CIS 4930-001: Introduction to Augmented and Virtual Reality

The History of Augmented & Virtual Reality

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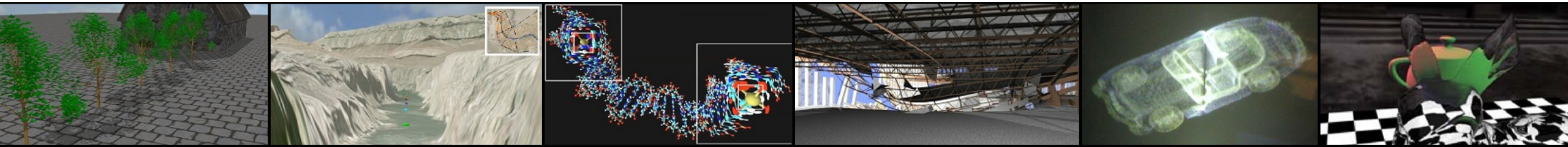
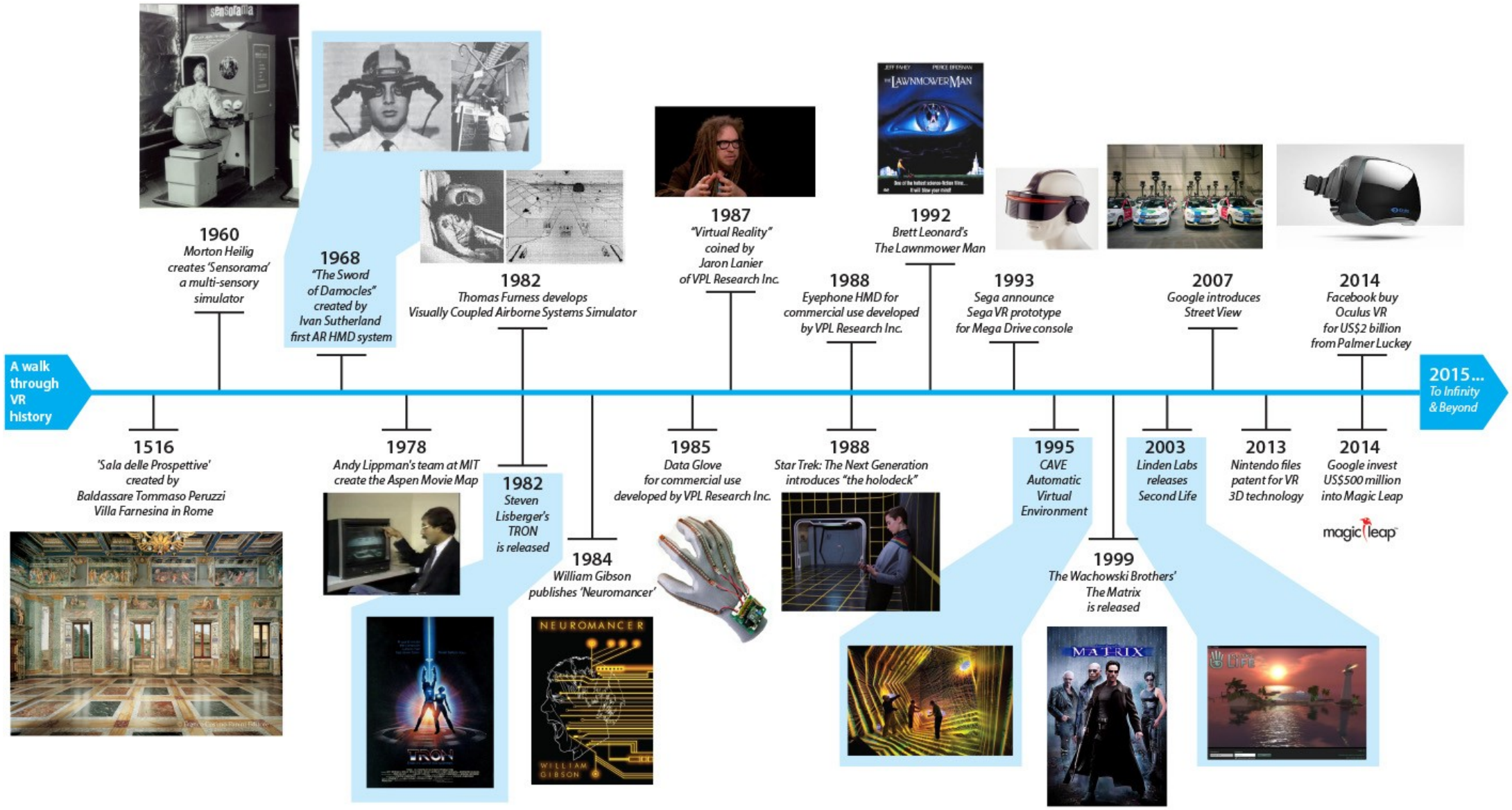


AR/VR History Timeline



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When anything new comes along, everyone, like a child discovering the world thinks that they've invented it, but you scratch a little and you find a caveman scratching on a wall is creating virtual reality in a sense.

MORTON HELIG (HAMMIT 1993)

Early History (30,000 BC -)

The history of VR is rooted in human's first attempts to reproduce the world around them

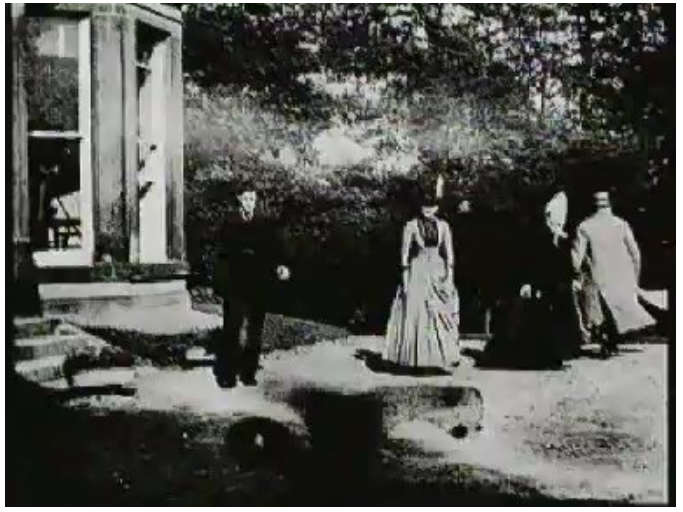
1800's – Capturing Reality

Panoramas (1790s)
- Immersive paintings

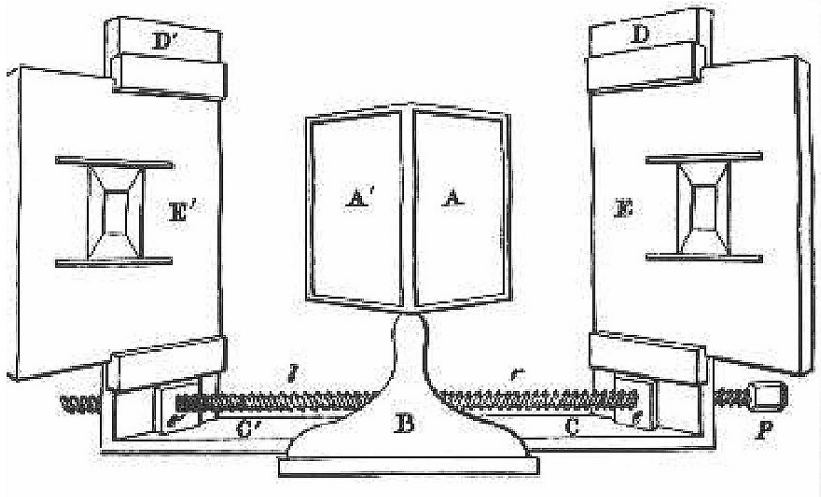
Photography (1820-30s)
- Oldest surviving photo (Niépce, 1826)

Stereo imagery (1830s)
- Wheatstone (1832)
- Brewster (1851)

Movies (1870s)
- Muybridge (1878)
- Roundhay Garden Scene (1888)



Stereo Viewers



Wheatstone Stereoscope (1832)

Brewster (1860)

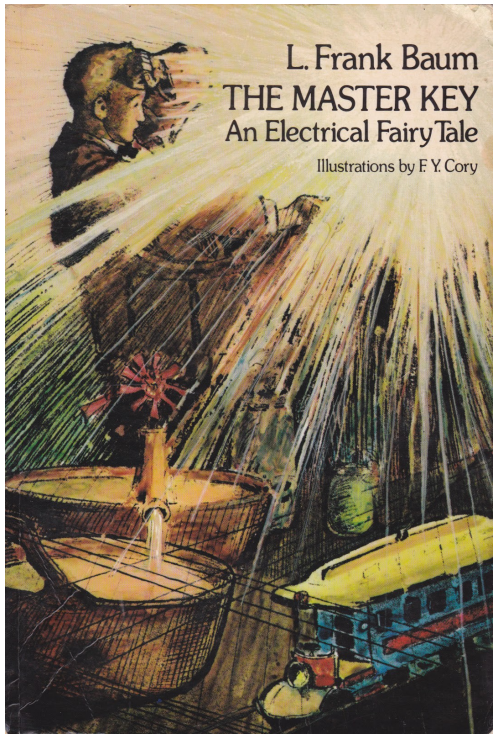
Pepper's Ghost (1862)

Dates back to Giambattista della Porta (1584)

The Master Key (1901) – AR Glass

"It consists of this pair of spectacles. While you wear them every one you meet will be marked upon the forehead with a letter indicating his or her character. The good will bear the letter 'G,' the evil the letter 'E.' … Thus you may determine by a single look the true natures of all those you encounter."

L. Frank Baum



VIEWMASTER (1939)

Pygmalion's Spectacles (1935)

Short Story by Stanley Weinbaum

Probably the first comprehensive VR model

Main character, Dan Burke, tries a pair of goggles that provide: "a movie that gives one sight and sound [...] taste, smell, and touch. [...] You are in the story, you speak to the shadows (characters) and they reply, and instead of being on a screen, the story is all about you, and you are in it."

3D Cinema Golden Era (1950-60s)

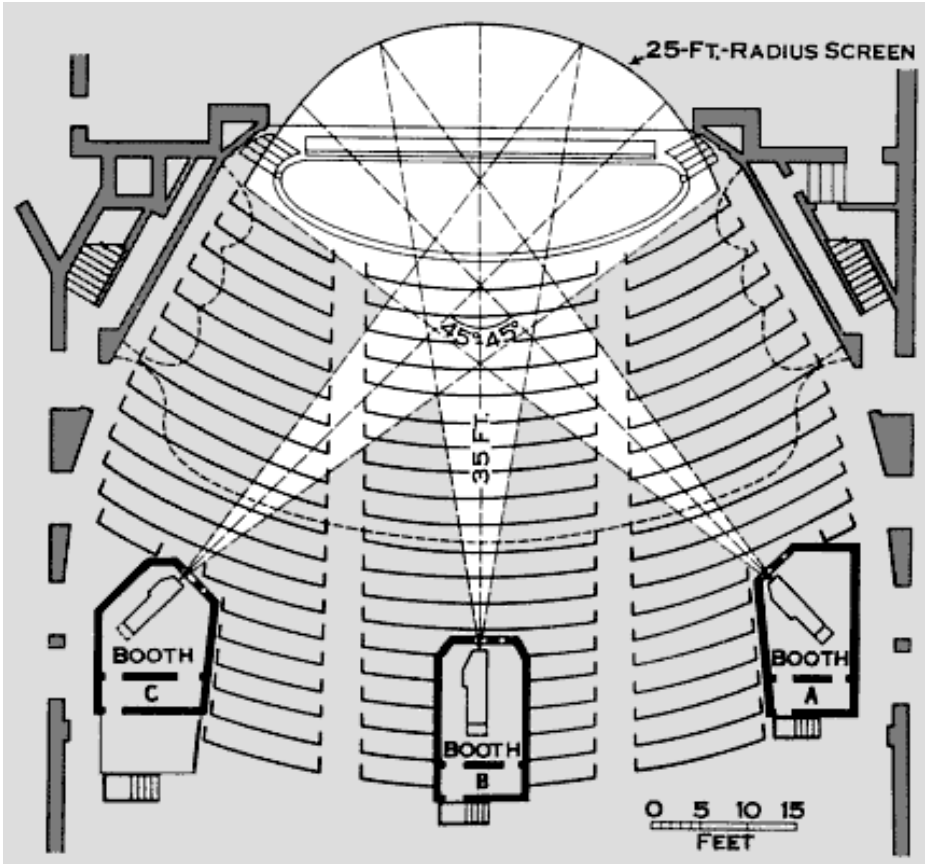
Polarized 3D projection or anaglyph (red/blue)

Early 1950s – Cinerama (Fred Waller)

Movie screen big enough to give a 180° horizontal view.

