CSC 2524, Fall 2018

# Graphics, Interaction and Perception in Augmented and Virtual Reality AR/VR

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*Inspired and adapted from material by Mark Billinghurst*

# What is this course about?

- Fundamentals of AR/VR:
  - Hardware and Technology.
  - Perception.
  - Interaction techniques.
  - Applications.
- Read and present AR/VR papers.
- Build an AR/VR project.
- Evaluation:
  - Creative experiment/prototype 25%.
  - Technical Paper presentation 25%.
  - Project (2-3 people working together) 50% (mid-term evaluation 10%, report 10%).

# What is Virtual Reality?

## virtual reality

*noun*

**Simple Definition of VIRTUAL REALITY**

Popularity: Bottom 40% of words

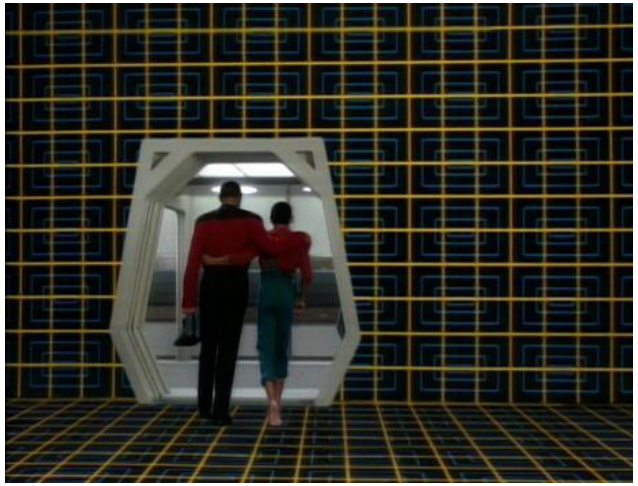
: an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it

