

CSC 2524, Fall 2019

Topics in Interactive Computing: Graphics, Interaction and Performance in Immersive Environments (AR/VR/XR)

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Inspired and adapted from material by Mark Billinghurst

What is this CS aspect of this course about?

- Fundamentals of AR/VR/XR:
 - Hardware and Technology.
 - Perception.
 - Interaction techniques.
 - Theatrical Applications.
- Read and present AR/VR/XR papers.
- Build an AR/VR/XR project.
- Evaluation:
 - Creative experiment/prototype 25%.
 - Technical Paper presentation 25%.
 - Project 50% (mid-term evaluation 10%).

What is Virtual Reality?

virtual reality

noun

Simple Definition of VIRTUAL REALITY

Popularity: Bottom 40% of words

: an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it

Source: Merriam-Webster's Learner's Dictionary

...an interactive computer-generated experience taking place within a simulated environment, that incorporates mainly auditory and visual, but also other types of sensory feedback like haptic.

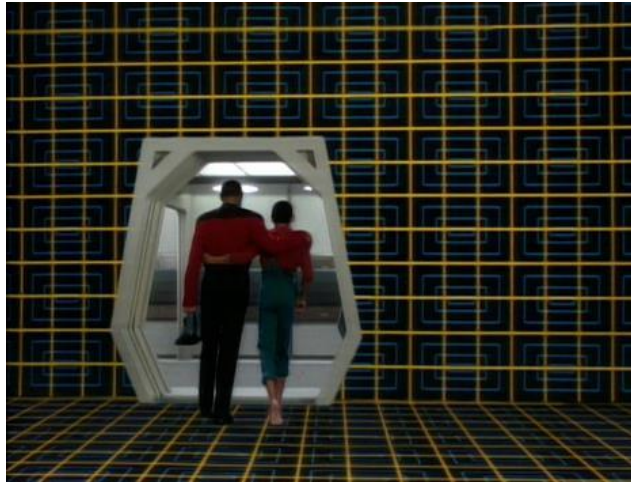
Wikipedia

The logo for Hammerhead, featuring the word "HAMMERHEAD" in a bold, white, sans-serif font. The letter "V" in "HAMMER" is stylized with a small triangle pointing downwards. The logo is centered on a solid blue background.

HAMMERHEAD

<https://www.youtube.com/watch?v=FPcbBJbGhmk>

Holodeck (Star Trek: The Animated Series 1974)



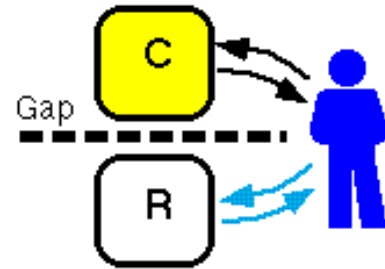
The Ultimate Display

“The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed 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.

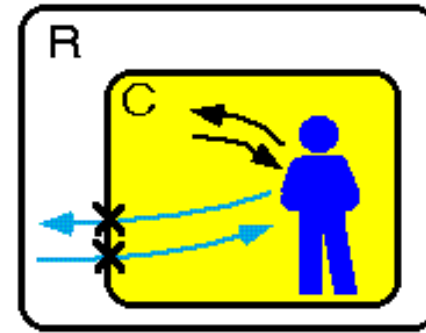
With appropriate programming such a display could literally be the Wonderland into which Alice walked.”

