

Introduction to Virtual Reality

071011-1

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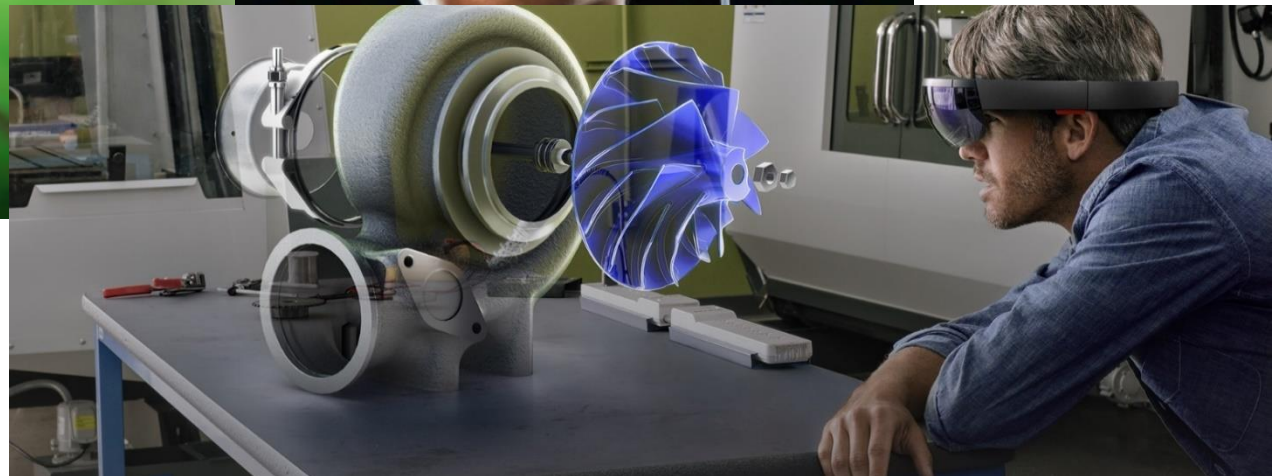
Virtual Reality and Augmented Reality

- ❑ Oculus Rift, HTC Vive, Samsung Gear VR, Sony Playstation VR, Google Glass, Microsoft HoloLens, Apple Vision Pro, etc



Virtual Reality and Augmented Reality

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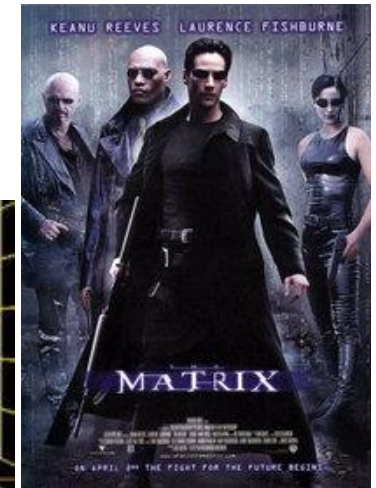
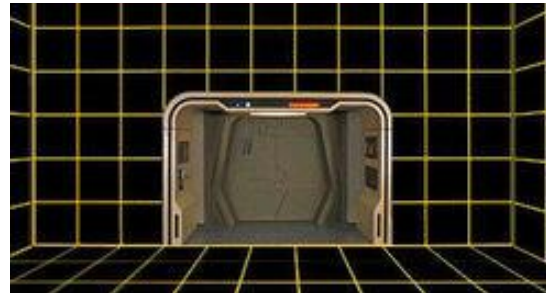
What is Virtual Reality?

❑ Possible definition:

- Immersion into an alternate reality or point of view, e.g. book, movie

❑ Popular conception of VR

- Star Trek: The Next Generation Holodeck
- The Matrix



❑ A better definition of VR

- Medium composed of interactive computer simulations that sense the participant's position and replace or augment the feedback to one or more senses

Virtual Reality

- ❑ Virtual reality (VR) is a technology which allows a user to interact with a computer-simulated environment, but it a real or imaged one. Most current virtual reality environments are primarily visual experiences, displayed either on a computer screen or through special stereoscopic displays, but some simulations include additional sensory information, such as sound through speakers or headphones. Some advanced, haptic systems now include tactile information, generally known as force feedback, in medical and gaming applications.
 - wikipedia

Virtual Reality

- 가상현실 (Virtual reality; VR) 은 3차원의 공간성, 실시간의 상호작용성, 자기 투사성의 세 요소를 수반한다. 인터페이스는 일반적으로 시각과 청각을 이용하지만, 촉각, 힘의 감각, 전정 감각 등, 다양한 인터페이스(멀티모달 인터페이스)를 이용한다. 1968년에 유타 대학의 Ivan Edward Sutherland에 의해서 HMD (Head Mounted Display, 머리 부분 탑재형 디스플레이) 가 제안된 것이 최초의 가상현실이다. 시각을 이용한 가상현실로서는, 1991년에 일리노이 대학의 Thomas DeFanti 등에 의해서 제안된 CAVE (Cave Automatic Virtual Environment, 몰입형의 투영 디스플레이)가 유명하다.
- 한국 위키백과





Characteristics of VR

Characteristics of VR

- ❑ Computer generated 3D world & real-time graphics
- ❑ Immersion (i.e., viewer-centered perspective)
- ❑ Interactivity (i.e., user controls)
- ❑ Sensory feedback (e.g. visual, audio, haptic feedback)

Virtual World

- ❑ The **contents** conveyed by a medium
- ❑ An imaginary space often manifested through a medium
- ❑ A description of a **collection of objects** in a space, and the **rules** and **relationships** governing those objects

Immersion

- Also called presence (being mentally immersed)
- Sense of “Being there” perspective
- To enhance immersion:
 - First-person view
 - Wide field-of-view
 - Stereo vision
 - Head tracking
 - Auditory, haptic or tactile feedback

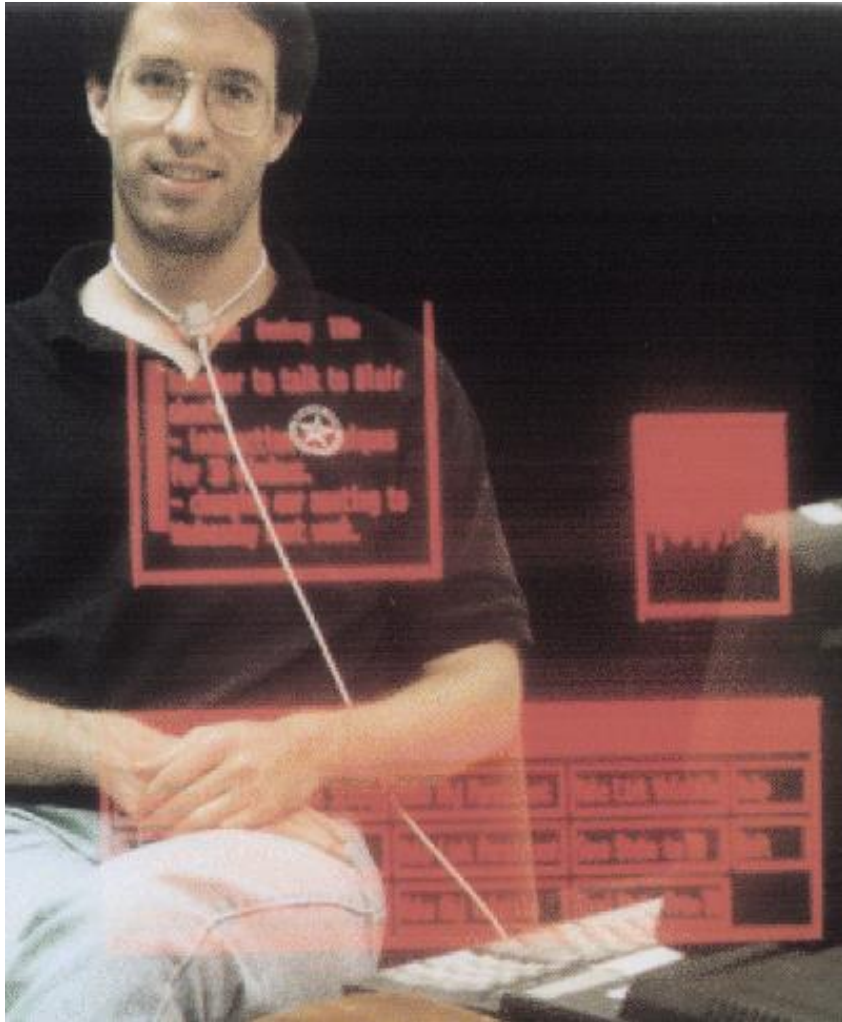
Interactivity

- ❑ The viewer controls interactively in the environment
- ❑ **Tracking** is the key to **interactivity**. The movement of the participant is being tracked and monitored as to yaw, pitch, roll and the position in x, y, z.
- ❑ The participants **interact with objects, characters, places in a virtual world** – i.e., manipulation and navigation.
- ❑ Collaborative environment refers to multiple users interacting within the shared virtual space or simulation. The user are represented as their avatars.

Sensory Feedback

- ❑ VR provides direct sensory feedback to the participants
- ❑ Mainly rely on visual sense
- ❑ Immediate interactive feedback requires the use of a high-performance computer
- ❑ To provide sensory output of the VR system on the position of the participants, the system must track their movement.

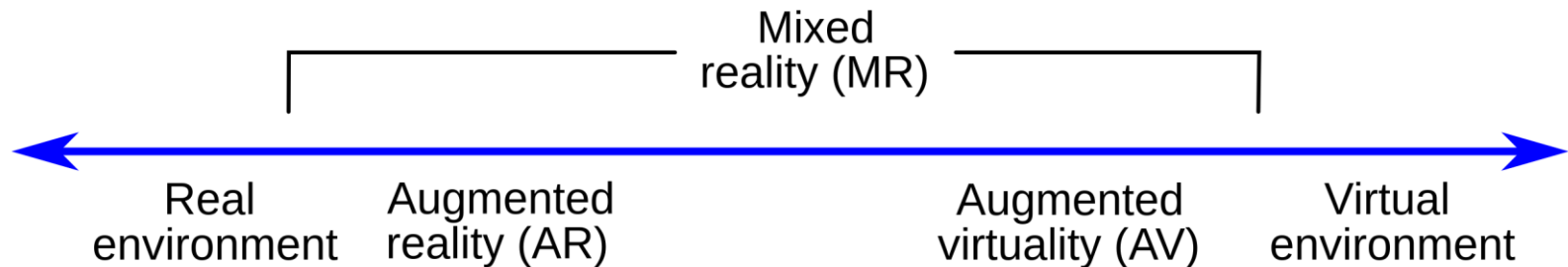
Other forms of VR



- ❑ Artificial Reality
- ❑ Virtual Environment
- ❑ Cyberspace
- ❑ Augmented Reality (AR)
- ❑ Tele-presence
 - Controlling a probe in a deep ocean area
 - Working with dangerous chemicals
- ❑ Mixed Reality (MR)
- ❑ Extended Reality (XR)

Reality-Virtuality Continuum

□ Milgram and Kishino's Reality-Virtuality Continuum (1994)



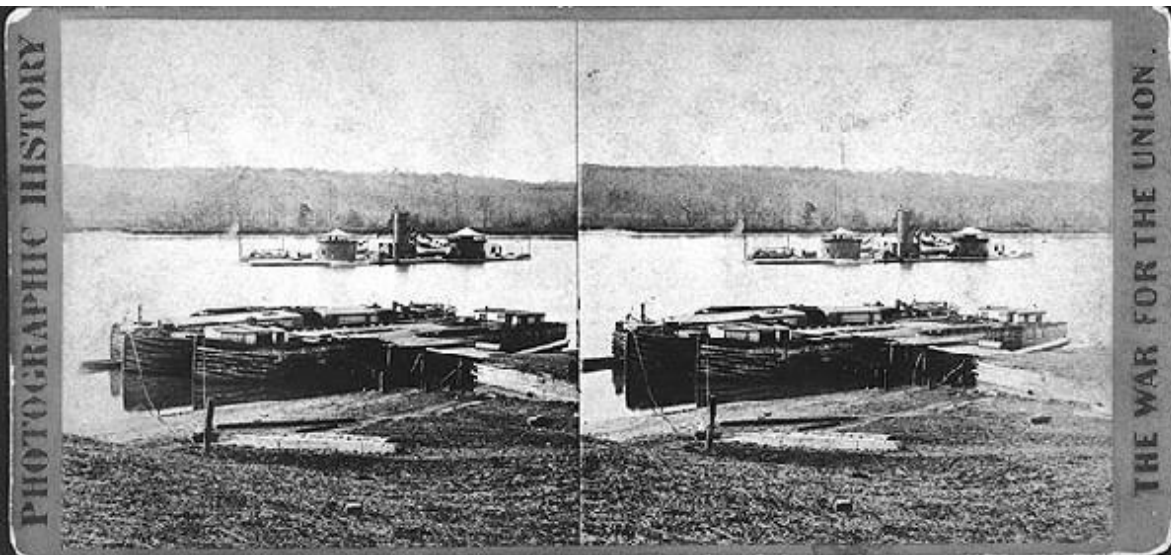
- Real Environment
- Augmented Reality (AR) – virtual augments the real
- Augmented Virtuality (AV) – real augmented the virtual
- Virtual Reality (VR) - completely immersed in a virtual world