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*


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

# Holodeck (Star Trek: The Animated Series 1974)



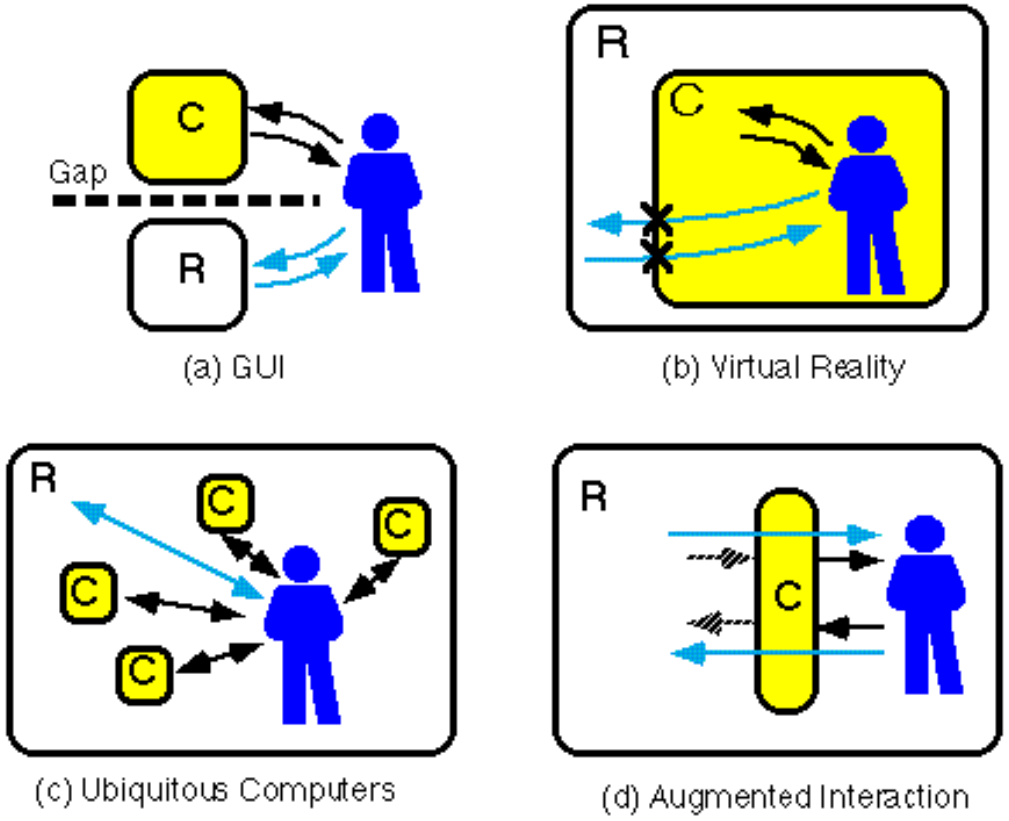
# The Ultimate Display

*“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

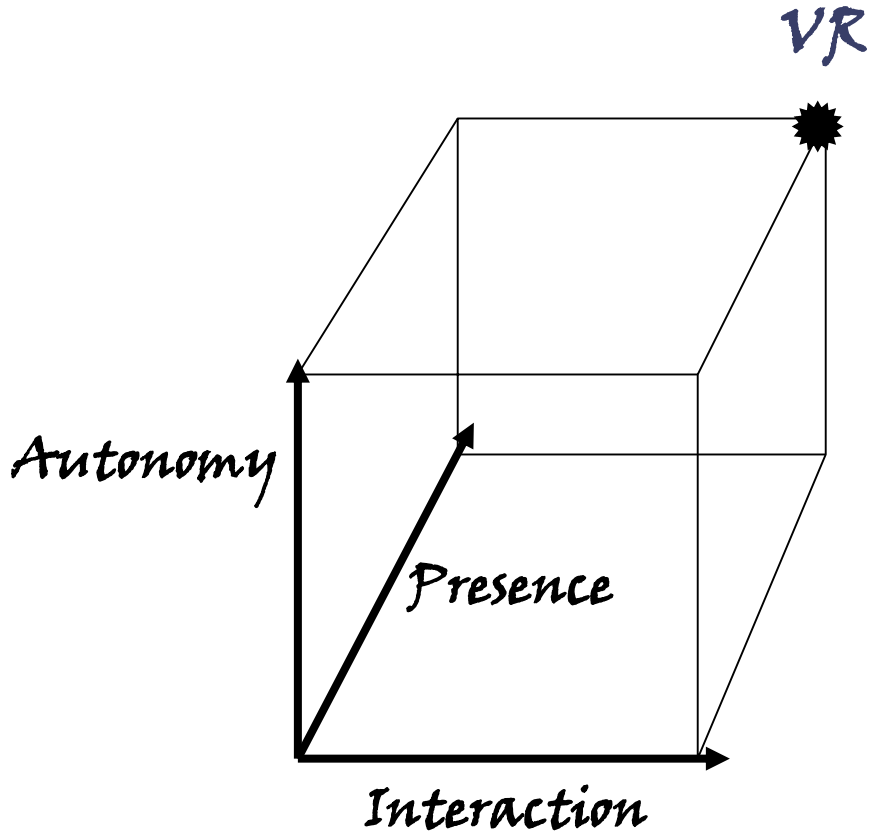
# Making Interfaces Invisible




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

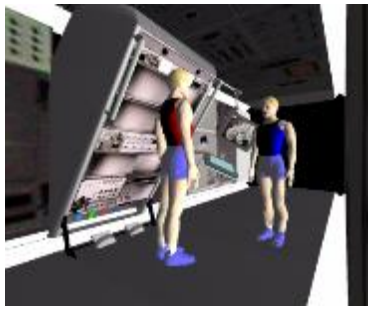
# Milgram's Reality-Virtuality continuum

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

**Mixed Reality**

Real Environment | Augmented Reality (AR) | Augmented Virtuality (AV) | Virtual Environment