Ivan Sutherland, 1965

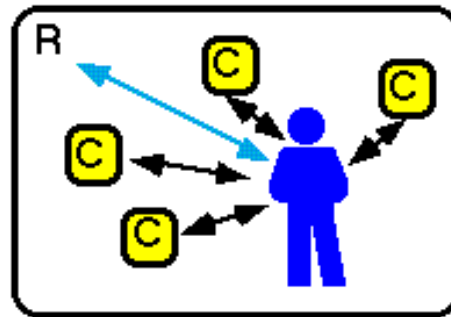
Making Interfaces Invisible



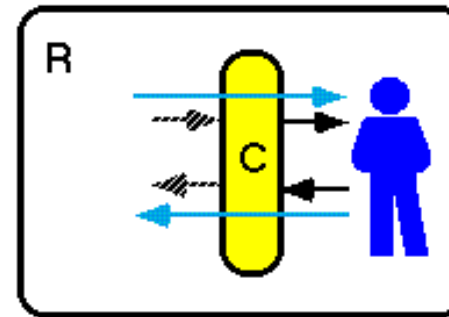
(a) GUI



(b) Virtual Reality



(c) Ubiquitous Computers

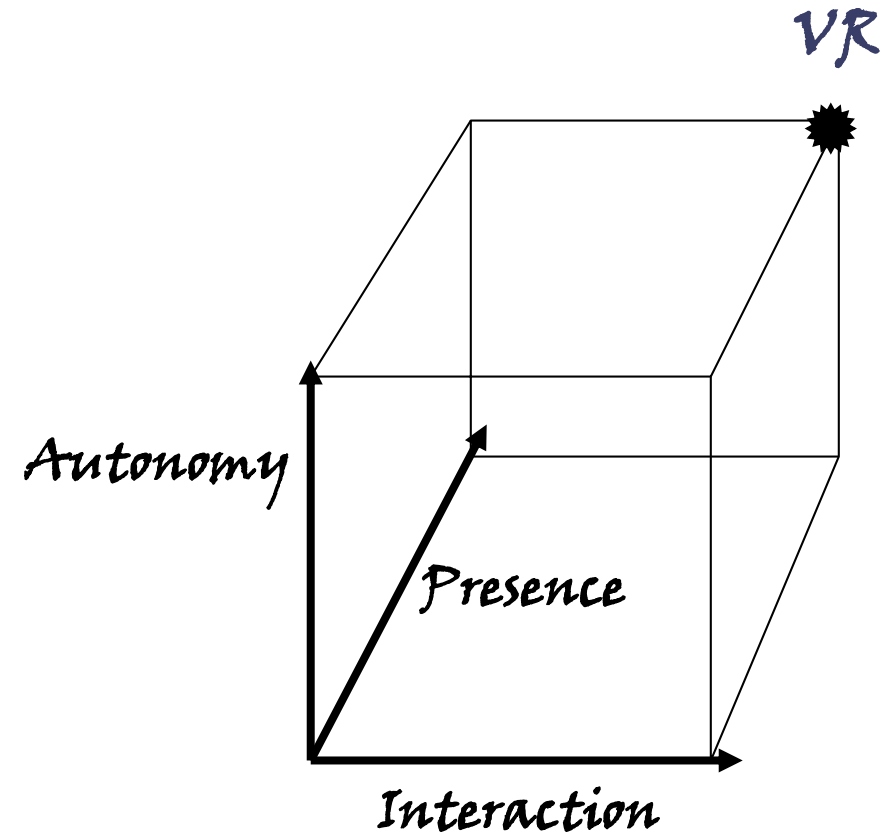


(d) Augmented Interaction

Rekimoto, J. and Nagao, K. 1995. The world through the computer: computer augmented interaction with real world environments. In *Proceedings of the 8th Annual ACM Symposium on User interface and Software Technology. UIST '95*. ACM, New York, NY, 29-36.

David Zeltzer's AIP Cube

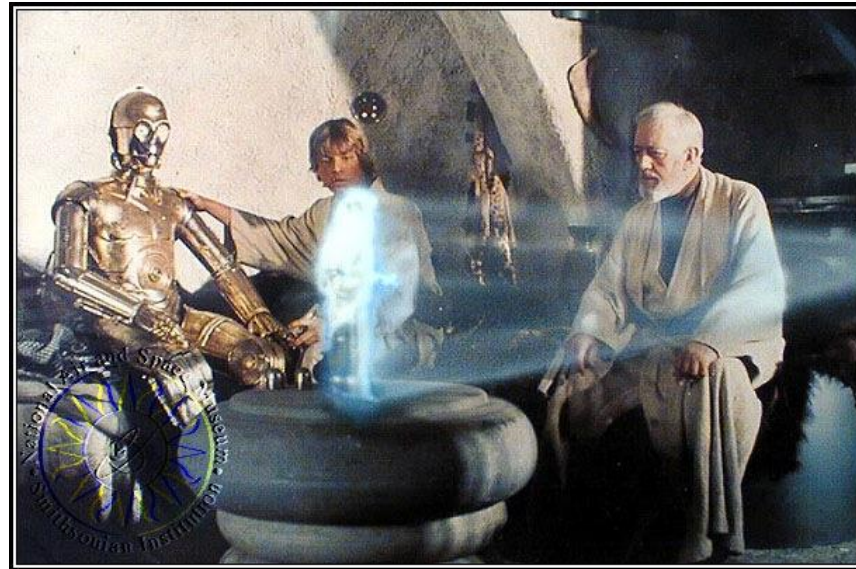
- **Autonomy** – User can react to events and stimuli.
- **Interaction** – User can interact with objects and environment.
- **Presence** – User feels immersed through sensory input and output channels.



Zeltzer, D. (1992). Autonomy, interaction, and presence. *Presence: Teleoperators & Virtual Environments*, 1(1), 127-132.

Augmented Reality

- Combines Real and Virtual Images registered in 3D.
- Interactive in real-time for virtual content.



1977: Star Wars

Azuma, R. T. (1997). A survey of augmented reality. Presence, 6(4), 355-385.

Pokemon GO..