VR History

VR History

- ❑ 1838 – Stereoscope, by Charles Wheatstone
- ❑ 1849 – Lenticular Stereoscope, by Brewster
- ❑ 1903 – Parallax Barrier, by Ives
- ❑ 1908 – Integral Photography, by Lippmann
- ❑ 1948 – Holography, by Gabor



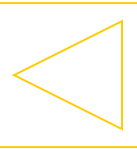
Holmes Stereoscope

VR History

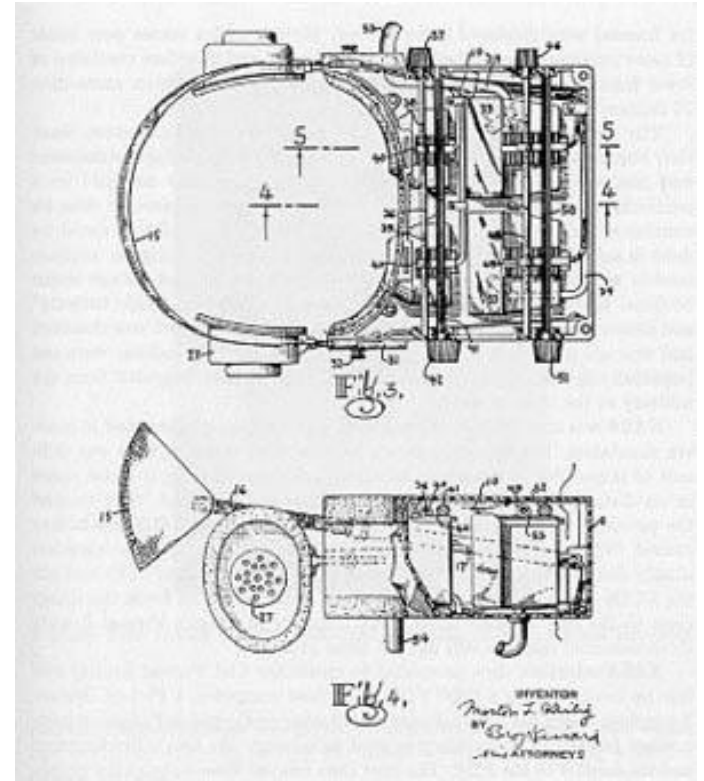
□ 1956 - Morton Heilig's Sensorama

- Cinematographer
- Wanted to expand on 'cinerama' which had 90 degree field of view (FOV) by shooting with 3 cameras simultaneously and then synchronized when projected. Academy ratio films typically had 18 degree FOV, and Cinemascope 55 degree (depending on where you sat in the theatre)
- 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 he made the scaled down 'sensorama' - arcade setup with a vibrating motorcycle seat and handlebars and 2 35mm projectors for stereo and wind and aromas and stereo sound as viewer moved through prerecorded experiences – for multi-sensory virtual experience
- Patented first head mounted display (1960) - used slides - couldn't get funding.

Sensorama



Heilig's Sensorama

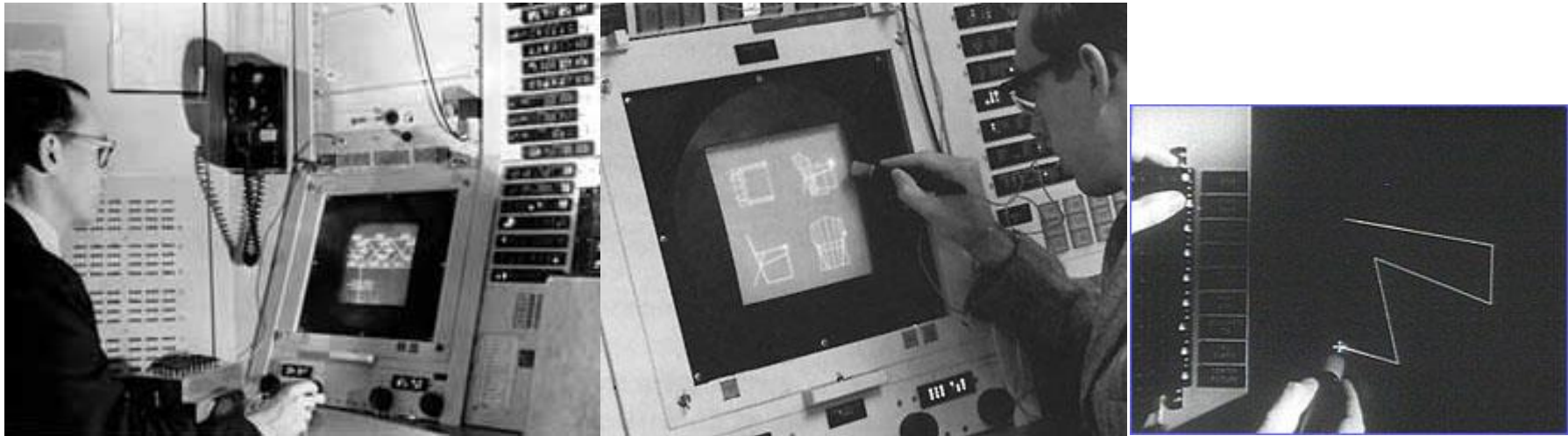
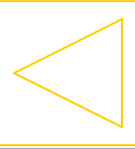


Heilig's US patent for HMD

VR History

- 1963 - Ivan Sutherland @ MIT
 - Sketchpad, interactive computer graphics
- 1965 - Ivan Sutherland @ University of Utah
 - Proposes the 'ultimate display' which is basically Star Trek's holodeck complete with the computer controlled generation of matter. "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"
- 1966 - Ivan Sutherland
 - Created 'Sword of Damocles' - first HMD
 - 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 (what we would call augmented reality today.) Two CRTs mounted by the users head along with other hardware suspended from the ceiling by a mechanical arm.

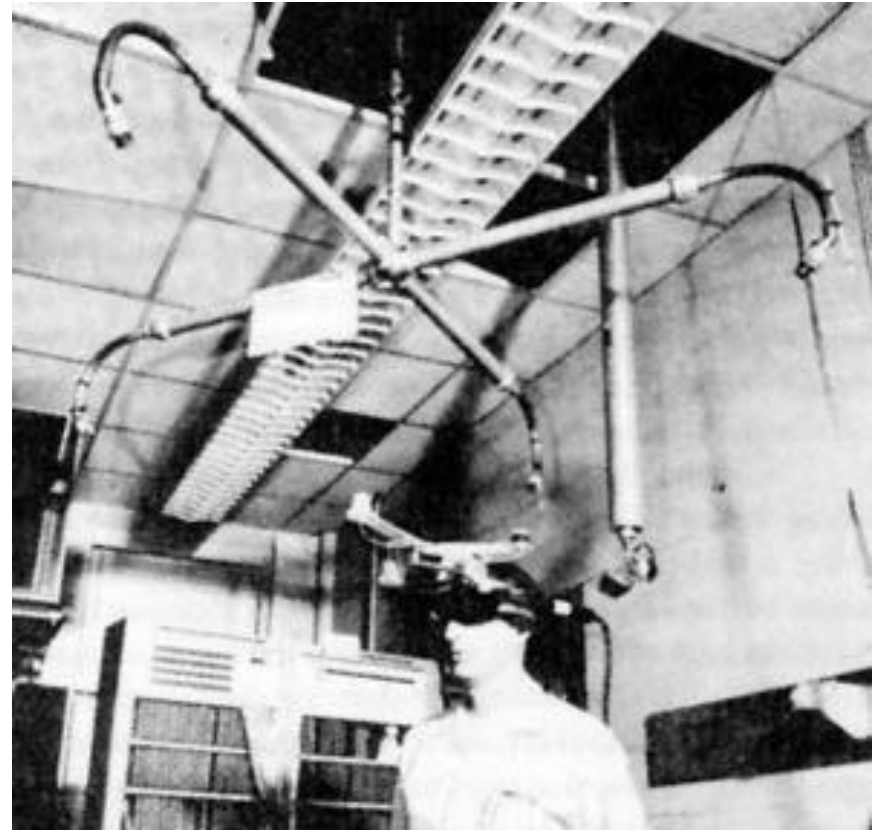
Sketchpad



Ivan Sutherland's Ph.D dissertation at MIT,
The Sketchpad: A Man-Machine Graphical Communication System
(1963)

The first interactive computer graphics system with a light-pen for design and engineering.

Ultimate Display



Sutherland's "Ultimate Display"

VR History

□ 1967 - GROPE @ UNC

- Force-feedback project (began in 1967)
- GROPE-I – 2D system for continuous force feedback
- GROUP-II – 6DOF (with 3 forces and 3 torques)
- GROUP-III – a full 6-DOF molecular docking system
- UNC uses a ceiling mounted
ARM (Argonne Remote Manipulator)
to test receptor sites for a drug molecule



UNC's GROPE II 6-DOF ceiling mounted ARM
(Argonne Remote Manipulator)

VR History

- 1970 - Myron Krueger
 - VIDEOPLACE - 'artificial reality' where cameras are used to place people into projected scenes
 - Image processing used to track the users in the 2D space

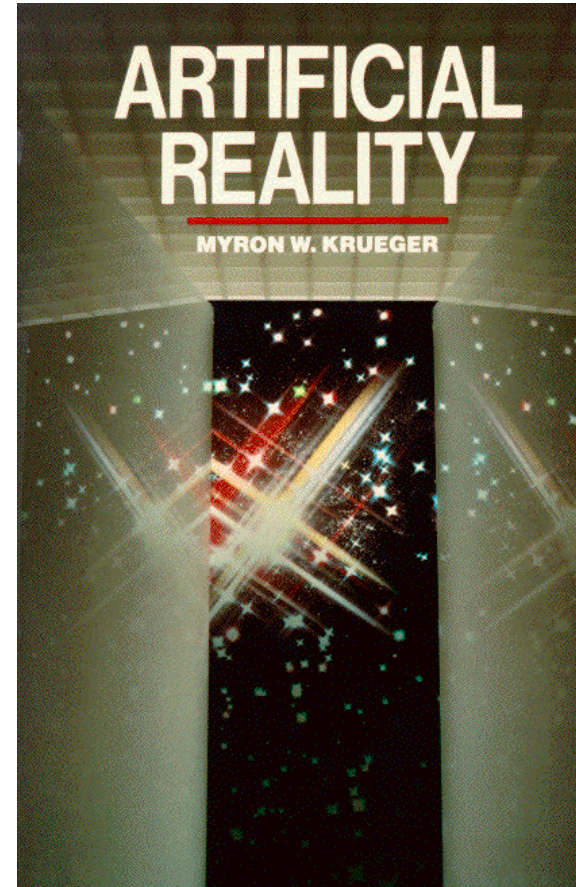


Krueger's Videoplace

Artificial Reality



- 1983 – Myron Kruger published his famous book, *Artificial Reality*.