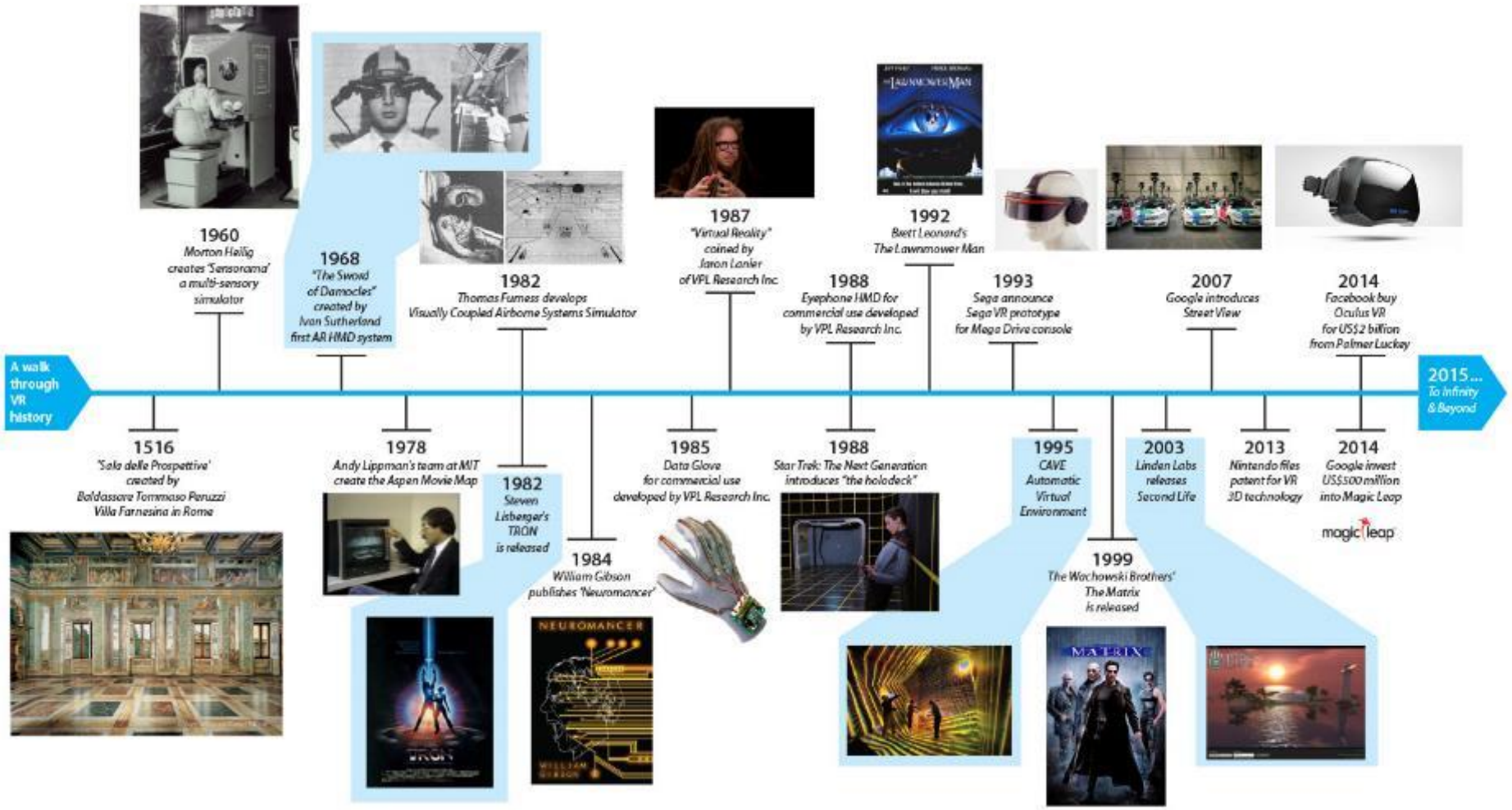


Reality - Virtuality (RV) Continuum

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

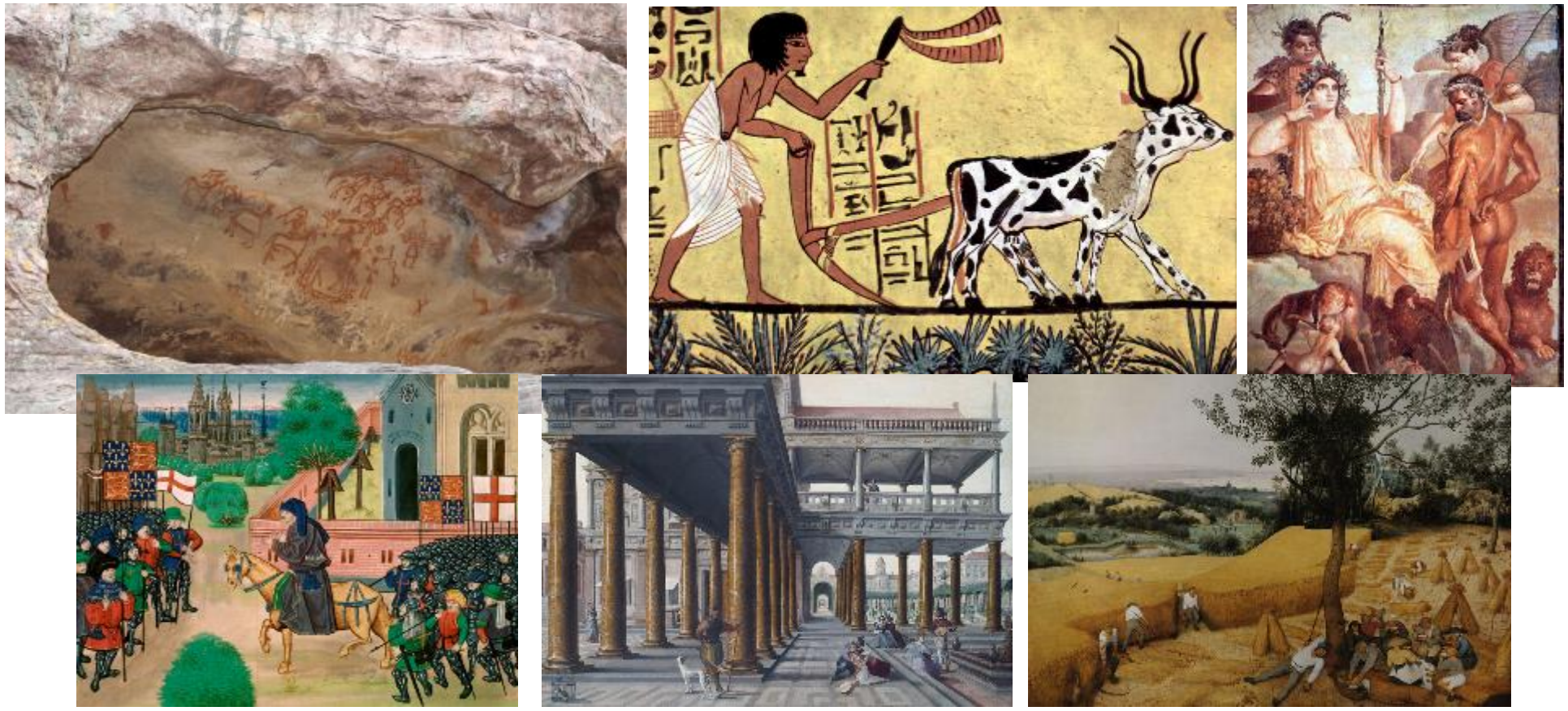



https://immersivelifeblog.files.wordpress.com/2015/04/vr_history.jpg

*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)

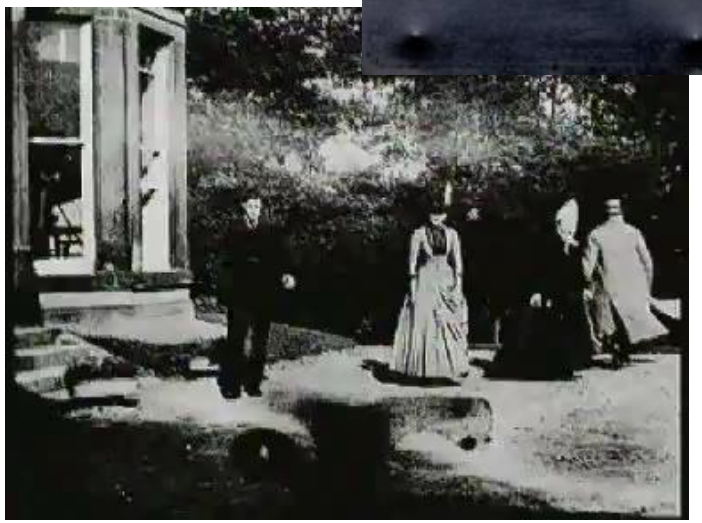
# Early History (30,000 BC - )



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)

