

CSE 190: Virtual Reality Technology

LECTURE #2: A BRIEF HISTORY OF VR

Announcements

This Saturday: Homework 1 to be released

- Will be linked on course schedule
- Will post notification on Campuswire
- Will not require VR equipment

Monday April 5, 2pm: Discussion project 1

Sunday April 11: Deadline for presentation date selection on wiki

Sunday April 18: Project 1 due

*“I hear and I forget.
I see and I remember.
I do and I understand.”*

Confucius?, 551-479 BC



Virtual Reality: Definition

Definition of **virtual reality** on Merriam-Webster:

An **artificial environment** which is experienced through **sensory stimuli** (such as sights and sounds) provided by a **computer** and in which one's **actions** partially determine what happens in the environment.

Related Terms

Virtual environment

Artificial reality

Computer generated environment

Computer simulated environment

Synthetic environment

Spatial immersion

Cyberspace

Virtual worlds

Virtual presence

VR History

Whirlwind: First CG System

1949: First computer graphics (CG) on Whirlwind Computer at MIT (Bouncing Ball)

Whirlwind development began in 1945

System was first demonstrated on April 20th, 1951

First digital computer capable of displaying real-time text and graphics on a video terminal (large oscilloscope screen)



1962: Sensorama

Morton Helig, 1950s: Designed and patented 'the experience theatre' - 180 degree horizontal and 155 degree vertical. 30 speakers, smell, wind, seats that moved.

Couldn't get funding, so in 1962 created the Sensorama: an arcade setup with a **vibrating motorcycle seat** and **handlebars** and two 35mm **projectors** for stereo and **wind** and **aromas** and **stereo sound** as the viewer moves through pre-recorded experiences.



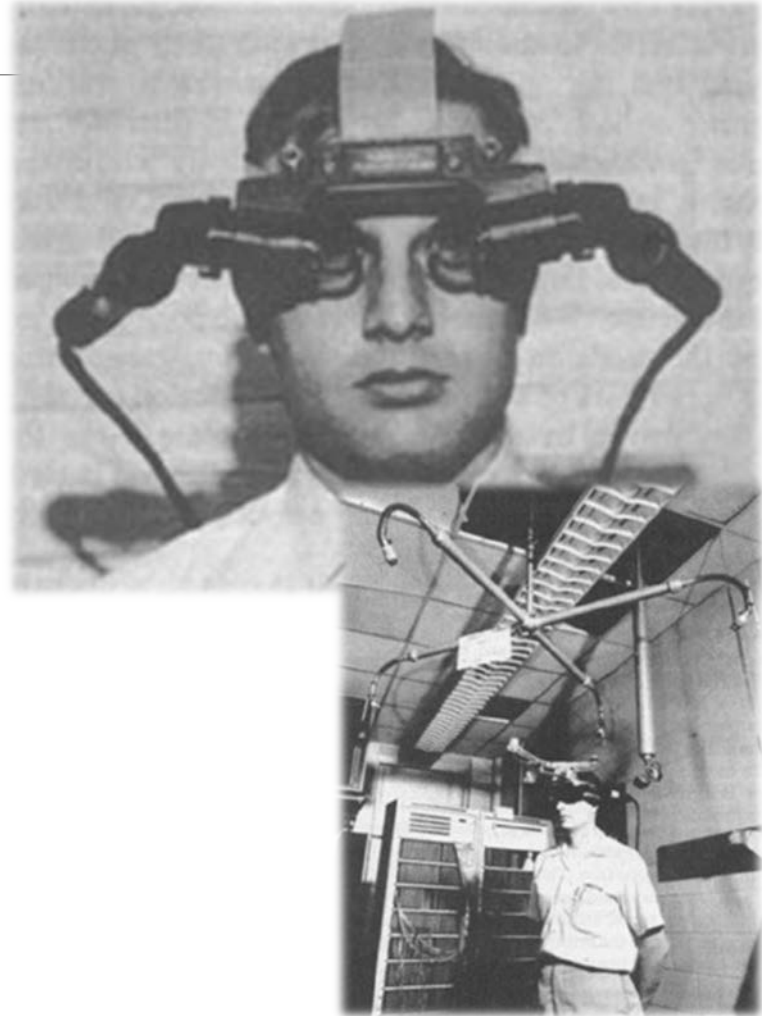
1965: Ivan Sutherland (University of Utah)

1963: Sketchpad: First **interactive** CG system with light pen

1965: Sutherland proposes the '**ultimate display**': "The ultimate display would, of course, be a room within which the computer can control the existence of matter. ... With appropriate programming such a display could literally be the Wonderland into which Alice walked"

1968: Sutherland created the first Virtual Reality and Augmented Reality (AR) Head Mounted Display (HMD) system: The **Sword of Damocles**

- **Real-time** computer generated display of wireframe cube with **head tracking** projected onto half-silvered mirrors so the cube floats in front of the user in the room.
- **Two heavy CRTs** mounted by the users head along with other hardware suspended from the ceiling by a **mechanical arm**.