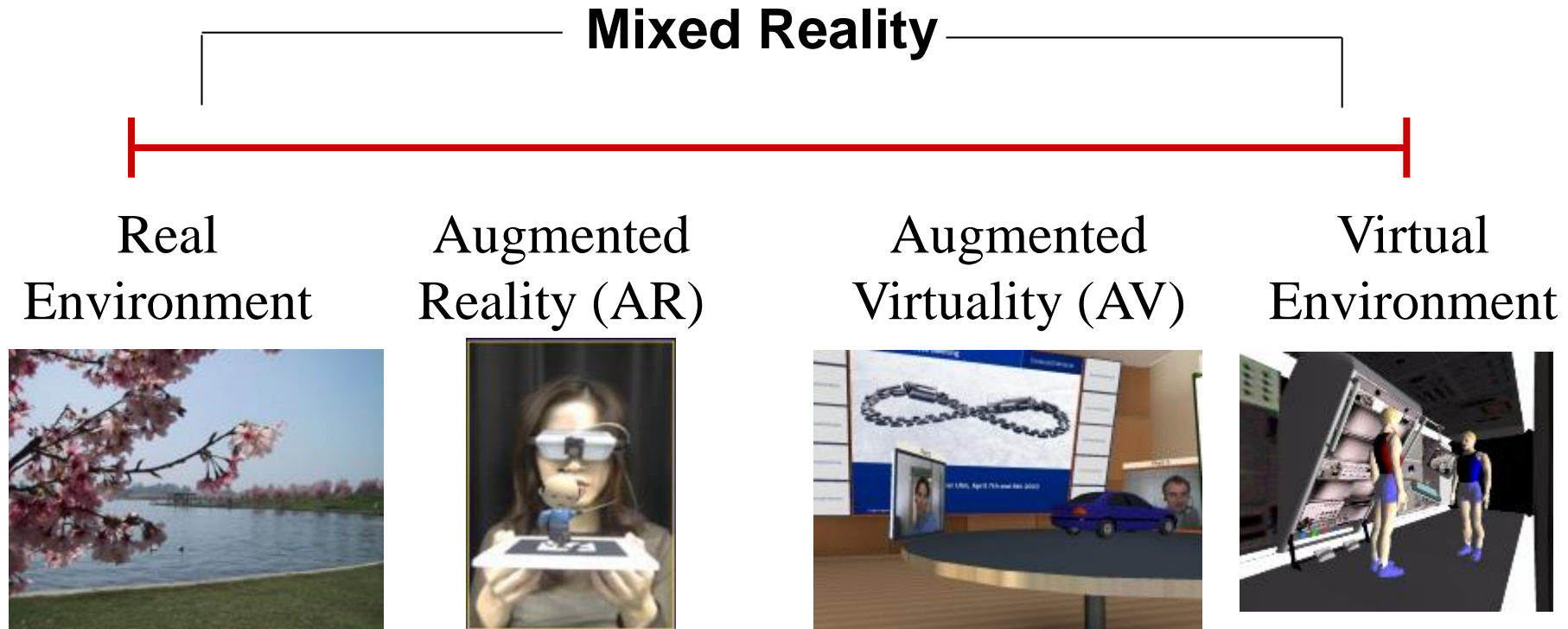


AR vs. VR

	Virtual Reality <i>Replaces Reality</i>	Augmented Reality <i>Enhances Reality</i>
<i>Scene Generation</i>	Requires realistic images	Minimal rendering okay
<i>Display Device</i>	Fully immersive, wide field of view	Non-immersive, small field of view
<i>Tracking</i>	Low to medium accuracy is okay	The highest accuracy possible