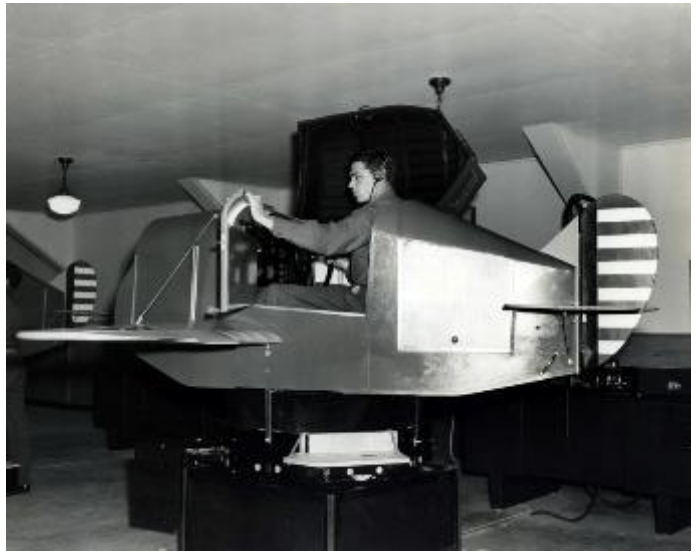


# Viewmaster (1939)

# 3D Cinema Golden Era (1950-60s)

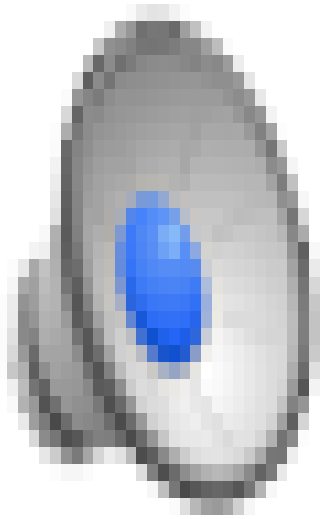

- Polarized 3D projection or anaglyph (red/blue)

# 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

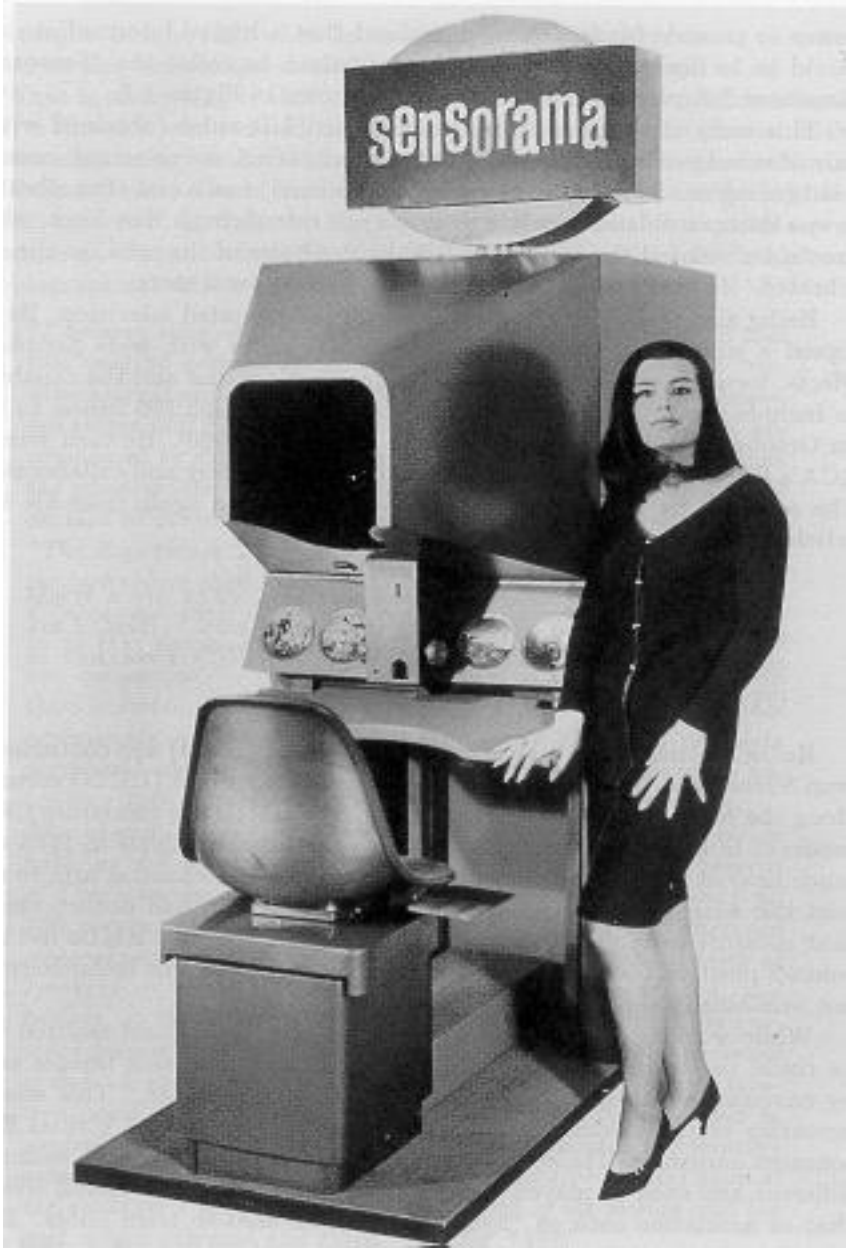
# Link Trainer Video (1966)



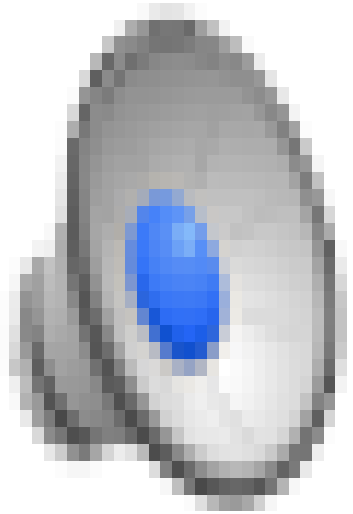
https://www.youtube.com/watch?v=MEKkVg9NqGM