VR Displays

1965: First commercial vector display (IBM, \$100K)

1967: First haptic display: Project GROPE (Fred Brooks, UNC)

“UNC uses a ceiling mounted ARM (Argonne Remote Manipulator) to test receptor sites for a **drug molecule**. The researcher, in virtual reality, grasps the drug molecule, and holds it up to potential receptor sites. Good receptor sites **attract** the drug, while poor ones **repel** it. Using a force feedback system, scientists can easily feel where the drug can and should go.”



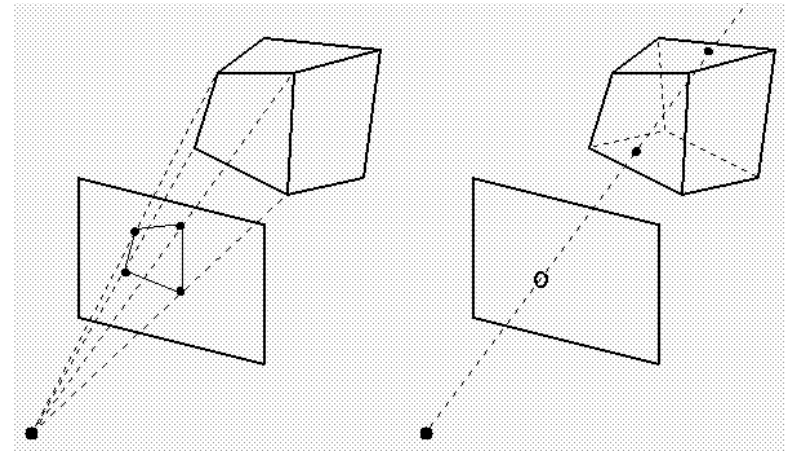
Rendering Techniques

1968 **Ray casting** principle (Arthur Appel)

1971 **Scan conversion** Principle

Ray tracing iterates over **pixels**

Scan conversion iterates over **vertices**



1971 **Gouraud Shading** (Henri Gouraud; method based on Lambertian diffuse lighting model)

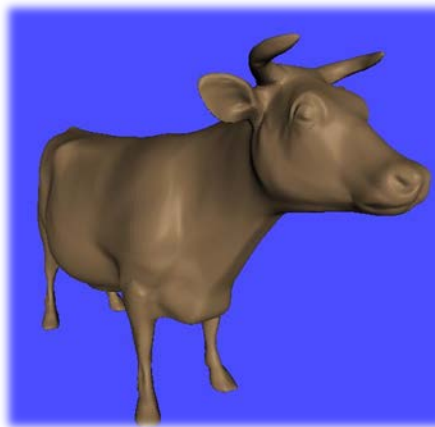
1974 **Texture Mapping** (Edwin Catmull, now President of Pixar)

Rendering Techniques

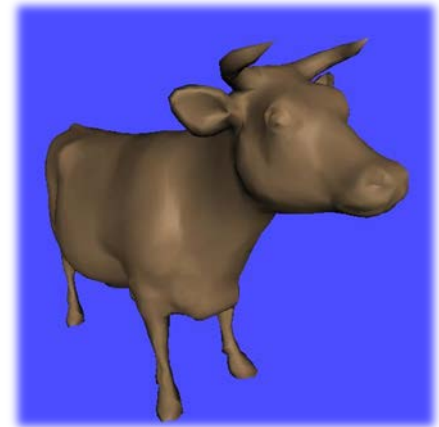
- 1975 **Phong Shading** (shading model developed by Bui Tuong Phong; PhD from University of Utah, then professor at Stanford; *1942 +1975)
About improving the quality of synthesized images he wrote, "We do not expect to be able to display the object **exactly** as it would appear in reality, with texture, overcast shadows, etc. We hope only to display an image that **approximates** the real object closely enough to provide a certain degree of realism."
- 1979 **Ray Tracing** (Turner Whitted)
- 1984 **Radiosity** (Goral, Torrance, Greenberg, Battaile; Cornell University)