Viewers feel like they´re in the scene

Required 3 cameras and 3 projectors (very much like IMAX or modern Powerwalls)

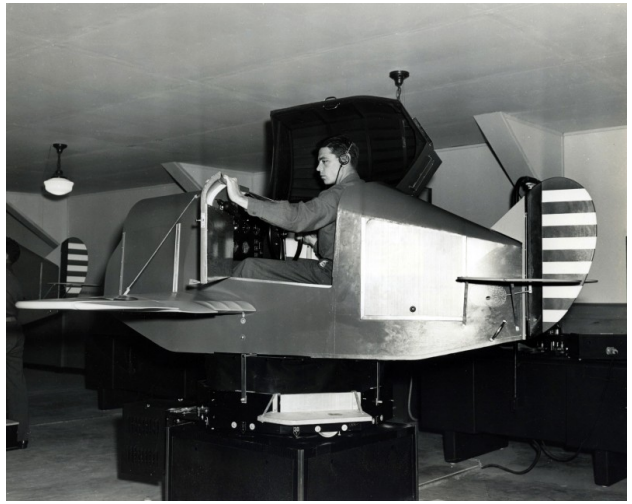


Link Trainer (1929 – 1950s)

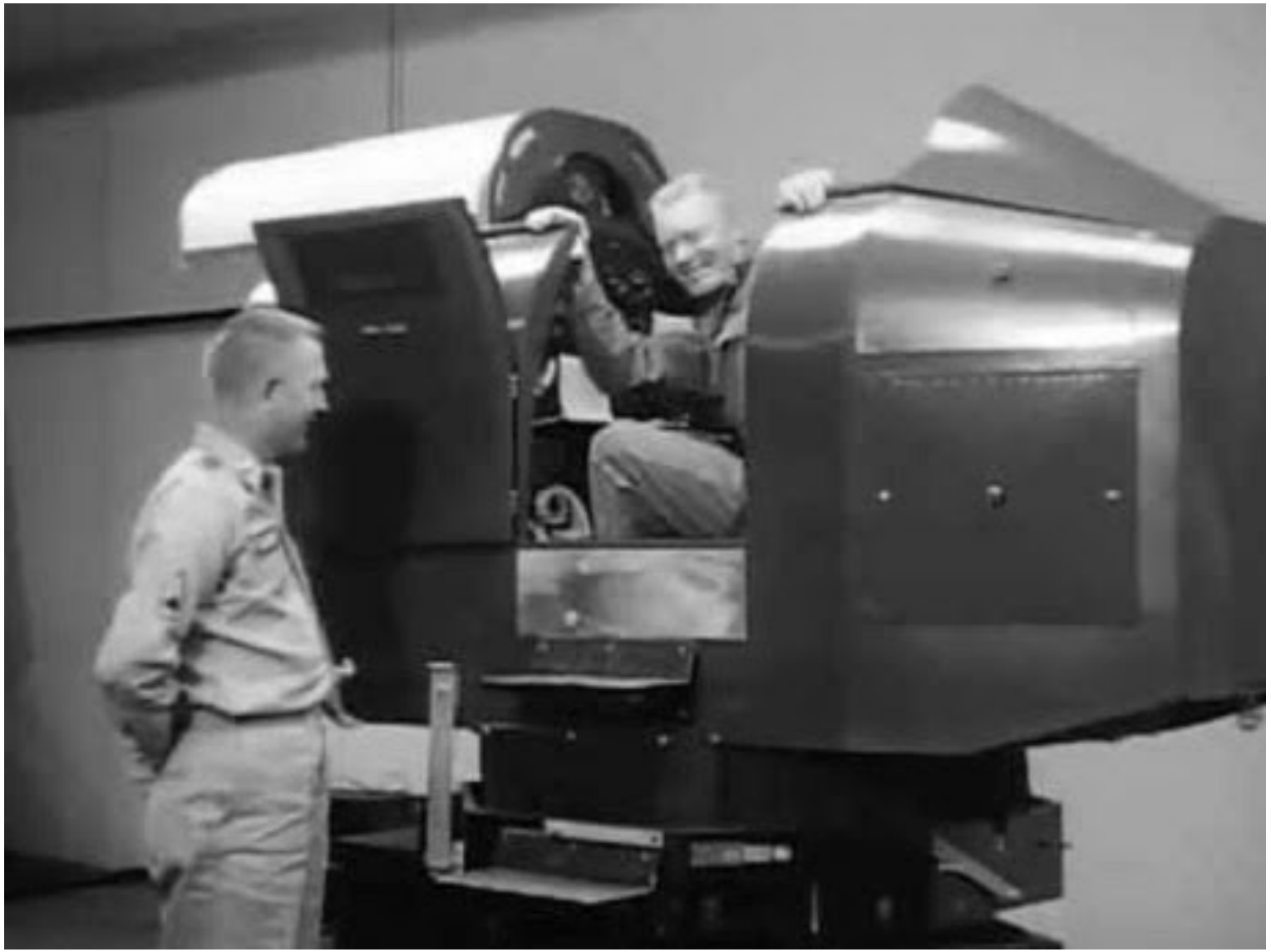
Flight Simulator Training

- Full six degree of freedom rotation
- Force feedback and motion control
- Simulated instruments
- Modeling common flight conditions

Over 500,000 pilots trained



Link Trainer Video (1966)



https://youtu.be/MEKkVg9NqGM

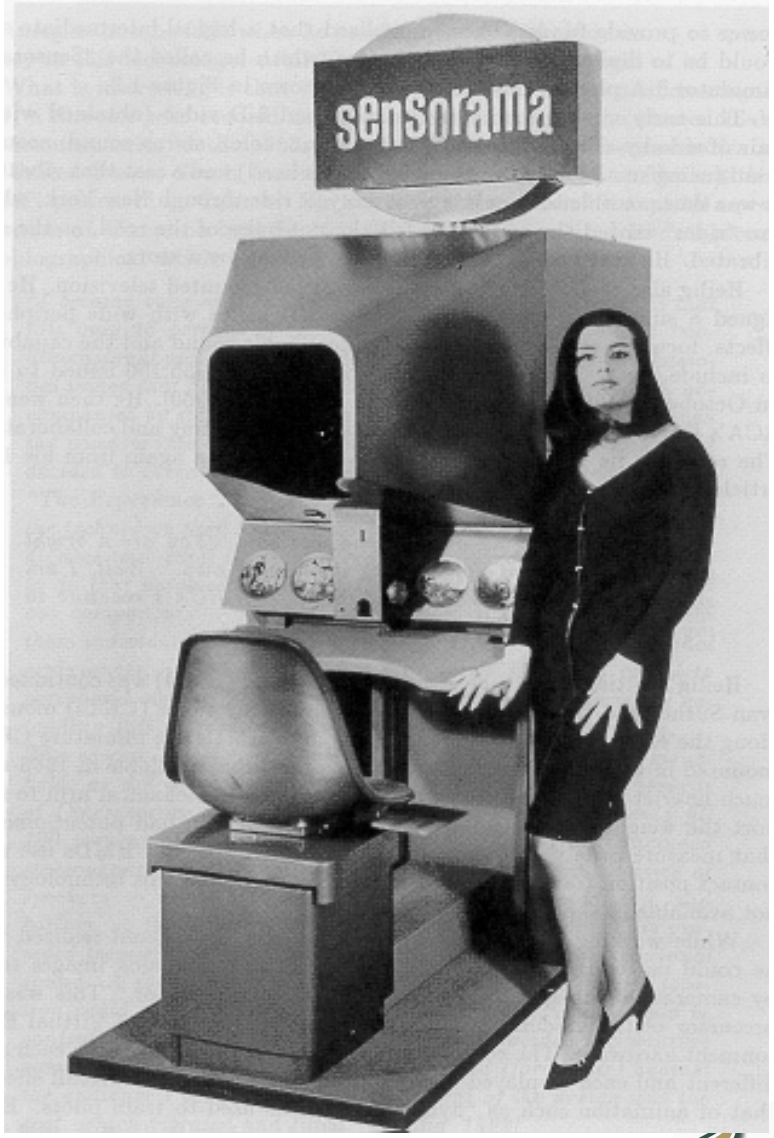
SENSORAMA (1955) - MORTON HEILIG

”… a virtual reality simulator with handlebars, binocular display, vibrating seat, stereophonic speakers, cold air blower, and a device close to the nose that would generate odors that fit the action in the film…”

Motorcycle ride on the streets of Manhattan!

Multi-sensory—Visuals, Sound, Wind, Vibration, and Smell

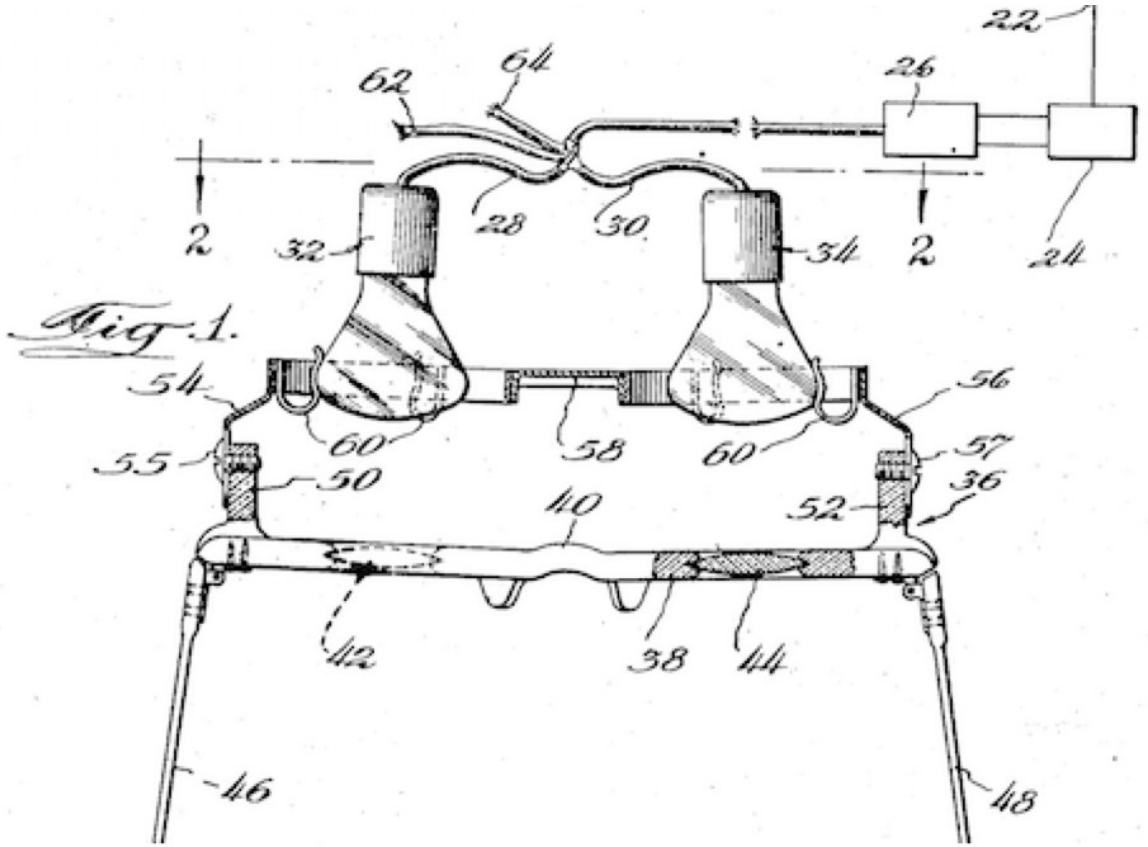
No financial support—commercial failure



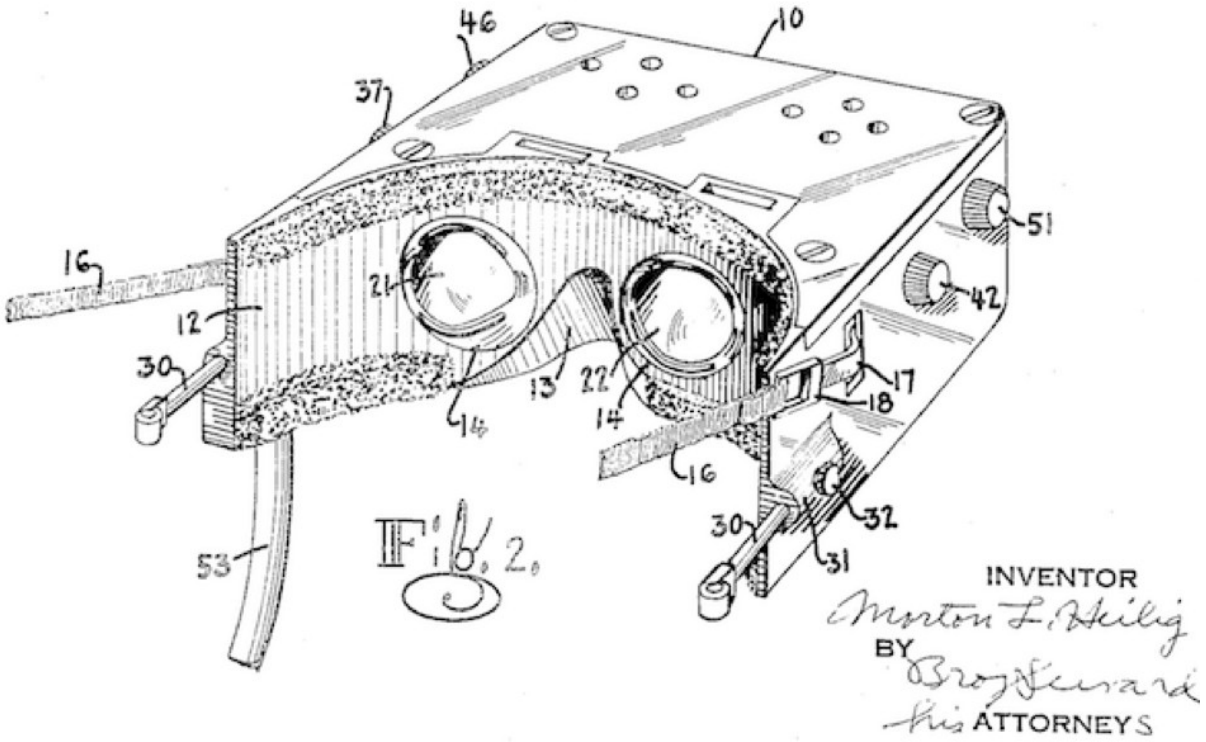
Sensorama Video

https://youtu.be/vSINEBZNCks

EARLY HMD PATENTS



McCollum's Stereo TV HMD (1943)

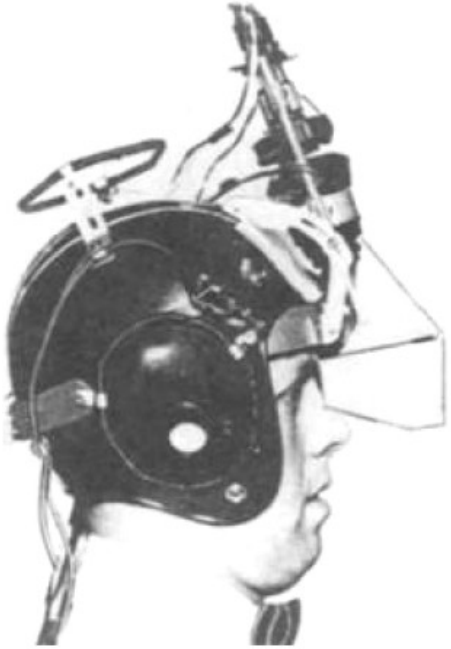


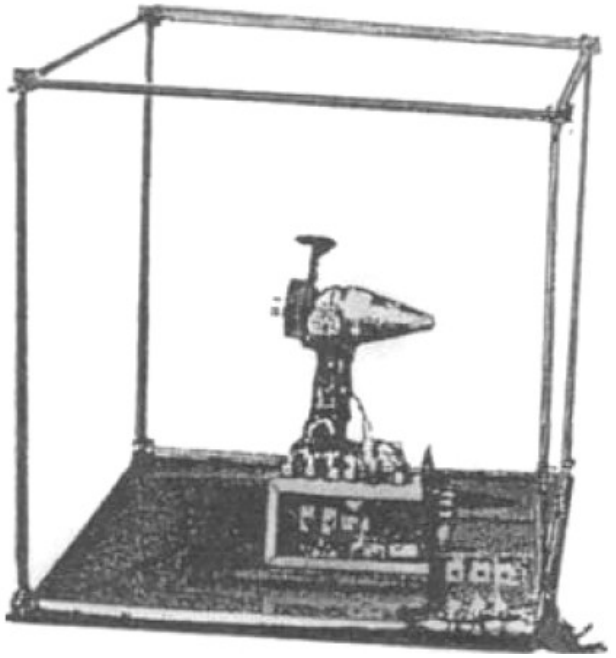
Heilig's Multisensory HMD (1960)