# Sensorama (1955)

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



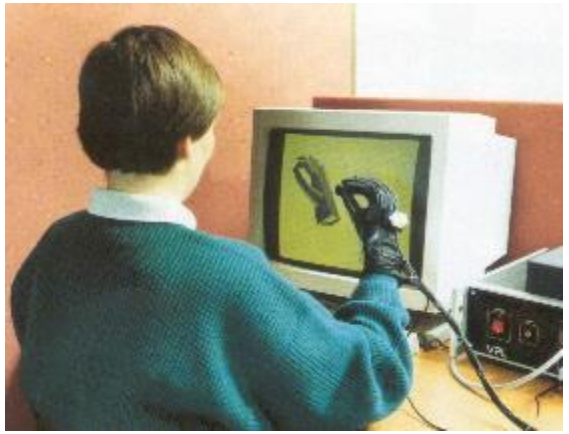
# Sensorama Video

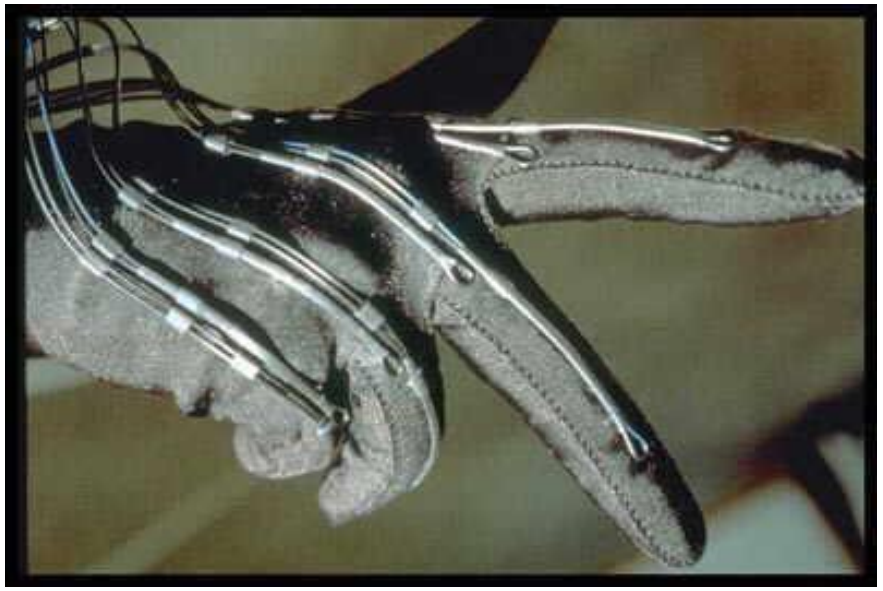


https://www.youtube.com/watch?v=vSINEBZNCks

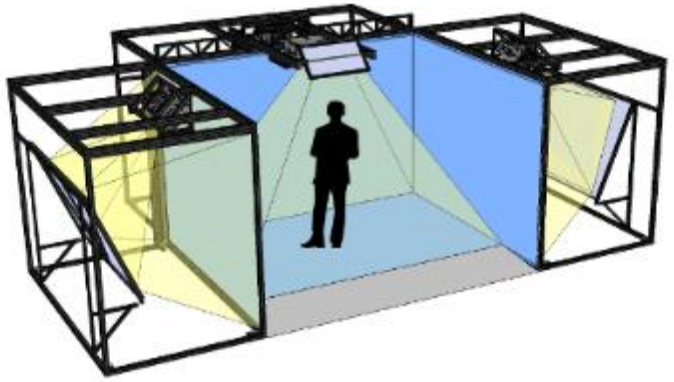
# The Data Glove (1981-82)

- 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)

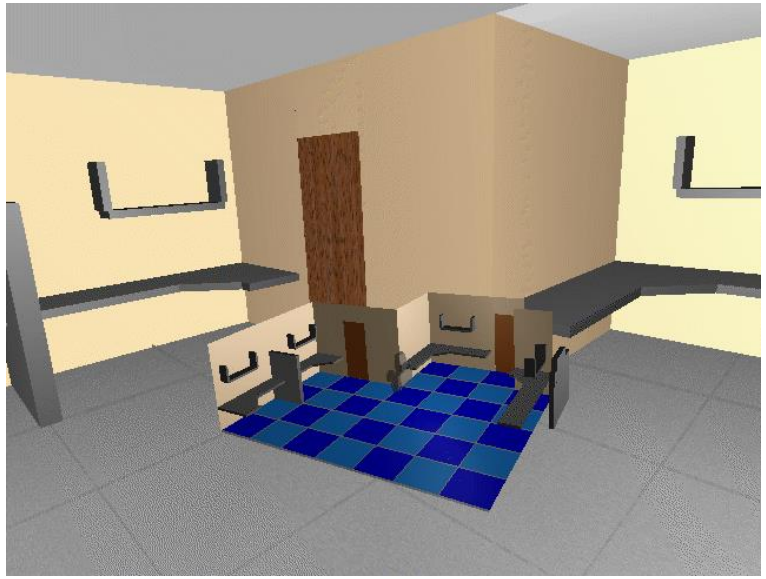
C. Cruz-Neira, D. J. Sandin, T. A. DeFanti, R. V. Kenyon and J. C. Hart. "The CAVE: Audio Visual Experience Automatic Virtual Environment", *Communications of the ACM*, vol. 35(6), 1992, pp. 64–72.

