

Virtual Reality

Greg Turk

School of Interactive Computing
and GVV Center

Virtual Reality (VR)

- Visual immersion in a synthetic world
- Turn of head modifies what user sees
- Necessary VR components:
 - 1) Track user's head motion
 - 2) Create images of virtual world
 - 3) Display these images to user

History of Virtual Reality

- Ivan Sutherland, 1960's
- Jaron Lanier, 1980's-1990's
- Palmer Lucky, 2010's

Ivan Sutherland

- Considered “father” of computer graphics
- Famous for Sketchpad (early drawing program with constraints)
- Won ACM Turing Award
- U. of Utah graphics program 1968-1974
- Quest for the “Ultimate Display”
- Built first head-mounted display system “Sword of Damocles” in 1968

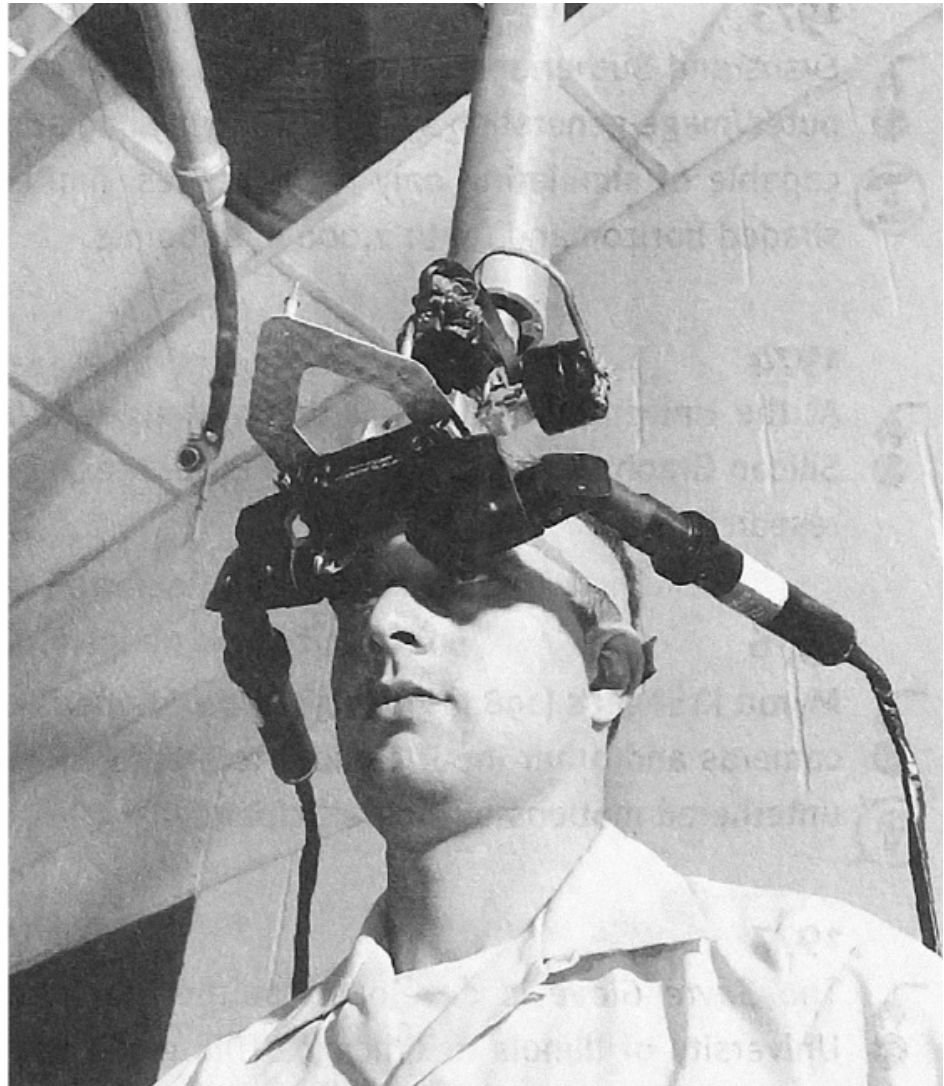
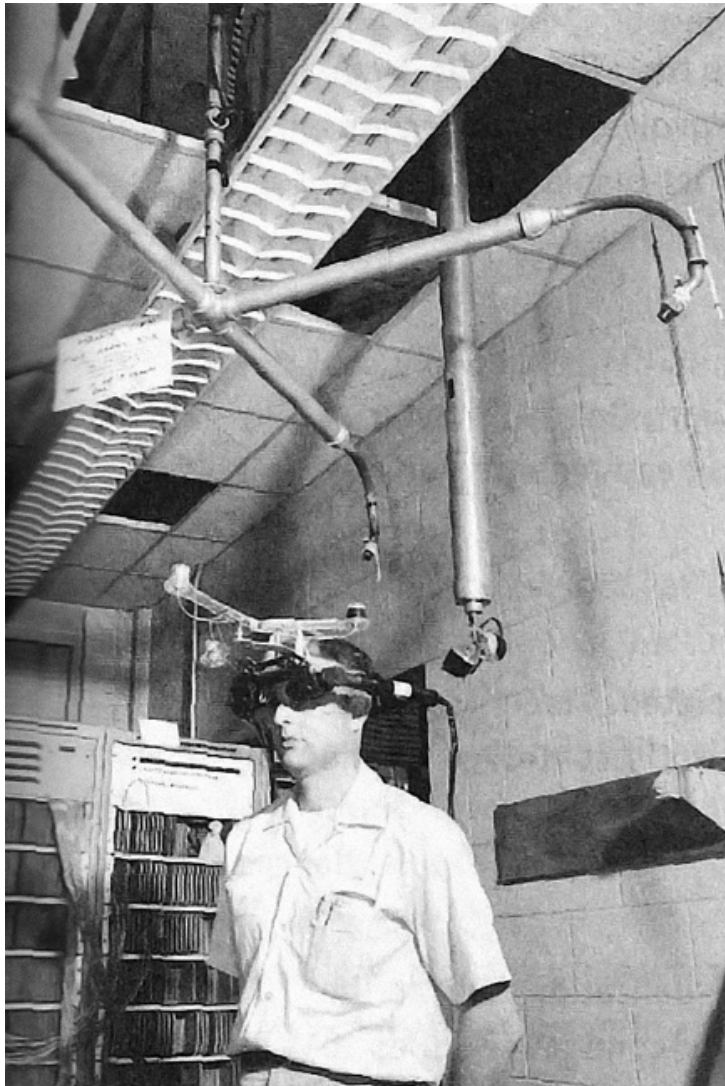
Sword of Damocles