EARLY HUD (1958)

F16 – Head Up Display

HMD (1961)



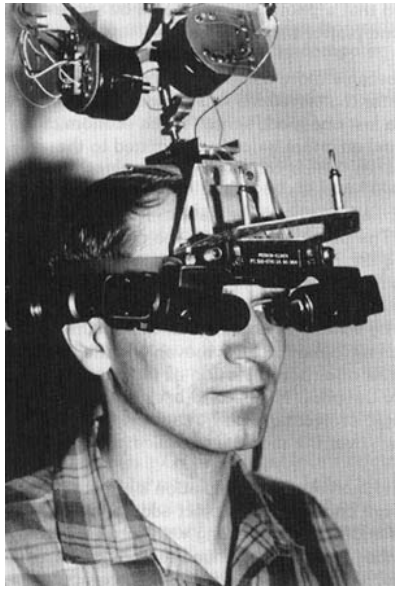


Philco Headsight– Remote Camera Viewing

Components – HMD, closed circuit television

Custom magnetic tracking for head orientation

Ivan Sutherland's Head-Mounted Display (1968)



See-through HMD

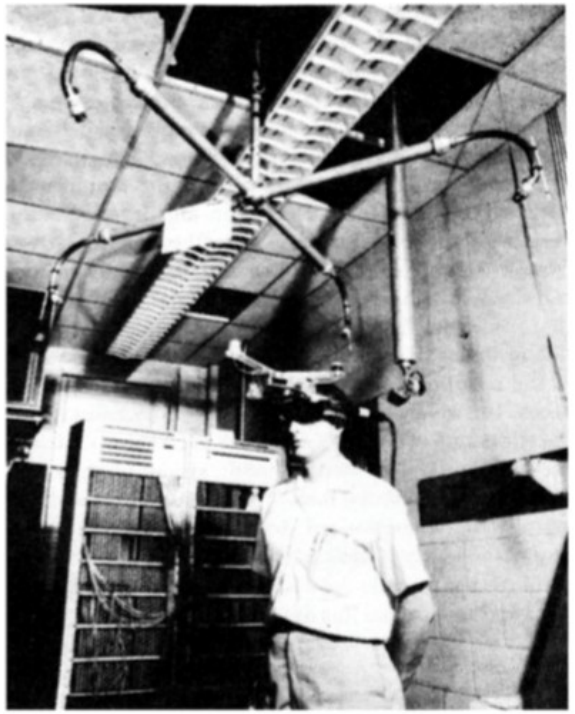
CRT based

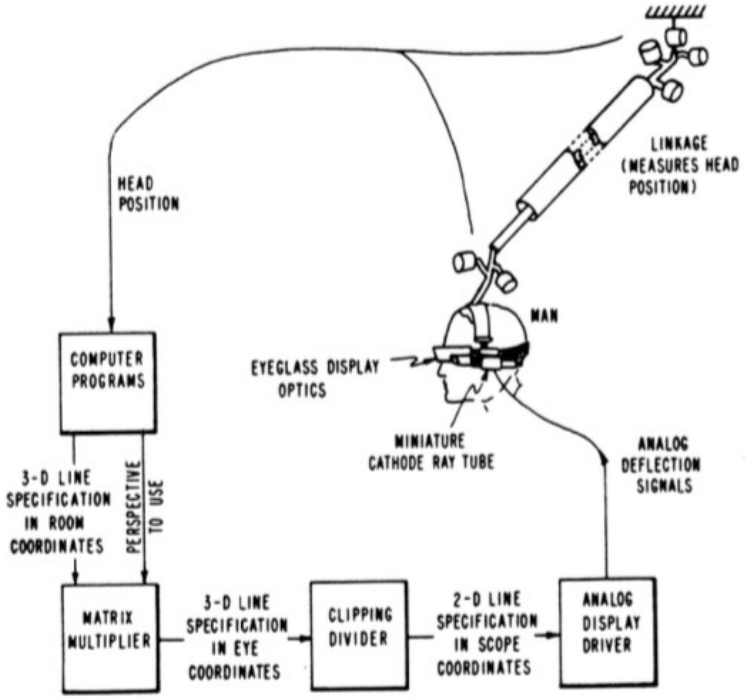
Hidden-line geometry

Mechanical head tracking

Binocular, not stereo

40 degree of view

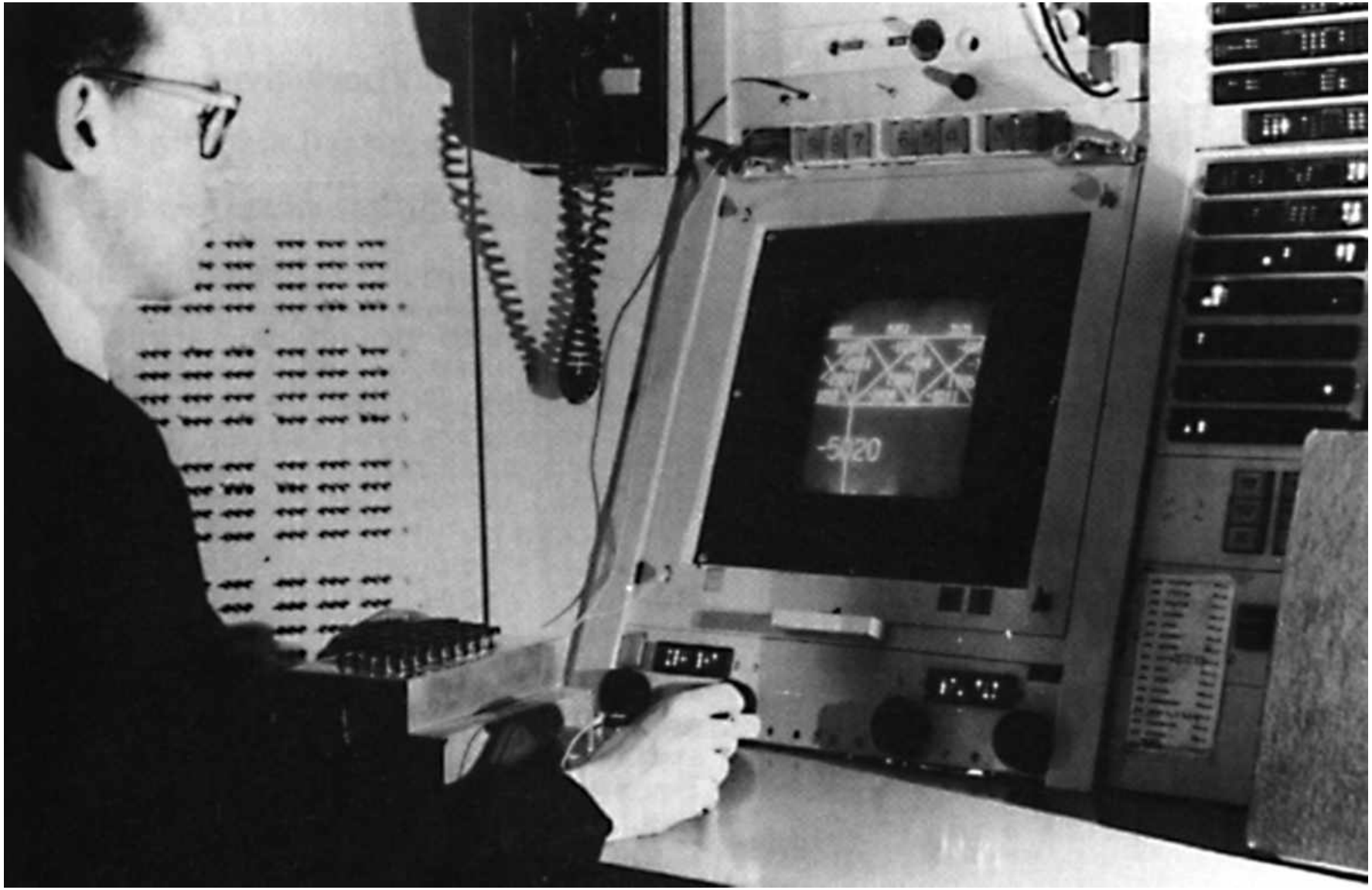




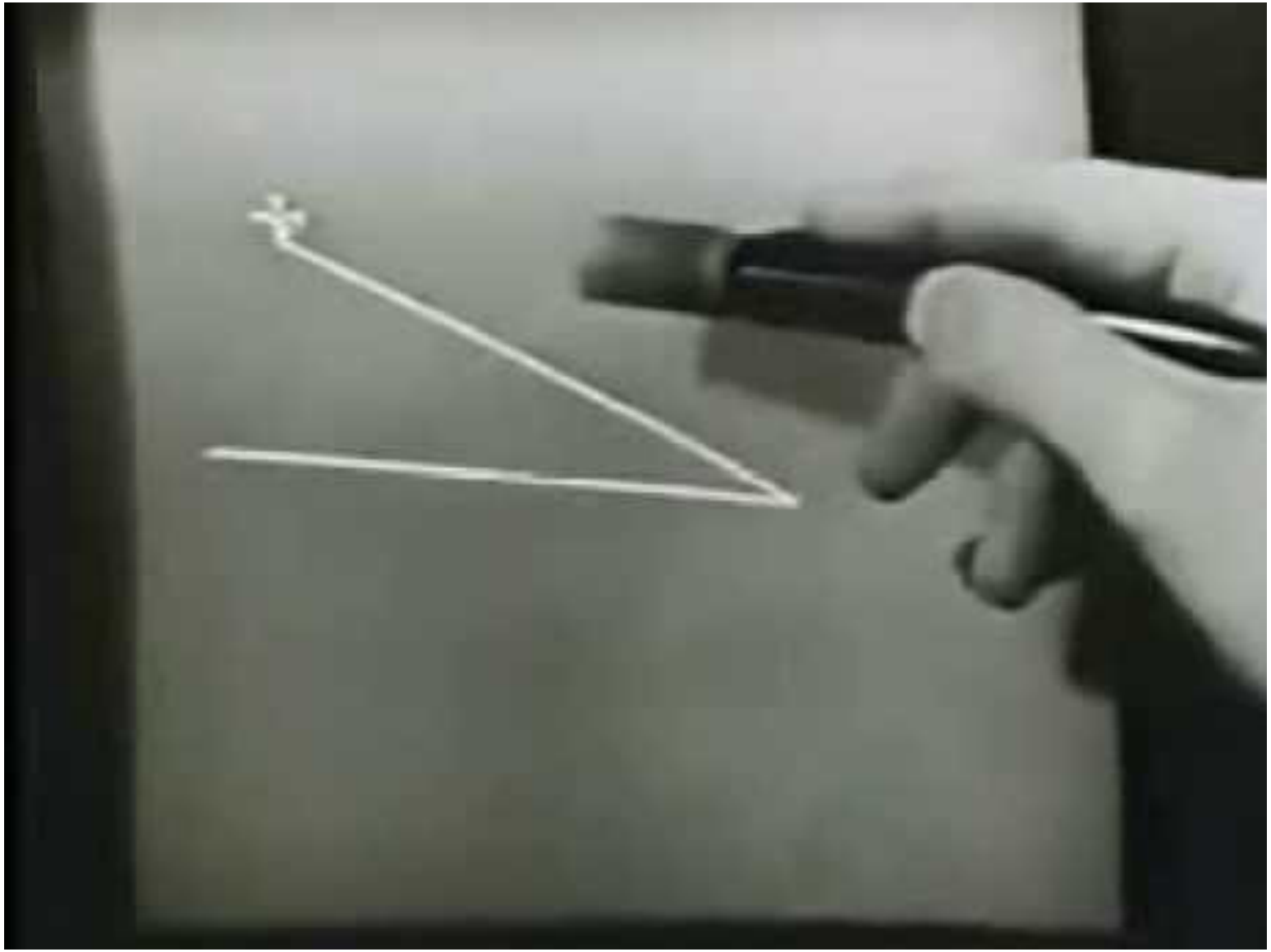
Sutherland Display

https://youtu.be/NtwZXGprxag

IVAN SUTHERLAND SKETCHPAD (1963)



Ivan Sutherland Sketchpad Demo



https://youtu.be/YB3saviItTI

Ivan Sutherland Vision (1965)

About Data Visualization: "A display connected to a digital computer…is like a looking glass into a mathematical Wonderland."

About Realism: "A chair display in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal."

About Reality: "There is no reason why the objects displayed by a computer have to follow ordinary rules of physical reality with which we are familiar."

An Invisible Interface

"With appropriate programming such a display could literally be the Wonderland into which Alice walked."

