface



VisCube C4-T3X
Extreme resolution CAVE
Compact, 12' tall
3 walls+floor, 13' wide front wall
6000×4096 front/floor
4096×4096 sides

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 Display Issues

VR Display Issues: Projectors

Vignetting, caused by hotspot effect

- Brightness falloff
- Viewpoint dependent
- Hotspot at intersection of eye point and projector lens

Polarization falloff

- Viewpoint dependent
- Polarization deteriorates towards more oblique angles

VR Display Issues: Passive LCD

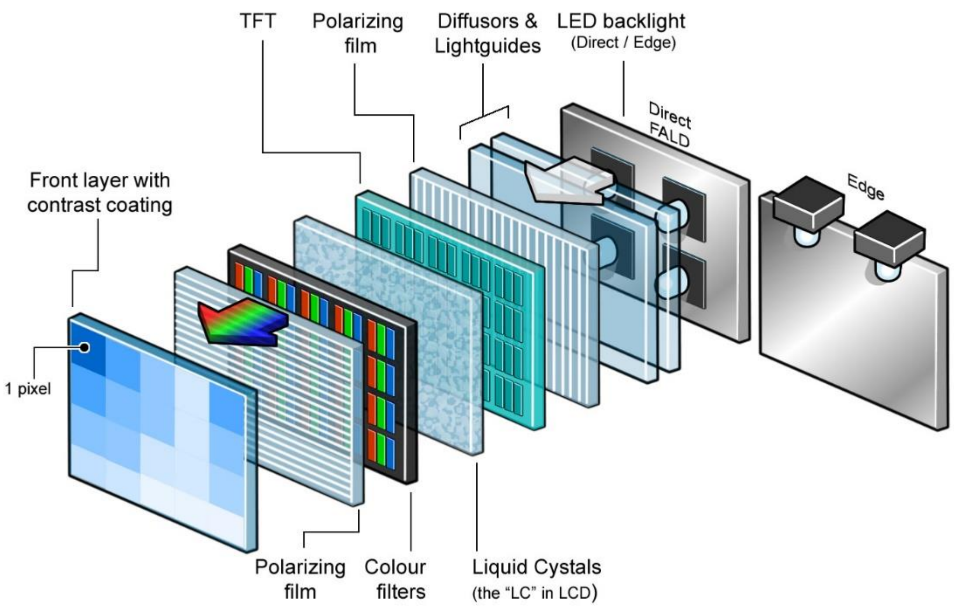
Frame synchronization (simultaneous buffer swaps)

Off-axis viewing along vertical axis causes ghosting

- Caused by distance between pixels and polarization layer (image below does not show polarization layer)

Brightness falloff

Discoloration



VR Display Issues: Passive OLED

Frame synchronization (simultaneous buffer swaps)

Off-axis viewing less bad than with LCDs

- Polarization layer closer to pixels

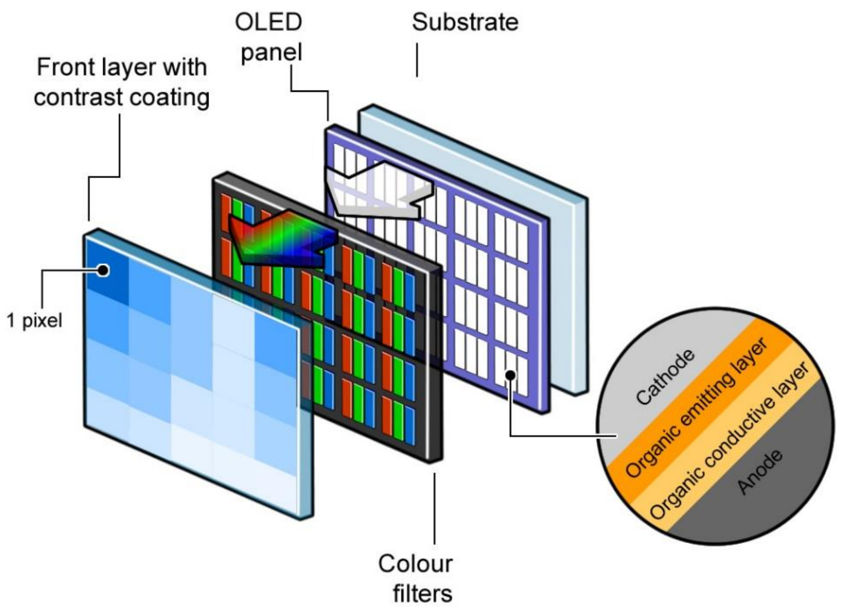
Brightness falloff

Image retention

Burn-in

Automatic Brightness Limiter (ABL)

- Limits overall screen brightness



VR Display Issues: Active Stereo

Synchronization between screens:

- Frame synchronization (simultaneous buffer swaps)
- Image generation ("electron beam"): needs to be in sync between screens and shutter glasses