Had all parts of Virtual Reality System:

- 1) Tracking device
- 2) Real-time rendering system
- 3) Head-mounted display

Actually Augmented Reality (see-thru to real world)

Sword of Damocles





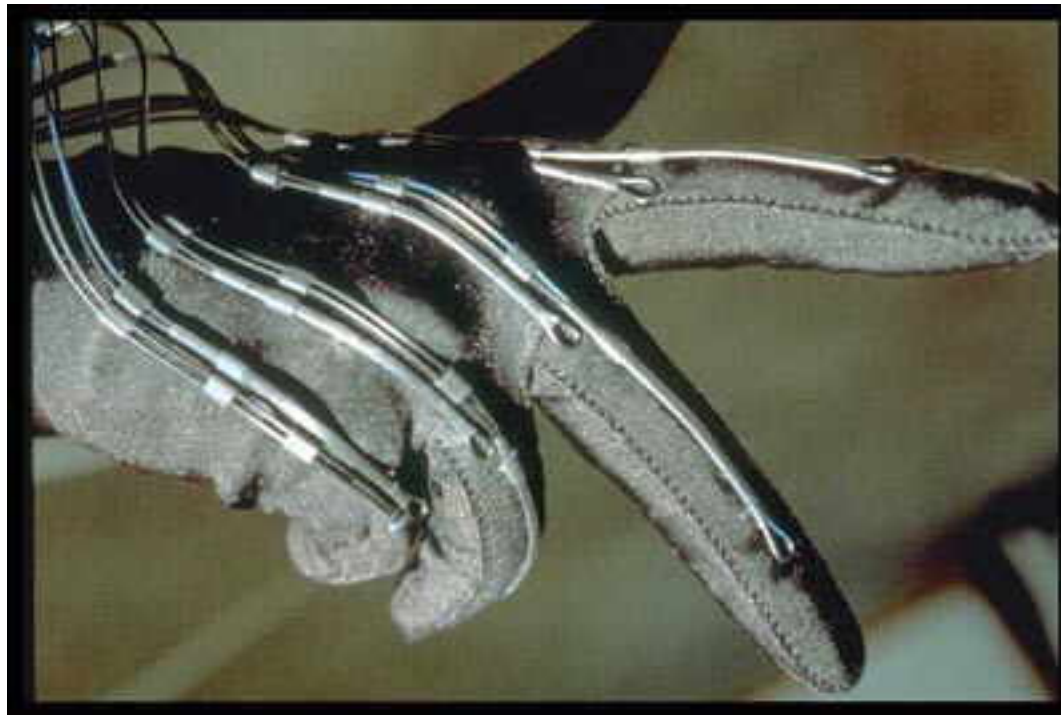
After Sutherland

- Several research labs continued ideas
- Henry Fuchs at UNC Chapel Hill
- Steven Feiner at Columbia
- Often called “Virtual Environments”