VR History

- 1977 – Sayre, DeFanti, Sandin @ EVL
 - **The Sayre Glove** – the inexpensive, lightweight, first data glove for gesture recognition
 - This glove uses light-conductive tubes to transmit varying amounts of light proportional to the amount of finger bending.
- 1978 – Andrew Lippman, Michael Naimark, Scott Fisher @ MIT
 - **The Aspen Movie Map**
 - The first true hypermedia system
 - It was a surrogate travel application that allowed the user to enjoy a simulated ride through the city of Aspen, Colorado



VR History

- 1979 – F.H.Raab, et al. utilized tracking systems in VR – the **Polhemus** (6-DOF electromagnetic position tracking)
 - Bill Polhemus started Polhemus Associates in 1964, working on projects related to navigation for US Dept of Transportation



Polhemus FASTrak and VISIONTrak tracking system

VR History

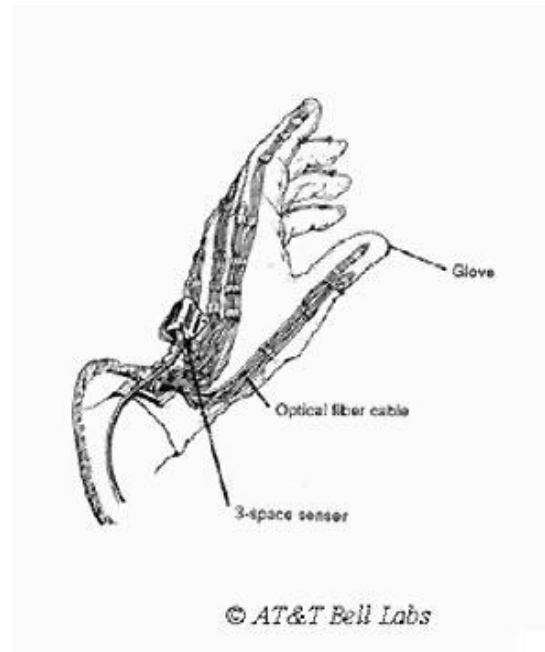
- 1982 – Thomas Furness III
 - VCASS (Visually Coupled Airborne Systems Simulator)
 - 6 degree of freedom HMD which isolated user from the real world
- 1986 – Thomas Furness III
 - Virtual Super Cockpit for pilots that fed 3D sensory information directly to the pilot, who could then fly by nodding and pointing his way through a simulated landscape below.
- 1989 – Thomas Furness III
 - found HITlab (Human Interface Technology Laboratory)



*Super Cockpit Program
Wright Patterson AFB
1986-1989*

VR History

- 1983 – Grimes' Digital Data Entry Glove @ Bell Labs
 - The first widely recognized device for measuring hand position.
 - Finger flex sensors, tactile sensors at the fingertips, orientation sensing and wrist-positioning sensors.



VR History

- 1984 - Michael McGreevy, et al.
 - VIVED (Virtual Visual Environment Display)
created inexpensive HMD with off-the-shelf components (e.g. Sony watchman, DEC PDP 11, Picture System2 graphics computer, and a Polhemus noncontact tracker)
 - Scott Fisher @ NASA Ames
continues to add features: data glove, quad-sound, voice control, etc
becoming **VIEW (Virtual Interface Environment Workstation)**



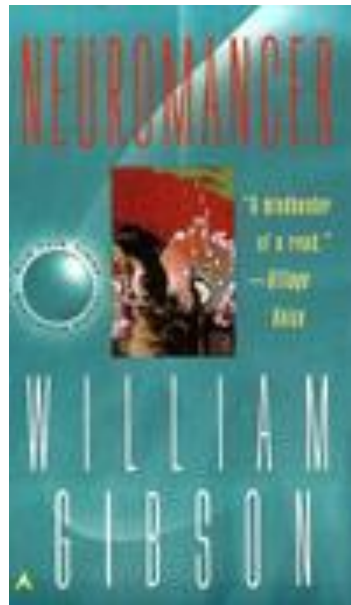
By 1988, four 3D virtual sound sources were added.

VIVED evolved into VIEW (Virtual Interface Environment Workstation)

VR History

□ 1984 – William Gibson

- In **Neuromancer**, he added the word “**cyberspace**” – the implications of a wired, digital culture, and have had tremendous influence on the scientists, researchers, theorists, and artists working with virtual reality.
- Cyborgian, cyber-habitats, virtual communities, online chat spaces



VR History

- 1985 - Jaron Lanier, Thomas Zimmerman & VPL Research
 - **Term: Virtual Reality**
 - First company focused on VR products
 - Sold **VPL data gloves** in 1985 and eye phones in 1988



VPL Data Glove



VIEW system, NASA Ames Research Center

VR History

- ❑ 1986 – Ascension Technologies founded from former Polhemus employees, Ernie Blood and Jack Scully
 - Develop a wide range of electromagnetic tracking systems for various applications, such as animation, medical imaging, biomechanics, virtual reality, simulation, military



Ascension Flock of Birds
motion tracker

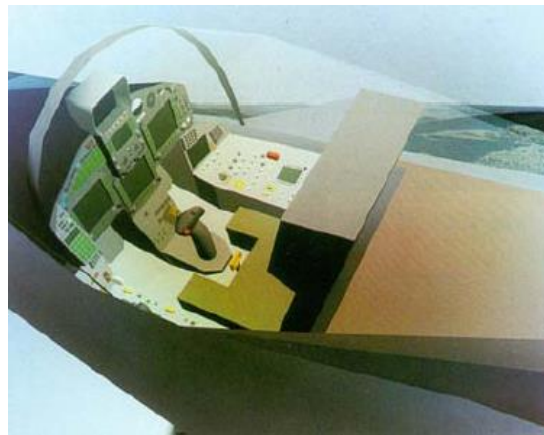


Maelstrom's virtual toolkit teaches technicians how to perform repairs to the Puma helicopter. Immersive tools – headset, cyber gloves, and Ascension's three sensor Flock of Birds – are used to simulate real-world conditions in which repairs often take place. Image courtesy Maelstrom Virtual Productions

Puma helicopter repair
training system

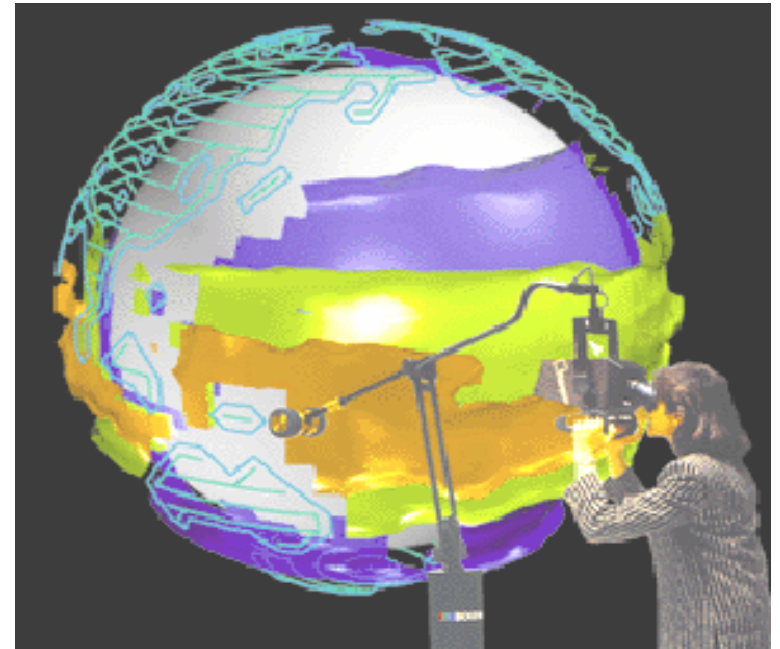
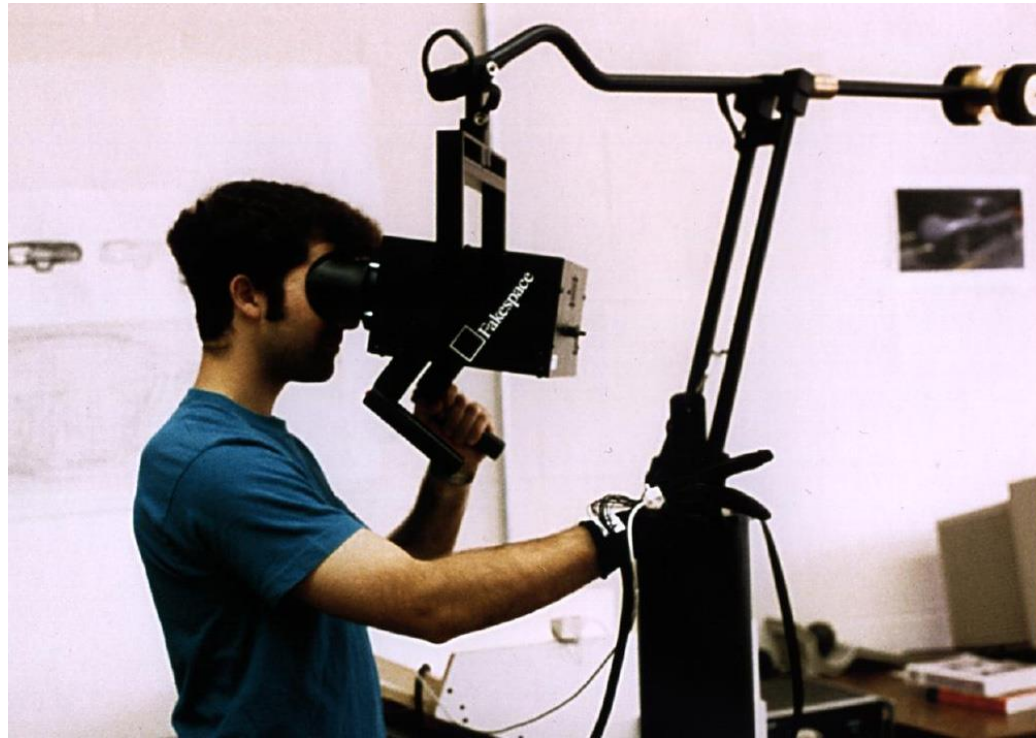
VR History

- ❑ 1987 – **Virtual Cockpit** (British Aerospace)
 - Head and hand tracking, eye tracking, 3D visuals, 3D audio, speech recognition, vibro tactile feedback
- ❑ 1989 - Autodesk
 - First PC based VR system
- ❑ 1989 - Fakespace Lab
 - Development of the **BOOM (Binocular Omni-Orientation Monitor)**



Virtual Cockpit

BOOM

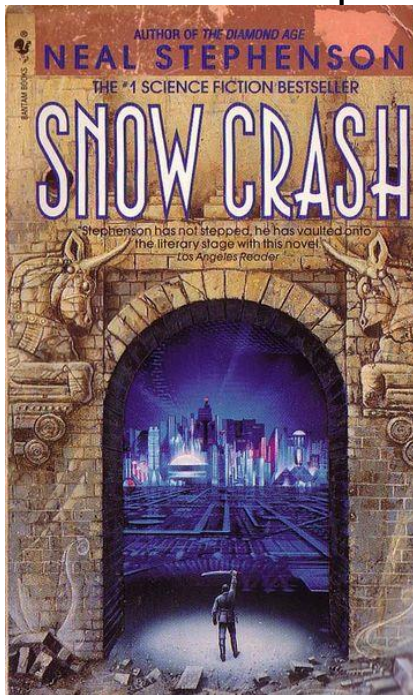


BOOM commercialized by Fakespace

VR History

□ 1992 – Snow Crash

- Neal Stephenson's best selling science fiction novel, published in 1992. **Snow Crash**, details a highly compelling conception of the "**Metaverse**" – a networked hyper-realistic virtual universe. The term "**avatar**" was extensively referred to describe one's representation in a virtual world.



VR History

- 1992 – Tom Caudell - Boeing
 - Coins term Augmented Reality
 - Creates see through HMD to guide wire bundle assembly in aircraft



VR History

- 1992 – Steve Feiner and friends - Columbia University
 - KARMA - Create see-through HMD to understand laser printer maintenance -
<https://graphics.cs.columbia.edu/projects/karma/karma.html>
 - Touring Machine - backpack computer - see through HMD with 3D graphics, GPS and orientation tracking

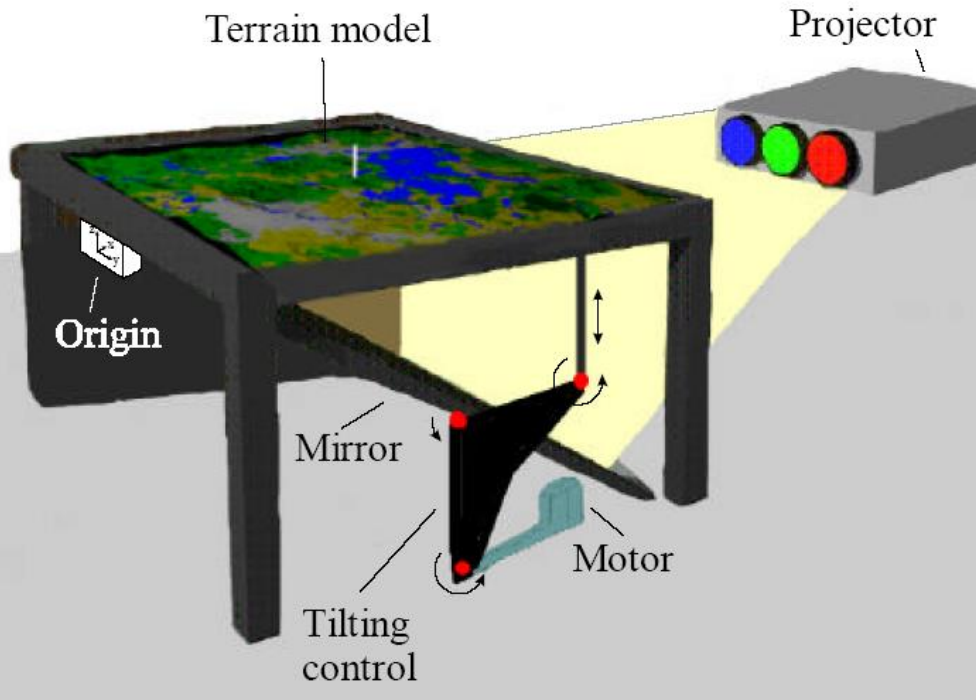
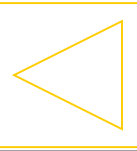


