CSE 190: Virtual Reality Technologies

LECTURE #7: VR DISPLAYS

Upcoming Deadlines

Sunday, April 25: Project 1 late deadline

Monday, April 26: Discussion Project 2

Sunday, May 2: Project 2 due

Monday, May 3: Discussion Project 3

Sunday, May 9: Project 2 late deadline

App Presentations

James Cor
- Gravity Sketch

Juan Carlos Amistoso
- Space Engine

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

3D capable monitors are hard to find

Powerwalls

Large 3D stereo display(s)

Configured as a mostly flat surface

Head tracking optional

3D projectors are available and inexpensive

VR Workbenches

Have one or two large (~60-80”) 3D displays

Can be a desk or a large single user display, tabletop metaphor

3D head and input device tracking

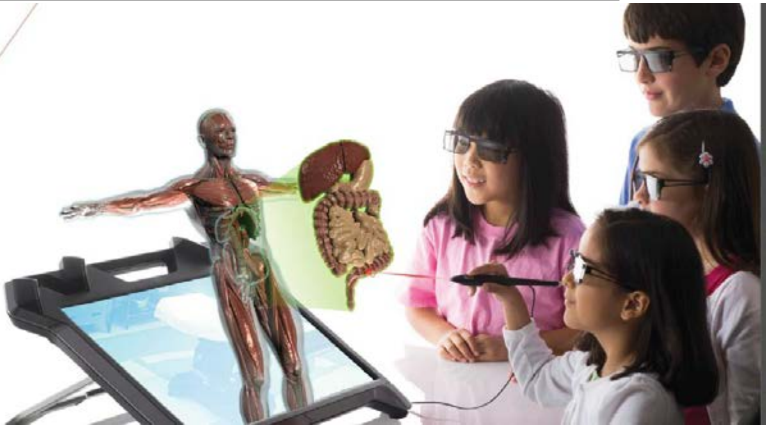
Angled VR Workbenches

More VR Workbenches

VR table display for medical applications

Dual-screen VR workbench: bigger FOR

LCD based 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 liquid crystal layer on top of regular LCD

zSpace laptop

Workbenches – Advantages

High resolution

For certain applications, makes for an intuitive display: shows objects at 1:1 scale

Best for a single user, but can be viewed by several users

Typically small enough to be movable

Workbenches – Disadvantages

Allow limited movement for user

Supports only a single head-tracked user

No surrounding screens: no peripheral vision

Physical objects (e.g., hands, input devices) can get in the way of objects on screen

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

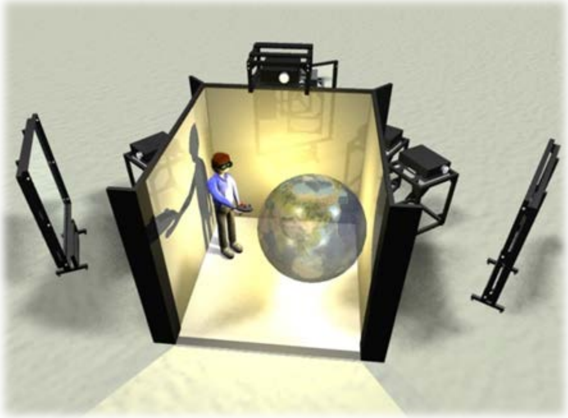
VE = Virtual Environment

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

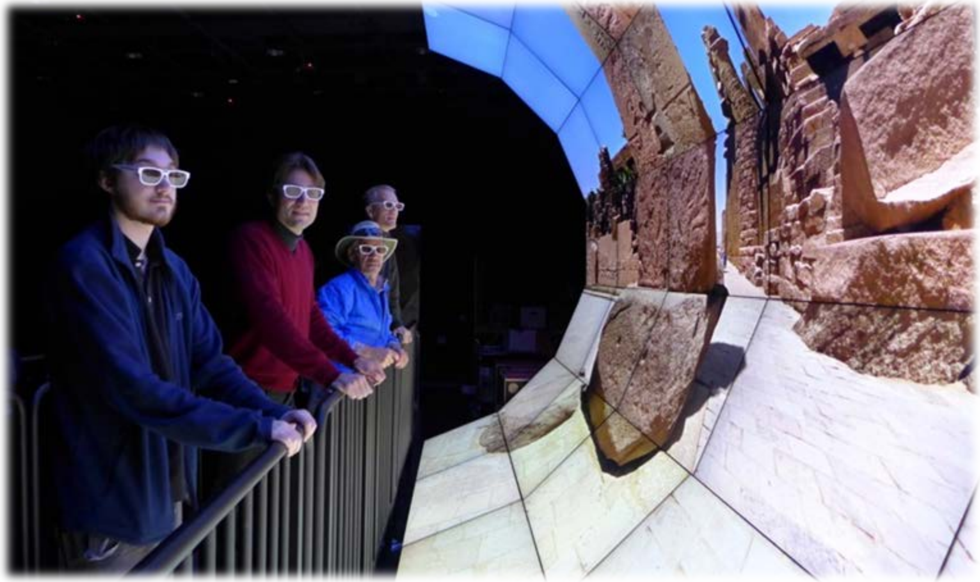
35 55” HD monitors with narrow bezels

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

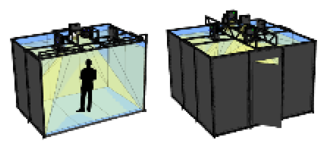
ART Trackpack optical tracking system

Network: 10 Gbit/sec Infiniband

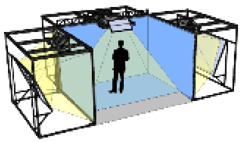
Other CAVEs

VisCube by Visbox (Illinois)