Flat shading



Gouraud shading



Phong shading

Tracking



Sayre Glove



Polhemus Fastrak

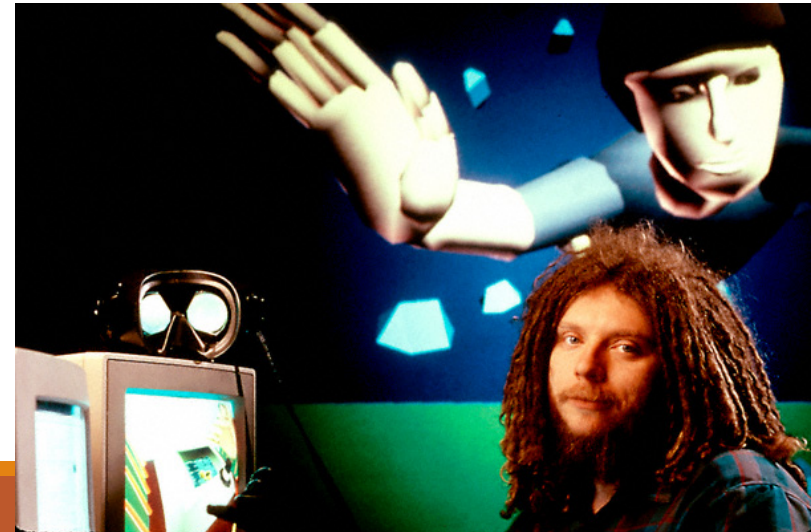
1977: First instrumented glove “**Sayre Glove**” (Sandin, DeFanti & Sayre)

1979: **Polhemus** Tracking System (Raab et al.)

1985: **Jaron Lanier & VPL** research

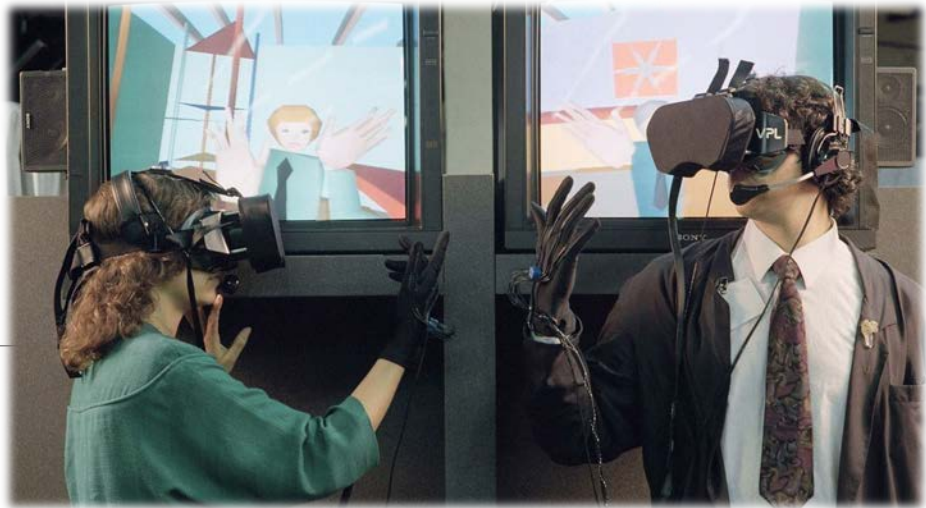
- First company focused on VR products
- Popularized the term “virtual reality”
- Sold **DataGloves** in 1985 and **EyePhones** in 1988

1986: **Ascension Technologies** founded from former Polhemus employees

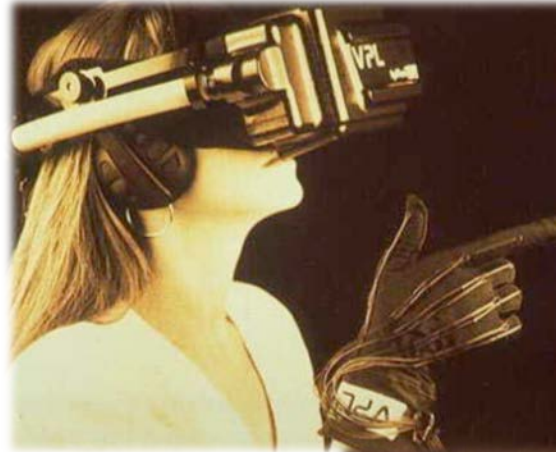


VPL EyePhone

Developer	VPL Research
Display	2.7", 2.75" or 3" B&W LCD with color filters (76,800 subpixels) From the Sony FLD-370 (1990) (3" 89,505 subpixels)
Resolution	~184.7x138.6 per eye (320x240 subpixels)
Optics	large expanse extra perspective (LEEP) optical system
Tracking	Polhemus tracker
FOV	90°x60° (80°x60° monoscopic)
Weight	2.4 kg
Release date	June 7, 1989
Price	\$9,400