Image from <http://monet.cs.columbia.edu/projects/mars/touring.html>

VR History

- ❑ 1991 – ICAT (International Conference on Artificial Reality and Telexistence)
- ❑ 1992 – Development of the [CAVE](#) @EVL
- ❑ 1993 – Silicon Graphics Reality Engine
 - Hardware-supported Gouraud shading, texture mapping, z-buffering, anti-aliasing
- ❑ 1993 – OpenGL standard
- ❑ 1993 – Development of the [Immersive Workbench](#),
 - by GMD (German National Research Center for Information Tech)
- ❑ 1993 – Development of [PHANTOM](#) by SensAble Technology
- ❑ 1993 – Development of [Virtual Retinal Display](#) by HIT lab
- ❑ 1995 – IEEE Virtual Reality Annual International Symposium

Immersive Workbench



Immersive Workbench

Phantom



Phantom Desktop



Phantom Omni

Virtual Retinal Display

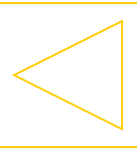
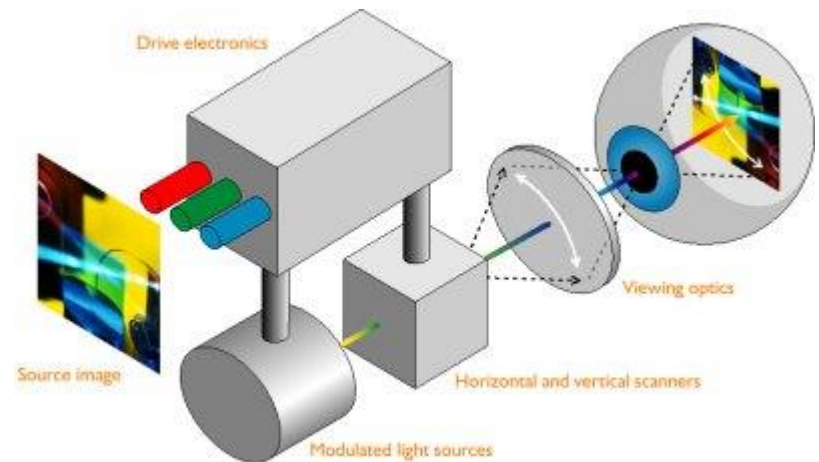
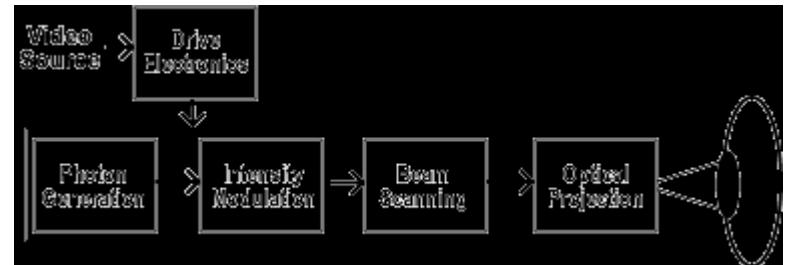


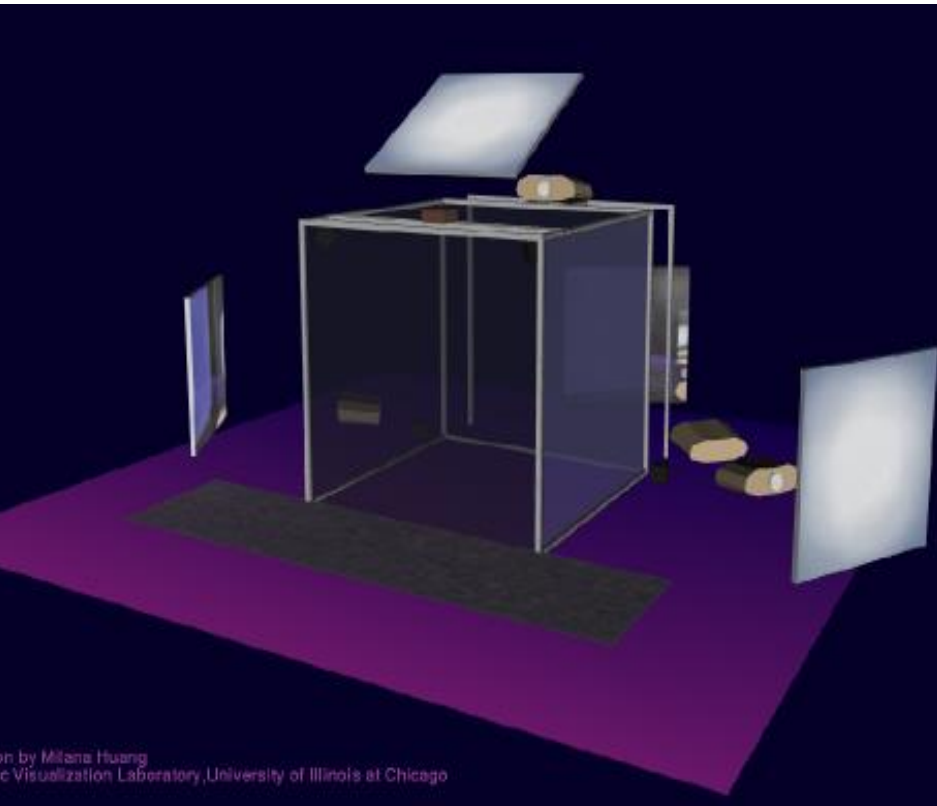
Figure 3: Virtual retinal display technology is being incorporated in helmet-mounted displays for military applications. (Photo courtesy of Microvision).



VR History

- 1995 – Development of the **ImmersaDesk** @ EVL
- 1996 – **Intersense** founded
 - Create a wide range of ultrasonic/inertial motion trackers
- 1998
 - Disney opens the first of their **DisneyQuest** family arcade centers, which features numerous VR attractions using both HMD and projection-based visual displays
 - **The first six-sided CAVE** installed at the Swedish Royal Institute of Technology
 - Development of **PARIS** @ EVL
- 1999 – ARToolkit by Mark Billinghurst@HITLab at University of Washington
- 2000 – Development of **Geowall** @ EVL
- 2002 – PC graphics & PC clusters
- 2003 – Development of SCAPE and the Head Mounted Projective Display @ University of Arizona
- 2003 – Development of **Varrier** @ EVL

CAVE

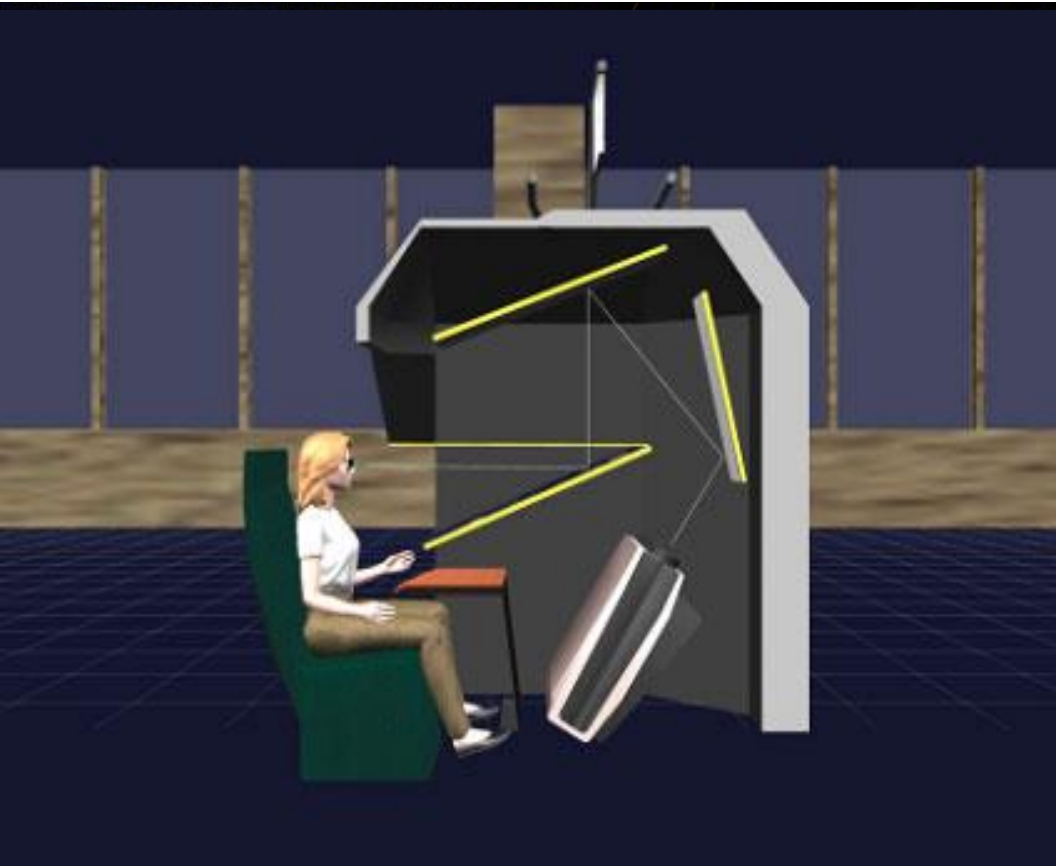


ImmersaDesk



- 1992 – 1 CAVE
- 2001 – at least 50 CAVEs & at least 100 ImmersaDesks around the world
- Silicon Graphics Inc. and FakeSpace Systems Inc.

PARIS



- ❑ PARIS (Projected Augmented Reality Immersive System)
- ❑ Projection-based “augmented” virtual reality system
- ❑ Half-silver mirror superimposes the displayed image over user’s hands

GeoWall



- ❑ Originally designed & developed by EVL in 2001
- ❑ Widespread adoption by GeoWall Consortium for research & education in the Geosciences (at least 70 GeoWall in 2001)
- ❑ www.geowall.org

Varrier



- ❑ Varrier Tiled Auto-Stereoscopic LCD Display
- ❑ Use barrier strip material in front of LCD to create autostereoscopic image.
- ❑ 4 horizontal pixels to create 1 stereoscopic pixel- oversampling to reduce aliasing.
- ❑ Use low-latency tracking to eliminate pseudo-stereo.

SONY's Patent on Brain Computer Interface

□ 2005 – Sony takes 3-D cinema directly to the brain

From [The Times](#)

April 7, 2005

Sony takes 3-D cinema directly to the brain

By [Michael Horsnell](#)

✓ RECOMMEND? (1)

THE cult sci-fi movie *The Matrix* might not have such an improbable plot after all.

The first step towards a real-life version, in which cyber-reality is projected into the brains of people via an electrode feed, could be just over the horizon.

Sony, the Japanese entertainment giant, has patented an idea for transmitting data directly into the brain, with the goal of enabling a person to see films and play video games in which they smell, taste and perhaps even feel things, *New Scientist* magazine says.

The patent is based purely on theory, not on any invention — but they used to say that man would never fly.

In Sony's patent, the technique would be entirely noninvasive. It would not use brain implants or other surgery. The patent has few details, describing only a device that would fire pulses of ultrasound at the head to modify the firing patterns of neurons in targeted parts of the brain.

The aim, it says, is to create "sensory experiences", ranging from moving images to tastes and sounds.