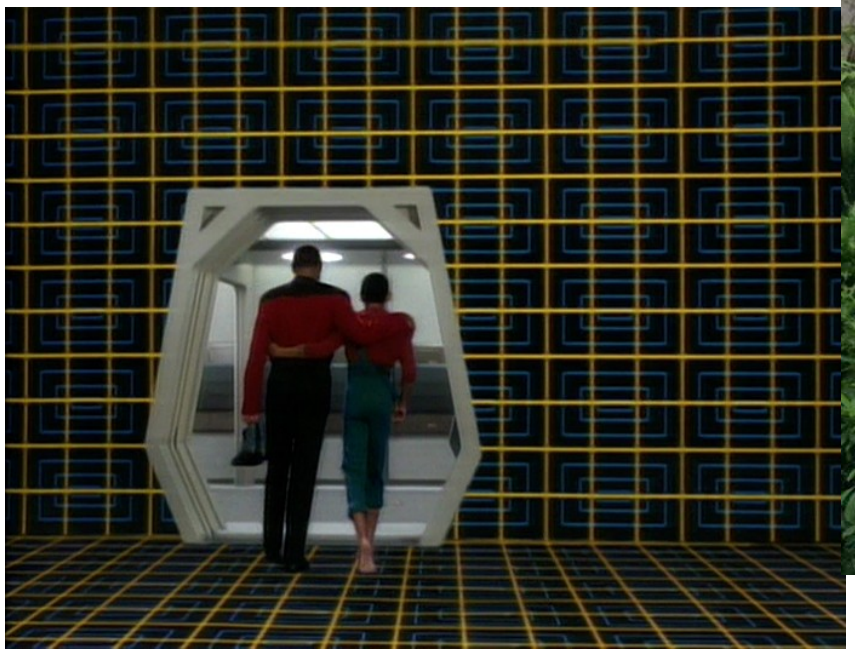
The Matrix: The Rabbit Hole

https://youtu.be/O4zICmyuNvs

HOLODECK (1974)

First shown in Star Trek: The Animated Series

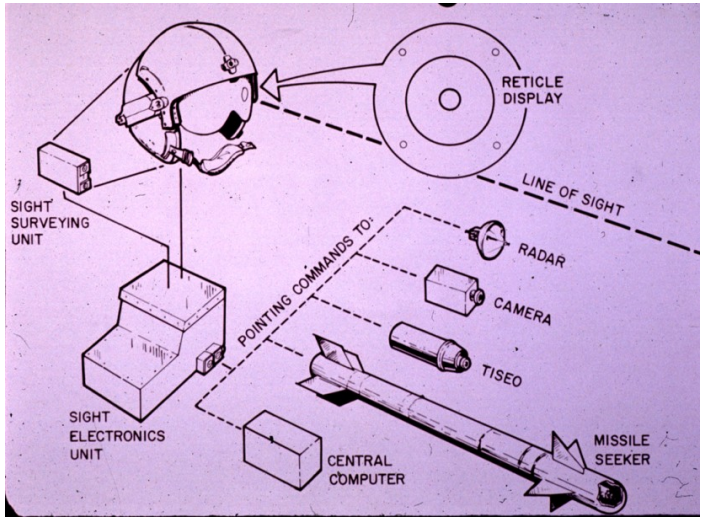
Later appeared in Star Trek: The Next Generation

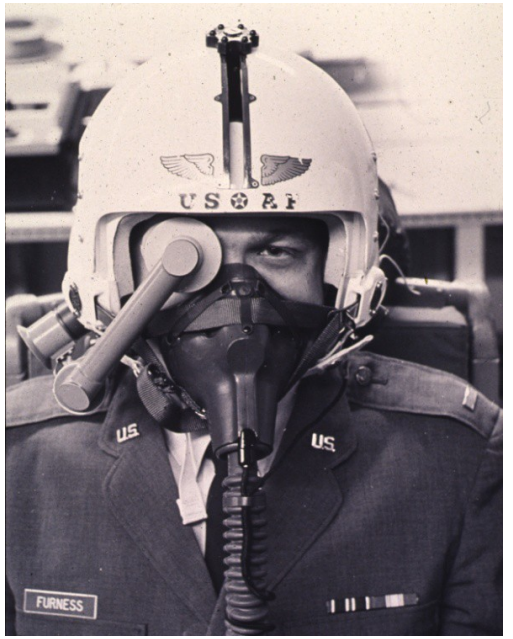


HoloDeck Video

https://youtu.be/oZwtVz7z0wM

US AIRFORCE HMDS





1960 - 70'S: US AIR FORCE HMDS (T. FURNESS III)

SUPER COCKPIT (1965-80'S)

US Airforce Research Program

- Wright Patterson Air Force Base
- Tom Furness III

Multisensory

- Visual, auditory, tactile
- Head, eye, speech, and hand input

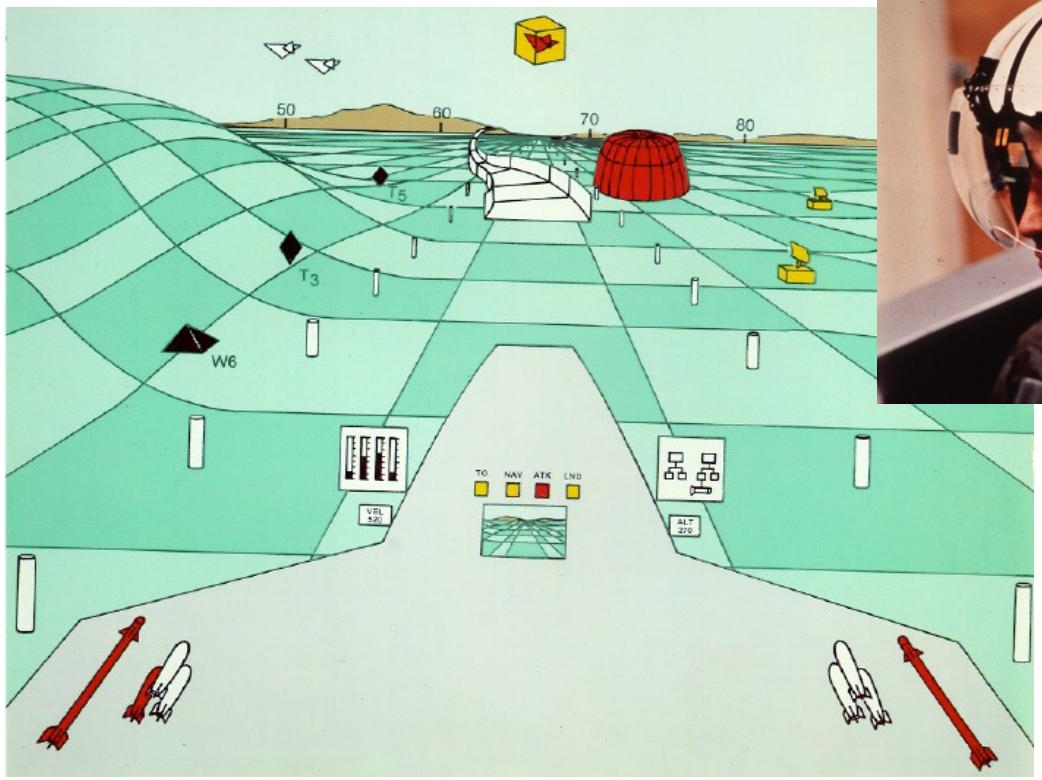
Addressing pilot information overload

- Flight controls and tasks too complicated

Research only

- big system, not safe for ejecting

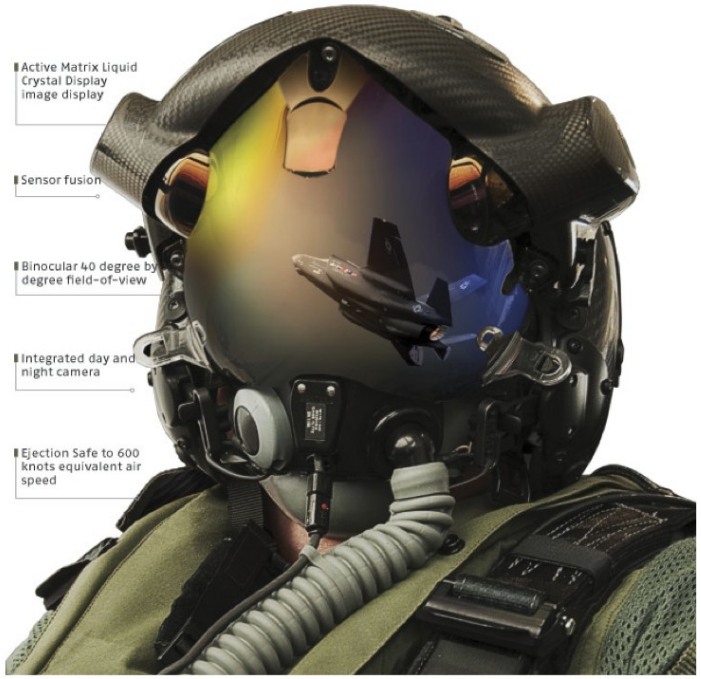
SUPERCOCKPIT PROGRAM



1970 - 80's: US Air Force Super Cockpit (T. Furness III)

Modern Airforce HMDs

Early IHADSS HMD



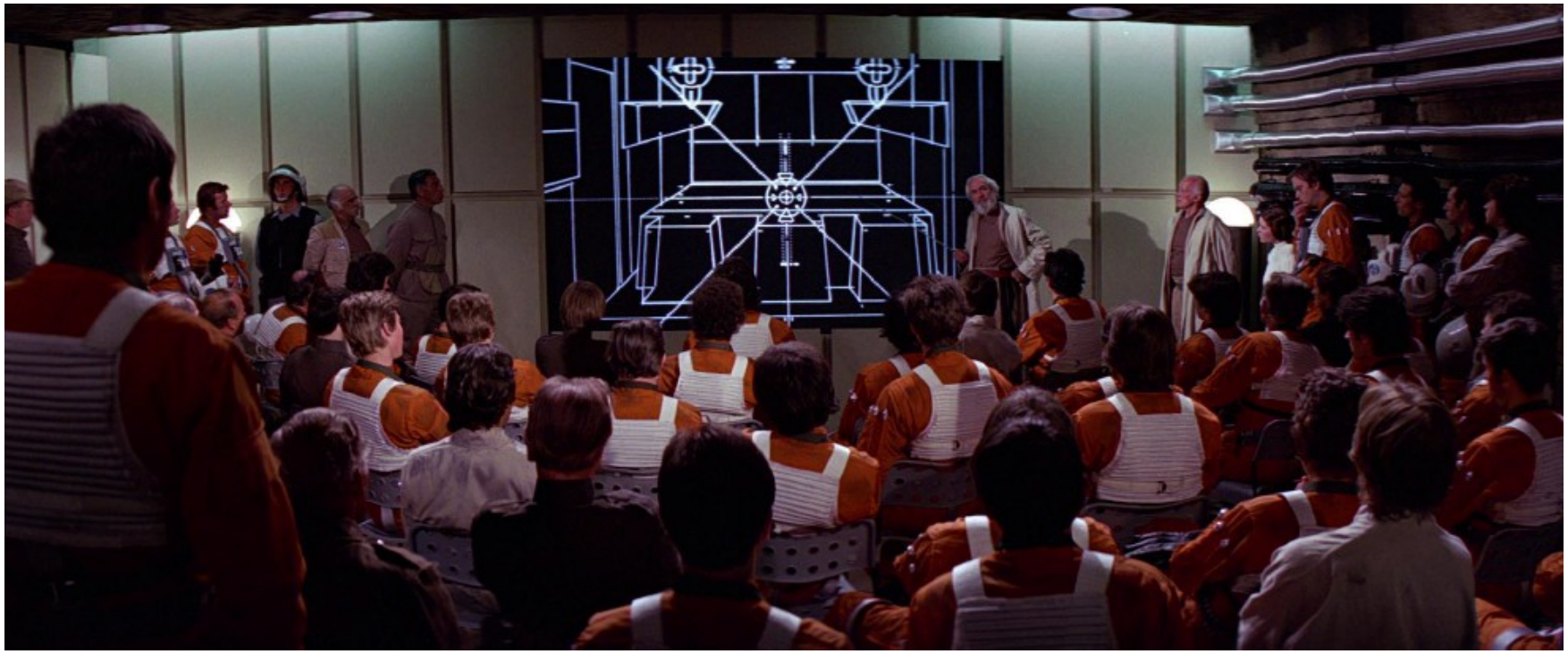
F-35 AR HMD

Honeywell Integrated Helmet and Display Sighting System (IHADSS) on AH-64 Apache attack helicopter in 1985

F35- HMD Demo (2014)

https://youtu.be/Ay6g66FbkmQ

StarWars (1977)



Use of 3D graphics and AR interfaces

Aspen Movie Map (1978)

Andrew Lippman, MIT

Car driven through Aspen

- 4 stop motion cameras
- Pictures every 10 feet

Interactive playback

- Played from laserdisc, touch screen
- People able to navigation in any direction
- Map interface
- 3D graphics overlay

Early version of Google StreetView

Aspen Movie Map Demo

https://youtu.be/X5Oj4S_x2Cc

VIDEOPLACE (1975-80'S)

Myron Krueger

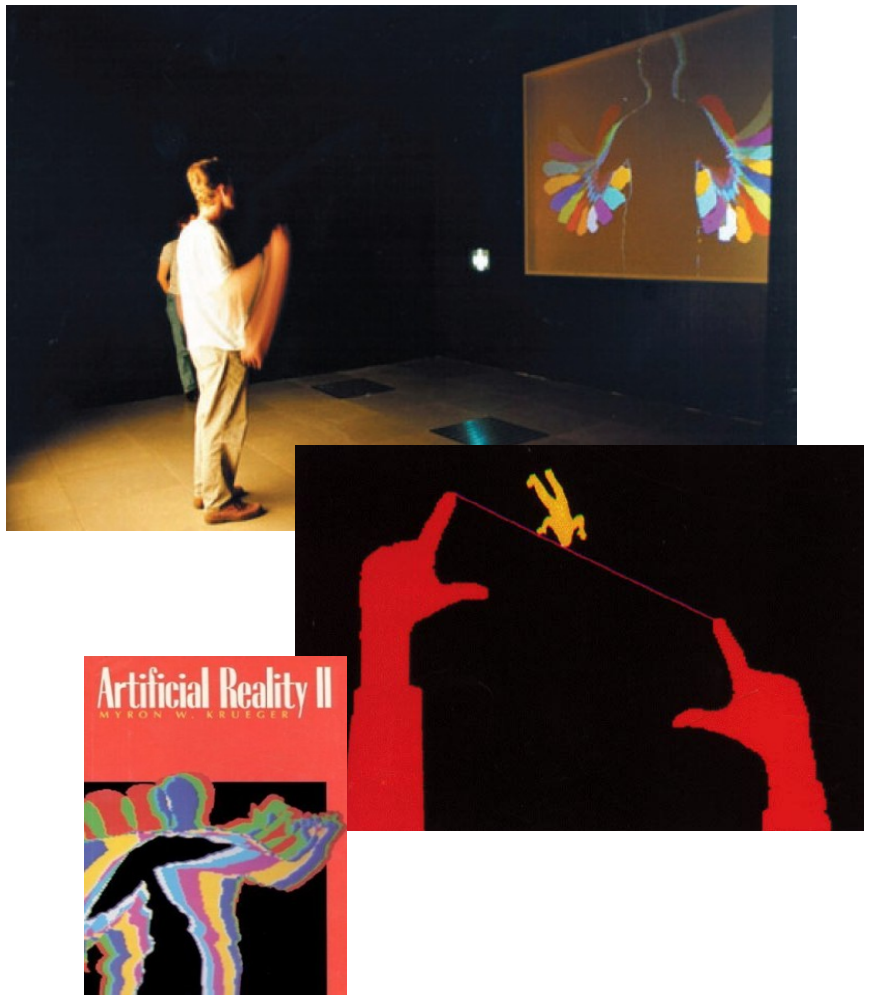
Graphics/gesture recognition

- Real time interaction

VideoDesk

- camera captures gestures
- relays to remote collaborator
- gestures control graphics
- paint, draw, menu selection

Wrote Book – Artificial Reality 2



VIDEOPLACE DEMO

HTTPS://YOUTU.BE/DQZYZRN3PL0

LEEP Optics (1979)