Jaron Lanier

- Founded company VPL in late 1980's
- Coined term “Virtual Reality”
- VPL sold VR systems
 - Rendering system
 - Magnetic tracking
 - Head-mounted display (HMD)
 - Data glove
- Drew lots of attention in tech field

VPL Data Glove



Data Glove

SCIENTIFIC AMERICAN

OCTOBER 1987
\$2.50

The next revolution in computers, the subject of this issue, will see power increase tenfold in 10 years while networks and advanced interfaces transform computing into a universal intellectual utility.



Wired Glove gives a computer user the sensation of handling objects on the screen: the image of the hand mimics the user's movements.

VPL System





VR in 1990's

- VR didn't live up to the hype
- No obvious market for VR
- Motion sickness also big problem
- Virtual Reality boom of 1990's died down
- Work quietly continued in various labs
- Fast forward to...

Palmer Lucky

- Head-mounted display prototype 2010
- Kickstarter fund 2012
- Founded Oculus VR
- John Carmack (Doom, Quake) early enthusiast
- Bought by Facebook in 2014 for \$2-3 billion
- Kicked off current VR craze
- Departed Facebook March 2017

AUGUST 17, 2015

TIME

The
Surprising
Joy of
**Virtual
Reality**

And why it's
about to change
the world

By Joel Stein

Palmer Luckey, 22,
inventor of the
Oculus Rift, is one
of the visionaries
making virtual reality
mainstream

time.com

Modern Rendering Systems

- GPU's are universally used
- Can render millions of polygons at 60 Hertz
- Huge improvement over 1990's rendering systems
- In VR world, rendering is “solved problem”
- Improvements still needed for HMD and Tracking