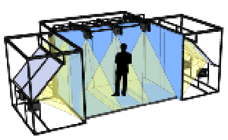
Founded in 2000 by former NCSA employees



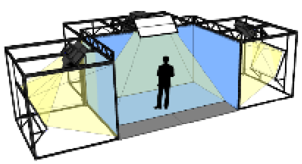
VisCube M4, M5
Low cost CAVE VR system
Ultra compact, 10'-11' tall
4-5 screens, 12' front wall
2560×1600 projectors



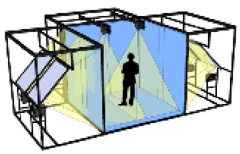
VisCube C4
Affordable CAVE VR system
Fits under 9' ceiling
3 walls + floor, 12' front wall
2560×1600 projectors



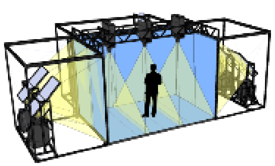
VisCube C4-T3
High Resolution CAVE
Fits under 9' ceiling
3 walls+floor, 12' wide front wall
4096×2560 front/floor
2880×2560 sides



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 of Surround VEs

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

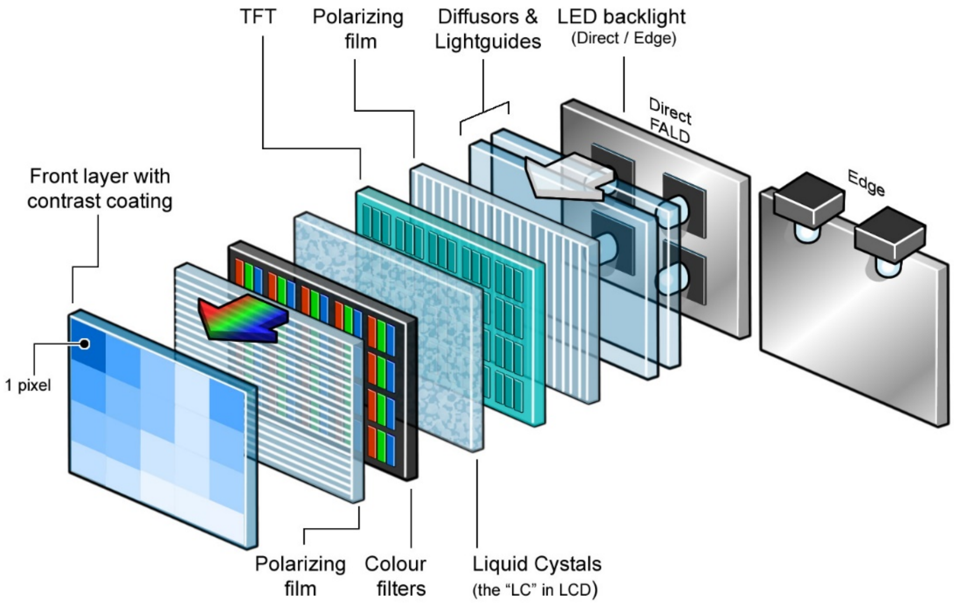
Frame synchronization (simultaneous buffer swaps)

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

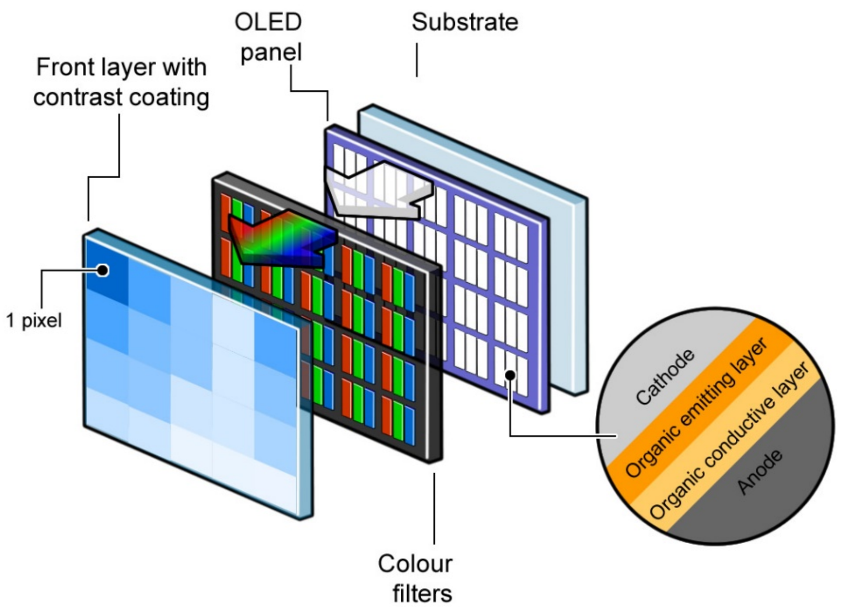
Brightness falloff

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