Reality-Virtuality continuum

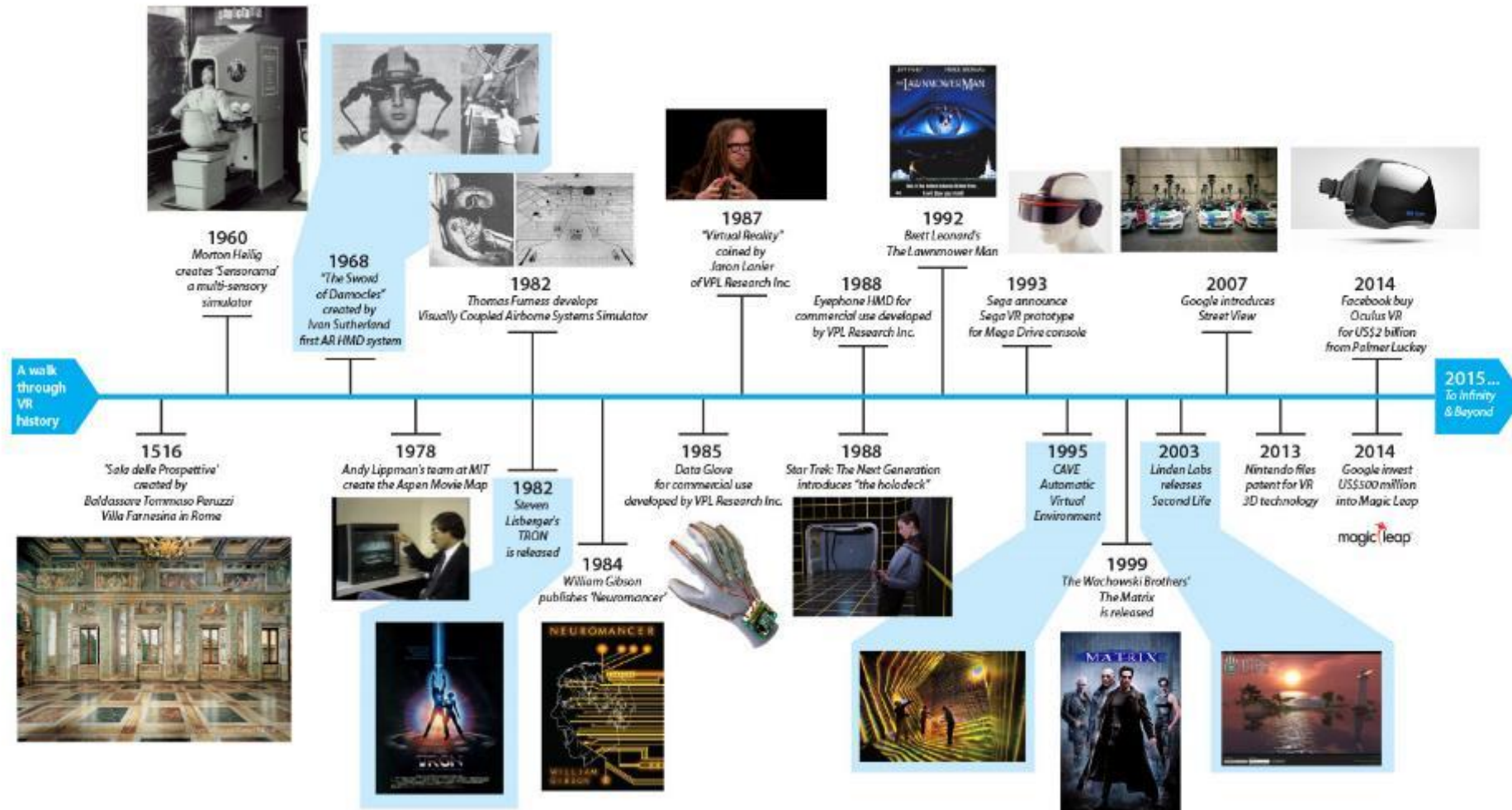
"...anywhere between the extrema of the *virtuality continuum*."



Reality - Virtuality (RV) Continuum

P. Milgram and A. F. Kishino, Taxonomy of Mixed Reality Visual Displays
IEICE Transactions on Information and Systems, E77-D(12), pp. 1321-1329, 1994.

VR History Timeline

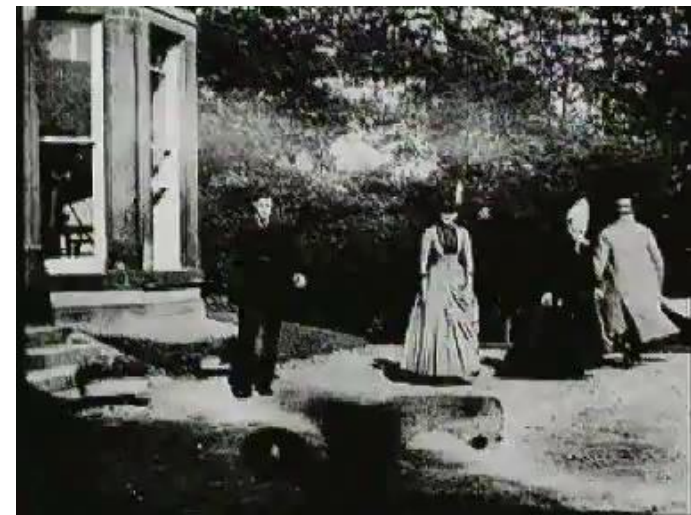


When anything new comes along, everyone, like a child discovering the world thinks that they've invented it, but you scratch a little and you find a caveman scratching on a wall is creating virtual reality in a sense.

Morton Helig (Hammit 1993)

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)



Viewmaster (1939)



3D Cinema Golden Era (1950-60s)



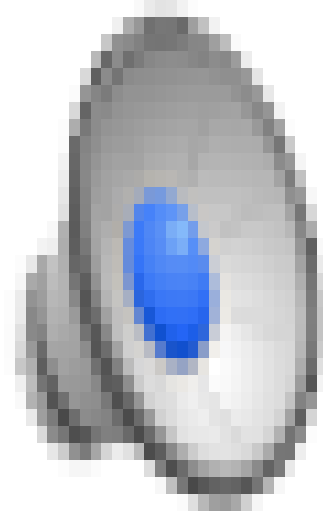
- Polarized 3D projection or anaglyph (red/blue)