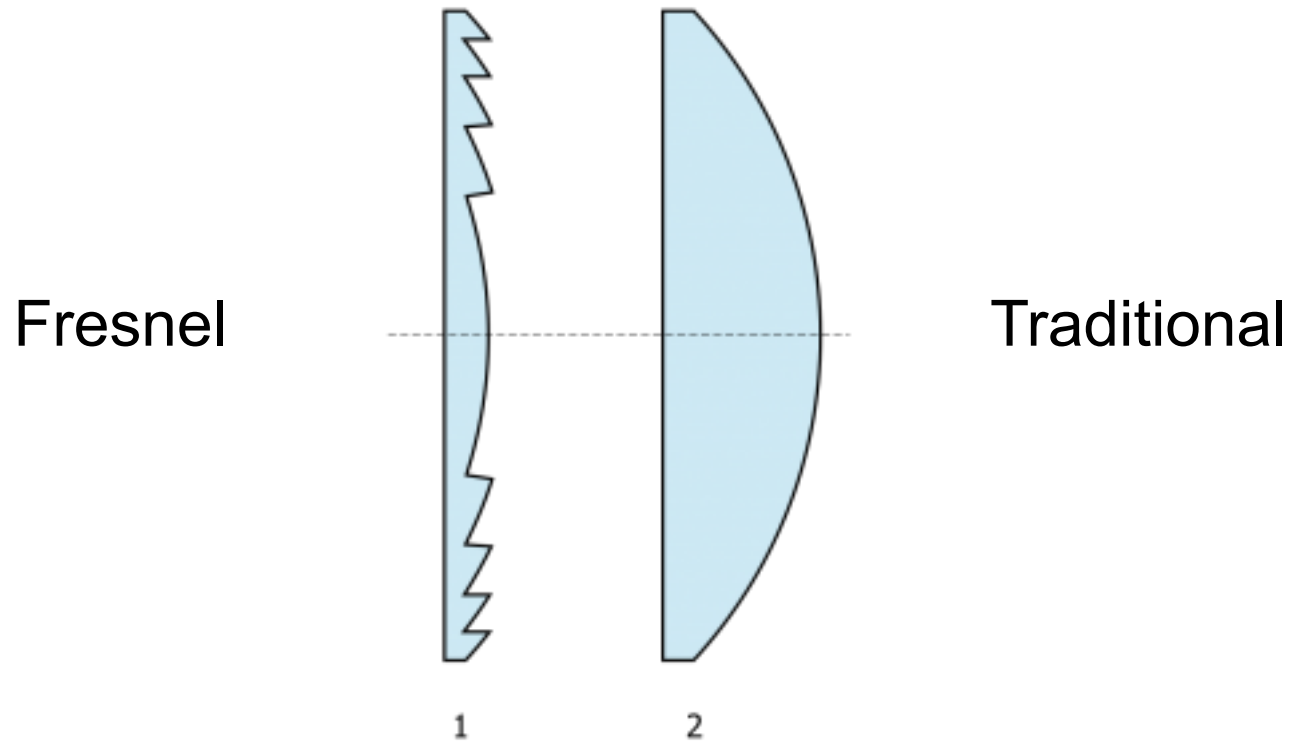
Features of HMD

- Deliver separate images to each eye
- Images shown on two small displays (LCD or OLED)
- Focus the image at comfortable distance
- Wider angle of view is better
- Heavy head-set is tough on user
- Wireless is preferred (no cables to trip over)