Version 1



Version 2



Virtual Environments

1987: British Aerospace **Virtual Cockpit**

1989: **NASA VIEW** System (Virtual Interface Environment Workstation)

- First complete VR system
- Project started in the early 80's
- General-purpose, multi-sensory, personal simulator and telepresence device
- Configuration included head and hand tracking, wide field-of-view stereo head-mounted displays, speech recognition, 3D audio output and a tracked and instrumented glove

1989: Fake Space Labs: Development of the **BOOM**

1992: **Virtual Portal** (M. Deering, Sun Microsystems)

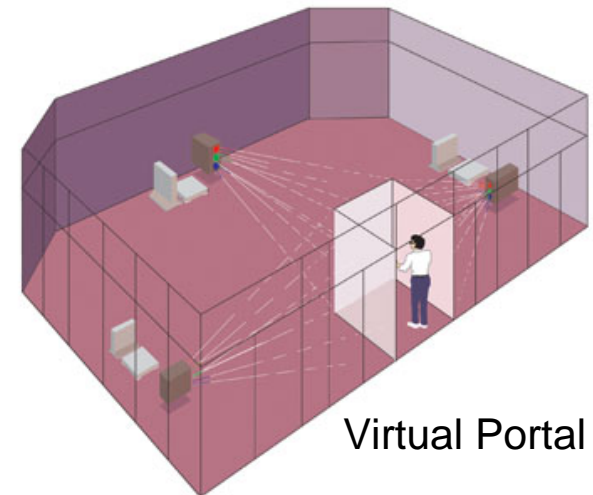
1992: **CAVE**: Cave Automated Virtual Environment (Carolina Cruz Neira et. al., University of Chicago)



NASA VIEW



EVL CAVE



Virtual Portal

The 1990s

1993: Silicon Graphics **Reality Engine**:

- Hardware-supported Gouraud shading, texture mapping, Z-buffering, anti-aliasing, 200,000 polygons/sec (Comp. w/Nvidia GTX 2080: 20 billion polygons/sec)

1993: **OpenGL** standard created

1993: **PHANTOM** Haptic Device (T. Massie, K. Salisbury)

1995: Nintendo **Virtual Boy**

- 3D monochrome display, shipped 1.26M units, released 22 games

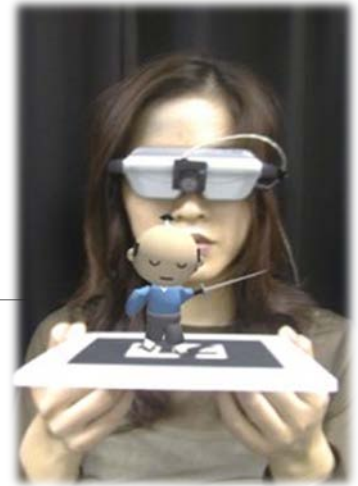
1996: Silicon Graphics **Infinite Reality** (5M polygons/sec)

1998: Silicon Graphics **Infinite Reality2** (13M polygons/sec)

1998: First **6-wall CAVE**

- Built by TAN at Royal Institute of Technology in Stockholm

1999: **ARToolKit** (Hirokazo Kato, HITLab, UW)



ARToolKit



Virtual Boy

Early 2000s

2002: **PC graphics** & PC clusters (NVIDIA FX4000: 130M polygons/sec)

2002: **DLP/LCD projectors**

- Time sequential (active) stereo possible with DLP technology

2002: **Optical tracking** for VR systems (e.g., Vicon, ART): predecessors of Oculus Rift tracking cameras



Optical Tracking System (Vicon)

This slide was not covered in lecture – it's here for context but won't be part of final exam

Sensics PiSight

First high-resolution, high FOV HMD

Released April 2006

2200x1200 color pixels per eye

150 degrees field of view

24 OLED microdisplays:

- 4x3 array for each eye
- 800x600 pixels

Full 6 degree of freedom tracking

Initially driven by PC cluster, later by single PC

~\$200k




Oculus

August 2012: Palmer Luckey revives VR with Oculus Kickstarter

March 2014: Facebook acquires Oculus for \$2B

Funded! This project was successfully funded on Sep 1, 2012.