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

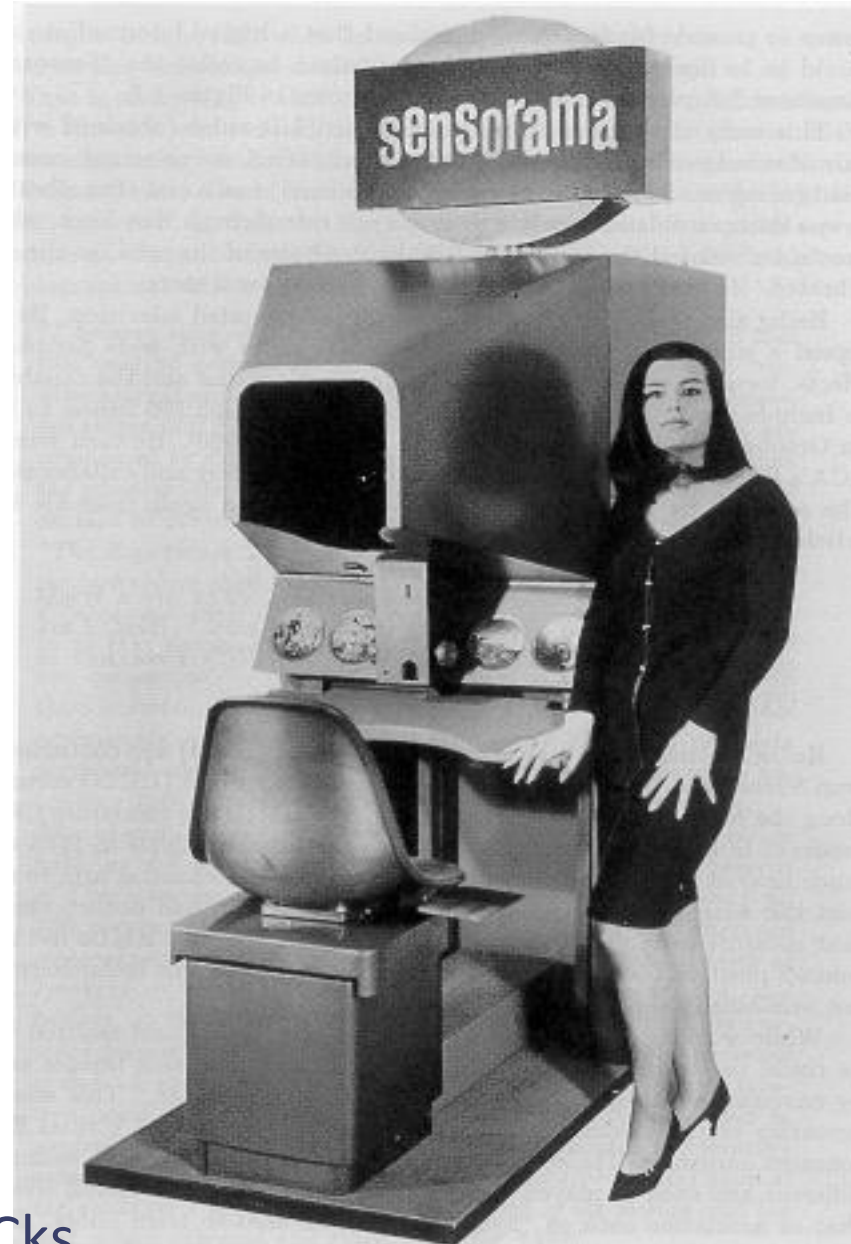
Link Trainer Video (1966)



<https://www.youtube.com/watch?v=MEKkVg9NqGM>

Sensorama (1955)

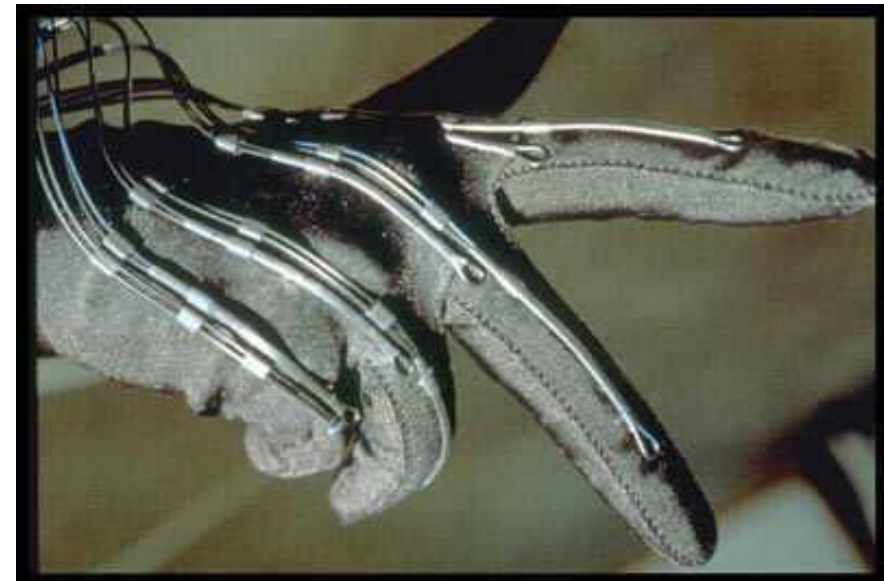
- Created by Morton Heilig
- Experience Theater
- Multi-sensory
 - Visuals
 - Sound
 - Wind
 - Vibration
 - Smell
- No financial support
 - Commercial failure