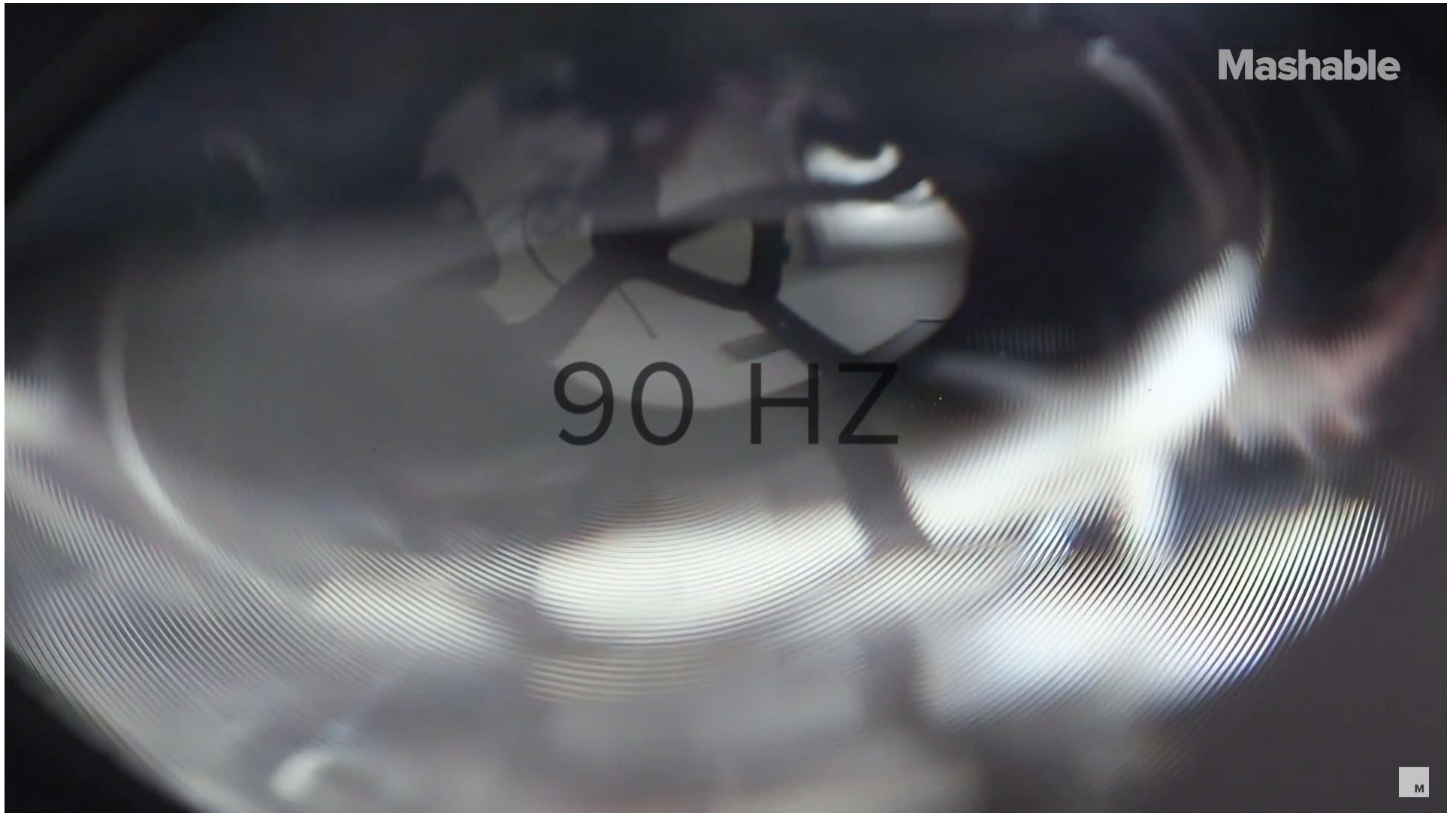
Oculus Rift HMD

- Wide field-of-view (270 degrees)
- Uses Fresnel lenses to focus images
- Fresnel lenses are light-weight (thin, plastic)
- Oculus Rift had series of prototypes
- Now available commercially

Fresnel Lenses



Fresnel Lens



Tracking Systems

- Determine (x,y,z) position of HMD
- Also determine *orientation* (3 values)
- Do this at 60 Hertz or faster
- Pass this information to rendering system
- Render scene from viewpoint of HMD
- Position & orientation give virtual camera placement

Head Tracking Systems

- Magnetic Tracking (popular in 1990's)
- Beacons on HMD, camera observes them (outside-in)
- Cameras on HMD, observes markers in room (inside-out)

Oculus Tracking System

- Infrared beacons mounted on HMD
- IR light not visible to user
- IR camera observes beacons
- Deduces HMD position and orientation
- Traditional computer vision methods
- More beacons observed, higher accuracy
- Accuracy decreases as HMD moves away from camera
- Best for sitting user