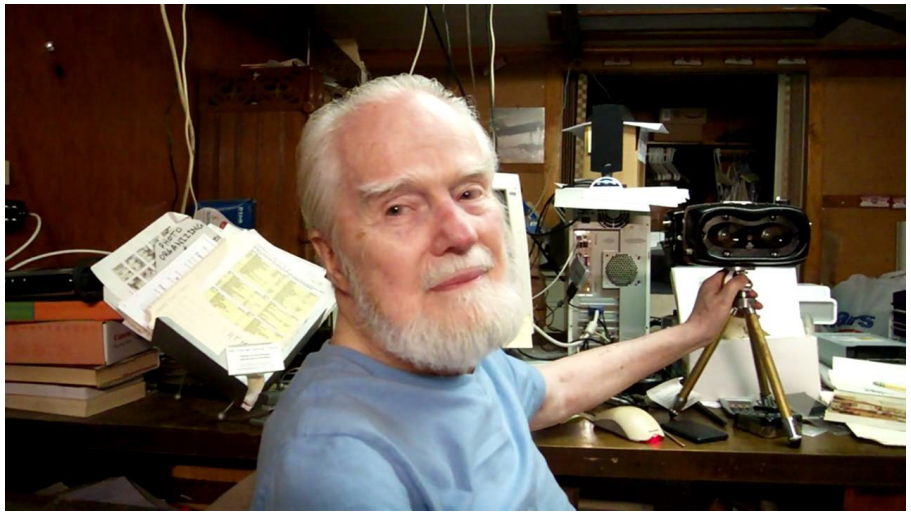
Large Expanse, Extra Perspective optics

- Developed by Eric Howlett

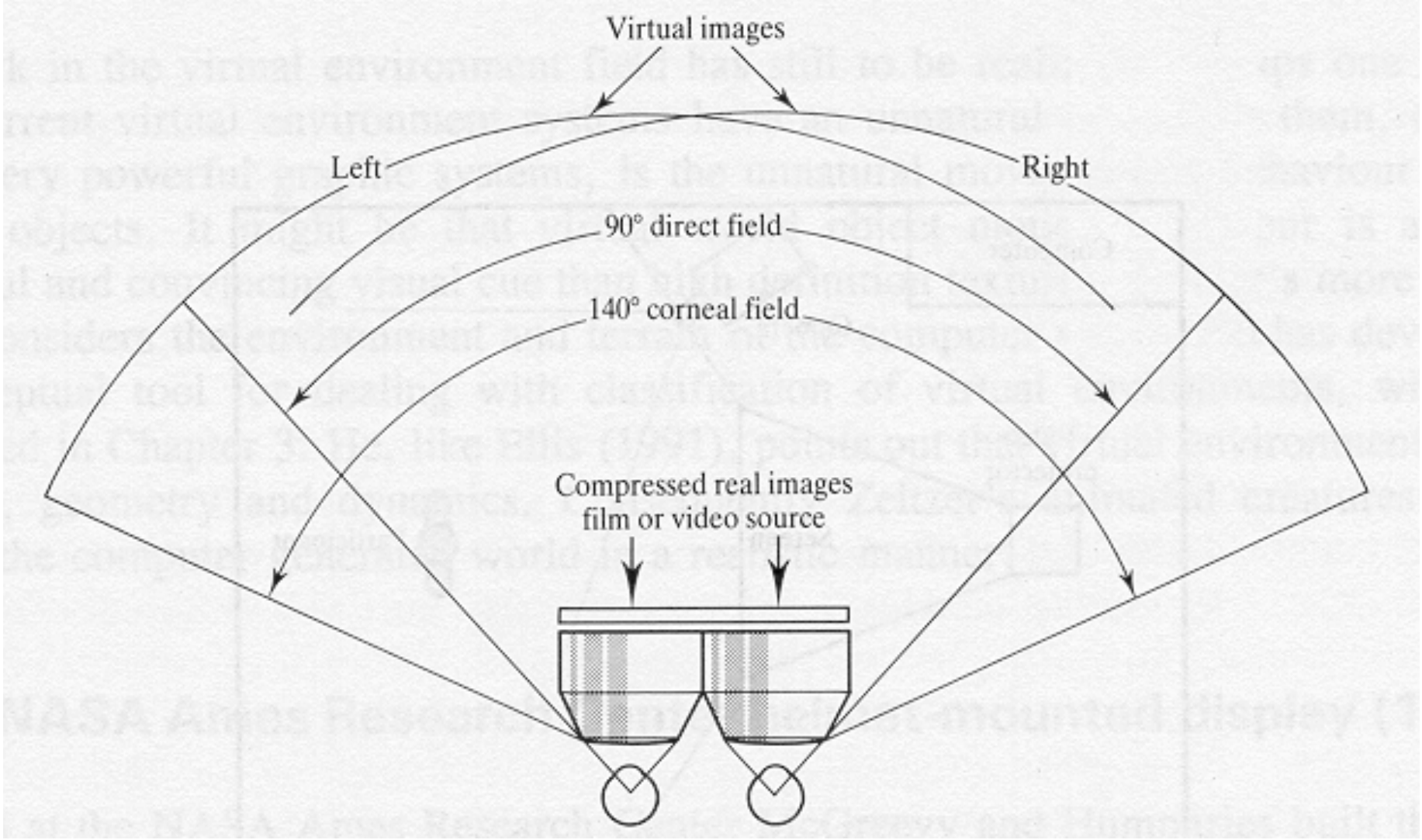
Lens design for extremely wide field of view

- High resolution in center, lower resolution in periphery
- 90° direct FOV, 140° corneal FOV

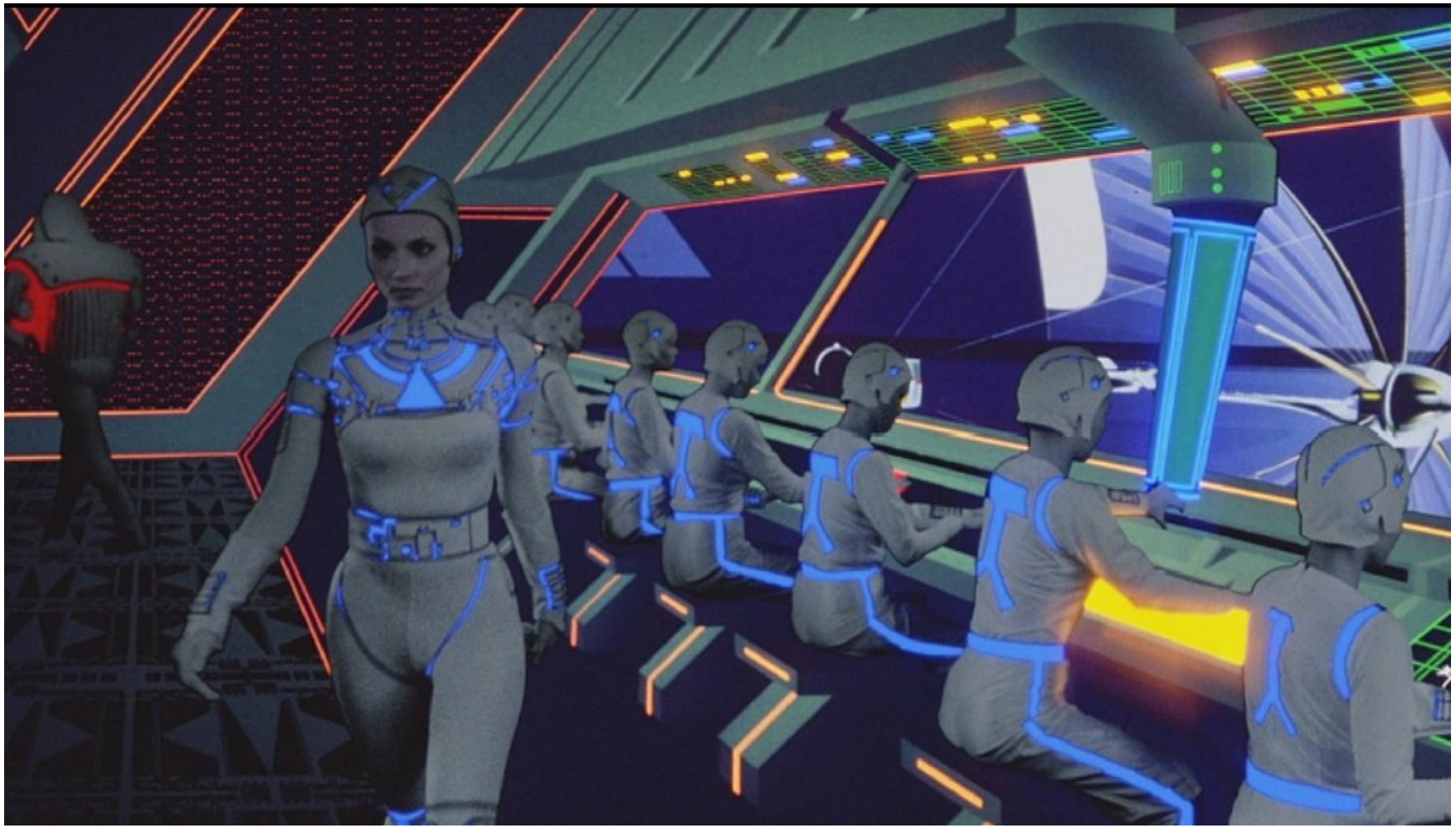
Used as basis for most VR HMDs



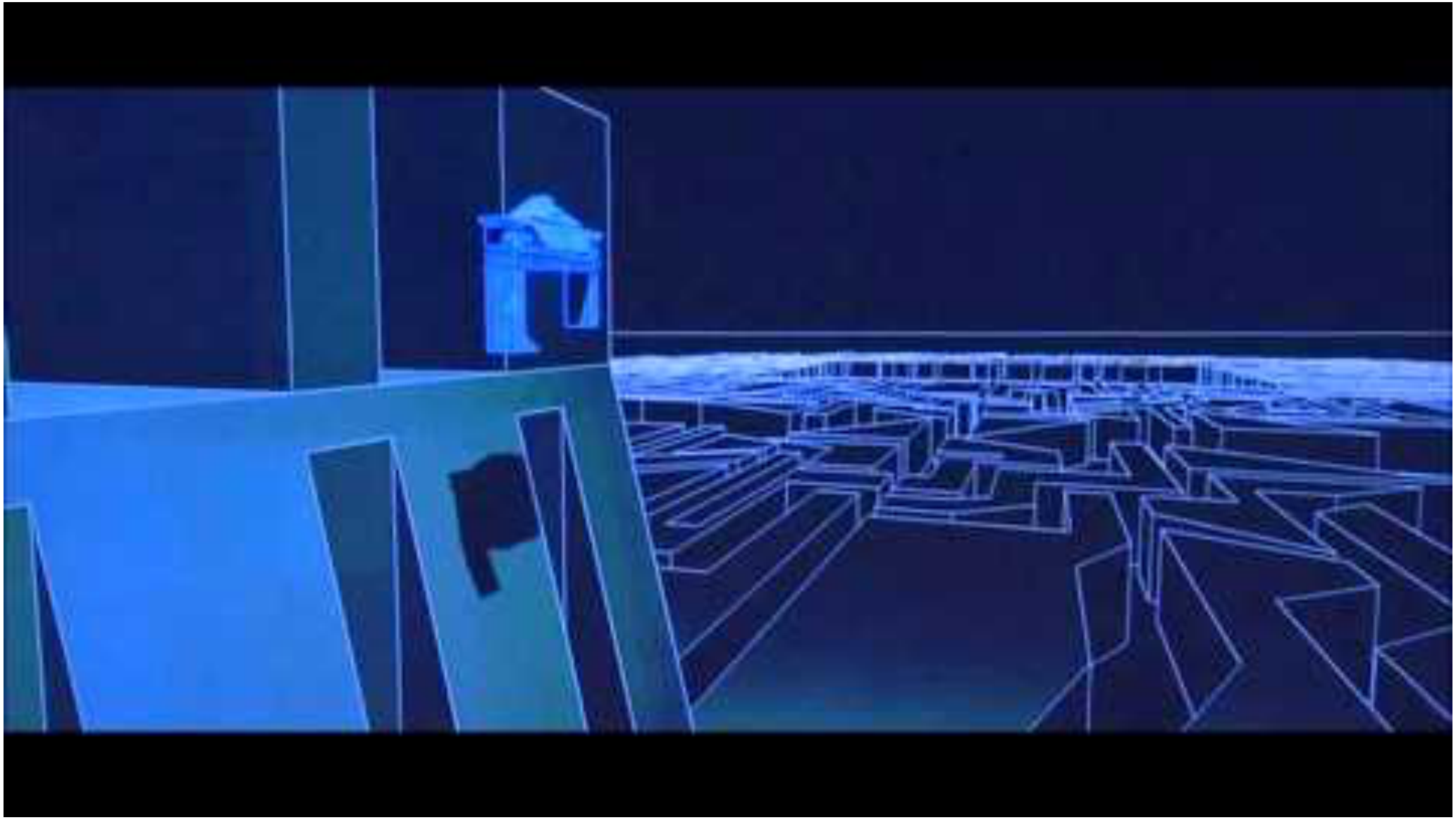
LEEP Optics Design



TRON (1982)



TRON (1982)



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The Data Glove (1981-82)

Precursor, Sayre Glove

- Univ. of Illinois, 1977

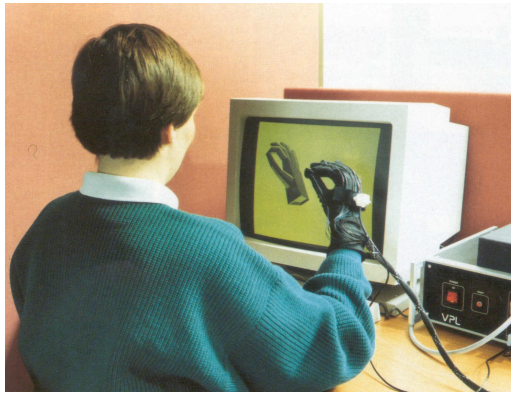
Thomas Zimmerman (1982)

Fiber optic bend sensors

- Detecting finger bending

Commercialized by VPL

- Mattel PowerGlove (1989)



VPL DataGlove Demo

https://youtu.be/fs3AhNr5o6o

NASA VIEW/VIVED (1981-86)

Early HMD (McGreevy Humphries)

- LCD "Watchman" displays

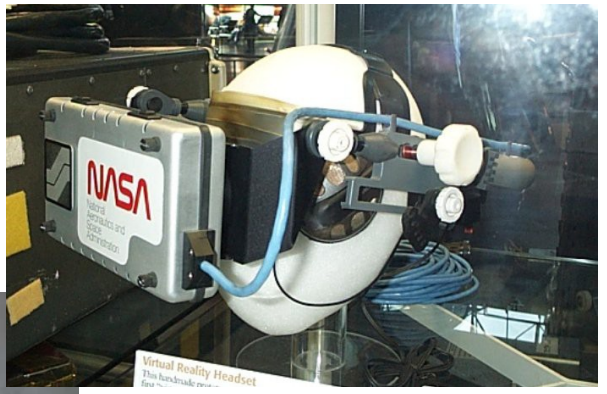
VIEW (Scott Fisher)