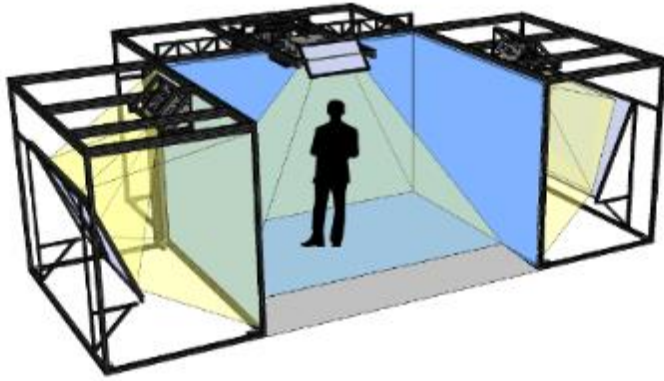
<https://www.youtube.com/watch?v=vSINEBZNCKs>

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)



CAVE (1992)

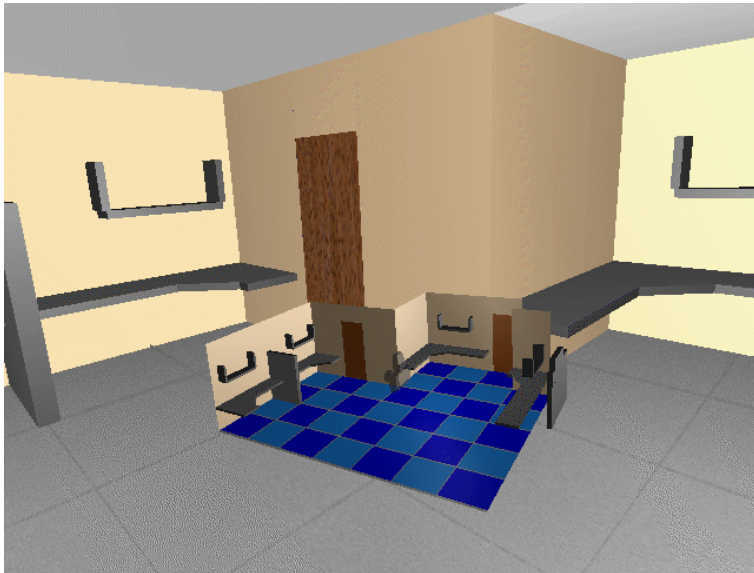


- Projection VR system
 - 3-6 wall stereo projection, viewpoint tracking
 - Developed at EVL, University of Illinois Chicago
- Commercialized by Mechdyne Corporation(1996)

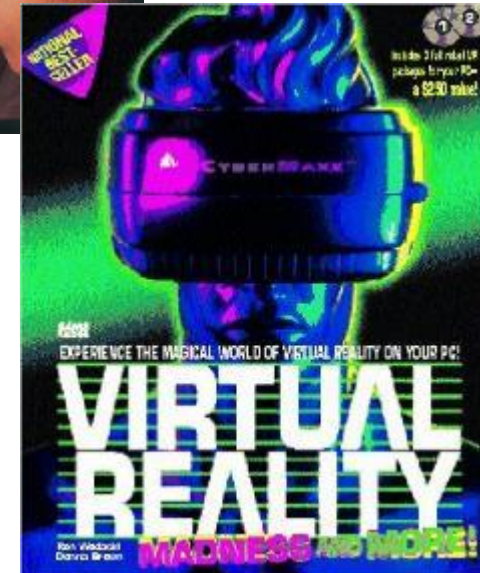
C. Cruz-Neira, D. J. Sandin, T. A. DeFanti, R. V. Kenyon and J. C. Hart. "The CAVE: Audio Visual Experience Automatic Virtual Environment", *Communications of the ACM*, vol. 35(6), 1992, pp. 64–72.

Desktop VR - 1995

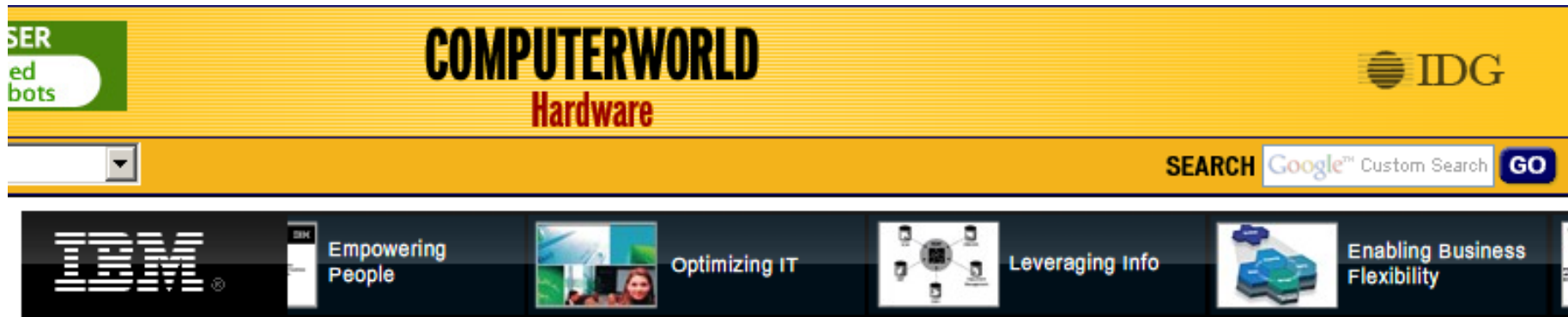
- Expensive - \$150,000+
- 2 million polys/sec
- VGA HMD – 30 Hz
- Magnetic tracking



Virtual Reality was HOT! .. In 1995..