Oculus HMD Beacons



Oculus HMD Beacons





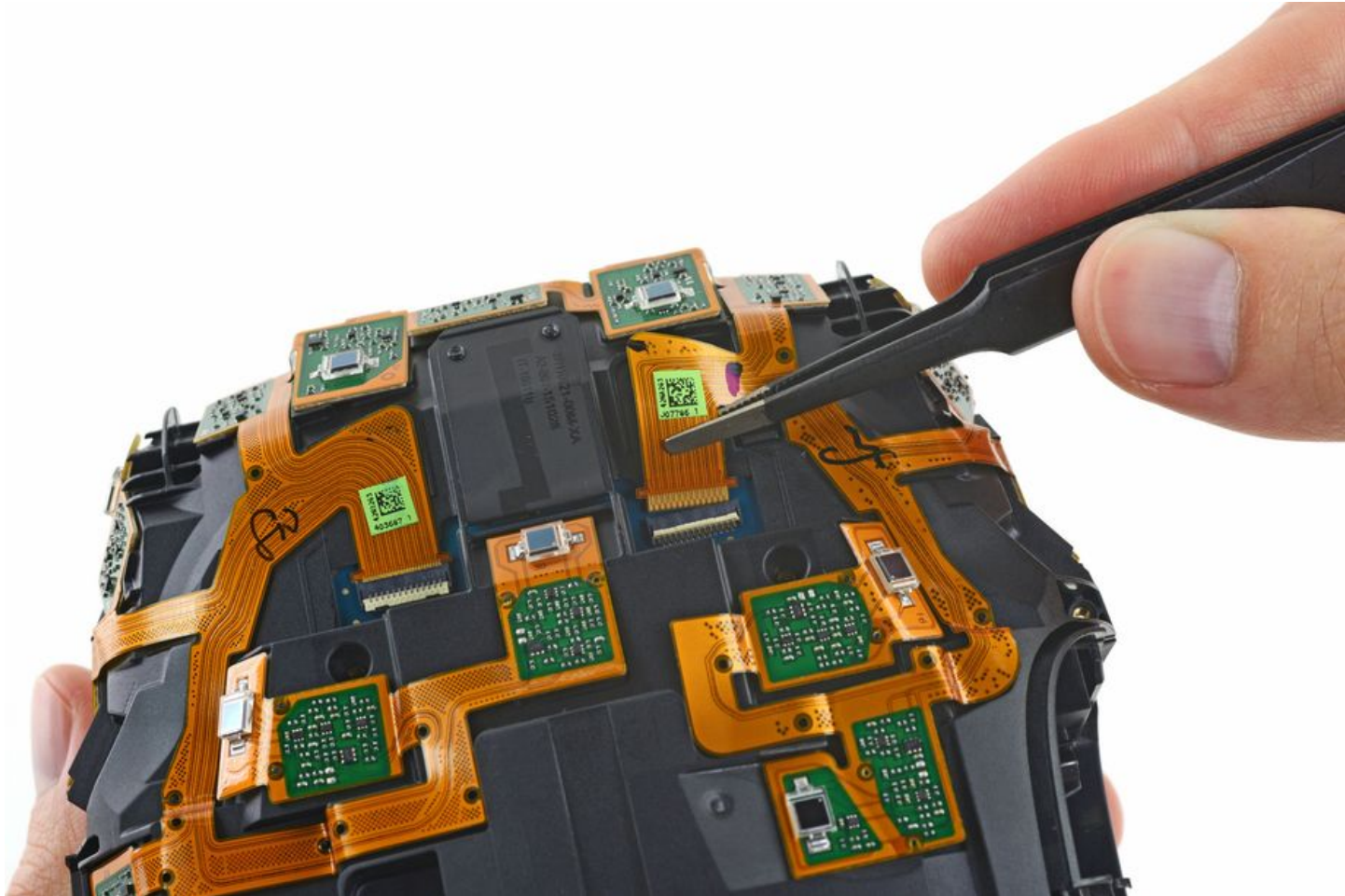
HTC Vive Lighthouse Tracking

- Large area tracking – user walks around
- Two “lighthouse” stations in room corners
- Lighthouse sweeps sheets of laser light
 - Horizontal sheet
 - Vertical sheet
- HMD has many light sensors (photodiodes)
- Timing given by when sensors “see” laser