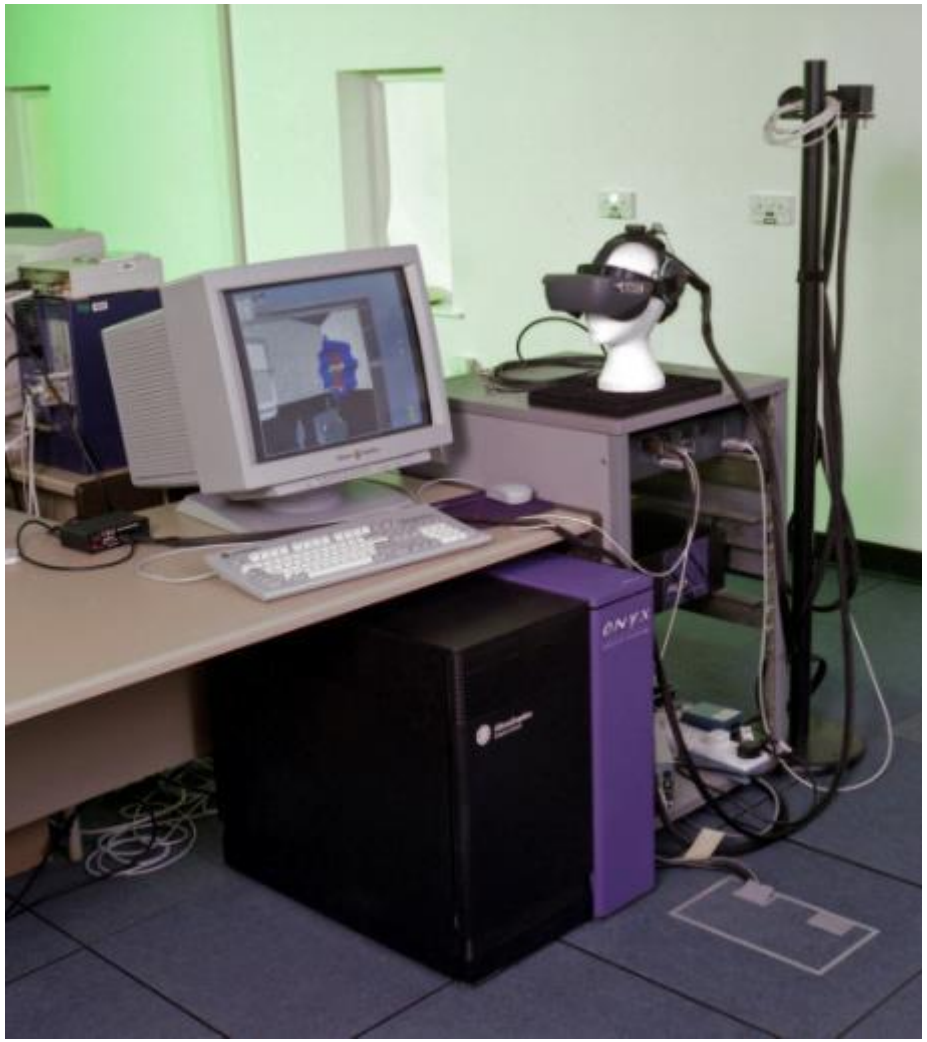
# CAVE Demo Video

https://www.youtube.com/watch?v=aKL0urEdtPU

# Desktop VR - 1995

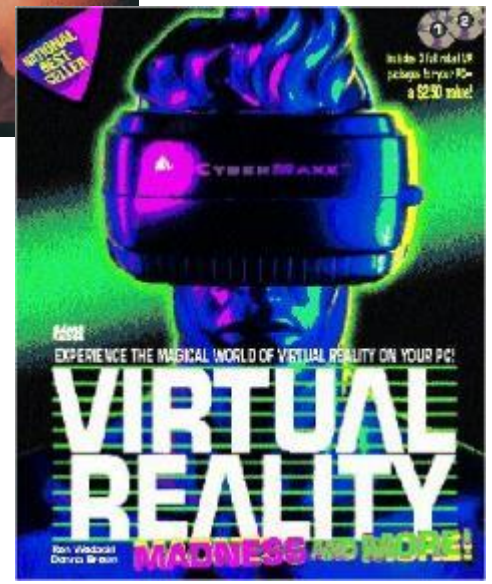
- Expensive - $150,000+
- 2 million polys/sec
- VGA HMD – 30 Hz
- Magnetic tracking



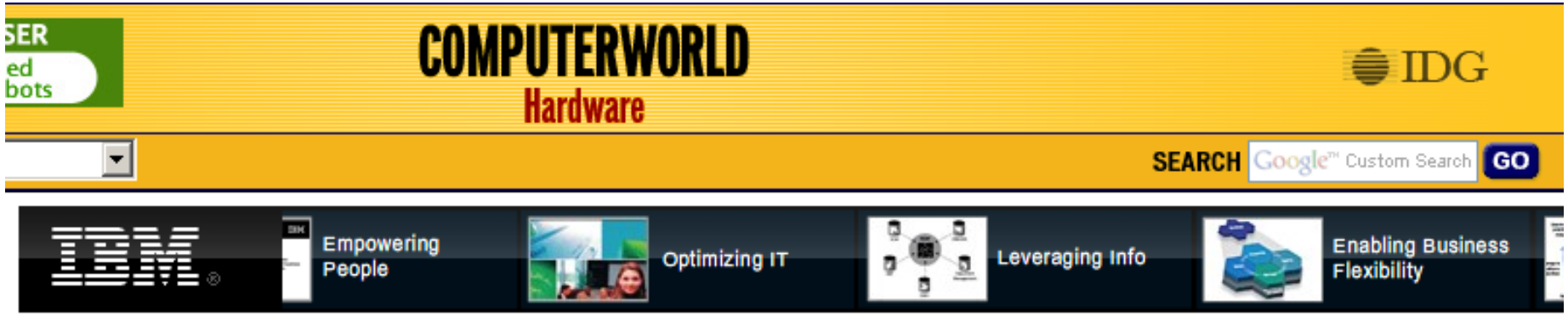


# Virtual Reality was HOT! .. In 1995..





# …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

# VR Second Wave (2010 - )

- Palmer Luckey
  - HMD hacker
  - Mixed Reality Lab (MxR) intern

- Oculus Rift (2011 - )
  - 2012 - $2.4 million kickstarter
  - 2014 - $2B acquisition FaceBook
  - $350 USD, 110$^{o}$ FOV