...hot then NOT!



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](#)

April 2007 Computer World

VR Voted 7th on list of 21 biggest technology flops

...hot again 2014

Oculus Rift (2011 -)

- 2012 - \$2.4 million kickstarter
- 2014 - \$2B acquisition FaceBook
- \$350 USD, 110° FOV



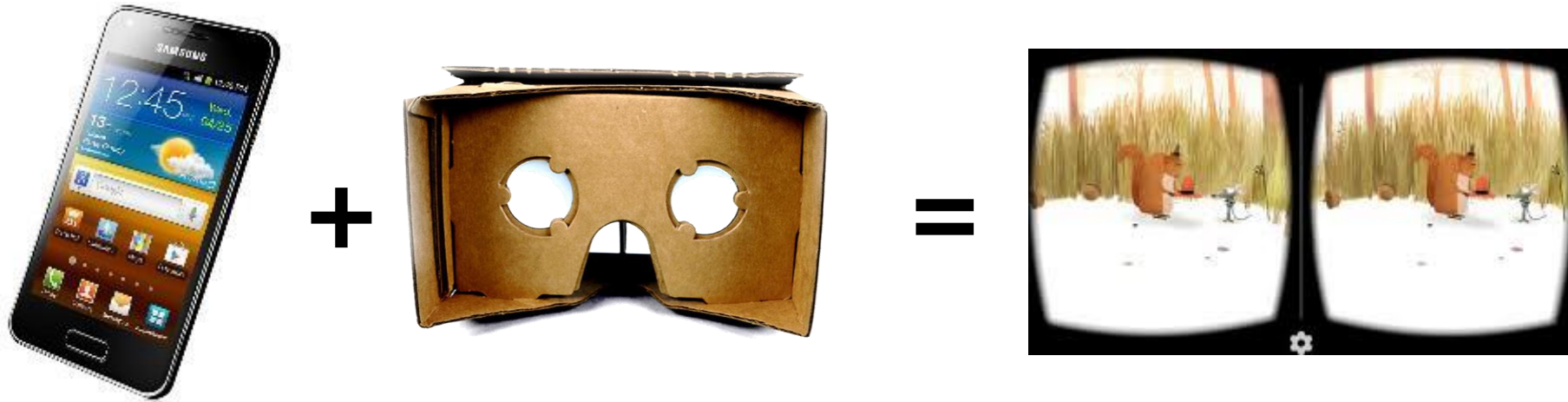
HTC Vive



- Room scale tracking
- Gesture input devices



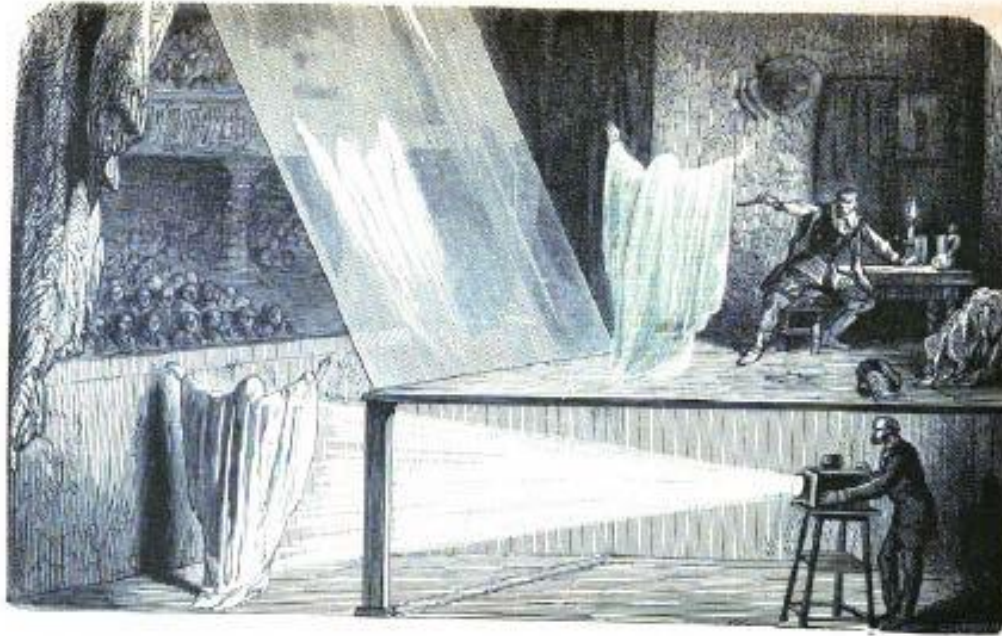
Google Cardboard



- Released 2014
- >5 million shipped/given away
- Easy to use developer tools

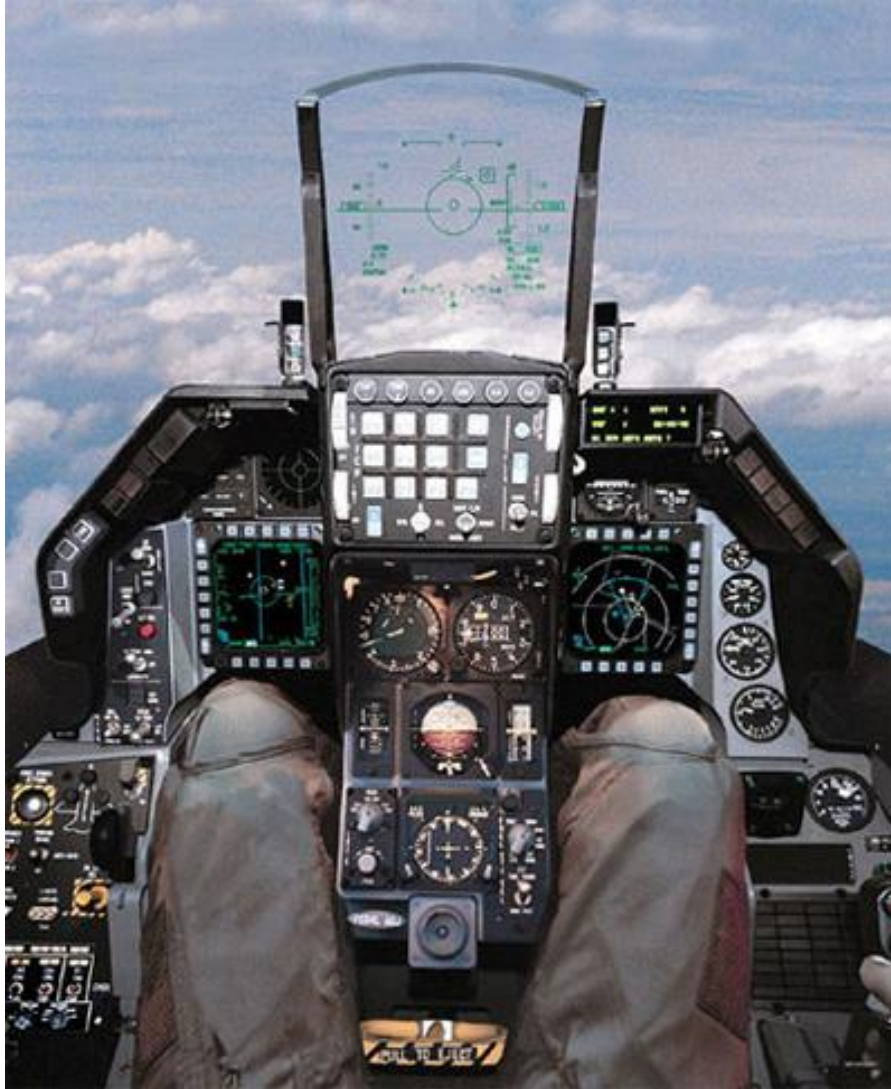


AR History: Pepper's Ghost (1862)



- Dates back to Giambattista della Porta (1584)

Early HUD (1958)



F16 – Head Up Display

Development of AR



- 1996: MIT Wearable Computing efforts