- Polhemus tracker
- LEEP-based HMD
- 3D audio (Convolvotron)
- DataGlove gesture input
- Simple graphics

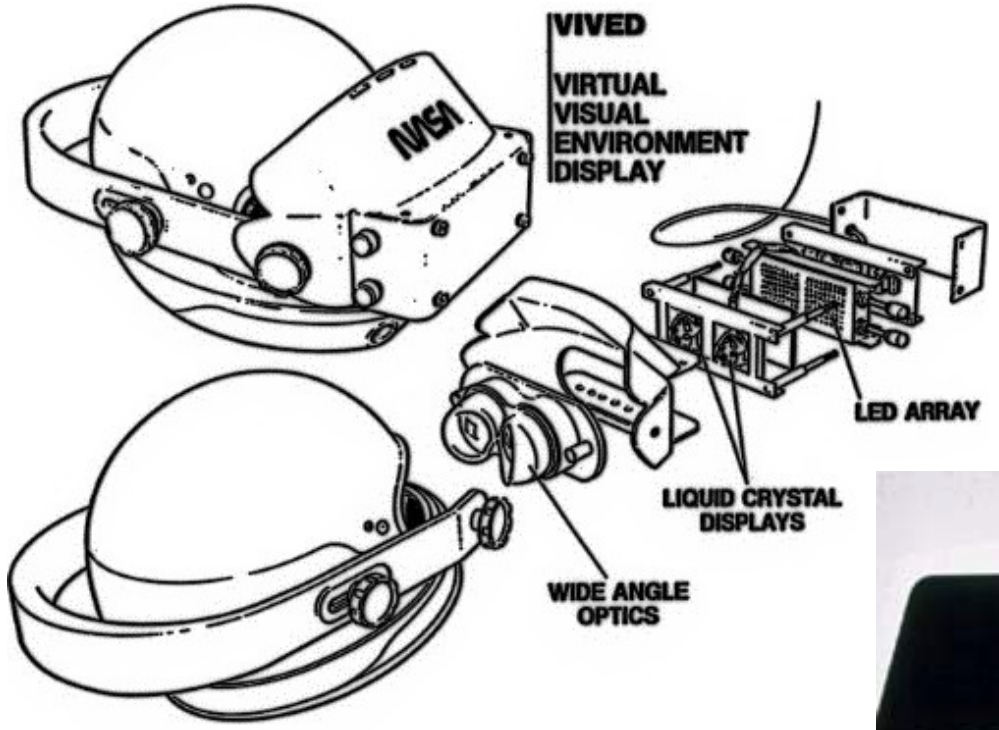
1984 – NASA Ames Virtual Visual Environment (ViVED)

- Dr. Michael McGreevy
- For use for future astronauts
- tactile input and feedback
- Voice recognition

1985 – NASA Ames Virtual Interface Environment Workstation (VIEW)



VIRTUAL INTERFACE ENVIRONMENT WORKSTATION



MOTORBIKE HELMET + LEEP

VPL Research (1985 – 1999)

First Commercial VR Company
- Jaron Lanier, Jean-Jacques Grimaud

Provided complete systems
- Displays, software, gloves, etc
- DataGlove, EyePhone, AudioSphere

Jaron Lanier coined term "Virtual Reality"

Rise of Commercial VR Companies

W Industries/Virtuality (1985 - 97)
- Location based entertainment
- Virtuality VR Arcades

Division (1989 – 1998)
- Turn key VR systems
- Visual programming tools

Virtual i-O (1993 -1997)
- Inexpensive gamer HMDs

Sense8 (1990 - 1998)
- WorldToolKit, WorldUp
- VR authoring tools

VIRTUALITY (1991 UK) –DACTYL NIGHTMARE

HTTPS://YOUTU.BE/2XJ7QPEUEQ0

The Virtual Retinal Display (1991)

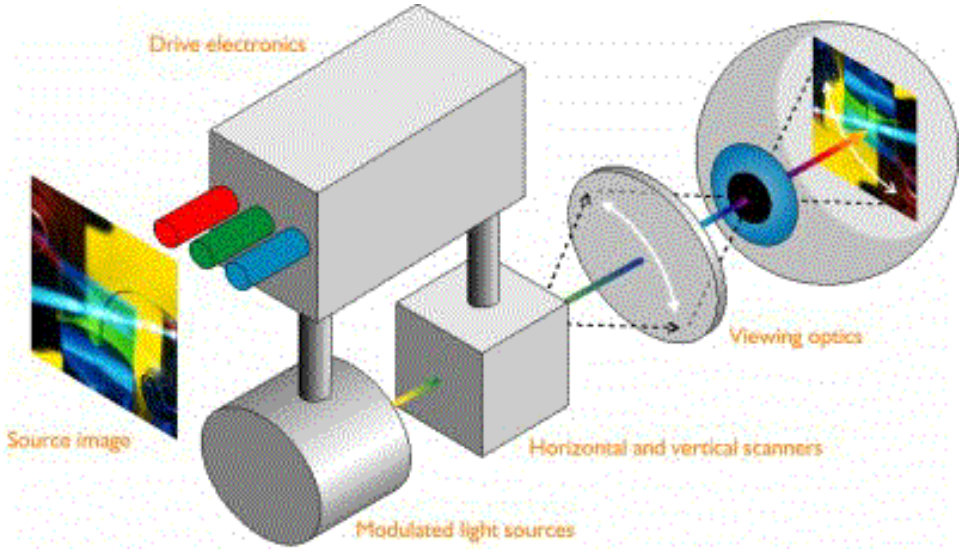


Image scanned onto retina

Commercialized through Microvision

- Nomad System - www.mvis.com

Lead to MagicLeap technology

Early Application

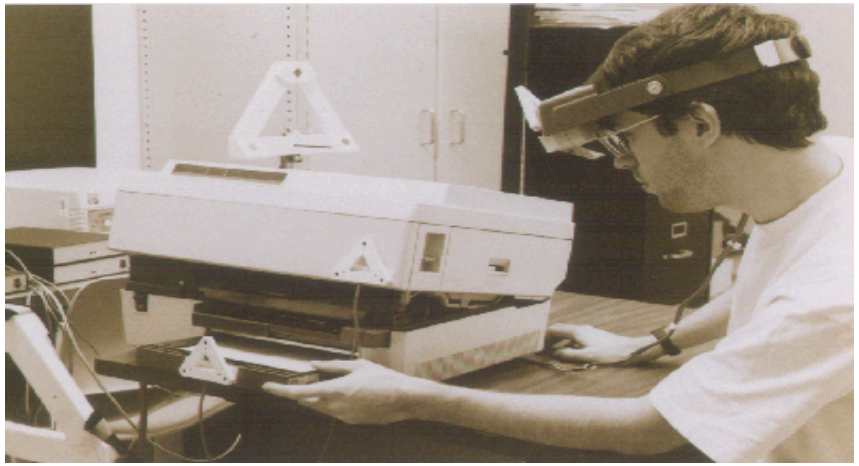
KARMA (91)

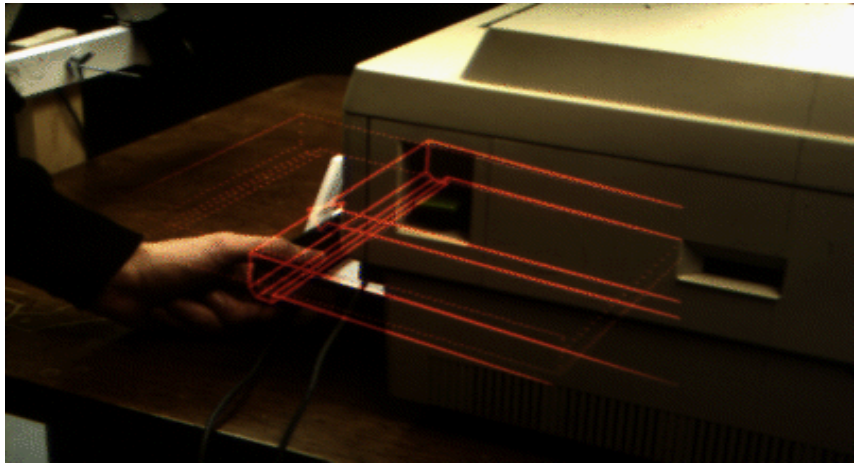
- Feiner

Optical see-through HMD

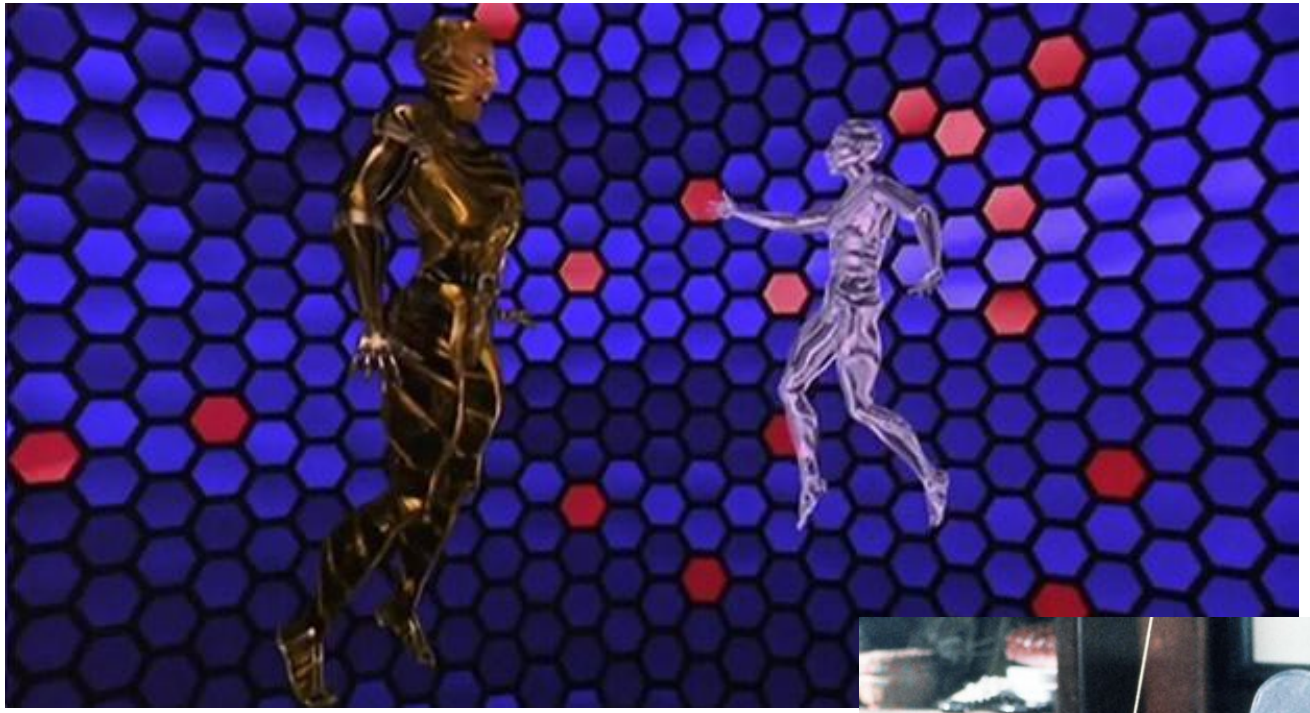
Knowledge-based assistant for maintenance

Ultrasound trackers attached to assembly parts





Lawnmower Man (1992)



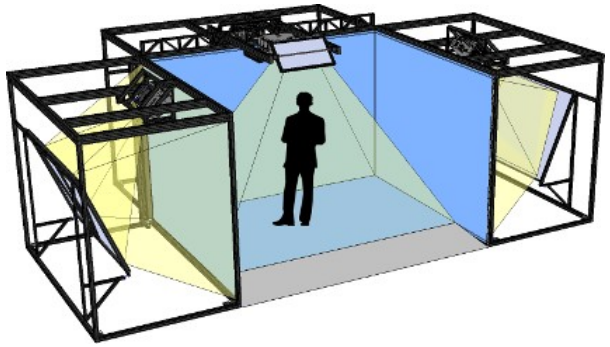
VR Learning in Lawnmower Man

https://youtu.be/zTrgHXNAs24

Lawnmower Man Inside VR

https://youtu.be/LUsWBCH8Ch8

CAVE (1992)



Projection VR system

- 3-6 wall stereo projection, viewpoint tracking
- Developed at EVL, University of Illinois Chicago

Commercialized by Mechdyne Corporation (1996)

C. Cruz-Neira, D. J. Sandin, T. A. DeFanti, R. V. Kenyon and J. C. Hart. "The CAVE: Audio Visual Experience Automatic Virtual Environment", Communications of the ACM, vol. 35(6), 1992, pp. 64–72.