EXPLORE UK NEWS

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TIMES RECOMMENDS

- How a gift horse revived island race
- The collective art of doing it on the cheap
- Helena Bonham Carter: 'I'm not a dirty person'

HUMAN FACE OF GANGS



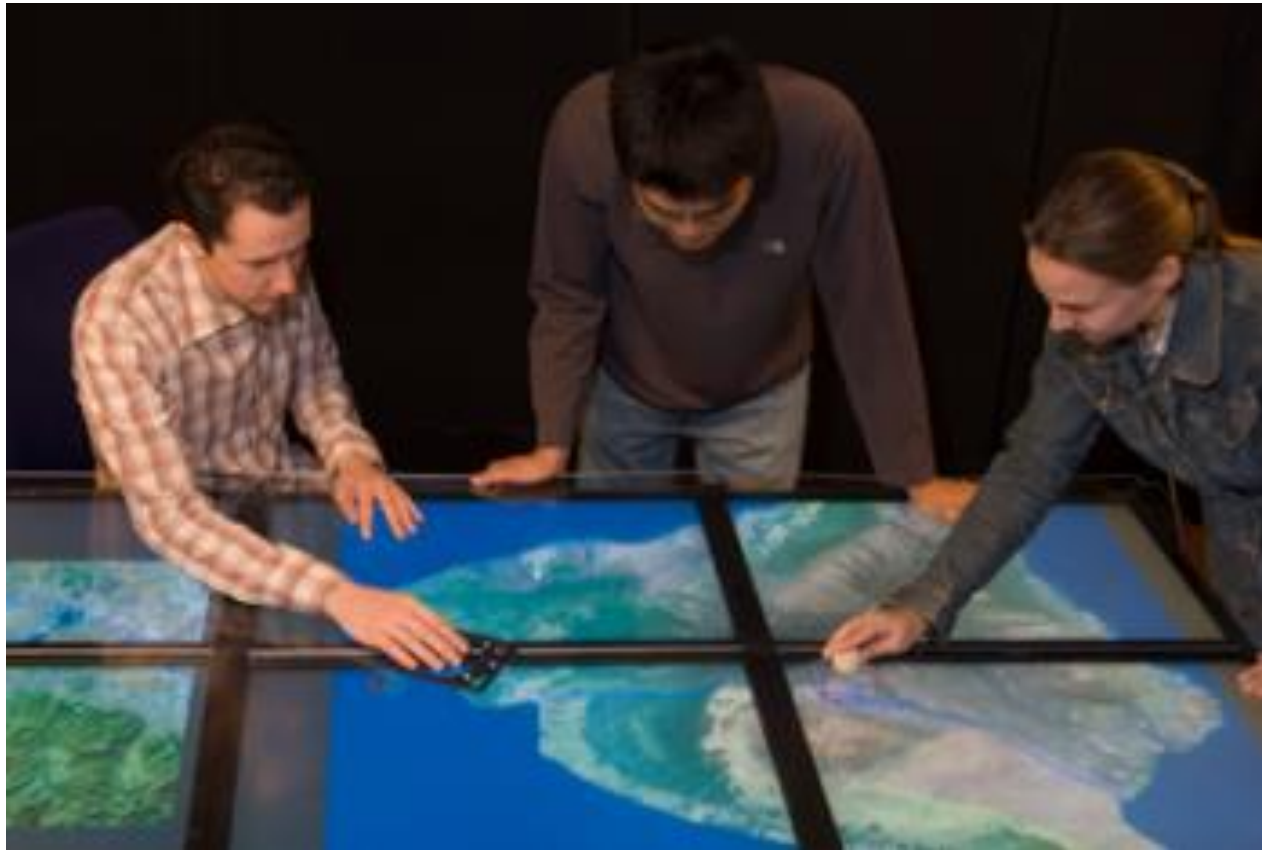
[An alternative view of London's mean streets](#)

<http://www.timesonline.co.uk/tol/news/uk/article378077.ece>

VR History

- ❑ 2008 – Development of **OmegaTable** @ EVL, a modular multi-sensory touch tabletop for interactive 2D and 3D visual data exploration.
- ❑ 2012 – Development of **CAVE2** @ EVL, Next-Generation Virtual-Reality and Visualization Hybrid Environment for Immersive Simulation and Information Analysis
- ❑ 2012 – **Oculus Rift**, a virtual reality headset, initiated a Kickstarter campaign in 2012. In March 2014, Facebook purchased Oculus for \$2 billion.
- ❑ 2013 - Google Glass, Low cost (\$1500) AR headsets
- ❑ 2015 – VR is on the cover page of **Time Magazine** (August 17, 2015 Issue)
- ❑ 2015 – **Samgsung Gear VR** release in May 2015
- ❑ 2015 – **SONY Project Morpheus**
- ❑ 2015 – **Microsoft** bought Minecraft for \$2.5 Billion because it's perfect for **HoloLens**

LambdaTable



LambdaTable <https://youtu.be/yaTovvEp7lg>

CAVE2



CAVE2 <https://youtu.be/H89ByPI2v7w?list=PL4071582316A3714C>

Oculus Rift

- ❑ Facebook Buying Oculus Rift For \$2 Billion (March 2014)
 - <http://kotaku.com/facebook-buys-oculus-rift-for-2-billion-1551487939/all>



Palmar Luckey, Inventor of Oculus Rift



Palmer Luckey, 22, inventor of the Oculus Rift, is one of the visionaries making virtual reality mainstream Photograph by Gregg Segal for TIME

Time Magazine (August 2015 Issue)

VR Headsets 2015

- ❑ The best VR headsets: Oculus Rift, Project Morpheus, Gear VR, HTC Vive... **Virtual Reality is back baby**
 - <http://www.wareable.com/headgear/the-best-ar-and-vr-headsets>



E3 2015

❑ Minecraft HoloLens Demo at E3 2015

- http://www.zdnet.co.kr/news/news_view.asp?artice_id=20150616091130



Minecraft HoloLens demo at E3 2015 (amazing!)

3DTV following the success of Avatar (2010-2016)

SAMSUNG 삼성		삼성·LG전자 3DTV 방식 비교		LG	
서터글래스방식(SG)		3D 구현방식	필름패턴	편광안경 방식(FPR)	
안경에서 화면을 좌우로 분리해 전송	특징	패널에서 화면을 두 개로 나눠서 전송			
색감 등에서 상대적으로 우수	장점	깜빡거림, 화면겹침 없음, 안경 저렴			
깜빡거림, 화면겹침 존재, 안경 고가	단점	누워서 볼 경우 입체감 떨어짐			
"해외 공인기관에서만 받겠다." 비교시연 여부			"어떤 방식이든 가능하다."		



<https://aboutcar.co.kr/1643>

VR History

- ❑ 2016 – Sony PlayStation VR headset (\$399) along with PS4
- ❑ 2016 – Pokemon Go releasing in July 2016
- ❑ 2017 – Dell, Asus and others release their Microsoft mixed reality based headsets (\$300) with 'inside out' tracking where the hand-held controllers are tracked from the HMD with mixed success.
- ❑ 2018 - Magic Leap AR display Dev Kits released (\$2,300 with no PC or tether)
- ❑ 2019 - Oculus releases Oculus Quest as a \$399 stand-alone device using smart phone level technology with 'inside out' tracking and two controllers, that is somewhat underpowered but works really well.
- ❑ 2019 - HoloLens 2

VR History

- ❑ 2020 - Oculus Quest 2 (now Meta Quest 2) released as a more powerful version of the Quest
- ❑ 2021 - Facebook changes ticker to **META** from FB, first announced in October 2021.
 - <https://about.fb.com/news/2021/10/facebook-company-is-now-meta/>
- ❑ 2023 - The Meta Quest 3 will be released in Fall 2023
- ❑ 2024 - Apple Vision Pro will be released in 2024

Pokemon GO



Pokemon GO (2016) <https://pokemongolive.com/>

Magic Leap AR Display



https://www.youtube.com/watch_popup?v=Vrq2akzdFq8

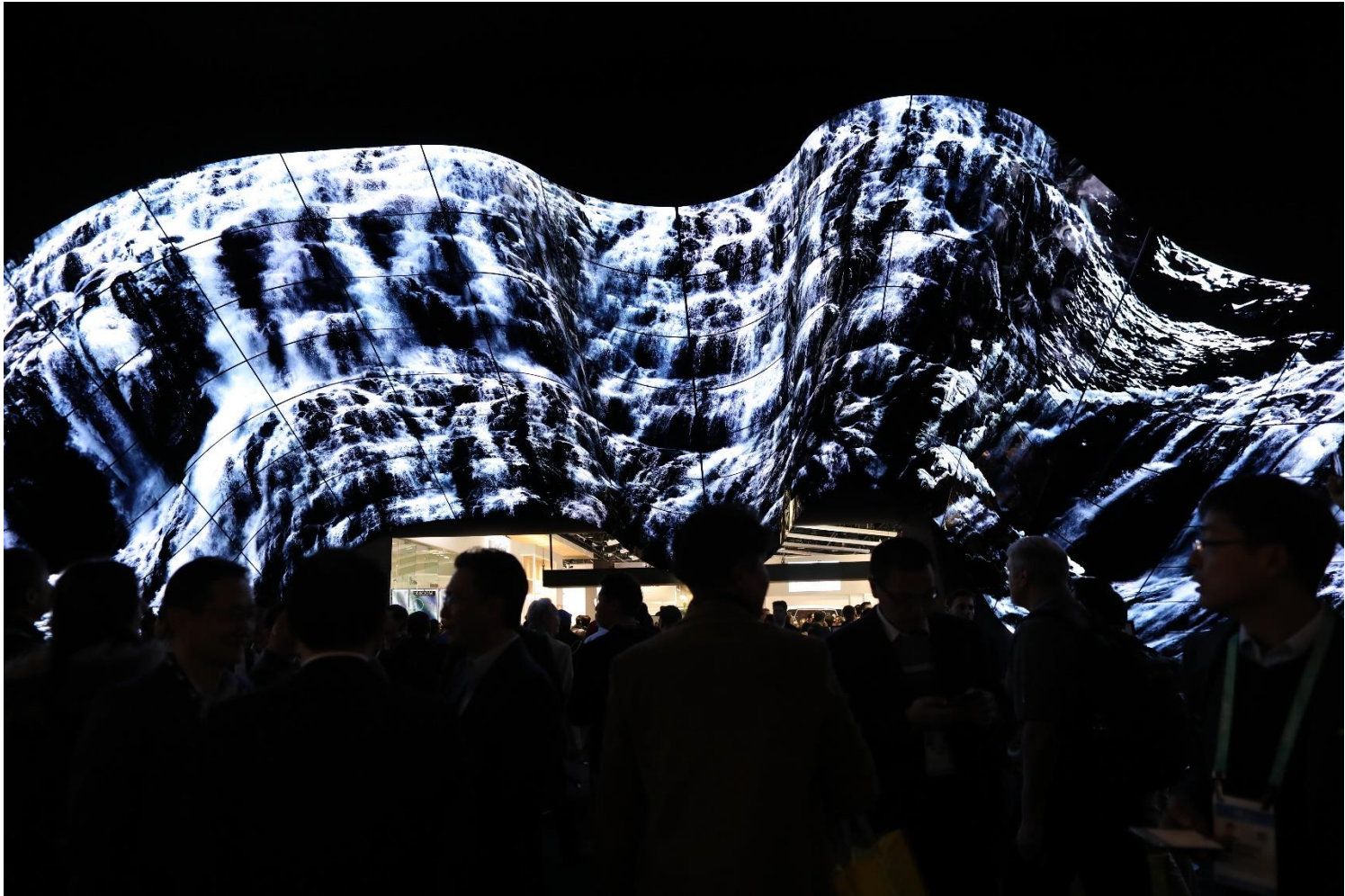
Quest

- ❑ Oculus Quest (\$399 64GB) released in May 21, 2019.
- ❑ Oculus Quest2 (\$299) debuted in October 2020 & Meta Quest2 (\$399 128GB) in August 1 2022.