23 OF 3 DONE

9,522
backers

\$2,437,42
pledged of \$250,000 goal

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seconds to go

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Oculus
Project by
Oculus
Long Beach, CA
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Modern Consumer VR/AR

March 25, 2016: Oculus CV1

March 30, 2016: Microsoft HoloLens

April 5, 2016: HTC Vive

October 13, 2016: Sony Playstation VR

March 20, 2018: Oculus Go

April 5, 2018: HTC Vive Pro

August 2018: Magic Leap

May 21, 2019: Oculus Quest

June 28, 2019: Valve Index

Nov 9, 2019: Microsoft HoloLens 2

Oct 13, 2020: Oculus Quest 2

Nov 2020: HP Reverb G2



Application Domains

Gaming

Entertainment

Training

Architecture

Medicine

Simulators

Scientific visualization



VR in Movies



The VR Spectrum

The VR Spectrum

There is a wide umbrella of experiences that people call Virtual Reality.



Source: Wired

360° Video
monoscopic



Source: GreenBot

360° Video
stereoscopic (cardboard viewer)



Source: Pocket-Lint

VR Application



Source: Sam Yash AF/Getty Images

Hyper Reality
Mixed Reality

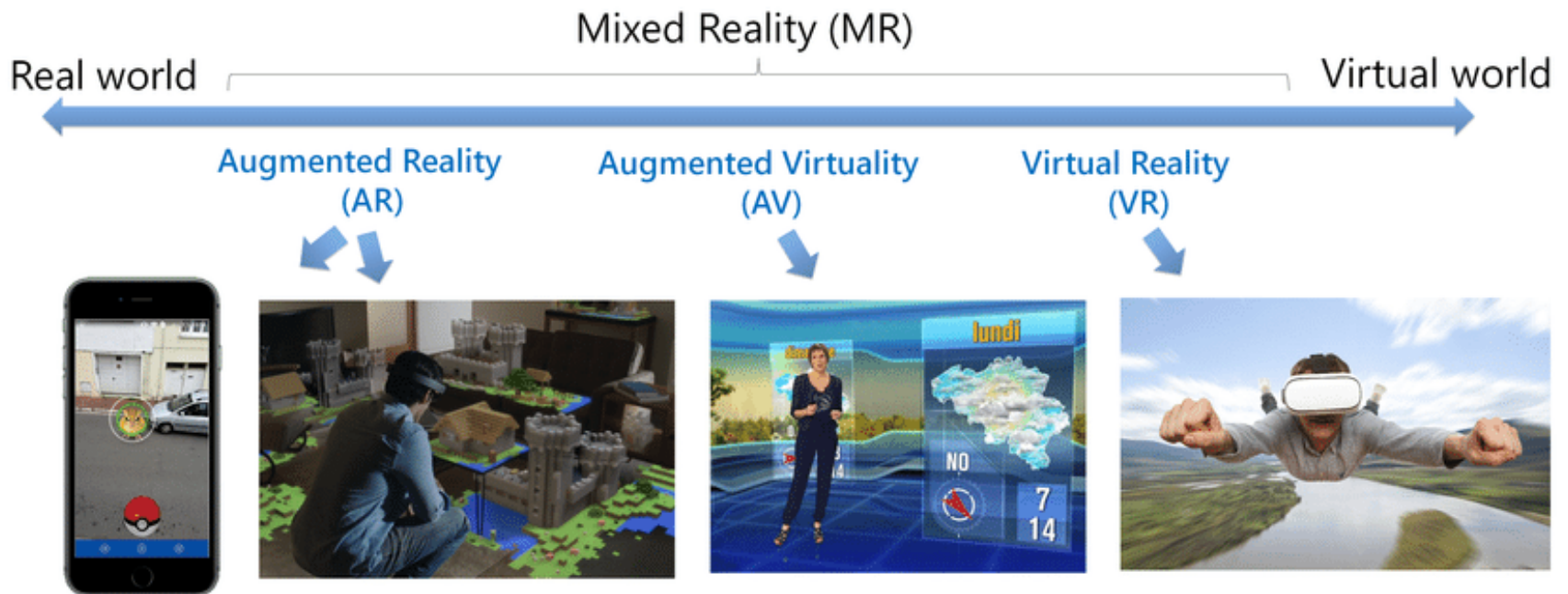


passive
experience

interactive experience

physical
fully immersive experience

The Mixed Reality Spectrum



Related Technologies

Vehicle/Flight Simulators

CAD

Computer animation/special effects

Video Games

Tele -Presence

- Teleconferencing
- Remote robotic control

Collaborative systems