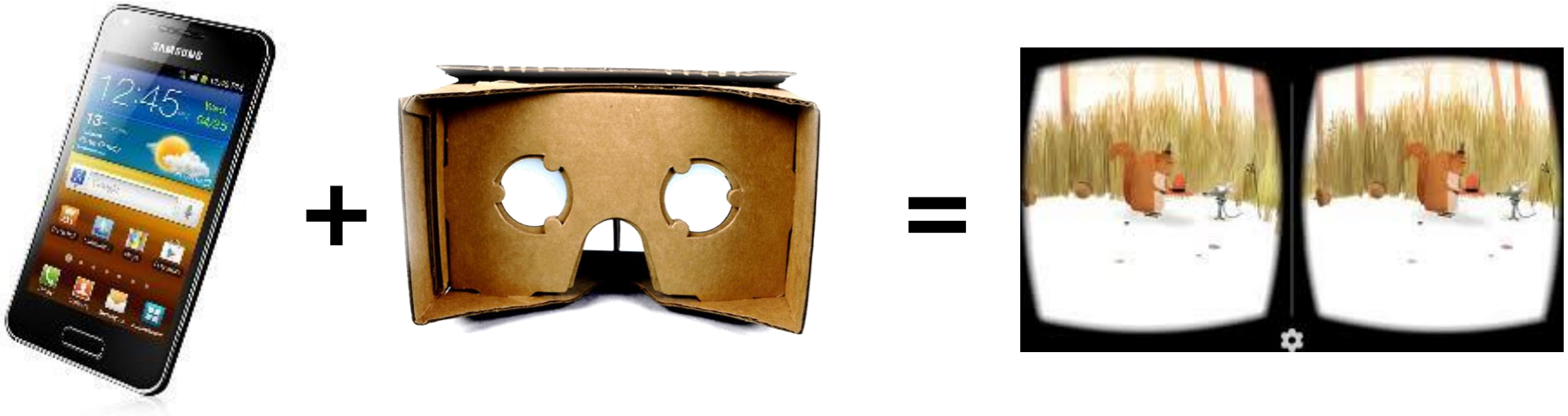
# The Oculus Kickstarter Video

https://www.youtube.com/watch?v=aNSYscbxFAw

# HTC Vive


- Room scale tracking
- Gesture input devices

# Google Cardboard



- Released 2014 (Google 20% project)
- >5 million shipped/given away
- Easy to use developer tools