Meta Quest 2

Digital Signage



LG's Wave Display made by connecting 200 sheets of OLED Flexible Signage
@CES 2020 Jan 7 - 10

Apple Vision Pro

- ❑ Apple Vision Pro (\$3,499) is set to launch in US early 2024 – by macrumors.com



Apple Vision Pro

<https://www.apple.com/kr/newsroom/2023/06/introducing-apple-vision-pro/>

VR Headsets 2023

- The best VR headsets for 2023:
 - <https://www.pcmag.com/picks/the-best-vr-headsets>
 - The Meta Quest 3 will be released in Fall 2023



VR Applications

Current Uses of VR

- ❑ Vehicle Design and Architectural Walkthroughs
- ❑ Education and Training
- ❑ Therapy and Rehabilitation
- ❑ Scientific Visualization
- ❑ Cultural Heritage
- ❑ Art and Entertainment

Vehicle Design & Manufacturing



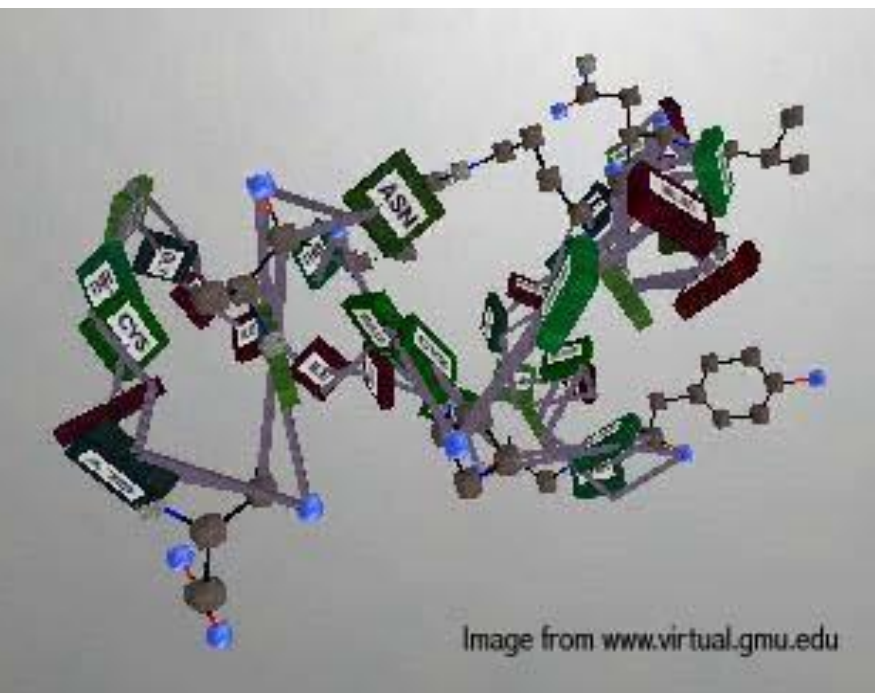
- ❑ Visual Eyes developed by General Motors Research, Hughes Research Lab & EVL
- ❑ Rapid prototypes for reviewing computer generated 3D CAD models

Architectural Walkthroughs



- ❑ Architectural Linked Immersive Environment (ALIVE) by SARA, The Netherlands & EVL
- ❑ Dutch architect Rem Koolhaas' design of the new Campus Center at the Illinois Institute of Technology in Chicago
- ❑ ALIVE lets viewers navigate through 3D CAD models

Education



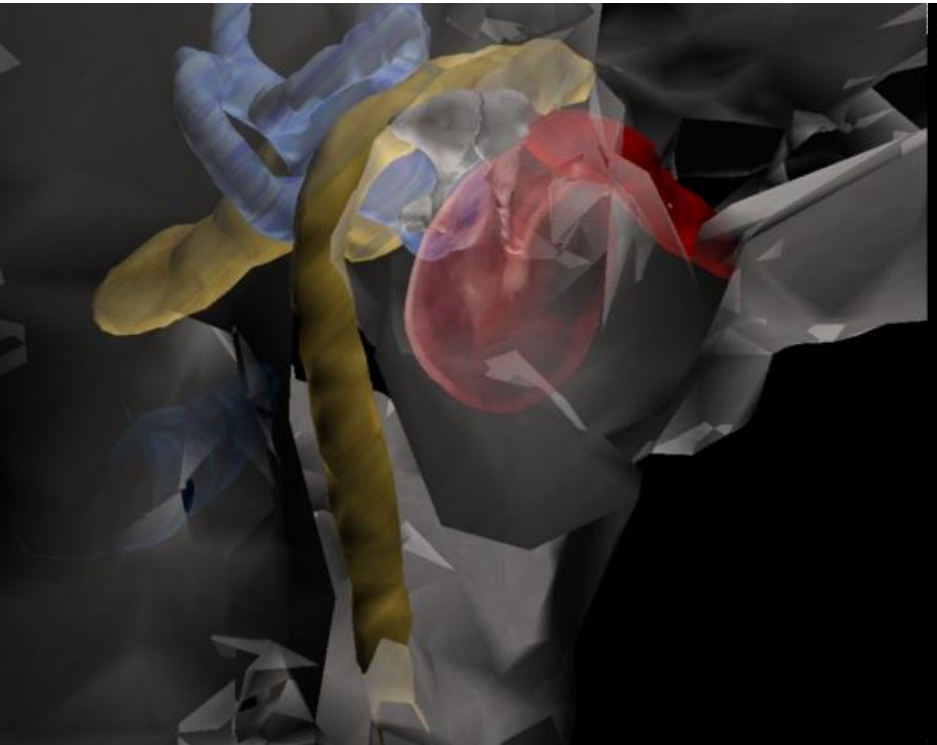
- ❑ Science Space for high school or college students, using HMD by George Mason University & University of Houston
- ❑ Newton World allows students to experience Newton's three laws where they control the environment
- ❑ Maxell World examines Gauss's Law by examining the nature of electrostatic forces and fields
- ❑ Pauling World studies chemical structure of molecules

Education



- ❑ For elementary students, by EVL
- ❑ NICE (Narrative Immersive Constructionist Environments) Persistent garden
- ❑ Round Earth Project is intended to teach young children the concept of a spherical Earth
- ❑ Virtual Ambients is designed to help students improve early stages of students' scientific inquiry skills

Medical Training



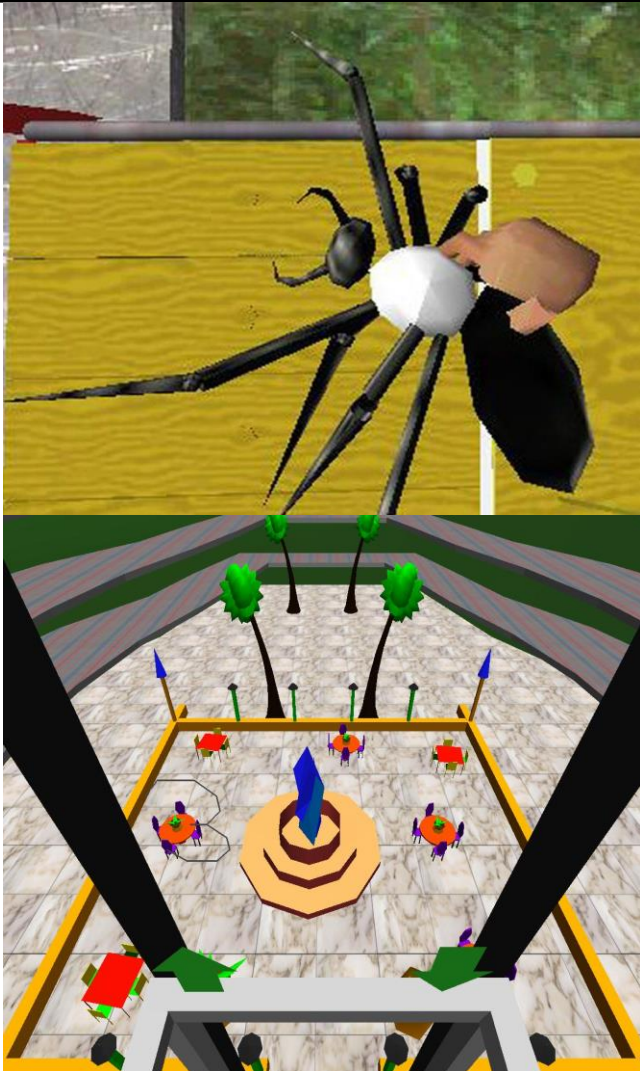
- ❑ Virtual Temporal Bone, developed by UIC's VR Medicine Lab lets physician teach medical students about 3D structure and function of the inner ear
- ❑ External view of the human ear
- ❑ Human temporal bone to reveal the delicate anatomic structures imbedded within bone
- ❑ Closeup view of the structure within the bone

Military Training



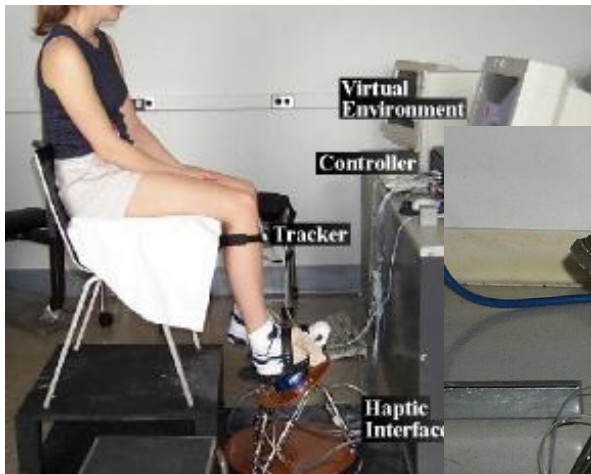
- ❑ NPSNET – Large Scale Virtual Environment Technology Testbed
- ❑ NPSNet is a real-time, interactive distribution simulation system, developed by Naval Postgraduate School

VR Therapy



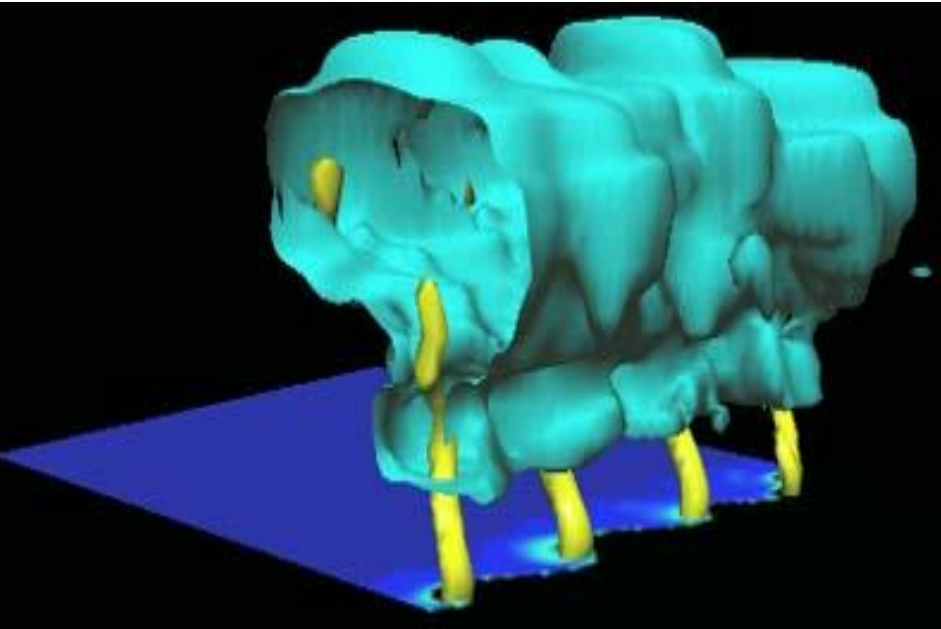
- ❑ Spider phobia, developed by HIT lab at University of Washington – VR exposure therapy for treating spider phobia
- ❑ Acrophobia (the fear of heights), developed by GVI at Georgia Tech – VR exposure therapy that involves exposing the subject to anxiety producing stimuli while allowing the anxiety to attenuate

VR Therapy



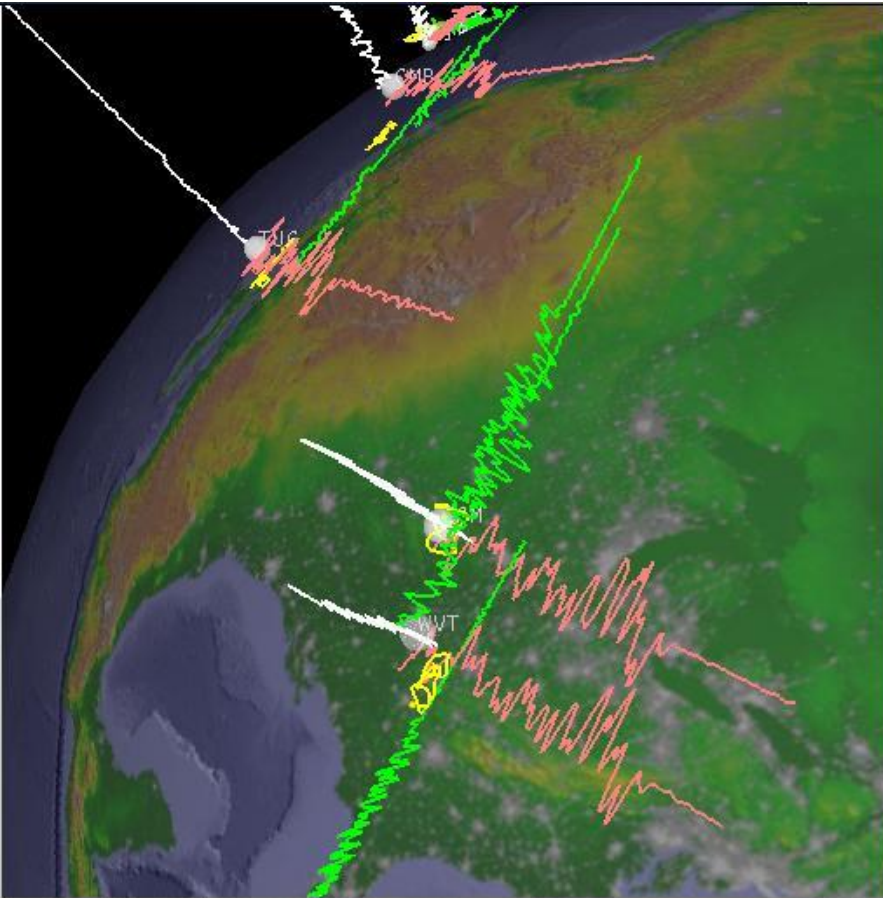
- ❑ 'Rutgers Ankle' Rehabilitation Interface, developed by Rutgers University
- ❑ Pilot the virtual plane
- ❑ The "Rutgers Ankle" Rehabilitation Interface is a robotic ankle rehabilitation device designed for at-home use and Internet-based remote monitoring by therapists