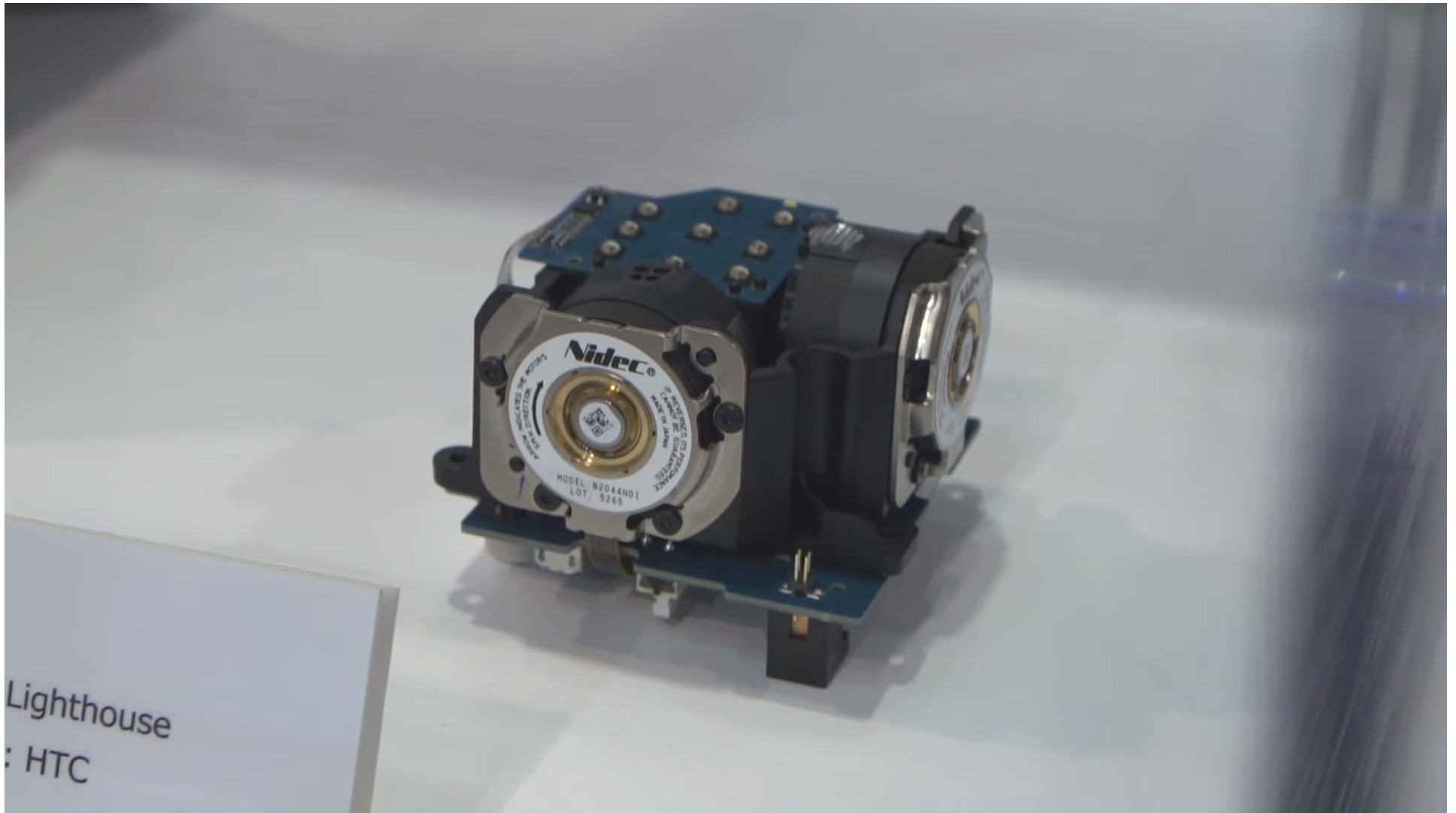
Photodiodes on HMD



Photodiodes on HMD

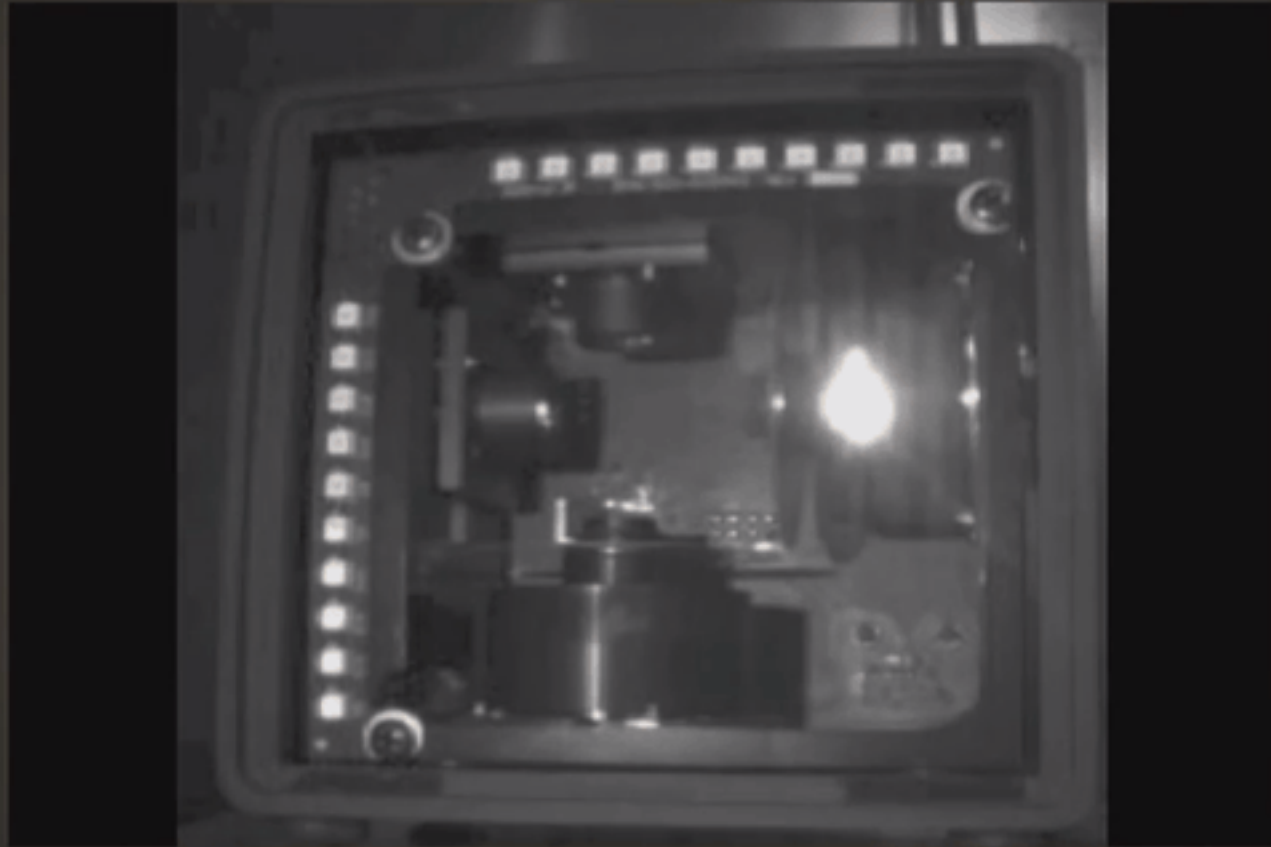


Lighthouse Unit

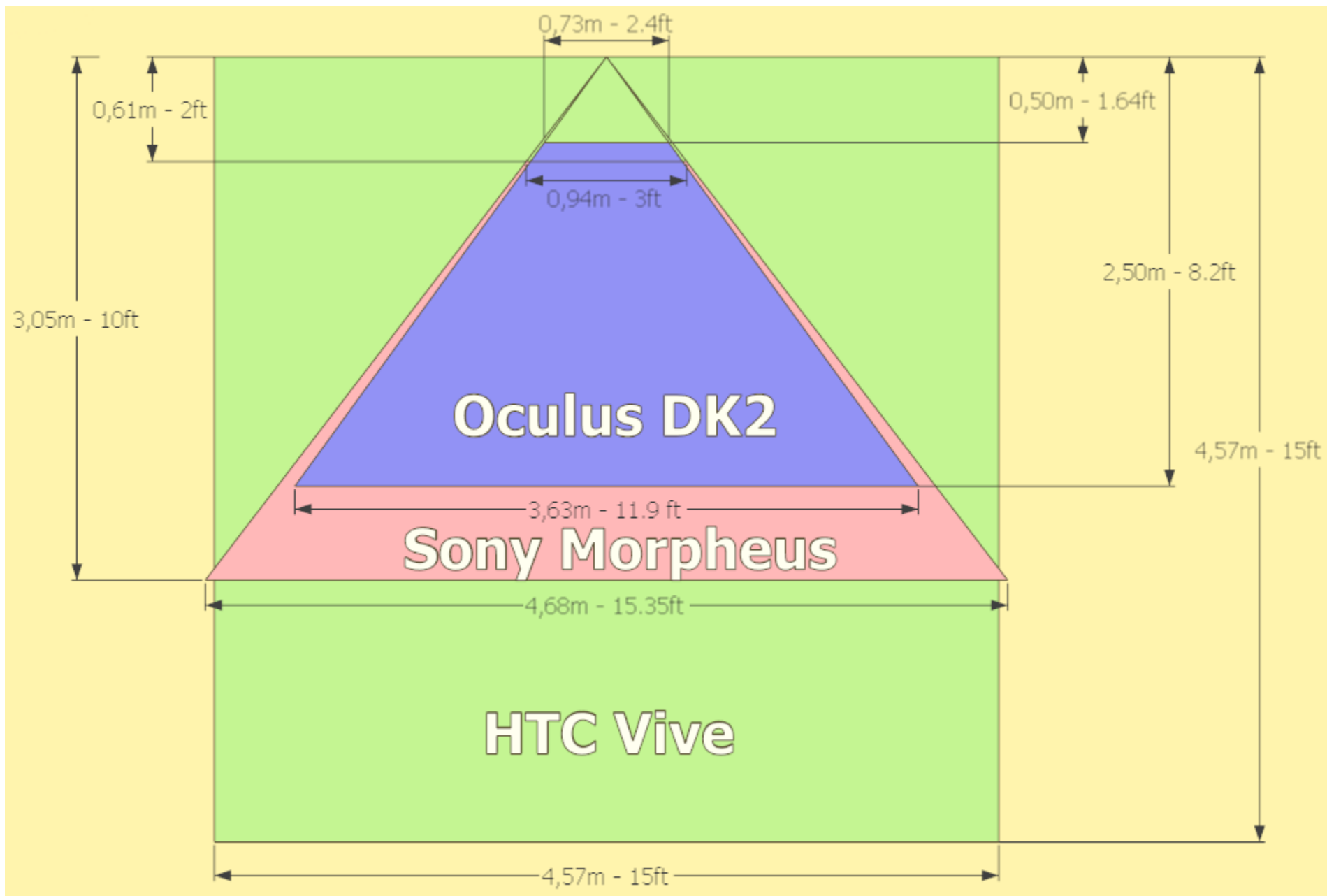


Lighthouse Unit

Lighthouse – How it works









Challenges of VR

- Motion sickness
- Lack of Killer App

Motion Sickness

- Many users report feeling dizzy
- Lag problem
 - Cannot draw new image instantly
 - Delay between sensed position and newly created image
 - Brain doesn't like this
- Eye focus problem
 - Optics presents image at one virtual “depth”
 - Our brain expects objects at varying distances

VR Applications

- Games
- Immersive Full Surround Films
- Collaboration at Distance (Telepresence)
- Medicine
- Education

Future of VR?