CAVE Demo Video

https://youtu.be/aKL0urEdtPU

Modern CAVE

https://youtu.be/kjAviW2alpA

TANGIBLE INTERFACES AND AUGMENTED SURFACES – BASIC PRINCIPLES

Virtual objects are projected on a surface

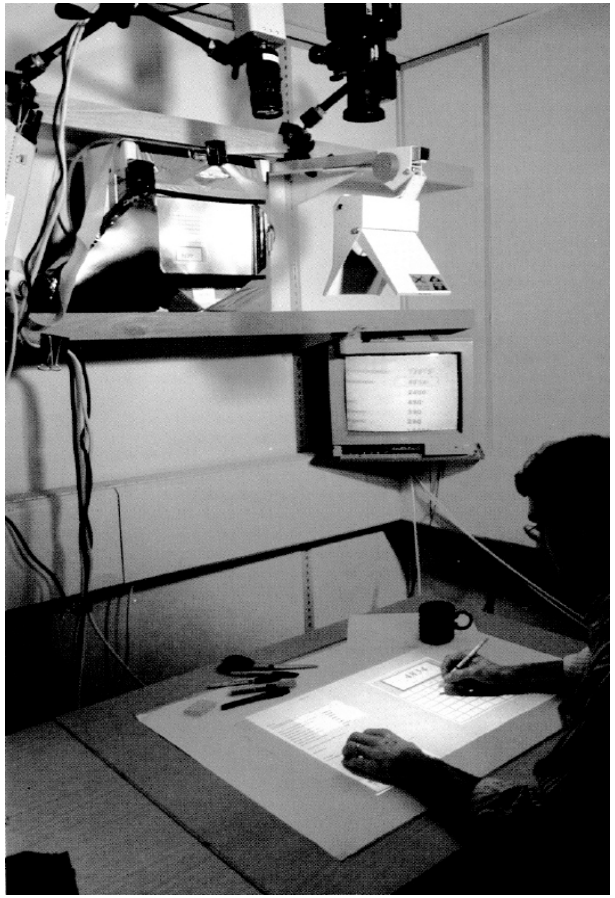
- back projection
- overhead projection

Physical objects are used as controls for virtual objects

- Tracked on the surface
- Virtual objects are registered to the physical objects
- Physical embodiment of the user interface elements

Collaborative

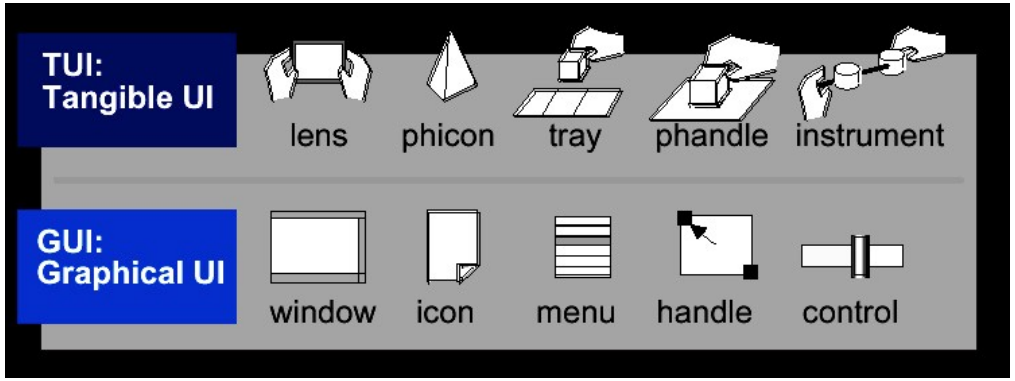
Digital Desk. 1993

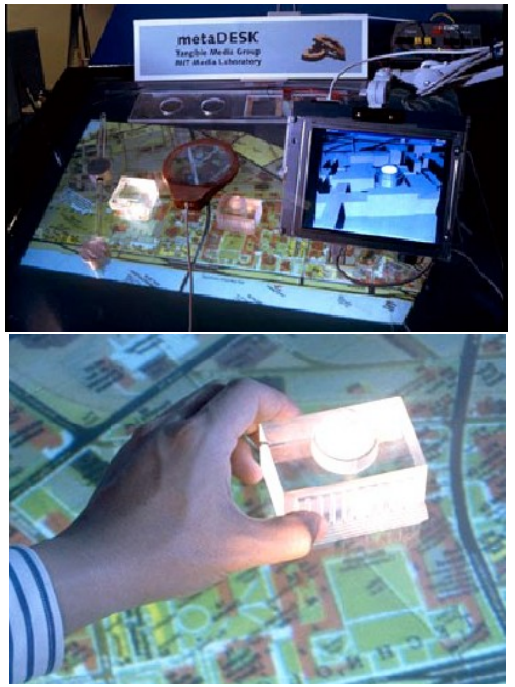


Tangible Interfaces and Augmented Surfaces (II)

Graspable interfaces, Bricks system (Fitzmaurice, et al. 1995) and Tangible interfaces, e.g. MetaDesk (Ullmer'97):

- Back-projection, infrared-illumination computer vision tracking
- Physical semantics, tangible handles for virtual interface elements





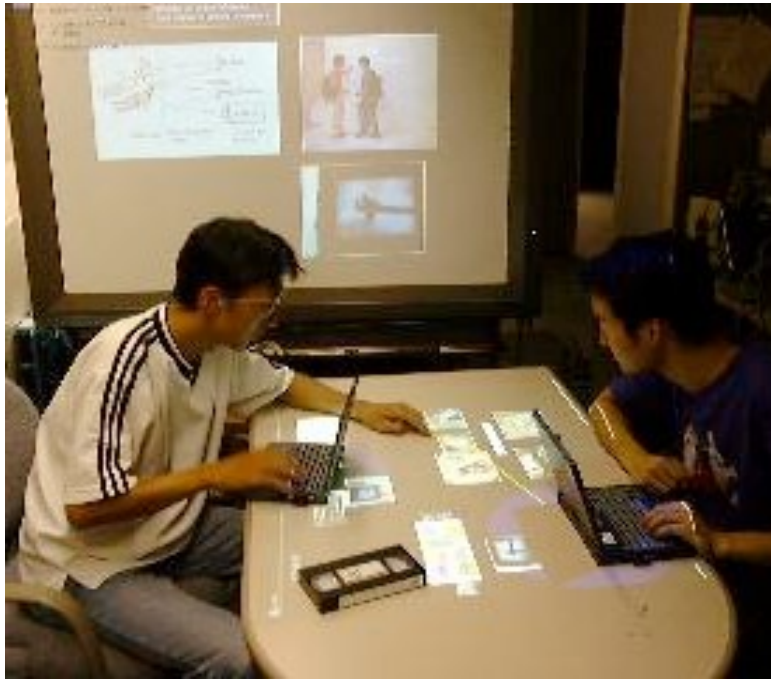
metaDesk. 1997

Tangible Interfaces and Augmented Surfaces (III)

- Front projection
- Marker-based tracking
- Multiple projection surfaces
- Tangible, physical interfaces

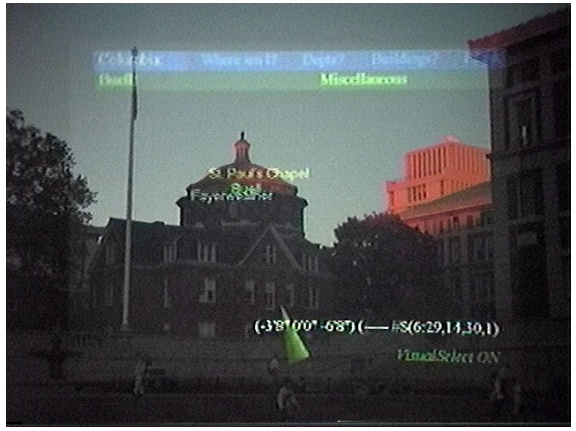
+ AR interaction with computing devices

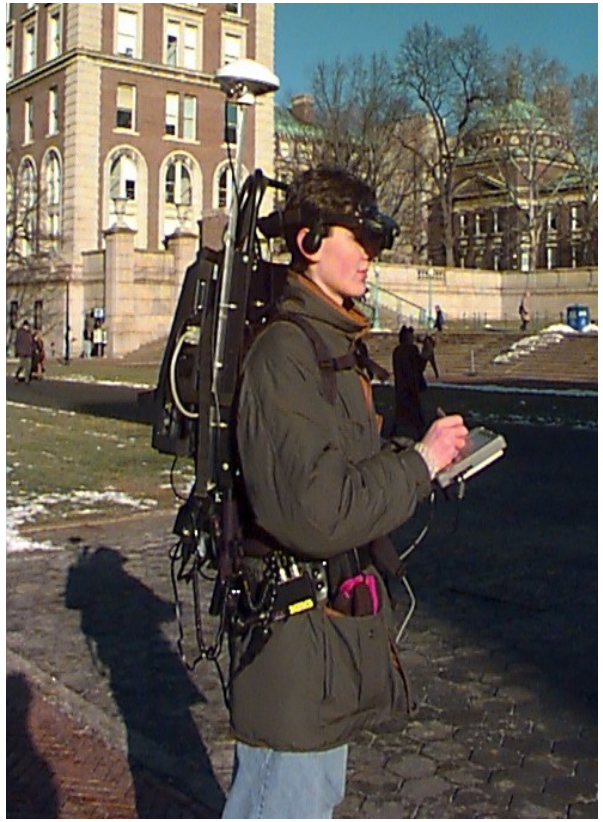
Augmented surfaces, 1998



Rekimoto, et al. 1998

Mobile/Wearable Systems





1995 Navicam (Rekimoto)

- Handheld AR

1997 Touring Machine (Feiner)

- Backpack AR
- GPS, see-through display

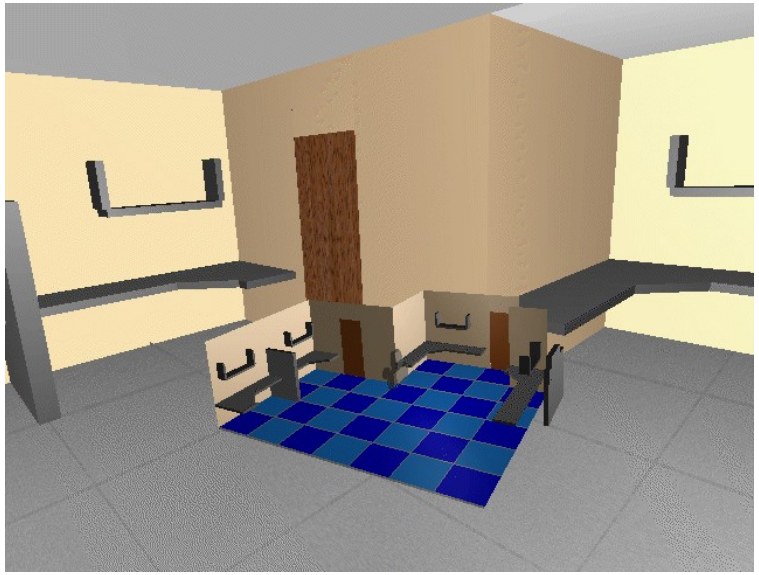
DESKTOP VR – 1995

Expensive - $150,000+

2 million polys/sec

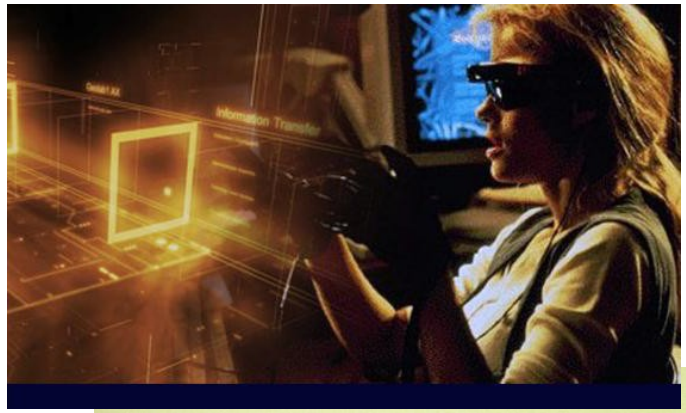
VGA HMD – 30 Hz

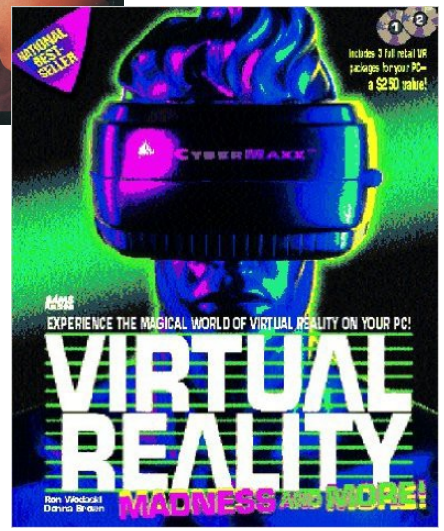
Magnetic tracking



VIRTUAL REALITY WAS HOT! ... IN MID-LATE '90'S

US ARMY – spend close to $1B 1998 in VR research!



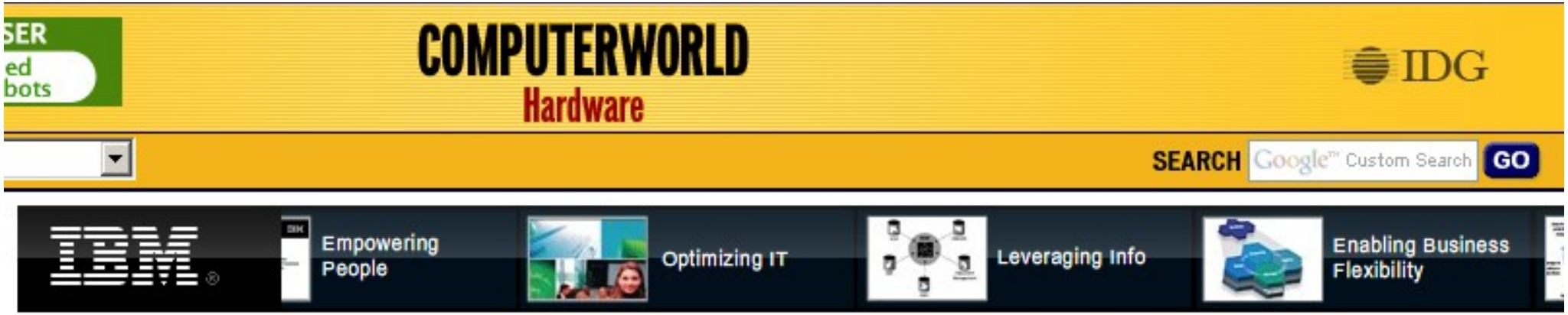


What Happened to VR?

https://youtu.be/tdAaU0CRHng

April 2007 Computer World

VR Voted 7th on list of 21 biggest technology flops



Don't Believe the Hype: The 21 Biggest Technology Flops

We fondly recall 21 overpromoted products and technologies that utterly failed to live up to their hype -- and we give you a chance to choose the biggest flop of all.