# Multiple Mobile VR Viewers Available

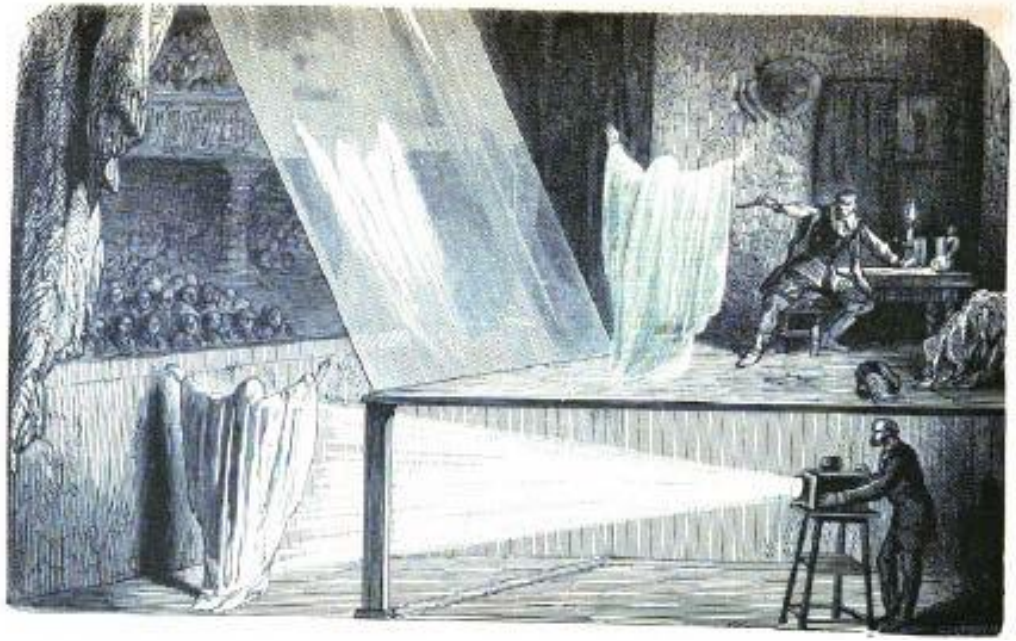




# Augmented Reality


1977 – Star Wars

# Pepper's Ghost (1862)

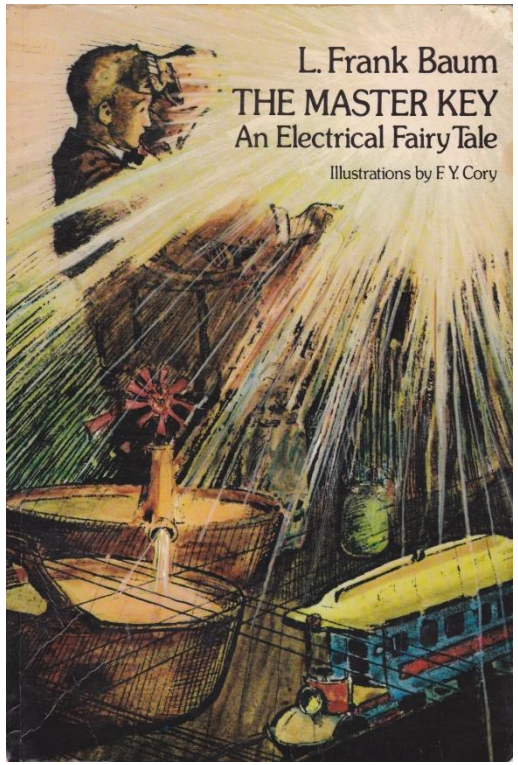


- Dates back to Giambattista della Porta (1584)

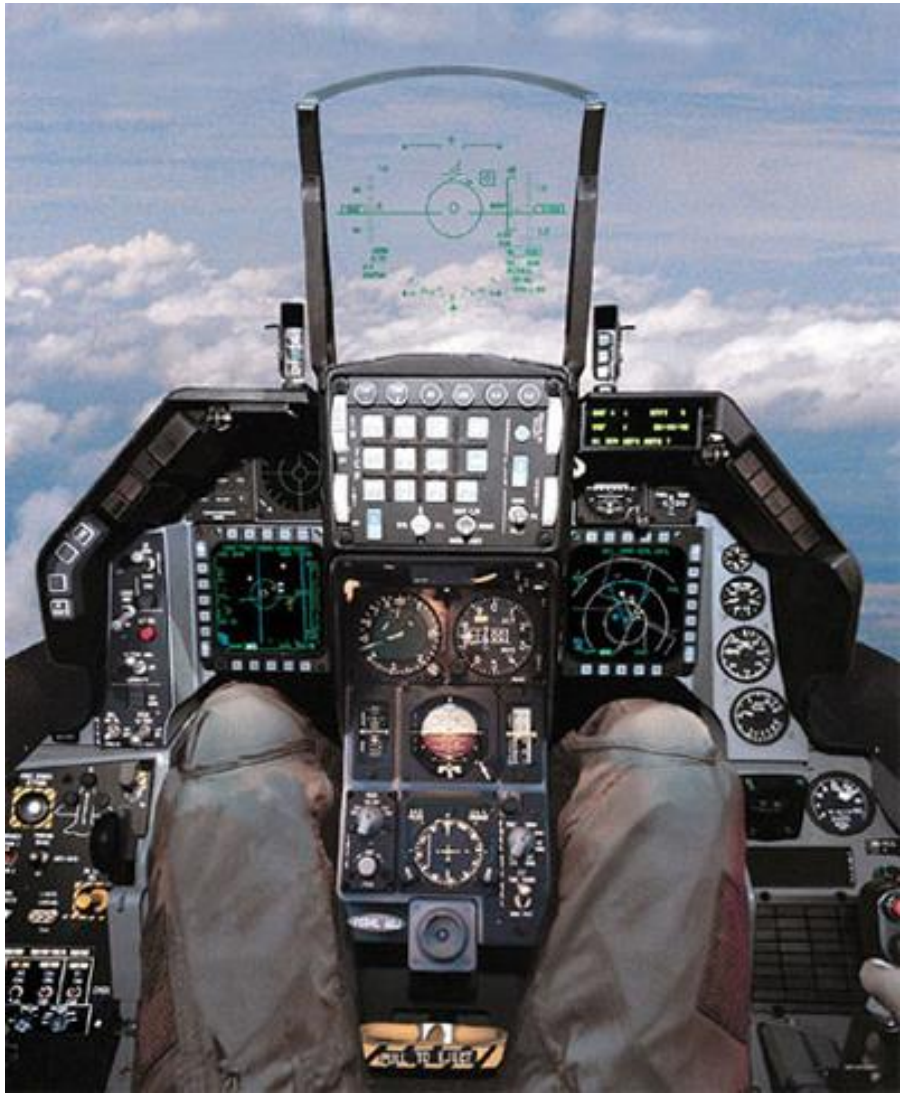
# The Master Key (1901) – AR Glass

- *"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



# Early HUD (1958)



F16 – Head Up Display

# Development of the Field



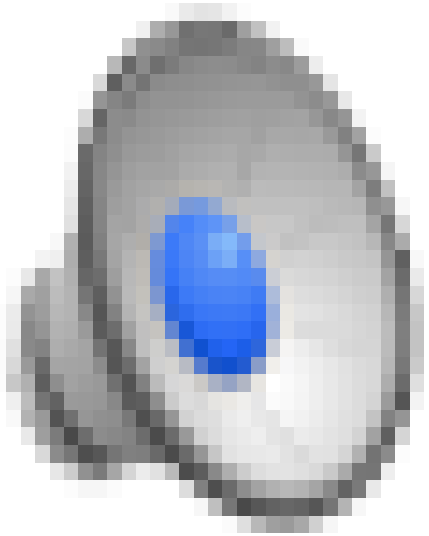
- 1996: MIT Wearable Computing efforts
- 1998: Dedicated conferences begin (ISMAR)
- Late 90’s: Collaboration, outdoor, interaction
- Late 90’s: Augmented sports broadcasts

# 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

# 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
  - Etc..