Scientific Visualization



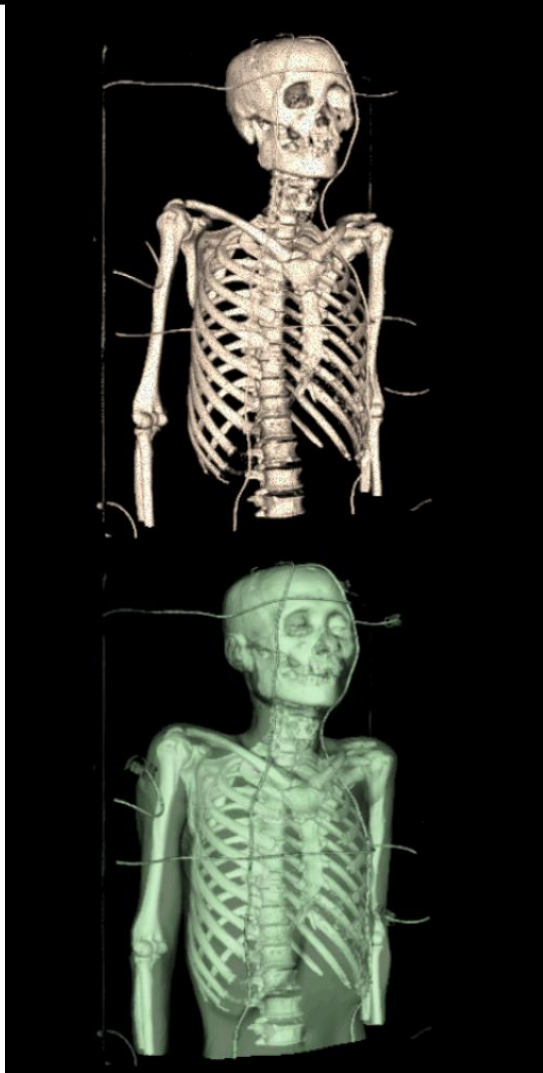
- ❑ Non-Supercell Tornado Simulation developed by UIUC Dept. of Atmospheric Sciences & NCSA
- ❑ Viewers can immerse themselves with the digital storm and understand how they form and develop

Scientific Visualization



- ❑ Wiggleview, developed by EVL
- ❑ Traditionally seismologists look at 2D X-Y plots of a time-series of the displacement of a seismometer in the North-South, East-West, and Up-Down directions
- ❑ Wiggleview allows to visualize the simultaneous recording of three channels of seismic data in response to an event

Scientific Visualization



- ❑ Visible Korean Human, developed by Computer Graphics Lab at Sogang U. & KISTI
- ❑ Volume visualization using image-based rendering technique
- ❑ CT, MRI, RGB datasets of a Korean senior, created by KISTI and Ajou Univ.
- ❑ allows users to investigate skin and bone of the human

Scientific Visualization



- ❑ Development of **Typhoon Maemi** landed on the southern coastal area of Korea during Sep 2003, developed by Digital Ocean & Virtual Environment Center at Korea Ocean Research and Development Institute
- ❑ Low-saline water in Yellow Sea due to spreading of Changjiang Diluted water toward Jeju Island, developed by DOVE at KORDI
- ❑ Scientific visualization to display multi-dimensional numerical data (e.g. atmospheric, oceanographic)

Cultural Heritage



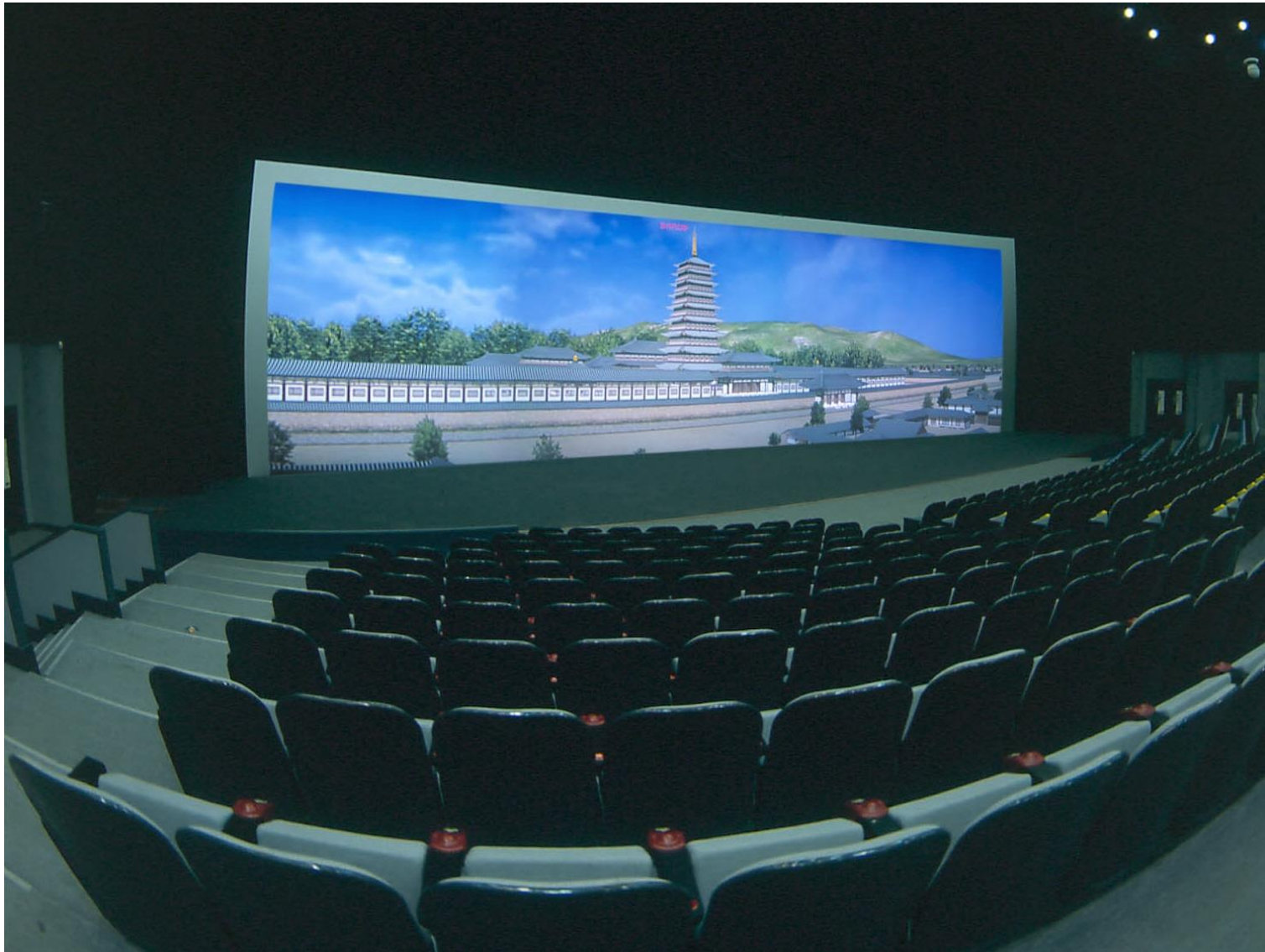
- Virtual Harlem allows people at remotely located CAVEs to tour 1920-40 Harlem, and listen to African American artists, writers and intellectuals of that time - notably Langston Hughes, Marcus Garvey and others.
- Collaborative effort between Central Missouri State University, Advanced Technology Center at University of Missouri, and EVL at UIC.

Cultural Heritage



- ❑ Digital restoration of Koguryo mural painting tomb, Anak No. 3 Tumulus, in virtual reality
- ❑ Allows children and adults to experience the life and times of Koguryo people and details custom to Korea
- ❑ In collaboration with Jeonju University, ICU Digital Media Lab, Sangmyung University, ATEC

Cultural Heritage



Interactive Art



- ❑ Crayoland created by Dave Pape, EVL – 2D crayon drawings placed in a 3D world
- ❑ Synesthesia by Rita Addison & Marcus Thieboux, EVL – a sensory input (e.g. music) is perceived as a different sensory mode
- ❑ CAVE Quake by Paul Rajlich, NCSA

Entertainment



Disney Quest - Aladdin

10 Top-Selling VR Games

□ <https://gamerant.com/top-selling-vr-games-according-steam/>

1. Half-Life: Alyx
2. Beat Saber
3. Boneworks
4. Pavlov VR
5. Blade And Sorcery
6. The Elder Scrolls V: Skyrim VR
7. Hot Dogs, Horseshoes & Hand Grenades
8. The Walking Dead: Saints & Sinners
9. Gorn
10. Job Simulator





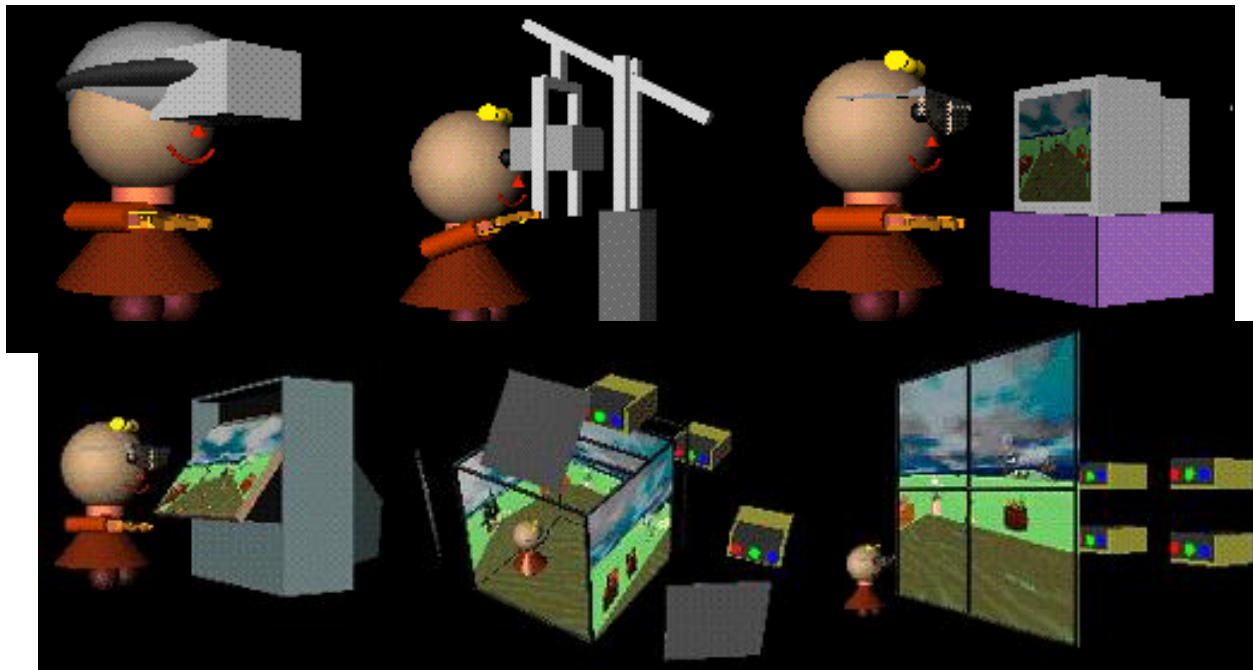
VR Components

VR Components

- ❑ Display
- ❑ Stereoscopy
- ❑ Image Generator (Computer Hardware)
- ❑ Tracking
- ❑ Input Devices
- ❑ Audio
- ❑ Networking
- ❑ Software

Display

- Head-mounted Display (including See-through VR)
- BOOM
- Fish tank VR
- Projection-based VR