David Haskin Today's Top Stories ▸ or Other Hardware Stories ▸

2007 - AR Reaches Mainstream

MIT Technology Review

- March 2007
- list of the 10 most exciting technologies

Economist

- Dec 6th 2007
- Reality, only better

GOOGLE SEARCHES FOR AR

Augmented Reality
Mid-2000s to Today

2005 - Mobile Phone AR

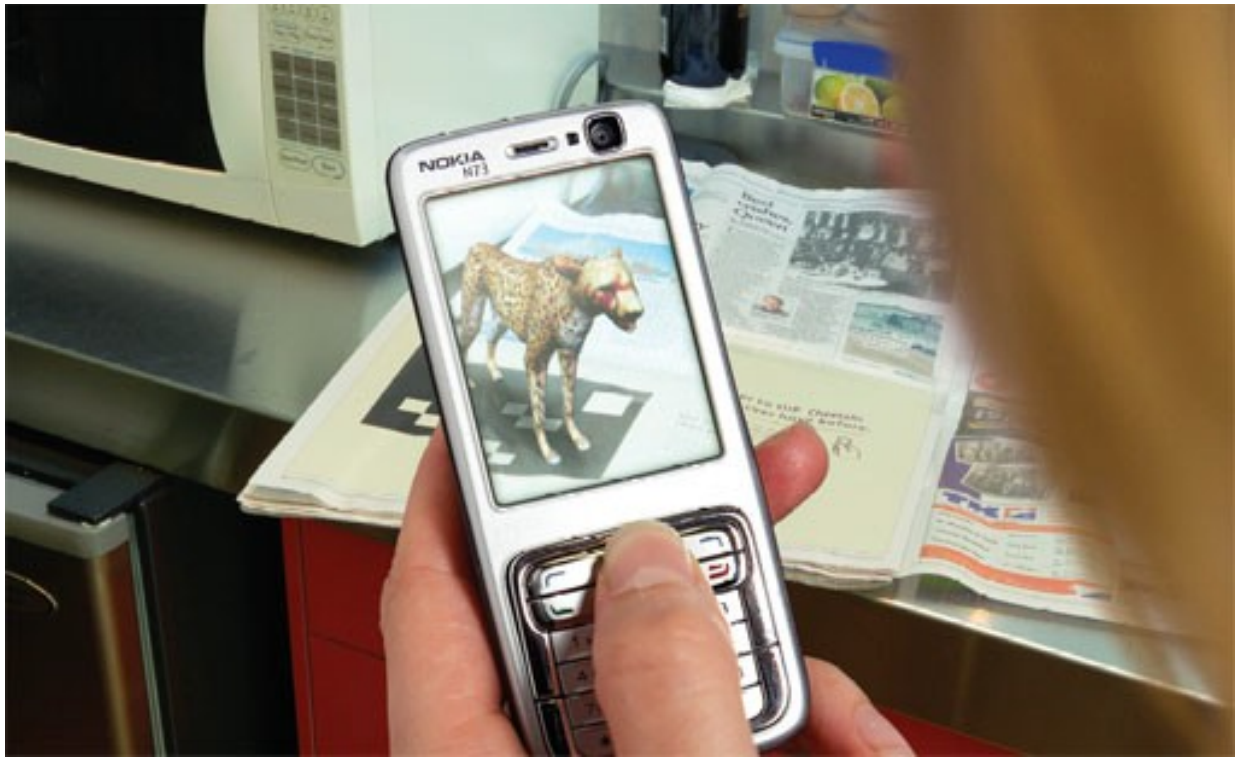
Mobile Phones

- camera
- processor
- display

AR on Mobile Phones

- Simple graphics
- Optimized computer vision
- Collaborative Interaction

AR Advertising (HIT Lab NZ 2007)



Txt message to download AR application (200K)

See virtual content popping out of real paper advert

Tested May 2007 by Saatchi and Saatchi

Wellington Zoo Demo

https://youtu.be/edTjuXcce_c

2008 - Browser Based AR

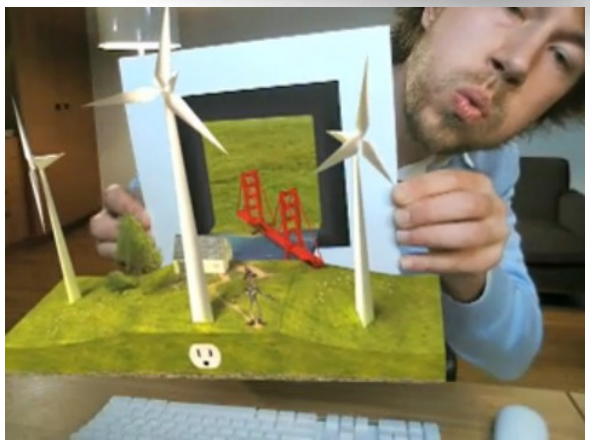
Flash + camera + 3D graphics
- ARToolKit ported to Flash

High impact
- High marketing value

Large potential install base
- 1.6 Billion web users

Ease of development
- Lots of developers, mature tools

Low cost of entry
- Browser, web camera



Demo: GE Smart Grid

https://youtu.be/vJO_AZkCL9U

2008: Location Aware Phones

Motorola Droid

Nokia Navigator

2009 - Outdoor Information Overlay

Mobile phone based

Tag real world locations

- GPS + Compass input
- Overlay graphics on live video

Applications

- Travel guide, Advertising, etc

Wikitude, Layar, etc..

- iOS/Android, Public API released

Layar Demo (2009)

https://youtu.be/b64_16K2e08

2009 - AR in Magazines

Esquire Magazine

- Dec 2009 issue
- 12 pages AR content

Many Others

- Wired
- Colors
- Red Bull
- Etc

Esquire Demo

https://youtu.be/LGwHQwgBzSI

Google Glass (2011)

Google Glass Demo

https://youtu.be/fNATuCkRWFE

Epson Moverio BT-200

Stereo see-through display ($700)

- 960 x 540 pixels, 23 degree FOV, 60Hz, 88g
- Android Powered, separate controller
- VGA camera, GPS, gyro, accelerometer

HOLOLENS (2016)

Integrated system – Windows

Stereo see-through display

Depth sensing tracking

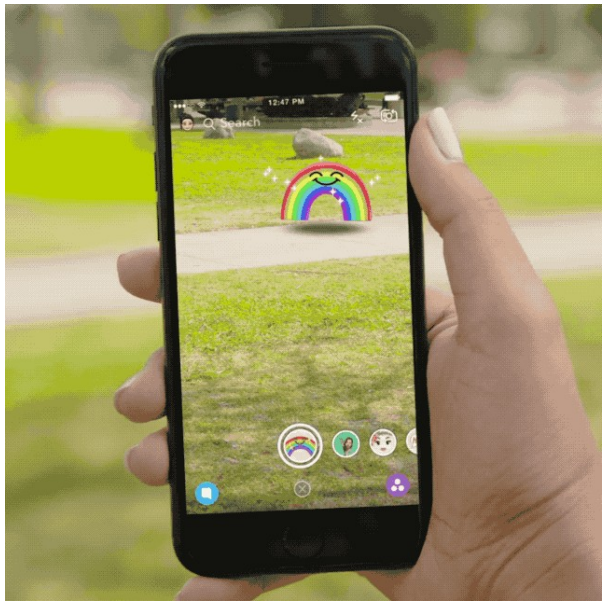
Voice and gesture interaction

View Through Hololens

https://youtu.be/2c9eiVyO6gM

SMART GLASSES AVAILABLE

Mobile Camera AR Apps (2015)

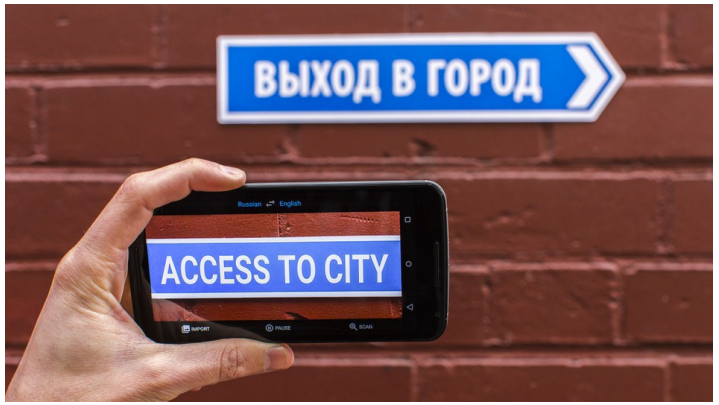


SnapChat - Lenses, World Lenses

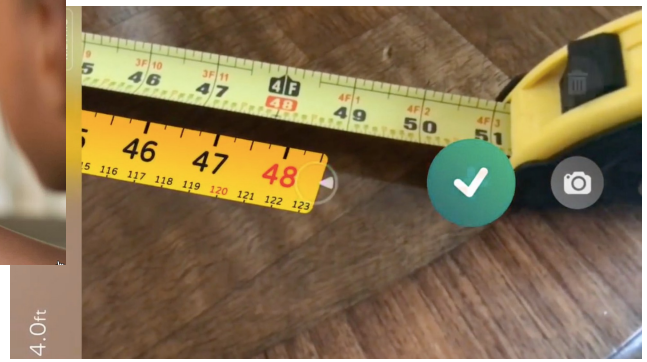
- Cinco de Mayo lens > 225 million views

Facebook - Camera Effects

Google – Word Lens/Translate



ARKit/ARCore (2017)



Visual Inertial Odometry (VIO) systems

Mobile phone pose tracked by

- Camera (Visual), Accelerometer & Gyroscope (Inertial)

Features

- Plane detection, lighting detection, hardware optimization

Links

- https://developer.apple.com/arkit/
- https://developers.google.com/ar/

ARKit Demos

https://youtu.be/6xDyVBsBtX8

Virtual Reality
Mid-2000s to Today

VR IN THE NEWS

Yahoo! News, September 2007:

- "Study: Kids' virtual worlds poised for growth spurt" (children's online usage)
- "Sony Delays 'Home' Virtual World for PS3"
- "VirTra Systems Receives 24-system Simulator Order from Department of Homeland Security" (video-based training)
- "It's a scream: Pizza patrons love coaster simulator" (motion base simulator)
- "Patient conscious during surgery" (3D brain imaging)
- "Digital education a virtual reality for children of Gen Net" (technology-based education)

VR IN THE NEWS

ACM Tech News, September 2007:

- "Folmer Believes a Virtual World Doesn't Have to Be a Visual One" (Second Life)
- "IT Joins Library of Congress Partnership to Preserve Online Games and Virtual Worlds" (Second Life)
- "Artists 'Draw on Air' to Create 3D Illustrations" (Brown Univ. CAVE)
- "Virtual Worlds Open Up to Blind" (Active Worlds)
- "The Promise of Parallel Universes" (World of Warcraft)
- "Virtual Reality Will Enhance Real-World Experiences" (future AR)
- "Is It Live or Is It AR?" (future AR)

PHOTOREALISM – 1997 VS 2015

PHOTOREALISM

VFX Tech Demo

VR Second Wave (2010 -)

2012, Palmer Luckey (@ 17yrs old) made a prototype headset duct taped!

Aug 2012, John Carmack (doom & quake) improved it and showed at E3.

Aug 2012, game industry leaders showed strong support, Oculus is founded

Sep 2012, Kickstarter very successful (raised $2.4m)

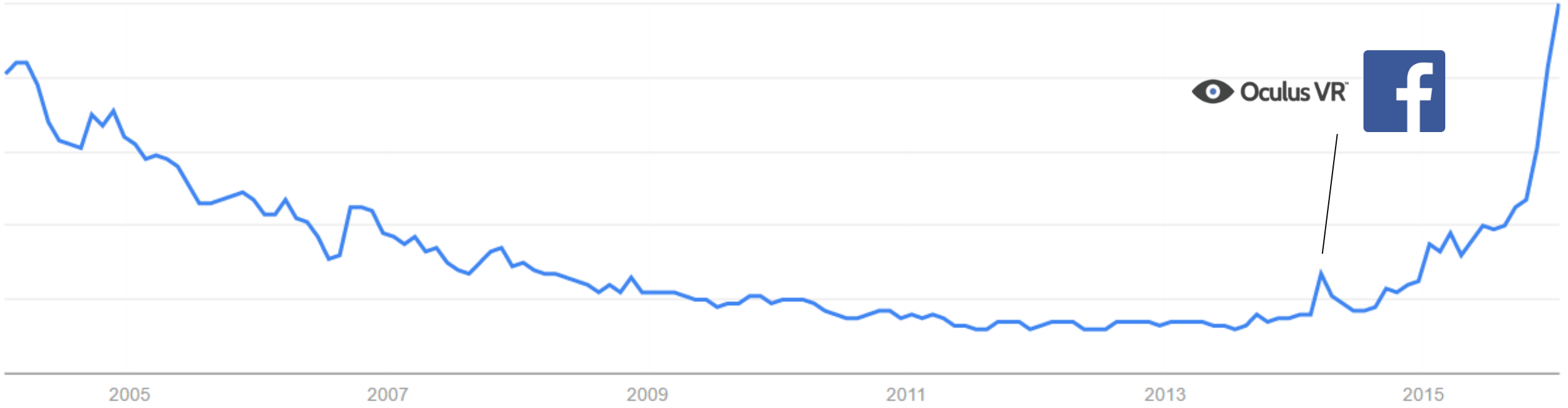
2012-2014, over 60,000 headsets sold

March 2014, Facebook acquires Oculus for $2 billion.

Oculus Kickstarter

https://youtu.be/hxptk8P15TI?t=10

VR Searches on Google



Virtual Reality relative to global search

Desktop VR Today

Graphics Desktop
- $1,500 USD
- >4 Billion poly/sec

HMD (Vive Pro)
- $800
- 1440x1600 (per eye)
- 90Hz refresh rate
- 110° FOV

Optical tracking
- Room scale

Rise of Consumer HMDs

Oculus Rift

HTC/Vive

Sony Morpheus

HTC Vive

Room scale tracking

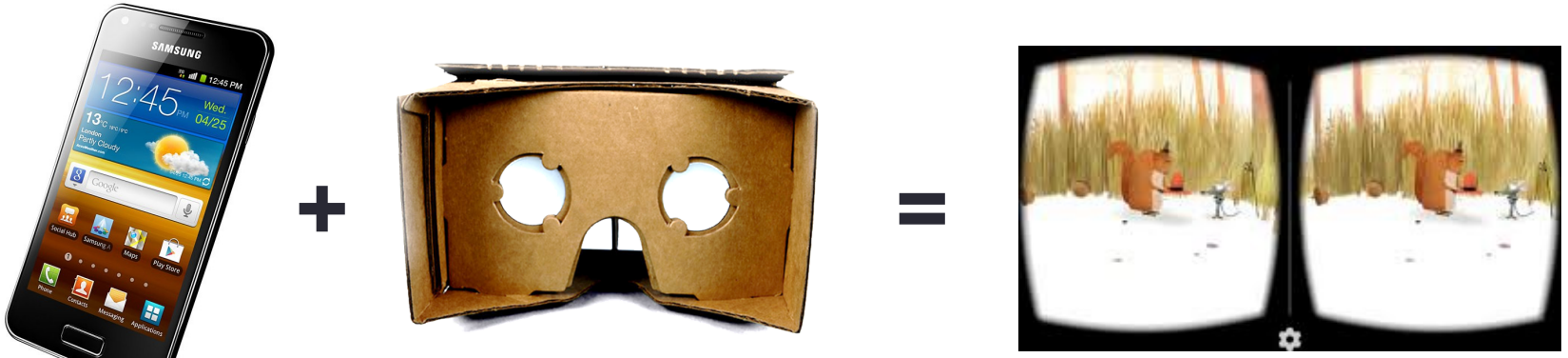
Gesture input devices

"Mobile" VR

Oculus Go

- Qualcomm Snapdragon 821 processor
- 5.5-inch display
- 1280 x 1440 (per eye)
- 60-72Hz refresh rate
- $200

Google Cardboard



Released 2014 (Google 20% project)

>5 million shipped/given away

Easy to use developer tools

Many Different Cardboard Viewers

WORKS WITH Google Cardboard

Google Cardboard

G.CO/CARDBOARD

MULTIPLE MOBILE VR VIEWERS AVAILABLE

Conclusion

Virtual Reality has a long history

- > 50 years of HMDs, simulators

Key elements for VR were in place by early 1990's

- Displays, tracking, input, graphics
- Strong support from military, government, universities

First commercial wave failed in late 1990's

- Too expensive, bad user experience, poor technology, etc

We are now in second commercial wave

- Better experience, affordable hardware
- Large commercial investment, Significant installed user base

Will Virtual Reality be a commercial success this time?