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
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