Display

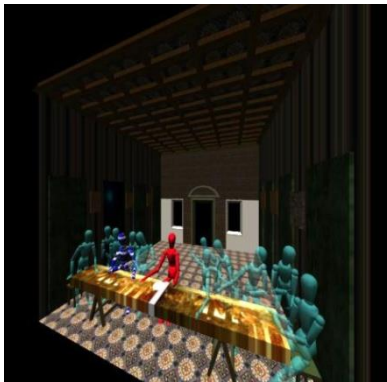
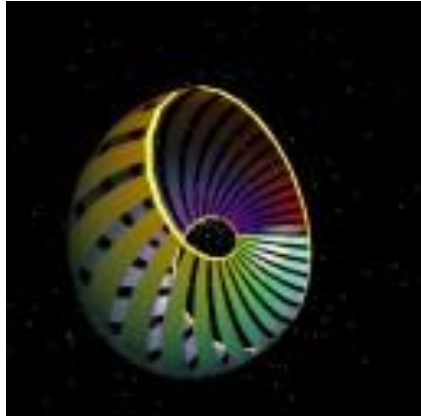


Attach display to the user



Surround the user by displays

Display

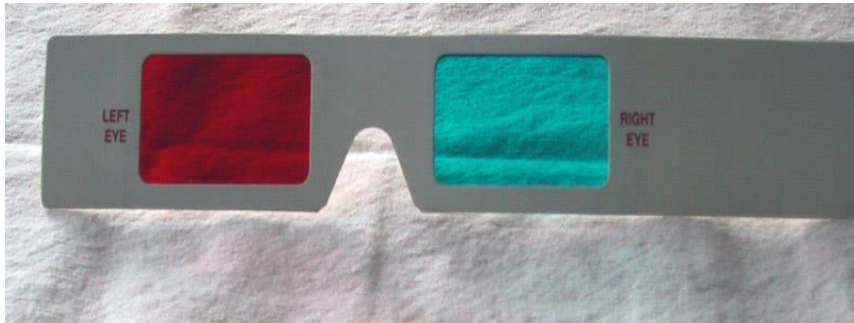


- It is important to note that although the field is called 'virtual reality', the goal is not always to create reality.
- Want to see things that can't be easily seen
- Want to create worlds that are more interesting or exotic than reality
- Want to create worlds that are simpler than real life for teaching

Display

- ❑ Computers are capable of creating very realistic images, but it takes a lot of time to render these.
- ❑ In VR we want to **at least 15 frames per second in stereo**
- ❑ For comparison:
 - Film is 24 frames per second monoscopic (with roughly 10-20 million pixels per frame)
 - Television is 30 frames per second monoscopic (with roughly 0.4 million pixels per frame)
 - HD Television is 24 or 30 frames per second monoscopic (with roughly 1 million pixels per frame)
- ❑ The tradeoff is **image quality** (especially in the area of smoothness of polygons, antialiasing, lighting effects, transparency) **vs. speed**

Stereoscopy



Stereoscopy

- ❑ If we want stereo visuals, we need a way to show a slightly different image to each eye simultaneously. The human brain then fuses these two images into a stereo image.
- ❑ One way is to isolate the users eye (As in a HMD or BOOM). Each eye watches its own independent TV.
- ❑ Another way is to use **color** – this has been done in 3D theatrical films since the 50s with red and blue glasses
- ❑ We can **use polarization** (linear or circular) – linear polarization was used in 3D theatrical films in the 80s
- ❑ We can **use time** – this was common in VR in the 90s and continues today where we show the left image then the right image and the user wears LCD shutter glasses which ensure that only the correct eye sees the correct image.

Image Generator



- ❑ Simulates virtual world, generates images and audio
- ❑ Should have fast processor, large memory, and fast graphics card
- ❑ Need a computer capable of driving the display device at a fast enough rate to maintain the illusion
- ❑ Needs two video outputs for passive stereo VR system
- ❑ Need multiple graphics engines are pretty much required if you have multiple display surfaces.

Tracking



- ❑ 6 degrees of freedom (DOF) tracking the position (x,y,z) and orientation (yaw, pitch, roll) of the user's head, hands, or devices
- ❑ Important for immersion and interactivity
- ❑ A common tracker for low-cost systems is the Ascension SpacePad (discontinued)
- ❑ A separate PC may be used for tracking

Input Devices

- Input devices are perhaps the most interesting area in VR research.
- While the user can move their head 'naturally' to look around, how does the user navigate through the environment or interact with the things found there?
- Input Devices:
 - 3D mice
 - Data glove
 - Voice
 - Treadmill or bicycle or other locomotion system
 - Physical locomotion
 - Haptic
 - Tracking for gesture recognition

Input Devices



Wand

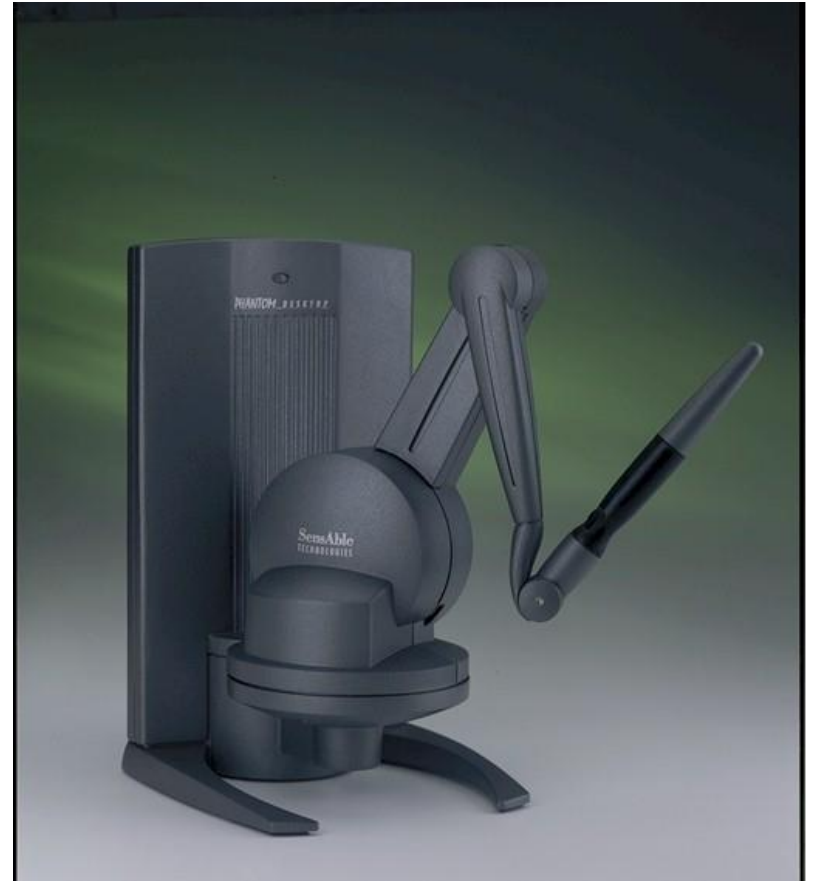


Wanda

Input Devices



Intersense IS-900 Controller



Phantom Haptic Interface

Input Device - Data Gloves



cyberglove

Input Device - Treadmill



Input Device – Omni-directional Treadmills



Cyberith Virtualizer
<https://www.youtube.com/watch?v=bH EXGGnuZtA>



Virtuix Omni One
<https://www.youtube.com/watch?v=M52ID0I0zlw>

Audio



- ❑ Ambient sounds are useful to increase the believability of a VR space (Important for Immersion)
- ❑ Sounds are useful as a feedback mechanism
- ❑ Important in collaborative applications to relay voice between the various participants
- ❑ Spatialized sound can be useful

Networking



- ❑ Often useful to network a VR world to other computers, such as supercomputers for computation and other VR devices for collaborative work
- ❑ Need high bandwidth networking for moving large amounts of data around
- ❑ Need network Quality of Service, especially latency and jitter

Software

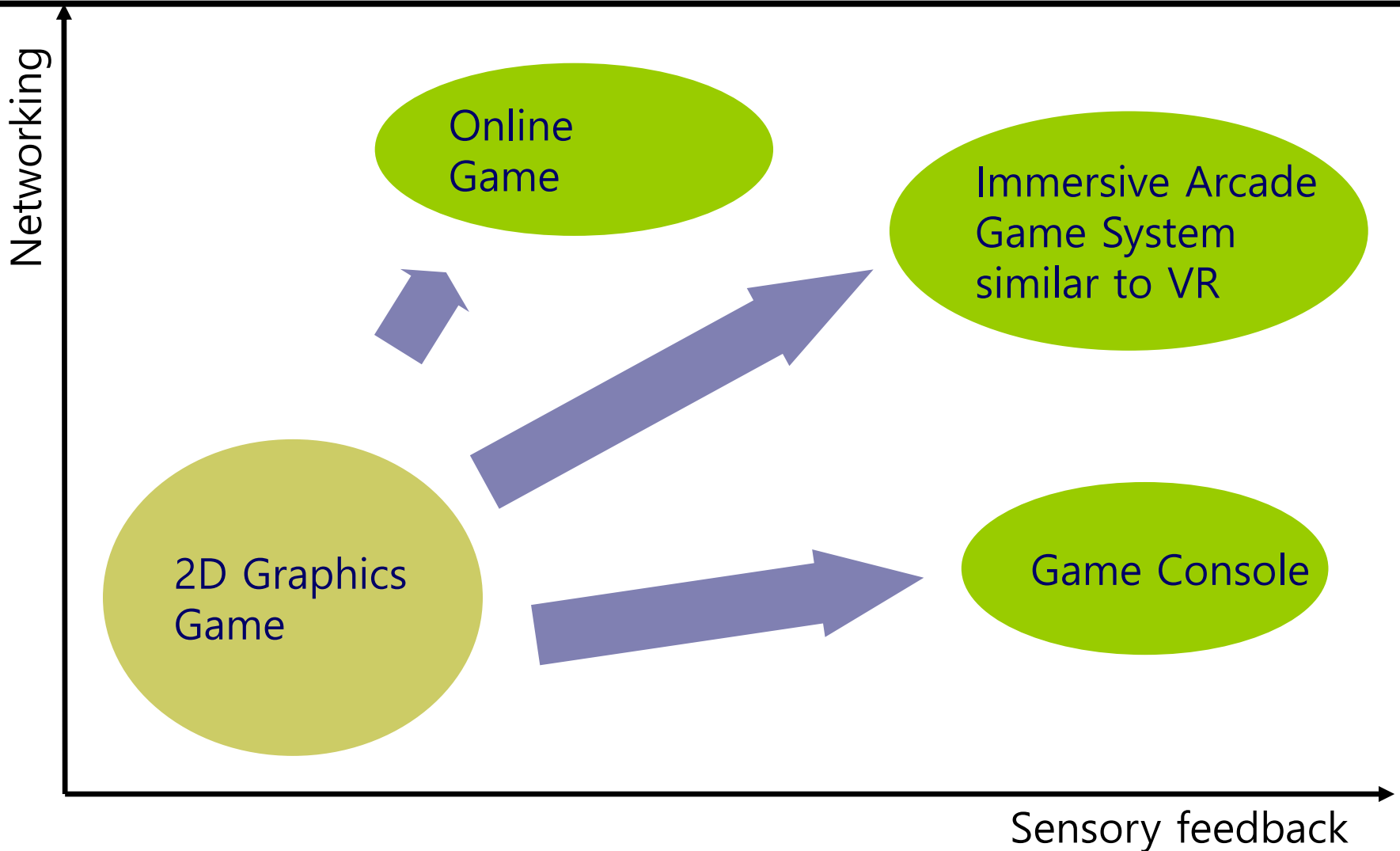
- Early VR programming is done mostly 'from scratch' or using lab-based software.
 - 3D graphics library, such as OpenGL, Performer, Open Inventor
 - VR system library, such as VRCO's CAVELib, VREC's VR Juggler, Virginia Tech DIVERSE
 - VR authoring tool, such as Sense8 WorldToolkit and WorldUP

Software

- With the newer consumer level devices a couple of the free big game development engines now support VR development.
 - Unity3D <https://unity3d.com/>
 - Unreal <https://www.unrealengine.com/>



Trends in Game Industry



Virtual Reality Arcade

▣ VR Zone Shinjuku (2017-2019)



National Museum of Korea (2020)

- ❑ 7 Media Facade Contents – 5 Billion Korean Won
- ❑ 13 Virtual Reality Contents – 5 Billion Korean Won



Reference

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- ❑ A Critical History of Computer Graphics and Animation: Virtual Reality
<http://accad.osu.edu/~waynec/history/lesson17.html>
- ❑ Metaverse <http://www.metaverseroadmap.org/>