- Late 90's: Augmented sports broadcasts

Google Glass (2011)

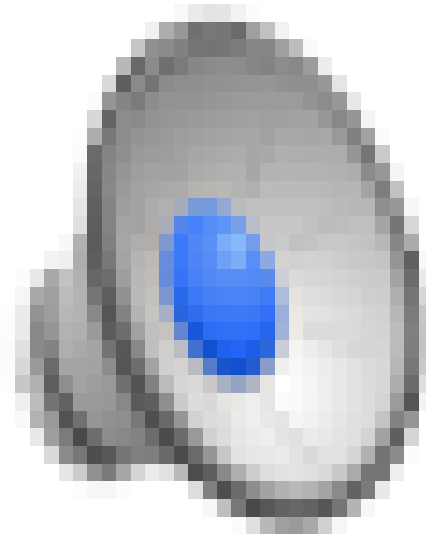


Hololens (2016)



- Integrated system – Windows
- Stereo see-through display
- Depth sensing tracking
- Voice and gesture interaction

View Through Hololens



- https://www.youtube.com/watch?v=RddvMLwT__g

Magic Leap



Strong vs. Weak AR

- Weak AR
 - Imprecise tracking
 - No knowledge of environment
 - Limited interactivity
 - Handheld AR
- Strong AR
 - Very accurate tracking
 - Seamless integration into real world
 - Natural interaction
 - Head mounted AR



Summary

- AR/VR technology can be used to develop a wide range of applications
- Promising application areas include
 - Games
 - Education
 - Engineering
 - Medicine
 - Museums
 - Real Estate
 - Theater